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ORIGINAL ARTICLE

A Randomized Control Trial Comparing the Maternal Hemodynamics Under Spinal Anesthesia with Various Positions for Cesarean Deliveries

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ABSTRACT

Background: Spinal anesthesia for cesarean delivery often causes maternal hypotension. The extent of visceral analgesia depends on sensory block height, which is influenced by maternal position after injection. This study evaluated how three post-spinal positions—supine, sitting, and semi-sitting—affect maternal hemodynamics, sensory block, intraoperative discomfort, and neonatal outcomes. **Methods:** In this randomized controlled trial, 216 ASA II term parturient undergoing elective cesarean section received 2.5 mL of 0.5% hyperbaric bupivacaine and were assigned to Group A (immediate supine), Group B (three minutes sitting), or Group C (three minutes semi-sitting) (n=72 each). The primary outcome was the incidence of hypotension; secondary outcomes included block height, vasopressor requirement, intraoperative discomfort, and Apgar scores **Results:** Hypotension occurred most frequently in Group A (65.3%), followed by Group C (47.2%) and Group B (33.3%) ($p < 0.001$). The odds of hypotension were 3.8 times higher in Group A than Group B. Ephedrine use was greatest in Group A (14.5 ± 3.2 mg) and lowest in Group B (8.1 ± 2.3 mg). Median sensory levels were T3 (A), T5 (C), and T6 (B). Intraoperative discomfort was highest in Group B (22.2%), compared with Group C (12.5%) and Group A (5.6%) ($p = 0.009$). **Conclusion:** Maternal position after spinal anesthesia significantly affects hemodynamics and block height. The sitting position reduces hypotension but may lower block height and increase discomfort, whereas the semi-sitting position provides a practical balance.

Keywords: Maternal hypotension; Maternal positioning; Sensory block height; Intraoperative discomfort; Neonatal outcome

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Introduction

Due to its quick onset, dense neural blockade, and low fetal drug exposure, spinal anesthesia is still the preferred method for elective cesarean deliveries **(1)(2)**. Up to 80% of cases still result in hypotension, which is mostly caused by sympathetic blockade and aortocaval compression **(3)**.

This may compromise fetal oxygenation by causing nausea, vertigo, altered consciousness, and even decreased uteroplacental perfusion in the mother **(4)**.

Several methods, such as fluid loading, vasopressors, and left uterine displacement, have been suggested to alleviate post-spinal hypotension **(5)(6)**.

The positioning of the mother right after intrathecal injection, however, is a less well-known but clinically significant factor that affects the anesthetic's spread within the subarachnoid space, changing block height and hemodynamic responses **(7)**.

During uterine traction or peritoneal manipulation, the height of the sensory block influences both the effectiveness of visceral analgesia and the degree of sympathetic blockade. Higher blocks (T2-T4) have a higher risk of hypotension even though they offer better analgesia **(8)**. Conversely, lower blocks (T5–T7) maintain hemodynamic stability, but because of insufficient visceral coverage, they may cause discomfort or intraoperative restlessness **(9)**.

Despite growing interest, the influence of brief post-spinal positioning on maternal comfort, block adequacy, and hemodynamic parameters remains underexplored in clinical trials. **(10)**. It is still unclear whether keeping a sitting or semi-sitting position for a short while following a spinal injection can improve block characteristics and lessen hypotension in the obstetric population.

Recent research indicates that using sitting or semi-sitting postures to delay the supine position may help control the local anesthetic's spread and possibly lower the risk of hypotension **(10)(11)**. Although post-spinal positioning may influence block height and hemodynamics, clinical evidence in obstetric settings remains limited.

Three maternal positions supine, sitting, and semi-sitting were evaluated for their effects on maternal hemodynamics during spinal anesthesia for cesarean sections in this randomized controlled trial. Assessing the impact on maternal discomfort during peritoneal manipulation, ephedrine consumption, sensory block height and neonatal Apgar score, were secondary goals. This study uniquely compares three maternal positions in a rigorous RCT design to determine an optimal compromise between cardiovascular stability and analgesic adequacy.

Methods

This prospective, randomized, double-blind controlled study was conducted at Aswan University Hospital between October 2024 and July 2025 after institutional ethical approval (IRB No: Asw.U./966/9/24) and trial registration (NCT06857162). Written informed consent was obtained from all participants.

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A total of 216 ASA II term parturients (18–40 years, BMI 18–35 kg/m²) scheduled for elective cesarean delivery under spinal anesthesia were enrolled. Exclusion criteria included refusal, contraindications to spinal anesthesia, cardiovascular or neurological disease, preeclampsia, multiple gestation, fetal anomalies, or emergency cases.

Participants were randomized into three equal groups: **A (supine immediately), B (sitting 3 min), and C (semi-sitting 3 min, 30° head elevation)** using sealed envelopes. Spinal anesthesia was performed at L4–L5 with 2.5 mL of 0.5% hyperbaric bupivacaine after 500 mL Ringer's preload.

Hemodynamic parameters were monitored every 2 min for 20 min, then every 5 min until 120 min. Hypotension (SBP < 90 mmHg or > 20% fall) was treated with fluids and 5 mg ephedrine. Sensory block level, nausea, discomfort, and Apgar scores were recorded.

Data were analyzed using SPSS 25. ANOVA or Kruskal–Wallis tests compared groups, with $p < 0.05$ considered significant.

Results

Out of 236 women assessed, 216 met inclusion criteria and were randomized equally into three groups (n=72 each). There were no losses or protocol deviations. Baseline demographic and hemodynamic parameters were comparable across all groups, confirming effective randomization in **Table 1**.

Table (1): Demographics data of the participant included.

Demographic Data	**Group A (n=72)** Immediate Supine Position (Control)		**Group B (n=72)** Sitting Position		**Group C (n=72)** Semi-Sitting Position		**P. Value**
Age (years) Mean ± SD.	30.1 ± 5.86		30.15 ± 6.45		29.22 ± 6.34		0.627
Weight (kg) Mean ± SD.	76.54 ± 9.03		74.71 ± 9.89		73.58 ± 9.55		0.171
Height (cm) Mean ± SD.	166.60 ± 7.68		168.03 ± 7.64		167.76 ± 7.64		0.492
BMI (kg/m²) Mean ± SD.	27.74 ± 4.06		26.58 ± 3.98		26.27 ± 3.88		0.068
Parity							
Primigravida (no &%)	14	19.4 %	20	27.8 %	23	31.9 %	
Previous 1 (no &%)	27	37.5 %	27	37.5 %	20	27.8 %	0.380
Multigravida (no &%)	31	43.1 %	25	34.7 %	29	40.3 %	

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Regarding Hemodynamics, Hypotension occurred in 65.3% of the supine group, 47.2% of the semi-sitting group, and 33.3% of the sitting group ($p < 0.001$). The odds of hypotension were 3.8 times higher in the supine versus sitting position **Table 2**. Mean arterial pressure and systolic blood pressure were most stable in the sitting group, intermediate in the semi-sitting, and lowest in the supine group. Heart rate remained similar across groups.

Table (2): incidence of hypotension at first 20 minutes between the three studied groups

Group	**Incidence Hypotension**	**Odds Ratio (vs. Group B)**	**p-value**
A (Supine)	65.3% (47/72)	3.79 [2.01–7.14]	<0.001
B (Sitting)	33.3% (24/72)	Reference	—
C (Semi-sitting)	47.2% (34/72)	1.79 [0.94–3.38]	0.020 (vs. A)

Regarding Sensory Block, Block height differed significantly ($p < 0.001$). Median sensory levels were T3 in the supine, T5 in the semi-sitting, and T6 in the sitting group. Higher blocks correlated with greater hypotension **Table 3**.

Table (3): maximum sensory block level Comparison between the three studied groups

Parameter	**Group A (Supine)**	**Group B (Sitting)**	**Group C (Semi-sitting)**
Maximum Sensory Block Level (Median [IQR], Dermatome)	T3 [T2–T4]	T6 [T5–T7]	T5 [T4–T6]
Patients with Block ≥ T4 n (%)	64 (88.9%)	20 (27.8%)	45 (62.5%)
Pairwise Comparison (p-value)	Reference	< 0.001 vs A; 0.006 vs C	0.013 vs A; 0.042 vs B

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Ephedrine requirement was highest in the supine group (14.5 ± 3.2 mg) and lowest in the sitting group (8.1 ± 2.3 mg). Discomfort during surgery was more frequent in the sitting group (22.2%) due to lower block height **Table 4**.

Table (4): Comparison between the three studied groups according to Ephedrine dose & Intraoperative Discomfort.

	Group A (n=72) Immediate Supine Position (Control)	**Group B (n=72)** Sitting Position	**Group C (n=72)** Semi-Sitting Position	**P.value**	Pairwise comparison Post Hoc Test (Tukey)
Ephedrine Requirement (mg) mean± SD	14.5 ± 3.2	8.1 ± 2.3	10.2 ± 2.9	< 0.001*	p_1 < 0.001* p_2= 0.004* p_3 = 0.031*
Intraoperative Discomfort N. (%)	4 (5.6%)	16 (22.2%)	9 (12.5%)	0.009*	P1 =0.002* P2 = 0.07 p3 = 0.04*

Apgar scores were ≥8 at both 1 and 5 minutes in all groups, with no neonatal complications , while nausea was most common in the supine group (19.4%) Table 5.

Table (5): Comparison between the three studied groups according to Nausea and Vomiting & Apgar Score.

	Group A (n=72) Immediate Supine Position (Control)	**Group B (n=72)** Sitting Position	**Group C (n=72)** Semi-Sitting Position	**P.value**	Pairwise comparison Post Hoc Test (Tukey)
Nausea score (Mean ± SD)	2.54 ± 0.50	0.46 ± 0.50	1.46 ± 0.50	< 0.001*	p_1<0.001* p_2<0.001* p_3<0.001*
Apgar score					
1 min. (Mean ± SD)	9.06 ± 0.82	9.17 ± 0.84	9.08 ± 0.80	0.700	- -
5 min. (Mean ± SD)	9.26 ± 0.71	9.42 ± 0.64	9.32 ± 0.77	0.426	

Discussion

This randomized controlled trial highlights the significant influence of maternal positioning after spinal anesthesia on hemodynamic responses, sensory block characteristics, intraoperative comfort, and vasopressor requirements during cesarean delivery. The findings demonstrate that delaying the supine position using a sitting or semi-sitting posture for three minutes can mitigate hypotension and modulate block height, offering valuable guidance for tailoring obstetric anesthesia practice.

The highest incidence of hypotension was observed in the immediate supine group (65.3%), consistent with previous literature reporting rapid cephalad spread of hyperbaric local anesthetic

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in the supine position due to gravitational pooling in the thoracic region and reduced lumbosacral cerebrospinal fluid volume during pregnancy **(13)(14)**.

This extensive sympathetic blockade increases the risk of peripheral vasodilation and venous pooling, necessitating higher vasopressor use. In contrast, the sitting group had the lowest hypotension rate (33.3%) and ephedrine requirement, reaffirming earlier findings that upright postures slow anesthetic ascent and preserve hemodynamic stability **(15)**.

The semi-sitting group demonstrated intermediate outcomes, suggesting that partial elevation offers a balanced approach attenuating hypotension while achieving satisfactory anesthetic spread. These findings align with those of Attali et al. (2024) and Albrecht et al. (2022), who showed that semi-sitting postures provide more stable cardiovascular profiles while maintaining sufficient block height for surgical anesthesia **(12)(16)**.

The sensory block level closely mirrored these hemodynamic trends. Group A (supine) attained the highest block levels (T2–T4), ensuring effective visceral analgesia and minimal intraoperative discomfort (5.6%). However, this came at the cost of greater cardiovascular compromise, evidenced by the highest ephedrine use and most pronounced MAP and SBP declines.

On the other hand, Group B (sitting) had the lowest block height (T6–T7), which, while hemodynamically favorable, resulted in increased reports of discomfort during peritoneal traction (22.2%). This supports previous work indicating that blocks below T4 may be insufficient for visceral anesthesia, leading to maternal restlessness or pain during surgery **(9)(15)**.

This study confirms a direct relationship between block height and vasopressor demand, as previously demonstrated by Pahuja et al. (2021), where higher thoracic sensory levels were associated with greater hypotension and need for vasopressors **(14)**. Additionally, our findings emphasize that achieving a block height sufficient to cover visceral innervation (T4 or higher) is essential for patient comfort, especially during uterine exteriorization and traction.

Interestingly, the semi-sitting position (Group C) achieved a median block level of T5, with lower discomfort rates (12.5%) than the sitting group and better hemodynamic stability than the supine group. This balance makes the semi-sitting posture particularly attractive in clinical practice, especially when patient comorbidities or surgical urgency limit the ability to tolerate higher blocks or manage profound hypotension.

Heart rate trends did not differ significantly among groups, suggesting that compensatory tachycardia had a limited role in mitigating hypotension. This aligns with prior studies that have reported a blunted chronotropic response in pregnant women undergoing spinal anesthesia due to the dominance of parasympathetic tone and reduced baroreceptor sensitivity **(8)**.

The occurrence of nausea, often correlated with hypotension during cesarean delivery, was highest in the supine group (19.4%) and lowest in the sitting group (6.9%) **(5)**. Vomiting was rare but exclusively seen in patients from the supine group, reinforcing the association between hypotension and gastrointestinal symptoms in neuraxial anesthesia.

Despite variations in maternal hemodynamics and block levels, neonatal outcomes remained favorable across all groups. Apgar scores were ≥8 at 1 and 5 minutes in all neonates, and no newborns required resuscitation or NICU admission. These results are consistent with Vallejo et al. (2020), who reported that prompt correction of maternal hypotension effectively prevents fetal compromise during cesarean delivery **(17)**.

From a methodological standpoint, this study's strength lies in its use of both pinprick and cold sensation testing to determine sensory block height, enhancing reliability and accuracy.

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Furthermore, the randomized, double-blind design and comprehensive monitoring support the validity of the observed outcomes.

These findings underscore the importance of post-spinal maternal positioning as a simple, non-pharmacological intervention to enhance the safety and effectiveness of spinal anesthesia in cesarean sections. The semi-sitting position, in particular, emerges as a practical strategy for achieving a satisfactory balance between analgesic efficacy and hemodynamic stability. Anesthesiologists should consider incorporating a brief delay in supine positioning, especially in parturients at increased risk of hypotension or where intraoperative discomfort could compromise patient experience.

This study had several limitations. High-risk obstetric patients were excluded, limiting generalizability. Discomfort was assessed without validated pain or satisfaction scales, and sensory block evaluation may have been affected by inter-rater variability. Long-term neonatal outcomes and the impact of adjunct anesthetic techniques were not assessed and warrant further investigation.

Conclusion

In conclusion, the clinical course of spinal anesthesia for cesarean delivery is considerably changed by post-spinal maternal positioning. Higher blocks and increased hypotension are the results of immediate supine positioning, but visceral analgesia is superior. Because of inadequate block spread, sitting posture causes discomfort even though it lowers hypotension. The best compromise is provided by the semi-sitting position, which encourages its use as a realistic and scientifically supported approach in standard obstetric anesthesia care.

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ORIGINAL ARTICLE

NEUROVASCULAR COMPLEX CHANGES BY OPTICAL COHERENCE TOMOGRAPHY IN TYPE II DIABETIC PATIENTS

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ABSTRACT

Background: Diabetes' most frequent consequence is diabetic retinopathy (DR). DR is currently regarded as a more complicated diabetes consequence, with microvascular alterations and neurodegeneration playing a major role. We aim to determine the ganglion cell complex (GCC) thickness in individuals with type 2 diabetes using spectral domain optical coherence tomography with early non-proliferative diabetic retinopathy who do not have retinal edema, and to compare their results with those of normal control subjects in the same age range.

Methods: 150 eyes were used in this cross-sectional study. Group 1 consisted of 100 eyes from diabetic patients who visited Menoufia University Hospital's outpatient eye clinic and had been diagnosed with early (mild) non-proliferative diabetic retinopathy without macular edema. Group 2 consisted of 50 eyes of control people without diabetes who were in the same age range as the diabetic group and did not have any other systemic conditions.

Results: There was no statistically significant link between FLV%, HbA1c%, and IOP, but there was a statistically significant positive correlation between FLV% and Average GCC thickness, GLV%, Age, BCVA, Creatinine, and Duration of Diabetes.

Conclusion: Diabetic patients, especially those with poorly controlled HbA1c, show early thinning of the GCC before any detectable vascular changes of DR. Type 2 diabetic patients exhibit reduced inner retinal thickness, indicating early neurodegeneration. Measuring GCC thickness with OCT can detect this early neuronal loss and should be included in routine macular and optic disc OCT evaluations for newly diagnosed diabetics, those suspected of DR, and patients on antihyperglycemic medications.

Keywords: OCT scanning, ganglion cell complex, diabetic retinopathy

INTRODUCTION

Chronic hyperglycemia caused by a malfunction in insulin production, action, or both is a hallmark of diabetes mellitus (DM), a metabolic disorder [(1)]. Globally, the prevalence of diabetes mellitus is rising, and with it are diabetic complications [(2)]. Patients with diabetes are at risk for numerous life-limiting and life-threatening complications, such as peripheral artery disease,

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ischemic heart disease, stroke, and/or microvascular-related retinopathy, neuropathy, and nephropathy.

The most prevalent microvascular consequence of diabetes is diabetic retinopathy (DR)[3]. Both the duration of diabetes and the degree of glycemic management have a high correlation with the prevalence of DR [4,5]. The most common cause of vision loss in people of working age is DR [6]. The diagnosis of DR is based on the clinical signs of vascular anomalies in the retina, and it has long been recognized as a microvascular consequence of diabetes [7]. The two clinical stages of DR are non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR), [6].

Neovascularization is a hallmark of PDR, the more advanced stage of DR, while NPDR is the early stage, during which individuals may not exhibit any symptoms. Patients may suffer from substantial visual impairment at this time [6]. Even before clinically discernible microvascular damage develops, retinal neurodegeneration (neuronal and glial abnormalities) can be detected in the early stages of diabetes, according to recent investigations [8,9]. According to a recent definition by the American Diabetes Association (ADA), DR is a neurovascular problem that is very tissue-specific and involves a progressive disturbance of the interdependence between various cell types in the retina [10].

In general, blood arteries are essential to the functioning of neurons because they remove carbon dioxide and metabolic waste while delivering nutrients and oxygen [11, 12]. To sustain their functions, neurons can also control local blood flow via glial cells and pericytes [13]. Because retinal neurovascular connection is impaired in early DR, these functions are reduced. [14]. The retinal neurovascular unit is composed of neurons (ganglion cells, bipolar cells, horizontal cells, and amacrine cells), glia (astrocytes and Müller cells), immune cells (microglial cells), and vascular cells (endothelial cells and pericytes). Chronic hyperglycemia disrupts the retinal neurovascular unit through oxidative stress, mitochondrial dysfunction and activation of inflammatory process. These processes impair the endothelial function, reduce the pericytes survival and induce Muller cell gliosis [15].

Neural apoptosis in RGC is initially observed during diabetes. The layer of retinal nerve fibers is reduced as a result. Functional problems most likely precede neuronal elimination [16]. In diabetic individuals, neuroretinal thickness is significantly reduced due to the gradual loss of retinal ganglion cells [17]. Retinal dysfunctions will result, which have been well-documented in patients with little to no microvascular retinopathy, and in certain circumstances, even before diabetes [18].

Novel and more effective preventive and interventional techniques based on a better understanding of the etiology of the early stages of the illness are required because current treatments target diabetic retinopathy in its late stages, when vision has already been seriously compromised [19]. The optical analogue of ultrasound imaging is optical coherence tomography (OCT), a noninvasive optical imaging method. In 1991, the OCT was first documented [20]. Because it can produce high-resolution cross-sectional images of the retina and optic nerve head that can be assessed both

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qualitatively and quantitatively [20], this device can offer a true "Optical Biopsy" of retinal microstructures [21].

In diabetic individuals, OCT may be a crucial technique for identifying the early indicators of neurodegeneration [22]. It has been determined that neuroretinal alteration may occur before microvascular problems in DM since SD-OCT has demonstrated that DM may decrease RNFL thickness and GCL in early stages of the disease [23]. Finally, identifying early neurodegenerative symptoms may help avoid visual loss and choose the best course of treatment for DR [11]. This study aims to determine the complex ganglion cell thickness in individuals with type 2 diabetes using spectral domain optical coherence tomography with early non-proliferative diabetic retinopathy who do not have retinal edema, and to compare their results with normal control subjects in the same age range.

PATIENTS AND METHODS

Study design

In this cross-sectional, observational study beginning in September 2021 and continuing through April 2022. 150 participants were split into two groups, Group I:, 100 patients with type 2 diabetes mellitus who have been diagnosed with early (mild) non-proliferative diabetic retinopathy without retinal edema who visited the outpatient clinic at the Department of Ophthalmology, Menoufia University Hospitals and Group II: For normative data, the eyes of 50 healthy individuals who were free of ocular or systemic diseases were examined. The study was conducted according to the principles of Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Menoufia Faculty of medicine (Approval number 9/2021 OPHTH 8)

Due to identical structural features in each person, just one eye was chosen for each participant in the diabetes and control groups to prevent false positive results when both eyes were recruited. Random selection or the lack of any exclusion criteria was used to select the included eye. Every patient had a known diagnosis of diabetes mellitus, which their primary care physician verified through laboratory tests. All participants gave their informed consent after being fully informed about the study's methodology, which protected their privacy and the confidentiality of their data. No artificial intelligence tools were used in any step of this study

Patients' criteria selection

The requirements for standard controls to be included have no prior history of ocular or systemic conditions or surgeries, have blood test results that are normal, have both anterior and posterior segment ocular examination results that are normal and both sexes aged of 30-65.

The inclusion criteria of the diabetic patients included Slit lamp biomicroscopy was used to diagnose type 2 diabetes patients' eyes with early non-proliferative diabetic retinopathy without DME, and fundus fluorescein angiography was used to confirm the diagnosis. Within the recognized normal range is the retinal thickness map and Patients, both male and female, aged 30 to 65.

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The exclusion criteria included a patient with OCT scans of low quality, such as media opacities, patients with neurological conditions like parkinsonism or poor fixation that make it difficult to properly detect the OCT picture, a patient whose visual acuity has been compromised for any other reason, indirect fundoscopy, slit-lamp stereo biomicroscopy, fundus fluorescein angiography, and other ophthalmologic examinations were used to grade the severity of diabetic retinopathy in patients with moderate to severe non-proliferative and proliferative DR, Individuals suffer from retinal conditions other than diabetic retinopathy, a patient who has previously been diagnosed with uveitis or glaucoma, individuals suffering from retinal ischemia or macular edema, a patient who has previously undergone intraocular intervention and more than six diopters of myopia or hyperopia. Patients with systemic diseases that may affect the retinal structure such as hypertension, renal impairment or autoimmune diseases were excluded

Each subject was subjected to:

- **Taking a complete history** a) Individual background: age, gender, race, and profession, b) Particular behaviors like smoking, c) The course and management of diabetes (as indicated by HbA1c), d) Any past medical records and e) The history of surgery for the eyes.
- **Conditions of the laboratory:** a) The level of hemoglobin A1c (HbA1c), b) Serum creatinine (SCr), serum uric acid (UA), and c) Triglycerides (TG), total cholesterol (TC), low-density lipoproteins (LDL), and high-density lipoproteins (HDL) comprise the lipid profile.
- **Ophthalmic examination:** Visual acuity: Snellen's chart was used to calculate Best Corrected Visual Acuity, which was then converted to decimal notation visual acuity for statistical analysis. a) Slit lamp examination and fundus biomiocroscopy with a +78 Diopter Volk lens for the anterior and posterior segments and b) Applanation tonometer for IOP measurement.
- **Imaging studies:** To aid with imaging, the patient received mydriatic eye drops containing tropicamide 1% (Mydriacyl, Alcon).

Fundus Fluorescein angiography (FFA): Heidelberg Retinal Angiogram-2 (Heidelberg Engineering, Germany) and an intravenous injection of 10% sodium fluorescein dye were employed.

OCT scanning was carried out to measure GCC thicknesses using an SD-OCT device (RTVue XR Avanti, USA). The GCC represents a segmented inner retinal parameter consisting of RNFL+GCL+IPL layers. Following pupillary dilation, the iVue GCC thickness technique was used for imaging.The SD-OCT instrument (RTVue XR Avanti, USA) obtains 26,000 A-scans per second with a tissue axial resolution of 5 μm.15 B-scans spaced 0.5 mm apart make up the GCC scan pattern, which is centered 0.75 mm temporally to the fovea and covers a 7 × 7 mm square grid on the central macula. The superior and inferior sectors of the GCC were used to measure thickness. Following the acquisition, three color-coded maps are automatically calculated by the software: a) a thickness map color-coded with cooler colors (blue and black) that shows more severe GCC loss, b) a deviation map that shows the percentage of thickness loss in relation to the normative database; and c) a significance map that shows statistically significant thickness changes from the normal. The analytical software also computes two pattern-based diagnostic indexes. The average focal

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GCC loss divided by the map area is known as the focal loss volume (FLV). The total of the negative fractional deviation is the global loss volume (GLV).[18,45] Because a focal GCC loss may go unnoticed in eyes with above-average GCC thickness, pattern-based measures (FLV and GLV) are thought to have superior diagnostic values than the mean GCC loss.

To enhance the quality of the scans, those with 40 signal strength intensity were not included in the analysis. The thickness of the central retina was measured. The result was a map of macular thickness that was color-coded. The circular sections had sizes of 1, 3, and 6 mm. 15 B-scans spaced 0.5 mm apart make up the GCC scan pattern, which is centered 0.75 mm temporally to the fovea and covers a 7 × 7 mm square grid on the central macula. The superior and inferior sectors were the two locations where the GCC thickness was measured.

Three color-coded maps are automatically calculated by the software after the acquisition: a) a thickness map that shows more severe GCC loss and is color-coded with cooler colors (blue and black); b) a deviation map that shows the percentage of thickness loss in relation to the normative database; and c) a significance map that shows statistically significant thickness changes from the normal. The analytical software also computes two pattern-based diagnostic indexes. The focal loss volume (FLV) is calculated by dividing the average focused GCC loss by the map area. The global loss volume (GLV) is the sum of the negative fractional deviation.

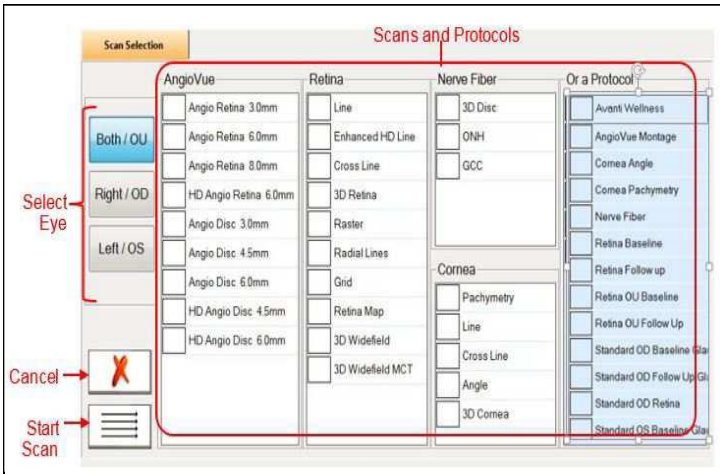

Figure (1): RTVue XR Avanti scans & protocols.

Figure (2): SD-OCT device (RTVue-100, Optovue Inc., Fremont, CA).

Statistical Analysis

Version 20 of the Statistical Package for Social Science (IBM SPSS) was used to collect, edit, process, and enter data. While quantitative data were displayed as means, standard deviations, and ranges when their distribution was determined to be parametric, qualitative data were displayed as numbers and percentages. The Chi-square test was employed to compare two groups with qualitative data, and when the expected count in any cell was less than five, the Fisher exact test was used in its place. The Independent t-test was used to compare two independent groups

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with quantitative data and parametric distribution. A 95% confidence interval and a 5% acceptable margin of error were established. P <0.05 indicates a significance level.

RESULTS

Results in Table (1) indicates that there were 81 male and 69 female cases, with ages ranging from 35 to 66 years (mean age of 46.64 years), **(Table 1).**

Table 1. Distribution of the cases studied according to demographic data.

		All Cases
		No.= 150
Gender	Female	69 (46.0%)
	Male	81 (54.0%)
Age	Mean ± SD	46.64 ± 9.09
	Range	35 – 66

As illustrated in Table (2); Group I had 56.0% men and 44.0% females, while Group II had 50.0% males and 50.0% females. The average age of Group I was 47.27 ± 9.79, while the average age of Group II was 43.20 ± 10.20. Group I and Group II did not differ statistically significantly in terms of gender or age **(Table 2).**

Table 2. Comparison between group I (no. =100) and group II (no. =50) regarding age and gender.

		Group I	**Group II**	**Test value**	**P-value**
		No. = 100	**No. = 50**		
Age/year	Mean ± SD	47.27 ± 9.79	43.20 ± 10.20	2.369	0.069
	Range	35 – 65	36 – 62		
Gender	Female	44 (44.0%)	25 (50.0%)	0.483	0.487
	Male	56 (56.0%)	25 (50.0%)		

Chi-square test (X^2), Independent t-test (t)

As illustrated in **table (3)**; In Group I; 52.0% of them were Right Eye and 48.0% were Left Eye, while Group II; 56.0% Of them, 44.0% had left eyes and 7.22 ±0.40 had right eyes. The average HbA1c% for Group I was 5.14 ± 0.28, and the average BCVA for Group I was 0.19 ± 0.15, while the average BCVA for Group II was 0.20 ± 0.13. Regarding Eye and BCVA, no significant difference between Group I and Group II; however, in terms of HbA1c%, there was a highly significant difference **(Table 3).**

Table 3. Comparison between Group I (no. =100) and Group II (no. =50) regarding Eye, HbA1c and BCVA

		Group I	**Group II**	**Test value**	**P-value**
		No. = 100	**No. = 50**		
Eye	Left	48 (48.0%)	22 (44.0%)	0.214	0.643
	Right	52 (52.0%)	28 (56.0%)		
HbA1c%	Mean ± SD	7.22 ± 0.40	5.14 ± 0.28	-32.491	0.000
	Range	6.4 – 7.7	4.8 – 5.7		
BCVA	Mean ± SD	0.19 ± 0.15	0.20 ± 0.13	-0.326	0.745

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	Range	0 – 0.5	0 – 0.4		

As illustrated in **table (4)**; With an average Group I FLV% of 2.76 ±2.38 and an average Group II FLV% of 0.34 ± 0.40, the average Group I GLV% was 6.77 ±3.75 and the average Group II GLV% was 1.62 ±1.56. The average Group I Average GCC thickness was 90.54 ± 6.60, while the average Group II Average GCC thickness was 99.16 ±5.99. The difference between Group I and Group II in terms of Average GCC thickness, FLV%, and GLV% was highly statistically significant **(Table 4).**

Table 4. Comparison between Group I (n=100) and Group II (n=50) regarding Average GCC thickness, FLV% and GLV%.

		Group I	**Group II**	**Test value**	***P-value***
		N= 100	**N= 50**		
Average GCC thickness	Mean ± SD Range	90.54 ± 6.60 79 – 105	99.16 ± 5.99 91 – 112	-7.771	0.000
FLV%	Mean ± SD Range	2.76 ± 2.38 0 – 8.63	0.34 ± 0.40 0 – 1.48	7.133	0.000
GLV%	Mean ± SD Range	6.77 ± 3.75 0.65 – 15.8	1.62 ± 1.56 0 – 5.4	9.305	0.000

As illustrated in **table (5)**; The mean IOP for Group I was 15.58± 2.04, the mean IOP for Group II was 15.26± 2.05, and the mean creatinine for Group I was 91.14 ± 10.01, while the mean creatinine for Group II was 90.18 ± 11.23. In terms of IOP and creatinine did not significant difference between Group I and Group II **(Table 5).**

Table 5. Comparison between Group I (no. =100) and Group II (no. =50) regarding IOP and Creatinine

		Group I	**Group II**	**Test value**	**P-value**
		No. = 100	**No. = 50**		
IOP	Mean ± SD	15.58 ± 2.04	15.26 ± 2.05	0.817	0.367
	Range	13 – 20	13 – 20		
Creatinine	Mean ± SD	91.14 ± 10.01	90.18 ± 11.23	0.282	0.596
	Range	74 – 110	70 – 119		

This table displays the kind of medication; 72 (72.0%) of the patients were on oral medicine, and 28 (72.0%) were on insulin treatment. The mean duration of diabetes ranged from 2 to 21 years **(Table 6).**

Table 6. Distribution of the studied cases concerning Duration of diabetes and Type of medication.

		Group I
		No. = 100
Duration of diabetes	Mean ± SD	8.50 ± 5.01
	Range	2 – 21
Type of medication	Oral	72 (72.0%)

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	Insulin	28 (28.0%)

According to the following table, there is no significant link between average GCC thickness, age, and IOP, but there was a statistically significant positive correlation between average GCC thickness and FLV%, GLV%, HbA1c%, BCVA, creatinine, and diabetes duration **(Table 7, Figures 3-8).**

Table 7. Correlation between Average GCC thickness with FLV%, GLV%, Age, HbA1c%, BCVA, IOP, creatinine and diabetes duration.

Group I	**Average GCC thickness**	
	r	**P-value**
FLV%	**0.323****	**0.001**
GLV%	**0.338****	**0.001**
Age	-0.076	0.452
HbA1c%	**0.243***	**0.015**
BCVA	**0.197***	**0.050**
IOP	0.131	0.194
Creatinine	**0.267****	**0.007**
Duration of diabetes	**0.310****	**0.002**

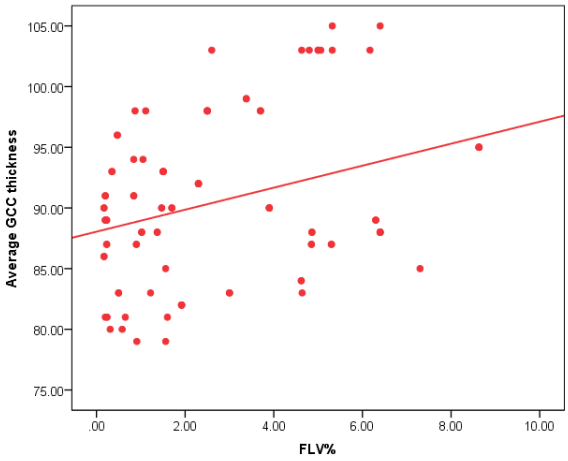

Figure (3): Positive Correlation between Average GCC thickness and FLV%.

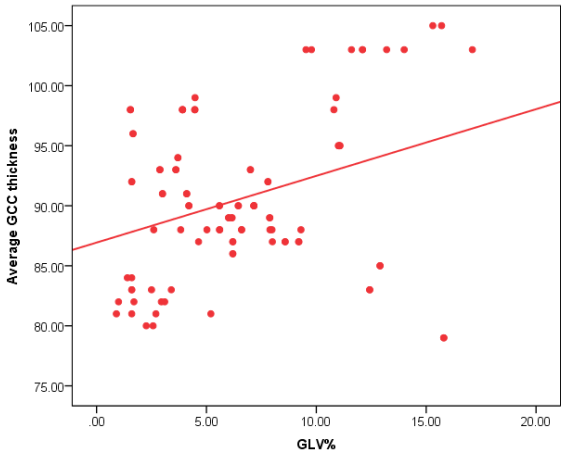

Figure (4): Positive Correlation between Average GCC thickness and GLV%.

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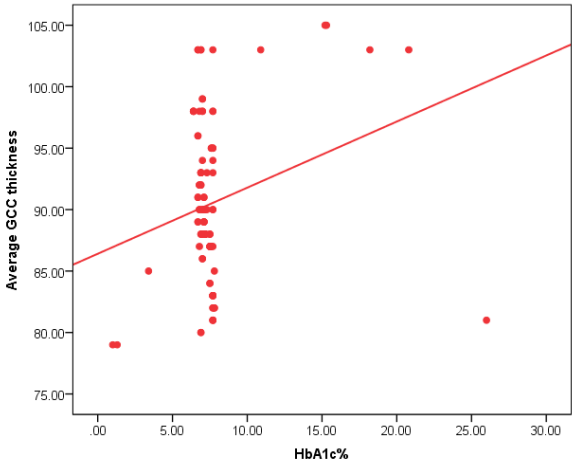

Figure (5): Positive Correlation between Average GCC thickness and HbA1c%.

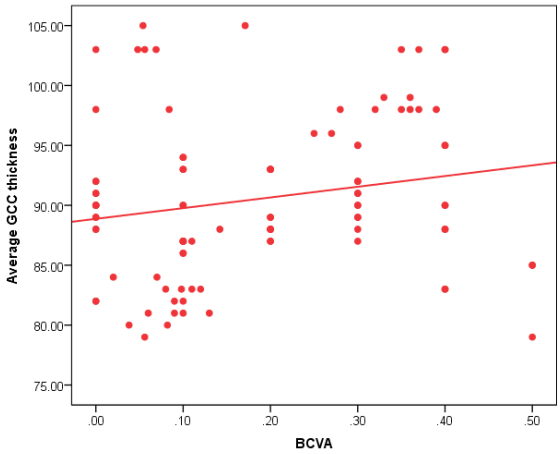

Figure (6): Positive Correlation between Average GCC thickness and BCVA.

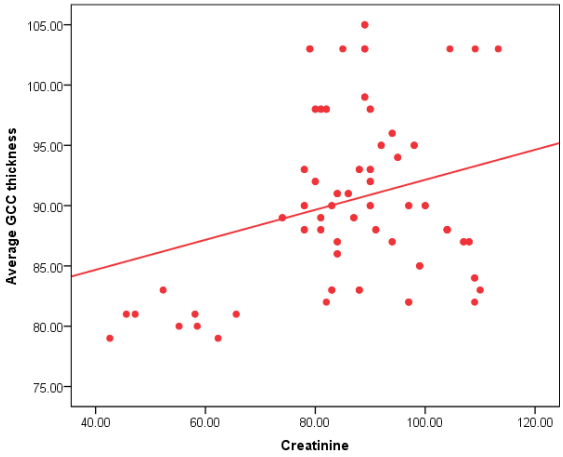

Figure (7): Positive Correlation between Average GCC thickness and Creatinine.

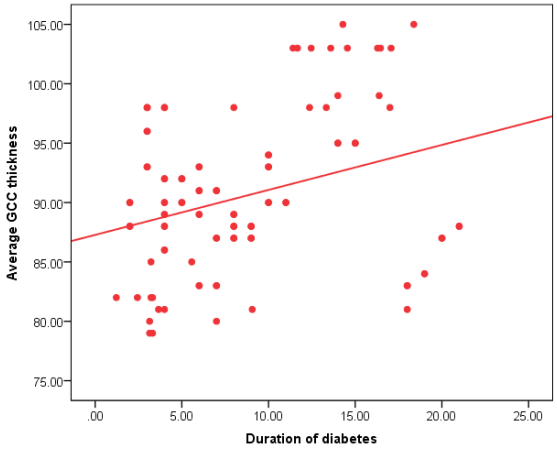

Figure (8): Positive Correlation between Average GCC thickness and Duration of diabetes.

There was no significant link between FLV%, HbA1c%, and IOP, although the previous table demonstrates a statistically significant positive relation between FLV% and Average GCC thickness, GLV%, Age, BCVA, creatinine, and diabetes duration **(Table 8, Figures 9-14).**

Table 8. Correlation between FLV% With Average GCC thickness, GLV%, Age, HbA1c%, BCVA, IOP, creatinine and diabetes duration.

Group I	FLV%	
	r	P-value
Average GCC thickness	**0.323****	**0.001**
GLV%	**0.463****	**0.000**
Age	**0.288****	**0.004**
HbA1c%	0.163	0.106
BCVA	**0.334****	**0.001**
IOP	0.015	0.996
Creatinine	**0.476****	**0.000**

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Duration of diabetes	**0.577****	**0.000**

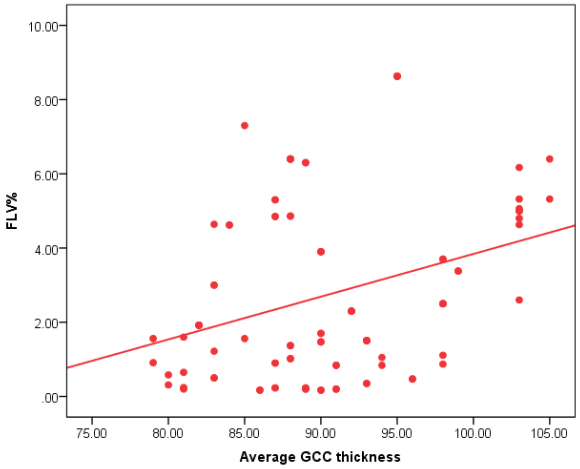


Figure (9): Positive Correlation between FLV% and Average GCC thickness.

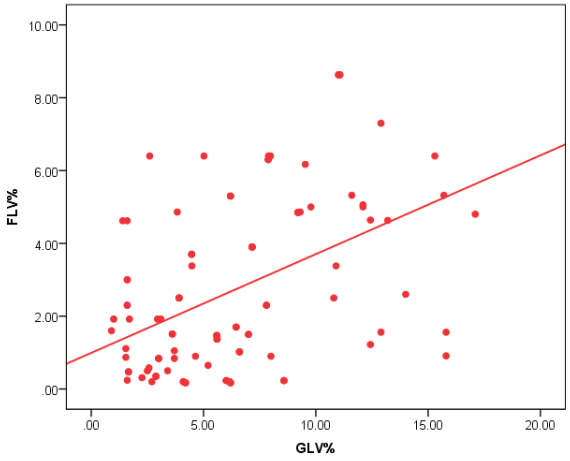


Figure (10): Positive Correlation between FLV% and GLV%.

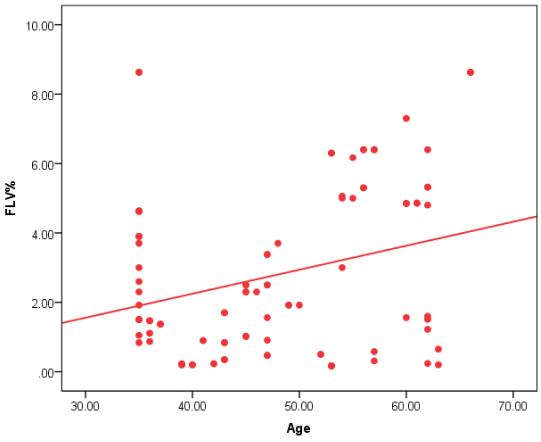


Figure (11): Positive Correlation between FLV% and Age.

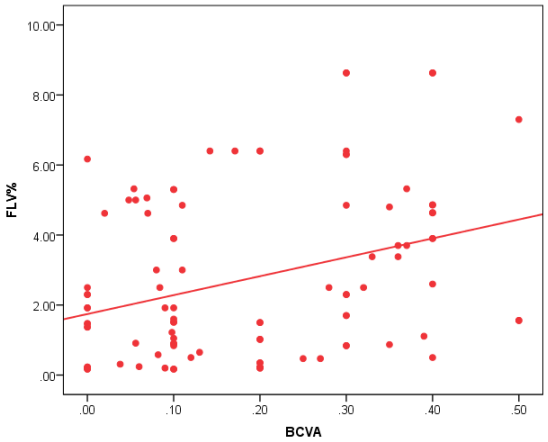
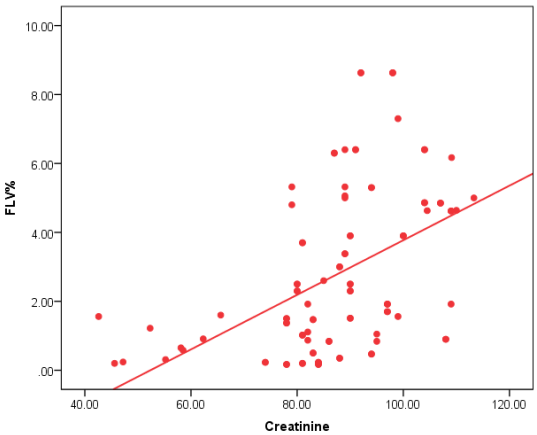


Figure (12): Positive Correlation between FLV% and BCVA.



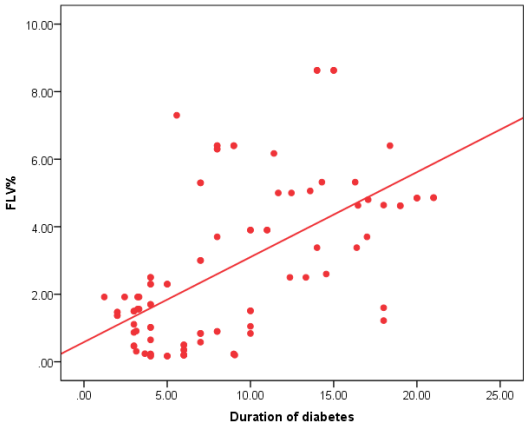


Figure (14): Positive Correlation between FLV% and Duration of diabetes.

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Figure (13): Positive Correlation between FLV% and Creatinine.

The above table indicates that GLV% did not exhibit a statistically significant link with HbA1c%, IOP, or creatinine, but it did have a statistically significant positive correlation with Average GCC thickness, FLV%, Age, BCVA, and diabetes duration **(Table 9, Figures 15-19).**

Table (9): Correlation between GLV% With Average GCC thickness, FLV%, Age, HbA1c%, BCVA, IOP, creatinine and diabetes duration.

Group I	GLV%	
	r	P-value
Average GCC thickness	**0.338****	**0.001**
FLV%	**0.463****	**0.000**
Age	**0.225***	**0.024**
HbA1c%	0.113	0.262
BCVA	**0.355****	**0.000**
IOP	0.064	0.526
Creatinine	0.090	0.374
Duration of diabetes	**0.394****	**0.000**

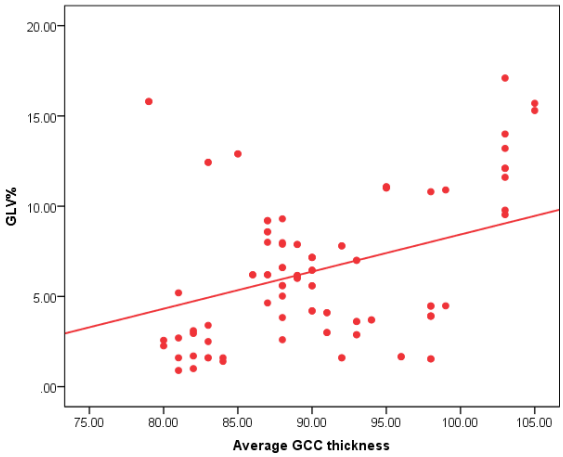

Figure (15): Positive Correlation between GLV% and Average GCC thickness.

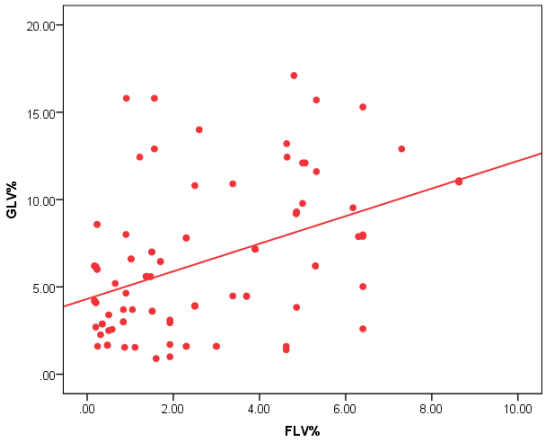

Figure (16): Positive Correlation between GLV% and FLV%.

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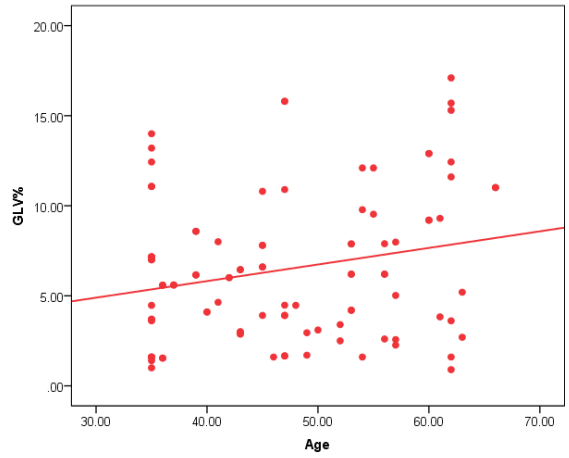

Figure (17): Positive Correlation between GLV% and Age.

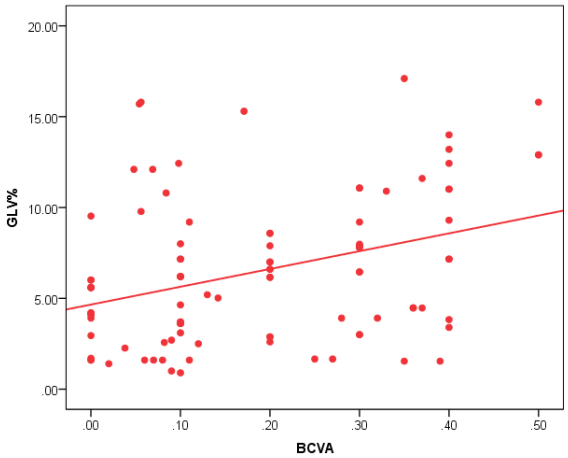

Figure (18): Positive Correlation between GLV% and BCVA.

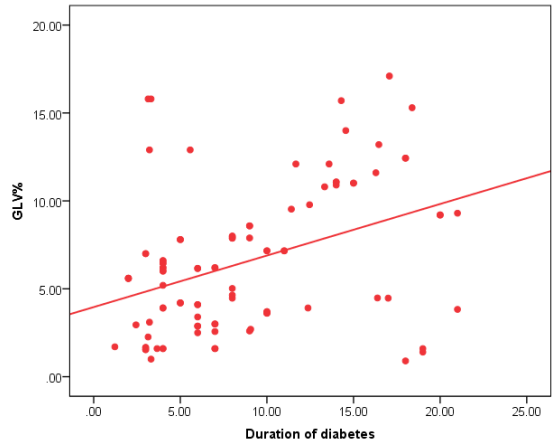

Figure (19): Positive Correlation between GLV% and Duration of diabetes.

According to the preceding table, there was no statistically significant link between average GCC thickness and FLV%, age, HbA1c%, IOP, or creatinine, however there was a statistically significant negative correlation between average GCC thickness, GLV%, and BCVA. **(Table 10, Figures 20-21).**

Table 10: Correlation between average GCC thickness with FLV%, GLV%, Age, HbA1c%, BCVA, IOP and creatinine.

Group II	**Average GCC thickness**	
	r	**P-value**
FLV%	-0.190	0.185
GLV%	**-0.905****	**0.000**
Age	0.030	0.838
HbA1c%	-0.070	0.630
BCVA	**-0.398****	**0.004**
IOP	0.003	0.986
Creatinine	-0.040	0.781

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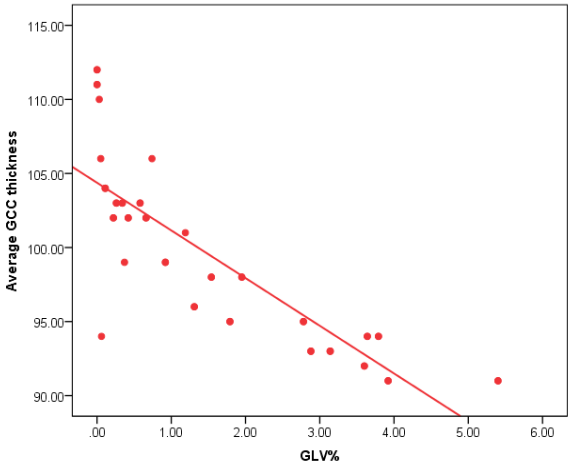

Figure (20): Negative Correlation between Average GCC thickness and GLV%.

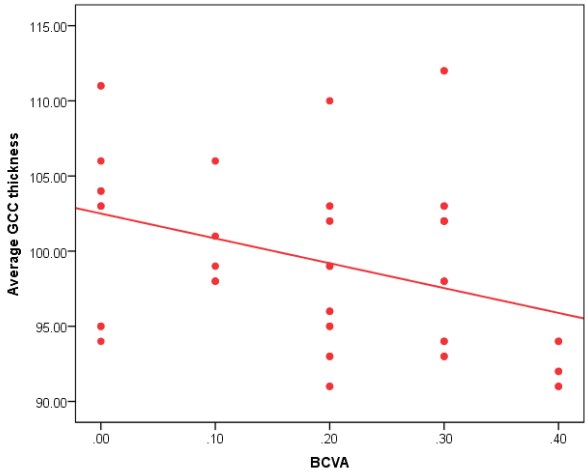

Figure (21): Negative Correlation between Average GCC thickness and BCVA.

A statistically significant positive correlations were found between FLV% and GLV%, negative correlations between FLV% and age, and no statistically significant correlations between FLV% and average GCC thickness, HbA1c%, BCVA, IOP, or creatinine, as indicated in the preceding table. **(Table 11, Figures 22-23).**

Table 11. Correlation between FLV% With Average GCC thickness, GLV%, Age, HbA1c%, BCVA, IOP, and creatinine levels.

Group II	**FLV%**	
	r	**P-value**
Average GCC thickness	-0.190	0.185
GLV%	**0.322***	**0.022**
Age	**-0.489****	**0.000**
HbA1c%	-0.048	0.743
BCVA	0.194	0.178
IOP	0.011	0.940
Creatinine	-0.049	0.737

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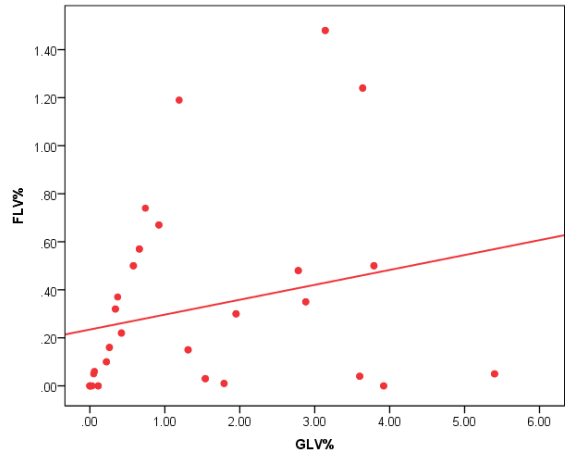


Figure (22): Positive Correlation between FLV% and GLV%.

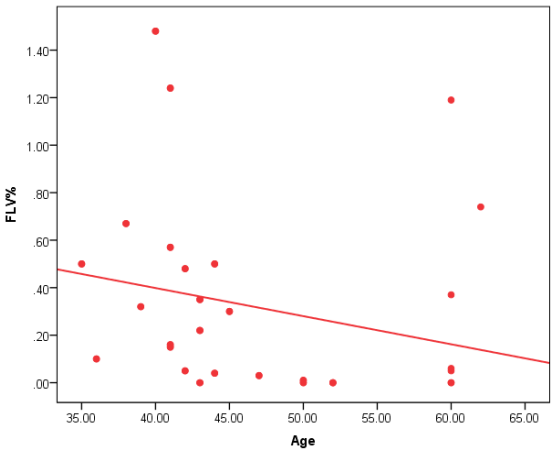
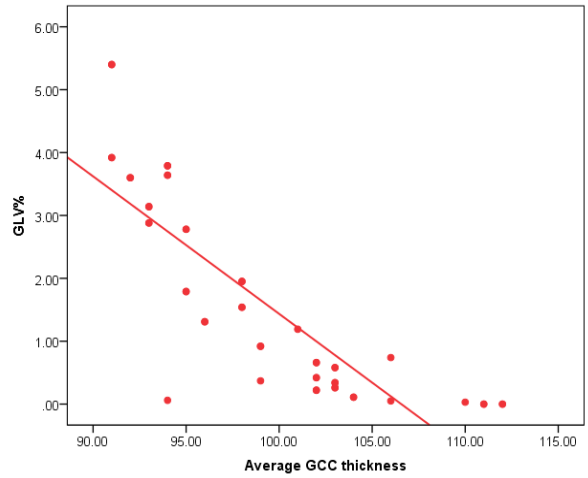


Figure (23): Negative Correlation between FLV% and Age.

Also, GLV%, FLV%, and BCVA showed a significant positive correlation, while GLV% and Average GCC thickness showed a significant negative correlation. GLV%, Age, HbA1c%, IOP, and creatinine didn't show significant correlations. **(Table 12, Figures 24-26).**

Table 12. Correlation between GLV% With Average GCC thickness, FLV%, Age, HbA1c%, BCVA, IOP, and creatinine levels.

Group II	**GLV%**	
	r	**P-value**
Average GCC thickness	**-0.905****	**0.000**
FLV%	**0.322***	**0.022**
Age	-0.069	0.632
HbA1c%	0.032	0.828
BCVA	**0.497****	**0.000**
IOP	0.156	0.278
Creatinine	0.092	0.523



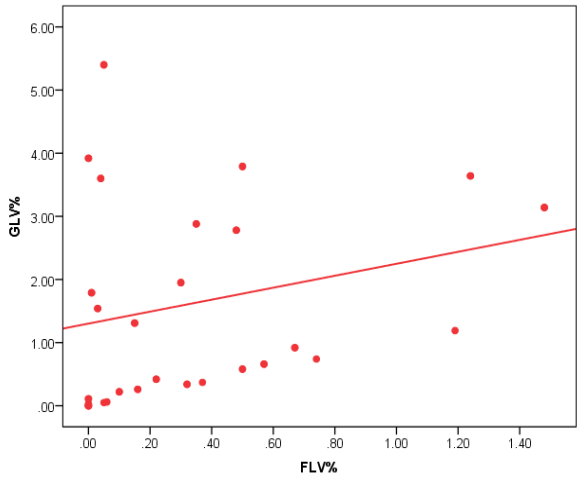


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Figure (24): Negative Correlation between GLV% and Average GCC thickness.

Figure (25): Positive Correlation between GLV% and FLV%.

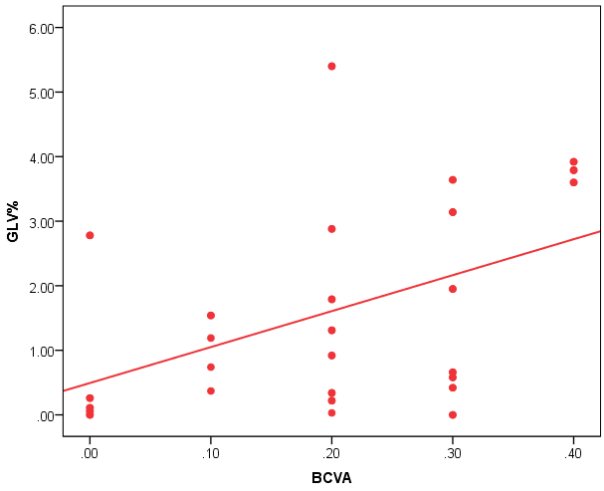

Figure (26): Positive Correlation between GLV% and BCVA.

DISCUSSION

Diabetic retinopathy (DR) and other long-term consequences of diabetes are positively correlated with HbA1c. DR is a degenerative disorder of the retinal microvasculature and neurons that can cause blindness [24]. Because DR impairs neurovascular coupling, endothelial-mural cell connections, Muller cell gliosis, and immune cell activation, it is becoming increasingly evident that DR also affects neuronal retinal cells, resulting in their malfunction and degeneration. These alterations in the diabetic retina's anatomy and physiology emphasize the need to think about vascular and neurological issues as possibly connected processes [25].

DM has been linked to retinal nerve fiber layer (RNFL) thinning in studies that use optical coherence tomography (OCT) to examine the potential impact of early retinopathy on the annual change in RNFL thickness. Both RNFL thinning and significant ganglion cell complex (GCC) thinning in diabetics may occur before retinal vasculopathy [26]. Spectral domain optical coherence tomography (RTVue-OCT) has demonstrated potential in the early identification of retinal neurodegeneration by measuring the thickness of individual layers at a higher resolution. Additionally, it implies that the fundamental cause of the macula's inner retina thinning is the loss of ganglion cells [27].

We discovered that Group I and Group II did not differ significantly in terms of gender or age. Like our investigation, Rodrigues et al. [28] examined diabetes alterations in neuroretina in 102 patients; their mean age was 58.67 years, which is marginally older than ours. The mean age was 57.5 years, according to Chhablani et al. [29]. The mean age of Carpineto et al. [22] was 60.9+8.3 years.

We discovered a highly significant difference between Group I and Group II in terms of HbA1c%. This supports findings from Ng et al. [30], who discovered that subjects with diabetes had significantly higher random serum glucose levels and HbA1c than controls. Demir et al. [23]

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also found that diabetic patients had significantly higher HbA1c levels than controls. However, in terms of Eye and BCVA, there was no significant difference between Group I and Group II. This is consistent with research by Carpineto et al. [22], Rodrigues et al. [28] and Tabakci et al. [31] that found no discernible differences between patients and healthy controls in terms of age, sex, intraocular pressure, and BCVA. These results were likewise in line with the study by Ng et al. [30], but diabetics had higher myopic spherical equivalent refraction and worse distance visual acuity than controls.

The difference between Group I and Group II in terms of Average GCC thickness, FLV%, and GLV% was highly statistically significant. The diabetes group's GCC thickness is significantly lower than that of the normal participants, following the study by Mahmoud et al. [32]. In the Alabdulwahhab [33] investigation, the odds ratio for HbA1c was 1.995. Patients with elevated HbA1c levels have a 1.995-fold increased risk of developing DR. Consequently, the HbA1c variable is a strong predictor of the onset of DR.

Patients with DR had a substantially higher HbA1c level than controls in the Demir et al. [23] investigation. DM patients had thinner GCC than controls, although this difference is not significant. According to the study by Refai and Hassan [34] that supported this viewpoint, almost 70% of diabetic eyes had abnormal FLV% readings when compared to normative data. Additionally, this study suggested that FLV% be considered as a trustworthy metric for tracking the severe advancement of DME prior to the onset of irreversible GCC damage. It was discovered that the FLV% was 22.2% greater in diabetic eyes than in normal eyes (P=0.024). Regarding GLV%, there is no significant difference between diabetes and control groups (P=0.160). Additionally, there was a negative correlation found between FLV% and HbA1c level [26].

Group I and Group II did not differ significantly in terms of IOP or creatinine. According to our research, among group I, there was no significant relationship between GCC thickness, age, and IOP, but a significant positive link between GCC thickness and FLV%, GLV%, HbA1c, BCVA, and creation of diabetes. This supports the findings of research by Darma and Virgana [35] that found that patients with greater HbA1c typically had smaller GC-IPL thickness. According to the study by Refai and Hassan [34] that supported this viewpoint, almost 70% of diabetic eyes had abnormal FLV% readings when compared to normative data. Additionally, this study suggested that FLV% be considered as a trustworthy metric for tracking the severe advancement of DME prior to the onset of irreversible GCC damage. It was discovered that the FLV% was 22.2% greater in diabetic eyes than in normal eyes. This is consistent with the findings of research by Van Dijk et al. [36] that showed no significant relationship regarding GC-IPL thickness and the subjects' age. Additionally, concur with the findings of studies by Chhablani et al. [29], Salvi et al. [37] and Singh et al. [38] that showed no significant relationship between the age in years of the groups under study and the thickness of the ganglion cell complex. In contrast to our findings, a study by Tabakci et al. [31] discovered a marginally negative relationship between the average GC-IPL thickness and age. Additionally, research by Rodrigues et al. [28] discovered that older age was independently associated with a thinner average GC-IPL thickness. The diverse age groupings of the groups

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under research may be the cause of this discrepancy with our findings. In the Tabakci et al. [31] study, the average age of diabetes patients was 62.01±11.26 years, which is older than ours. In the Rodrigues et al. [28] study, the average age of diabetes patients was 58.67 years, which is likewise somewhat older than ours.

In the study by Li and colleagues [39] they found strong negative connection between the length of diabetes and the thickness of GC-IPL. This is consistent with the findings of a study by Lim et al. [40], which showed a strong correlation between the length of diabetes and variations in the average GC-IPL thickness over time. These previous studies agree with our results, which indicated no significant link between FLV%, HbA1c%, and IOP, and between GLV% and HbA1c%, IOP, or creatinine but a significant positive correlation between FLV% and GCC thickness, GLV%, age, BCVA, creatinine, and diabetes duration and between GLV% and GCC thickness, FLV%, Age, BCVA, and diabetes duration. Also, Van Dijk and colleagues' [36] study, which supports our findings, discovered that individuals with thinner GC-IPL had noticeably longer durations of DM than others. Additionally, the findings of Rodrigues et al. [28] and Carpineto et al. [22] showed that the length of diabetes did not substantially connect with the thickness of the inner retinal layers; however, DR status was the only significant explanatory variable for the thinning of the inner retinal layers in the pericentral and peripheral regions of the macula. This discrepancy with our study can result from the fact that glucose metabolism might be disrupted years before a patient with type-2 diabetes is diagnosed, making it difficult to predict how long the disease will last. As a result, it is less accurate to evaluate any potential relationship between the length of the disease and the thinning of the inner retinal layers.

This parameter (FLV%) is a strong indicator of the structural damage to the macula in long-term diabetic macular oedema. For the group with diabetic macular oedema, the duration of diabetes mellitus showed a statistically significant correlation with the FLV% but a nonsignificant correlation with the other studied GCC parameters. In contrast to the control group, which displayed values of 0, 6.67, and 93.33% for abnormal, borderline, and normal values, the FLV% was abnormal in 70% of eyes, borderline in 6.67% of eyes, and normal in 23.33% of eyes in the diabetic macular oedema group. The difference between the two groups was highly significant, underscoring the significance of viewing FLV% as the primary indicator of damage. However, the GLV% revealed that the normative values for the two groups did not differ significantly. The GCC FLV was the greatest single predictor of conversion, according to Zhang et al. [41] on follow-up of 513 eyes (of 309 patients), which revealed that 55 eyes (46 patients) had VF conversion over a follow-up period of 41±23 months. Therefore, there seems to be a correlation between glaucoma and chronic macular oedema, where the FLV% is the most helpful predictor of possible harm. The hallmark of both conditions is progressive, long-term retinal impairment.

Study limitations: OCT measurements may be influenced by the axial length which was not measured in this study. Also follow up of the patients was not performed to determine the progression of neurodegeneration

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CONCLUSION

Diabetic patients, especially those with poorly controlled HbA1c, show early thinning of the ganglion cell complex (GCC) before any detectable vascular changes of diabetic retinopathy (DR). Type 2 diabetics exhibit reduced inner retinal thickness, indicating early neurodegeneration. Measuring GCC thickness with OCT can detect this early neuronal loss and should be included in routine macular and optic disc OCT evaluations for newly diagnosed diabetics, those suspected of DR, and patients on antihyperglycemic medications.

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ORIGINAL ARTICLE

HEMATOLOGICAL INDICES AS BIOMARKERS TO ASSESS THE SEVERITY OF SYSTEMIC SCLEROSIS

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ABSTRACT

Background: Systemic sclerosis (SSc) is a rare, chronic autoimmune disorder predominantly affecting women, marked by the progressive fibrosis of the skin and multiple organs and systems, along with vascular abnormalities. Biochemical markers that can assess the severity of disease in SSc, and their measurement is often prohibitively expensive for routine clinical application. The aim of this work was to evaluate the utility of hematological indices as accessible biomarkers for assessing disease activity and severity in SSc patients. **Methods:** This Case-control study was carried out on 56 individuals aged above 18 years old, both sexes. Studied individuals were divided into two groups(28 in each): cases group fulfilling the 2013 ACR/EULAR classification criteria for SSc and control group matched in age and sex. All patients were subjected to medical history taking, lab investigation, clinical examination as the severity and extent of skin sclerosis were evaluated using the mRSS, and collecting data about regarding current therapeutic treatments, including GCs,MMF,MTX,CYC,RTX,PPI, vasodilators, and antiplatelet agents, was also recorded. **Results:** The study highlights significant haematological changes in SSc patients, revealing a mean Hb level of 10.95g/dL, notably lower than the control group (13.71g/dL), indicating a prevalent anemia associated with the disease ($p<0.001$). Additionally, RBCs and PLTs counts were significantly reduced, while WBCs and neutrophil counts were elevated, suggesting an ongoing inflammatory response. **Conclusions:** The findings suggest that routine blood indices may serve as accessible, cost-effective markers for disease activity and severity assessment in SSc, supporting their potential utility in clinical monitoring and risk stratification.

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Keywords: Systemic Sclerosis, Haematological Indices, Biomarker Assessment, platelet to lymphocyte ratio

Introduction

A novel set of inflammatory biomarkers associated with multiple autoimmune conditions is proposed, based on specific indices derived from blood cell types that are routinely measured during a complete blood count. Notably, lymphocytes, neutrophils, monocytes, and platelets (PLTs) have been demonstrated to play a crucial role in the systemic sclerosis (SSc) pathophysiology in both clinical and experimental studies [1].

SSc is a rare, chronic autoimmune disease primarily impacting women, characterized by the progressive skin fibrosis and multiple organs and systems, accompanied by vascular abnormalities [2].

Dysregulated immune responses mediated by various growth factors, cytokines, and immune cells are linked to the development of fibrosis and vasculopathy, potentially playing a substantial role in the SSc pathogenesis [3]. The evaluation and diagnosis of SSc patients depend on specific findings observed during physical examinations and the existence of serological abnormalities [1].

There is a restricted availability of biochemical markers capable of evaluating disease severity in SSc, and their measurement is frequently prohibitively costly for routine clinical use [4]. Consequently, current research is centered on identifying simple, accessible, reliable, and cost-efficient tools capable of evaluating the severity of the condition.

The platelet-to-lymphocyte ratio (PLR) and the neutrophil-to-lymphocyte ratio (NLR) have been recognized as innovative biomarkers that reflect the inflammation degree, a condition traditionally evaluated through the acute phase reactants measurement such as C-reactive protein (CRP) and

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erythrocyte sedimentation rate (ESR) [5]. The objective of this study was to evaluate the utility of hematological indices as readily available biomarkers for evaluating disease activity and severity in SSc patients.

Patients and Methods

This Case-control study was executed on 56 individuals aged above 18 years old, both sexes, with fulfilling the 2013 ACR/EULAR classification criteria for SSc.

A comprehensive written informed consent was secured from the patient. The research was carried out subsequent to obtaining approval from the Ethical Committee Aswan University Hospitals.

Exclusion criteria were Systemic disease such as DM, Concomitant autoimmune disease, Malignancy, lung diseases from other causes, kidney and liver failure, Acute or chronic infection and pregnancy or up to 6 months postpartum.

Participants in the study were categorized into two distinct groups (28 in each): cases group and control group matched in age and sex.

All patients underwent: medical history[disease onset, age at first hospital visit, disease duration, presence of shortness of breath, dry cough, chest pain, scleroderma renal crisis, dysphagia, arthralgia, myalgia, and other clinical manifestation], clinical examination, and laboratory investigations[CBC determined by the COULTER LH 750 assay analyzer with special consideration to NLR, PLR, MLR, RDW, and MPV. Also, CRP, ESR, serum alanine transaminase (ALT), serum creatinine, serum aspartate transaminase (AST)].

The skin sclerosis severity and extent were assessed utilizing the mRSS, which evaluates skin thickness across 17 body surface areas on a scale from 0 to 3: 0 with a maximum possible score of

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51. BP was measured, Additionally, the major organ involvement severity was determined utilizing the Medsger severity score, which categorizes organ function into five grades [6].

The primary outcome was to compare the haematological indices in SSc patients with those of healthy controls. The secondary outcomes were developing simple, less expensive, and convenient investigations to assess the severity of SSc and in early detection of organ involvement so early treatment will improve the prognosis and life quality.

Statistical analysis

Statistical analysis was performed by SPSS v27 (IBM©, Armonk, NY, USA). Shapiro-Wilks test and histograms were utilized to assess the normality of the distribution of data. Quantitative parametric data were presented as standard deviation (SD) and mean and were analysed by unpaired student t-test. Quantitative non-parametric data were presented as interquartile range (IQR) and the median and were analyzed by Mann Whitney-test. Qualitative variables were presented as percentage (%) and frequency and analyzed using the Chi-square test or Fisher's exact test when appropriate. A two-tailed P value < 0.05 was considered statistically significant. Utilizing Spearman's rho method, correlation analysis is conducted to evaluate the degree of association between two quantitative variables

Results

Significant statistical differences in weight, age, sex distribution, or BMI between cases and controls were not observed. However, height was significantly lower in cases compared to controls ($p = 0.002$). Several hematological parameters showed highly significant differences ($p < 0.001$) between cases and controls as hemoglobin (Hb), red blood cell count (RBCs), platelet count (PLTs), hematocrit, and lymphocyte count were significantly lower in cases, white blood cell count

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(WBCs), neutrophils, mean platelet volume (MPV), red cell distribution width (RDW), NLR, and ESR, in addition monocyte-to-lymphocyte ratio (MLR) was significantly higher in cases ($p = 0.004$), while PLR insignificantly different($p = 0.896$).CRP was positive in 50% of cases and absent in all controls, showing a highly significant difference ($p < 0.001$). Table 1

Table 1: Patient characteristics and haematological indices of the studied patients (n = 56)

		Controls(N= 28)	Cases(N= 28)	P-value
Age (years)		34.36 ± 5.59	38.82 ± 11.84	0.079*
Sex	Male	2 (7.14%)	2 (7.14%)	1.00
	Female	26 (92.86%)	26 (92.86%)	
Weight (Kg)		62.43 ± 5.69	59.18 ± 12.03	0.204
Height (m)		167.93 ± 7.64	161.13 ± 8.14	**0.002****
BMI (kg/m^2)		22.1 ± 1.49	22.73 ± 4.41	0.478
Hematological indices				
Hb		13.71 ± 0.86	10.95 ± 1.71	**<0.001****
RBCs		4.74 ± 0.31	4.2 ± 0.74	**<0.001****
WBCs		5.14 ± 0.72	6.77 ± 2.04	**<0.001****
PLTs		285.61 ± 35.55	229.5 ± 63.88	**<0.001****
MPV		8.45 ± 0.54	9.25 ± 1.07	**<0.001****
RDW		12.55 ± 0.5	13.93 ± 2.52	**0.008***
Hematocrit		39 ± 2.23	33.94 ± 4.31	**<0.001****
Neutrophils		2.53 ± 0.32	4.6 ± 2.21	**<0.001****
Lymphocytes		2.13 ± 0.35	1.66 ± 0.46	**<0.001****
Monocytes		0.4 (0.3 - 0.5)	0.5 (0.4 - 0.6)	0.137
NLR		1.18 (1.13 - 1.23)	2.1 (1.5 - 4.85)	**<0.001****

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PLR	134.78 (119.24 - 157.79)	125.6 (90.2 - 210)	0.896
MLR	0.2 (0.17 - 0.26)	0.26 (0.22 - 0.38)	**0.004***
ESR	19 (15 - 20)	30 (20 - 45)	**<0.001****
CRP	0 (0%)	14 (50%)	**<0.001****

Data are presented as mean ± SD, frequency (%), or IQR: interquartile range. R: Spearman's rho. *: significant p value (<0.005), **highly significant p value (<0.001).

The median disease duration was 87 months (IQR: 48–142), the majority of patients had the limited subtype (78.57%), while 21.43% had the diffuse subtype, Raynaud's phenomenon was highly prevalent (89.29%), as was skin pigmentation (89.29%) and dysphagia (82.14%), telangiectasia was present in 82.14% of patients, Dyspnea and interstitial lung disease (ILD) were both reported in 64.29% of cases, digital ulcers (DUs) were present in 50% of patients; most had 1 or 2 ulcers, but a few had 3, scarring was noted in 46.43% of patients, less frequent but notable manifestations included arthritis (28.57%), renal involvement (17.86%), and muscle weakness (17.86%). The mean modified Rodnan Skin Score (mRSS) was 25.96 ± 7.42, regarding laboratory Findings ANA positivity was found in 92.86% of patients, a common hallmark of SSc, Anti-Scl-70 antibodies were positive in all 16 patients tested, suggesting a strong association with the diffuse form and lung involvement, ACA was positive in 4 patients, often associated with limited cutaneous disease, Liver enzymes were within the mild to moderate range (ALT: median 18; AST: median 21). Serum creatinine remained within normal limits (median 0.7), suggesting preserved renal function in most patients. Table 2

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Table 2: Present illness data, presenting signs and symptoms, mRSS assessment, lab investigations among the cases group(n=28)

		cases group(n=28)
Disease duration by months		87 (48 - 142)
Limited		22 (78.57%)
Diffuse		6 (21.43%)
Dyspnea		18 (64.29%)
ILD		18 (64.29%)
Pigmentation		25 (89.29%)
Telangiectasia		23 (82.14%)
Ulcers		14 (50%)
Count of ulcers	1	7 (50%)
	2	4 (28.57%)
	3	3 (21.43%)
Scars		13 (46.43%)
Count of scar	1	4 (30.77%)
	2	6 (46.15%)
	3	2 (15.38%)
	7	1 (7.69%)
Raynaud’ s		25 (89.29%)
Arthritis		8 (28.57%)
Renal		5 (17.86%)
Muscle weakness		5 (17.86%)
Dysphagia		23 (82.14%)

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mRSS	25.96 ± 7.42
ALT	18 (17 - 28)
AST	21 (13 - 30)
Creatinine	0.7 (0.6 - 0.9)
ANA	26 (92.86%)
ACA	4 (100%)
Anti Scl 70	16 (100%)

Data are presented as , frequency (%) or IQR: interquartile range

None of the blood indices showed statistically significant correlations with age or disease duration. Although NLR showed an increasing trend across severity grades by PCV, Hb, and vascular severity, only the association with vascular severity grade was statistically significant ($p = 0.033$). A highly significant association was observed between NLR and skin severity by TSS ($p < 0.001$), with a marked increase in NLR in higher skin severity grades, meanwhile PLR showed no significant association with PCV, Hb, or general grade. However, there was a highly significant association between PLR and skin severity grade by TSS ($p < 0.001$), No significant association was found between MLR and general severity grades or Hb-based classification, however, MLR was significantly associated with skin severity grade by TSS ($p = 0.029$), indicating a potential role in skin involvement assessment. MPV showed no significant associations with severity grading by PCV, Hb, or TSS. RDW demonstrated significant associations with overall severity grade ($p = 0.019$) and skin grade by TSS ($p = 0.003$), with values progressively increasing across higher grades. Table 3

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Table 3: Correlation between different blood indices and age of patients & disease duration, and severity among the cases group

Cases group(N= 28)		Age	Disease duration by months
MPV	r	-0.016	-0.062
	p-value	0.937	0.756
RDW	r	-0.307	-0.110
	p-value	0.112	0.578
NLR	r	0.093	-0.090
	p-value	0.637	0.647
PLR	r	0.039	-0.007
	p-value	0.845	0.973
MLR	r	-0.110	-0.219
	p-value	0.576	0.263
	Blood indices		P-value
NLR			
grade by PCV	1	2.05 (1.55 - 3)	0.768
	2	2.75 (2.08 - 4.8)	
	3	3.3 (1.5 - 7.5)	
grade by Hb	1	1.58 (1.52 - 2.63)	0.188
	2	2.75 (2 - 5)	
	3	3.3 (2.7 - 7.2)	
Grade by vascular severity	1	1.5 (1.45 - 2.15)	0.033
	2	1.6 (1.5 - 2.5)	
	3	3.15 (2.7 - 6.8)	
	1	1.66	<0.001*

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skin grade by TSS	2	1.5 (1.47 - 1.7)	
	3	6.5 (3 - 7.1)	
PLR			
grade by PCV	1	104.45 (91 - 114)	0.573
	2	153.75 (109.45 - 219.5)	
	3	192 (94.7 - 300)	
grade by Hb	1	101.85 (89.4 - 136.6)	0.281
	2	111.75 (100.25 - 243.5)	
	3	192 (114.6 - 251.8)	
Grade by vascular severity	1	96.85 (85.7 - 204.5)	0.272
	2	99.4 (91 - 114)	
	3	181.45 (109.5 - 239)	
skin grade by TSS	1	190	<0.001*
	2	91 (85 - 114)	
	3	210.5 (153.75 - 275.9)	
		MLR	
grade by Hb	1	0.27 (0.23 - 0.33)	0.961
	2	0.28 (0.23 - 0.4)	
	3	0.26 (0.21 - 0.5)	
	1	0.27 (0.23 - 0.41)	0.164

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Grade by vascular severity	2	0.2 (0.2 - 0.25)	
	3	0.3 (0.23 - 0.5)	
skin grade by TSS	1	0.46	**0.029***
	2	0.23 (0.2 - 0.27)	
MPV			
grade by PCV	1	9.2 ± 0.84	0.519
	2	9.51 ± 0.39	
	3	9.1 ± 0.82	
grade by Hb	1	9.73 ± 0.22	0.117
	2	8.9 ± 0.9	
	3	9.2 ± 0.65	
Grade by vascular severity	1	8.78 ± 0.8	0.091
	2	8.8 ± 0.87	
	3	9.72 ± 1.12	
skin grade by TSS	1	8	0.28
	2	9.1 ± 1.12	
RDW			
grade by PCV	1	14.6 ± 0.9	0.08
	2	15.2 ± 0.3	
	3	15.42 ± 0.46	
grade by Hb	1	14.88 ± 0.4	0.176
	2	14.7 ± 1.15	
	3	15.36 ± 0.42	
	1	12.79 ± 3.13	**0.019***
	2	14 ± 0.35	

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Grade by vascular severity	3	15.28 ± 0.56	
skin grade by TSS	1	11.9	0.003*
	2	12.82 ± 2.88	
	3	15.48 ± 0.56	

Data are presented as mean ± SD, frequency (%), or IQR: interquartile range. R: Spearman's rho.
*: significant p value (<0.005)

Discussion

SSc constitutes a connective tissue disorder that potentially impacts the cardiovascular, pulmonary, gastrointestinal and renal systems This condition is defined by microvascular injury, which is subsequently followed by the progressive development of fibrosis in both the internal and skin [7].

SSc is characterized by extensive microvascular and macrovascular pathology, which may impact RDW. This parameter has been associated with PAH, SRC, peripheral arterial disease, and deficiencies in vitamin B12 or iron due to malabsorption syndrome [8].

The current investigation revealed that, the mean age was 36.59 ± 9.44 years, ranging from 20 to 67 years. Male patients comprised 7.14%, while females accounted for 92.86%, with no statistically significant differences among the two groups across any sociodemographic parameters ($p > 0.05$), except for height, as the case group was shorter than the control group ($p = 0.002$).

Sakr et al [4] Indicated that the ages of both patients and controls spanned from 22 to 75 years, with six male patients (17%) and twenty-nine female patients (83%).

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In the present study, the median (IQR) of disease duration was 87 (48–142) months, with a range from 12 to 288 months. The limited subtype accounted for 78.57%, while the diffuse subtype comprised 21.43%.

Tezcan et al., [7] revealed that the median duration of disease among the excluded patients was 8 years (IQR = 10), with a range from 1 to 17 years.

The current investigation revealed that the predominant clinical manifestations comprised pigmentation (89.29%) and Raynaud's phenomenon (89.29%), followed by dysphagia and telangiectasia, each observed in 82.14% of the cases. Less frequently encountered complications encompassed muscle weakness (17.86%) and renal involvement (17.86%). Approximately 64.29% of cases presented with cardiopulmonary complications, with pulmonary complications being the most prevalent (64.29%). Disease severity was notably indicated by higher grades of peripheral vascular and skin involvement according to the Medsger Severity Scale (MSS) and organ involvement grades in SSc patients.

Sakr et al [4] reported that limited skin tightness was identified in 29% of the patient cohort, while diffuse skin tightness was observed in 71%. Additionally, RP was observed in all patients (100%), with digital pitting scars and ulcers identified in 77%. Lung involvement, including lung fibrosis or pneumonitis, was present in 57%. Gastroesophageal reflux was reported in 83%, while esophageal dysmotility was observed in 80%. Pulmonary arterial hypertension was diagnosed in 23%, and cardiac abnormalities—comprising tricuspid regurgitation in two patients, hypertrophic cardiomyopathy in one, and restrictive cardiomyopathy in one—were identified in 11%. Furthermore, myositis was observed in 29% and arthritis in 34% of the studied SSc patients.

In the present study, it was found that mean mRSS is 25.96 ± 7.42 ranging from 14 to 38.

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Sakr et al [4] revealed that the mRSS varied between 4 and 46, with an average value of 11 among SSc patients.

In the current investigation it was observed that Hb levels are significantly lower in cases (10.95 ± 1.71 g/dL) compared to controls (13.71 ± 0.86 g/dL). Red blood cells and platelets are also significantly reduced in these cases, whereas white blood cells and neutrophils are elevated. Blood indices such as MPV, RDW, NLR, and MLR are significantly increased in cases (p-value < 0.05). Inflammatory markers, including ESR and CRP, are elevated in the case group, with each parameter demonstrating a p-value of less than 0.001.

Limited studies have been performed on the relationships of MLR, NLR, MPV, and RDW with disease manifestations, activity, and severity in patients diagnosed with SSc.

Sakr et al [4] emphasized that Hb levels are significantly lower in cases (12.3 ± 1.6 g/dL) compared to controls (13 ± 1 g/dL), with a p-value of 0.02. Red blood cell counts and platelet counts are also significantly decreased in cases (p-values of 0.001 and <0.001, respectively), whereas white blood cell counts and neutrophil levels are elevated (p-values <0.001 for both).

Balbaloglu et al. [9] found that patients with OA and synovitis demonstrated reduced MPV values, indicating a negative correlation between CRP and MPV levels in OA patients with synovitis relative to those without.

A higher platelet count was noted in patients with SSc relative to the control group. This finding is aligned with the research carried out by **Boilard et al**., [10] which identified that platelets (PLTs) are instrumental in the pathogenesis of inflammatory arthritis. Previous studies have suggested that NLR may function as a marker of disease activity across various systemic autoimmune conditions [11-15].

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Yayla et al [16] .indicated that NLR may be related with the severity of vascular manifestations, such as DUs, in SSc.

A study conducted by **Lescoat et al.** [17] indicated that patients with SSc demonstrate increased levels of absolute and CD16+ monocytes in their peripheral blood relative to control subjects. While monocyte counts did not significantly differ between SSc patients and healthy controls, the MLR was elevated in SSc patients compared to the healthy control group. Furthermore, MLR exhibited a correlation with multiple clinical presentations, including cardiac involvement and DUs and demonstrated a positive correlation with mRSS, EUSTAR disease activity, and Medsger disease severity scores. Furthermore, monocyte count was recognized as an independent predictor of elevated severity and activity scores. Importantly, both NLR and MLR demonstrated a correlation with CRP levels in SSc patients, with NLR, MLR, and CRP levels being higher in SSc patients relative to healthy controls. However, CRP showed no correlation with disease manifestations such as ILD, PAH, DUs, or activity and severity scores, unlike NLR and MLR.

This result contrasts with the findings of **Soydinç et al**. **[18]** who found increased MPV levels in patients with SSc. Notably, the latter study demonstrated an inverse correlation between MPV and disease activity, while also identifying a positive association with particular disease manifestations such as cardiac involvement, gangrene and DUs. Our study revealed no significant differences in MPV values between SSc patients and healthy controls, nor did we identify any correlation between MPV and disease manifestations, activity, or severity scores.

Sakr et al [4]demonstrated that the MPV, RDW, NLR, and PLR were markedly elevated in patients with SSc when compared to control subjects ($p = 0.03$, <0.001, <0.001, 0.02, respectively). Additionally, regarding clinical manifestations, both NLR and PLR were significantly higher in

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SSc patients presenting with myositis compared to those lacking this condition. The parameters analyzed did not demonstrate any significant differences between patients receiving corticosteroid treatment and those who did not. Additionally, no statistically significant difference was evident in corticosteroid dosages when comparing patients exhibiting muscular weakness with those who did not.

Farkas et al. and **Yayla and his colleagues** [16, 19]demonstrated that RDW is markedly raised in patients with SSc, leading to the conclusion that this increase in RDW predominantly indicates pronounced inflammation associated with SSc and uses as a valuable marker for evaluating disease severity and prognosis .

Considering that Hb levels in SSc patients were significantly lower relative to the control group, we examined whether the increased RDW observed in SSc patients is attributable to diminished Hb concentrations. The findings of the logistic regression analysis demonstrated that RDW continued to be independently associated with SSc, even after adjusting for age, gender, and Hb levels. [4].

In the present study, NLR was significantly increased in patients with SSc compared to healthy control subjects, supporting the findings of **Jung et al**. and **Atilla et al.** [20, 21] Furthermore, **Yayla and his associates** [16].indicated that SSc patients exhibited markedly elevated NLR. This elevation can be ascribed to a persistent inflammatory response that concurrently elevates the neutrophil count and impacts the downstream lymphocyte lineage, leading to an overall increase in the NLR.

Gao et al. [22] exhibited a significant correlation between the NLR and disease activity in individuals diagnosed with polymyositis. Moreover, their results demonstrated that NLR values

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were considerably higher in myositis patients relative to those without muscle weakness throughout the course of their disease.

Our results indicated that the PLR elevated considerably in patients with SSc relative to the control group. This elevation is ascribed to thrombocytosis prompted by elevated concentrations of inflammatory cytokines linked to SSc, including IL-8 and TNF-α [23].

In the current study, it was observed that PLR levels were significantly increased in SSc patients having sever proximal muscle weakness. and myositis, as indicated by the Medsger score, in comparison to those without muscular weakness. This result is consistent with the study of **Peng et al..**, [24] which indicated that PLR was significantly higher in individuals with IIM, demonstrating a positive correlation between PLR and higher muscle weakness scores. The conclusion derived from this is that PLR is associated with IIM and may function as a useful marker for assessing disease activity in patients with IIM.

MLR is significant only for skin grade severity (p-value= 0.029). Nevertheless, MPV demonstrated no statistically significant association with disease complications (p-values < 0.05). Additionally, significant differences were observed in peripheral vascular and skin grades, which contributed to an increase in RDW associated with disease severity and the presence of peripheral vascular involvement.

Sakr et al. [4] demonstrated that in a multivariate logistic regression analysis, RDW was found to be independently correlated with SSc after controlling for variables such as gender, age, and Hb levels (p = 0.001, p = 0.29, p = 0.54, p = 0.91, respectively). Furthermore, the PLR and NLR emerged as the most significant predictors of muscle involvement (p = 0.005, p = 0.003,

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respectively) and the muscle weakness severity (p = 0.001, p = 0.003, respectively) among the patients.

The most frequently administered medication is MMF (71.42%), indicating its essential role in managing SSc manifestations. PPI (60.71%) and CCB (42.85%) underscore an emphasis on addressing potential gastrointestinal or peripheral vascular complications in these cases. The least frequently utilized medications, such as Anti-HF drugs and ACE inhibitors (3.5%), may suggest that their application is restricted to particular or severe cases.

Based on the findings of **Sakr et al**, [4] the pharmacological treatments administered to patients with SSc included oral corticosteroids for 82%, CYC for 51%, azathioprine for 66%, low-dose aspirin for 50%, CCB for 86%, sildenafil for 43%, MTX for 20%, and proton pump inhibitors for 83% of the patients.

We recommend utilizing a larger sample size through multi-center cooperation to validate our findings, additional investigations are advised to validate the generalizability of our findings, and NLR, MPV, PLR and RDW are suggested as economical and readily obtainable inflammatory biomarkers in SSc, particularly emphasizing the PLR and NLR significance as markers of disease severity and clinical manifestations.

Limitations: Insufficient studies to adequately support our findings. The study was in a single center. The sample size was relatively small.

Conclusions

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The findings suggest that routine blood indices may serve as accessible, cost-effective markers for disease severity and activity assessment in SSc, supporting their potential utility in clinical monitoring and risk stratification

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Conflict of Interest: Nil

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ORIGINAL ARTICLE

AGE-DEPENDENT OUTCOMES AFTER DEGA PELVIC OSTEOTOMY IN DEVELOPMENTAL DYSPLASIA OF THE HIP: A PROSPECTIVE COMPARATIVE COHORT STUDY IN TODDLERS

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Background: Background: Dega pelvic osteotomy is frequently performed to address acetabular dysplasia in young children with developmental dysplasia of the hip (DDH). However, how age influences early acetabular remodeling, recovery, and potential complications remains poorly addressed.

Purpose: To compare the early clinical and radiographic outcomes of Dega osteotomy in younger versus older toddlers with DDH**.**

Methods: A prospective cohort study encompassed 20 children (comprising 26 hips) diagnosed with Tönnis grade III–IV Developmental Dysplasia of the Hip (DDH), who underwent treatment involving open reduction, capsulorrhaphy, and Dega osteotomy. The participants were categorized into two groups: Group A (aged 25–35 months) and Group B (aged 11–24 months). The variables assessed included age, acetabular index (AI), duration of casting, recovery period, operative time, healing time of the osteotomy, trajectory of acetabular remodeling, and occurrence of complications. The minimum follow-up period was eight months.

Results: Comparison of preoperative AI between groups was not statistically significant (p=0.78). Group B recorded greater AI correction than Group A at 6 months and final follow-up. At 6 months, AI was 17.2° in Group B and 20.1° in Group A (p=0.03). At final follow-up, AI was 13.1° in Group B and 17.6° in Group A (p=0.02). Operative time and cast duration were similar. The recovery period was shorter in Group B (5.6 versus 7.9 weeks; $p < 0.01$). Osteotomy healing time was comparable. Mechanical complications were more frequent in Group B (p=0.04).

Conclusion: : Dega osteotomy is effective for younger children (under 24 months) with DDH, as it results in improved acetabular remodeling and faster functional recovery. However, they are more susceptible to mechanical complications at the osteotomy site because of the softer bone.

Keywords: toddlers, acetabular index, pelvic osteotomy, acetabular remodeling,

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INTRODUCTION

Developmental dysplasia of the hip (DDH) is a spectrum of disorders characterized by abnormal acetabular development and femoral head containment and may lead to early degenerative arthritis if inadequately treated [1,2]. Achieving concentric reduction and stimulating acetabular growth are the primary objectives of management [3,4].

When diagnosis is delayed or conservative treatments are ineffective, surgical intervention becomes essential. For children with advanced dysplasia, open reduction with capsulorrhaphy and pelvic osteotomy is commonly recommended [5,6]. Among pelvic osteotomy techniques, the Dega pelvic osteotomy (DPO) is particularly valued for its ability to provide multidirectional coverage of the femoral head while maintaining pelvic stability and allowing growth [7,8].

The optimal timing for performing a DPO remains a topic of debate. Traditionally, it is recommended to delay pelvic osteotomy until after 18 months to reduce the risk of graft instability and mechanical failure, particularly in patients with thin iliac bones [9,10]. However, earlier intervention may leverage the immature acetabulum's greater biological remodeling capacity and potentially reduce the risk of residual dysplasia [11,12].

Recent advances in pelvic osteotomy methods have increased focus on how outcomes vary with age [13,14,15]. Amin et al. conducted a multicenter study comparing a new high trans-iliac incomplete bicortical osteotomy (HTIBO) with the conventional DPO technique in young children, demonstrating that both procedures effectively correct the condition. They also highlighted the importance of bone quality and patient age when assessing the risk of complications [13].

Although the long-term outcomes of DPO in children over two years are well established [11,10], few studies directly compare early acetabular remodeling and perioperative recovery across toddler age groups. This information is crucial for fine-tuning surgical timing and providing more accurate guidance to families about the risks and benefits.

This study aimed to compare outcomes at DPO between younger toddlers (11–24 months) and older toddlers (25–35 months). We hypothesized that the younger group would exhibit faster acetabular remodeling and more rapid recovery, but also higher rates of mechanical complications.

PATIENTS AND METHODS

This prospective comparative cohort study was conducted from March 2022 to August 2024 at two tertiary pediatric orthopedic centers. Ethical approval was obtained from the institutions, and written informed consent was obtained from parents or legal guardians in accordance with the Declaration of Helsinki.

The study included children aged 11-35 months with unilateral or bilateral DDH classified as Tönnis grade III or IV. [16] Exclusion criteria included neuromuscular disorders, congenital arthrogryposis multiplex, hydrocephalus, myelomeningocele, revision hip surgeries, septic hip cases, and cases requiring femoral shortening osteotomy.

The study included 20 children (26 hips) who underwent DPO, divided equally into two groups: Group A, 11 children aged 25–35 months, and Group B, 11 children aged 11–24 months.

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Baseline demographic data, affected sides, Tönnis grade, and preoperative acetabular index (AI) were recorded.

All eligible patients treated during the study period were included. Although a formal prospective sample size calculation was not feasible, a post hoc analysis indicated that the sample size was sufficient to detect a moderate effect size (approximately 0.7–0.8) in acetabular index correction between age groups, with 80% power at a two-sided alpha of 0.05.

Surgical technique:

Under general anesthesia and in the supine position on a radiolucent table under C-arm guidance. Sterilization and draping of the affected lower limb and the hemi-pelvis (front and back).

Using a bikini incision, proceed deeply between the tensor fascia Lata and sartorius muscle, exploring and preserving the lateral femoral cutaneous nerve of the thigh. Then split the medial and lateral flaps, exposing the iliac apophysis with a periosteal flap. Perform iliopsoas and direct head of rectus femoris tenotomy. Proceed to capsulotomy and removal of the ligamentum teres, pulvinar fatty tissue, and excision of the transverse acetabular ligament. Reduce the femoral epiphysis into the prepared acetabular cavity. Perform adductor longus tenotomy. Then perform capsulorrhaphy.

Dega osteotomy was performed via the outer table of the iliac bone, extending distally and medially away from the greater sciatic notch while maintaining a posterior hinge of the posterior column, followed by the placement of an autologous iliac crest graft [7,10]. The direction of the DPO is confirmed with intra-operative fluoroscopy. The iliac apophysis was reconstructed anatomically, followed by wound closure in layers. A hip spica cast was applied for Postoperative immobilization for 8–10 weeks.

Postoperative radiographs are obtained early after surgery, then again at 1, 2, and 6 months, and at final follow-up. Patients in both groups were prospectively evaluated and compared with respect to age at surgery, operative time, AI (preoperative, postoperative, 6 months, and final follow-up), cast duration, osteotomy healing time (radiographic union), acetabular remodeling trajectory, recovery period (time to independent ambulation), and complications.

Radiological evaluation included Severin classification [17] and avascular necrosis grading using the Kalamchi–MacEwen system. [10,18]

Statistical Analysis

Data analysis was conducted using SPSS (version XX). The normality of continuous variables was assessed with the Shapiro–Wilk test. Data is presented as mean ± SD or median with interquartile range. Between-group comparisons for age used Student's t-test or Mann–Whitney U test, while categorical variables were analyzed with chi-square or Fisher's exact test. Within-group changes over time were evaluated with paired t-tests or Wilcoxon signed-rank tests.

Radiographic parameters were evaluated at three time points: preoperatively, at six months postoperatively, and at the final follow-up to assess acetabular remodeling after Dega pelvic osteotomy. Within-group changes over time were analyzed using repeated measures ANOVA,

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with post hoc comparisons when appropriate. Effect sizes (Cohen's d) were calculated for key outcomes. All statistical tests were two-tailed, with statistical significance set at $p \leq 0.05$.

RESULTS

The study included 20 children with 26 hips. Group A comprised 10 children (13 hips), aged 25-35 months, with a mean age of 29.4 ± 3.1 months (range, 25–35). Group B also included 10 children (13 hips), with a mean age of 17.6 ± 4.2 months (range, 11–24). In Group A, there were 8 females and 2 males: in Group B, 7 females and 3 males. Bilateral involvement was observed in three children in each group. The distribution of Tönnis grade IV hips was 11/13 in Group A and 12/13 in Group B. (Table 1)

The mean operative time was 92 ± 15 and 95 ± 18 minutes for Groups A and B, respectively, with no significant difference ($p = 0.64$). The duration of casting did not differ significantly ($p = 0.42$), with means of 9.2 ± 0.8 for Group A and 9.4 ± 0.7 for Group B. The recovery period was shorter in Group B (5.6 ± 1.3 weeks) than in Group A (7.9 ± 1.6 weeks, $p < 0.01$). Radiographic union was not statistically significant between the study groups ($p = 0.58$), occurring at 11.2 ± 2.1 weeks in Group A and 11.6 ± 2.4 weeks in Group B. (Table 2)

Acetabular index and remodeling

Preoperatively, mean AI was 41.2 ± 6.5° and 40.6 ± 7.3° for groups A and B, respectively, with no significant difference ($p = 0.78$). Both groups showed significant postoperative improvement. At 6 months, mean AI was 20.1 ± 4.6° and 17.2 ± 3.8° for groups A and B, respectively, with a significant difference ($p = 0.03$). At final follow-up, mean AI was 17.6 ± 4.8° and 13.1 ± 3.9° for groups A and B, respectively, with a significant difference ($p = 0.02$), indicating faster acetabular remodeling. Group B showed greater AI reduction than group A at 6 months and at final follow-up, with mean acetabular remodeling occurring more rapidly in group B than in group A. (Table 3)

Complications

Complications were reported both per patient and per hip. This distinction was necessary because some patients had bilateral hip involvement, resulting in a higher number of hips than patients. Therefore, complication rates were analyzed accordingly.

Overall, postoperative complications were documented in 7 of 26 hips (26.9%) and in 7 of 20 patients (35.0%).

In Group A, 2/13 hips (15.4%) and 2/10 patients (20.0%) were complicated. One patient (7.7%) developed radiographic AVN of the Kalamchi–MacEwen type II, was clinically asymptomatic at final follow-up, and was managed conservatively. Another patient (7.7%) had transient postoperative hip stiffness at early follow-up and was successfully treated with a prolonged rehabilitation program. No mechanical problems at the osteotomy site were observed.

In Group B, complications were documented in 5 of 13 hips and in 5 of 10 patients (50.0%). AVN (Kalamchi–MacEwen type IV) was observed in 1 patient (7.7%). Mechanical issues at the osteotomy site were identified in 4 patients (30.8%): 2 patients (15.4%) with partial crushing of the distal iliac osteotomy fragment, managed with prolonged immobilization; 1 patient (1 hip,

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7.7%) with graft dislodgment, resulting in partial loss of the secondary surgical stabilization; and 1 patient (1 hip, 7.7%) with an intraoperative fracture of the anterior inferior iliac spine, which healed without complications.

Mechanical complications at the osteotomy site were significantly more frequent in Group B than in Group A (4/13 hips [30.8%] versus 0/13 hips, p = 0.04). No deep infections were observed in either group.

Illustrative cases

Group A

A case of female child patient with right sided DDH
Operated at the age of 25 months by open reduction, capsulorrhaphy and DPO
Preoperative AI was 46 º (Figure 1.1)
Immediate post operative AI was 33.6º (Figure 1.2)
1 year post operative AI was 31.6º (Figure 1.3)

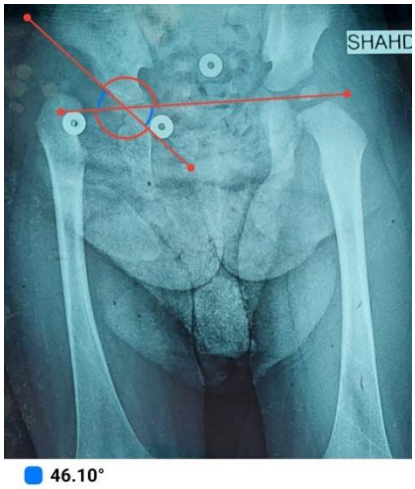

Figure 1.1

Preoperative AI was 46 º (blue angle)

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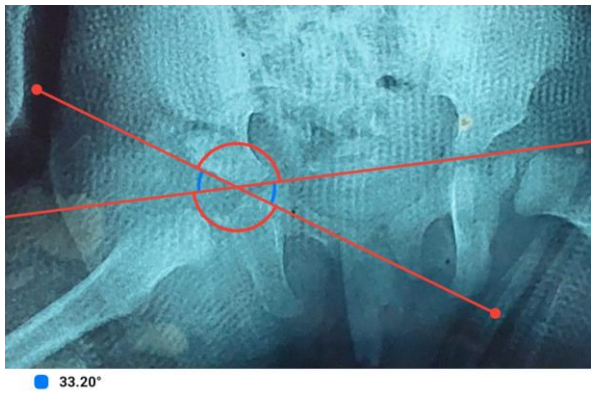

Figure 1.2
Immediate post operative AI was 33.6º (blue angle)

Figure 1.3
1 year post operative AI was 31.6º (blue angle)

Group B

A case of female child patient with bilateral DDH Operated at the age of 18 months by open reduction, capsulorrhaphy and DPO preoperative AI was 44º and 40.5º for right and left side, respectively. (figure 2.1)
Immediate post operative AI was 29.5º and 28.5º for right and left side, respectively. (figure 2.2)
1 year post operative AI was 21.5º and 21.17º for right and left side, respectively. (figure 2.3)

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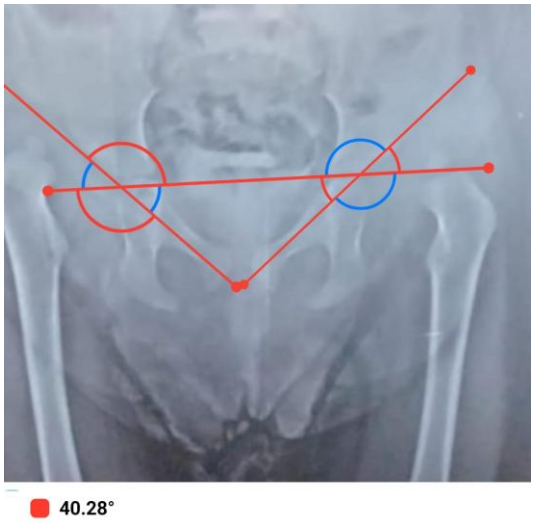

Figure 2.1

preoperative AI was 44º (blue angle) and 40.5º (red angle) for right and left side, respectively.

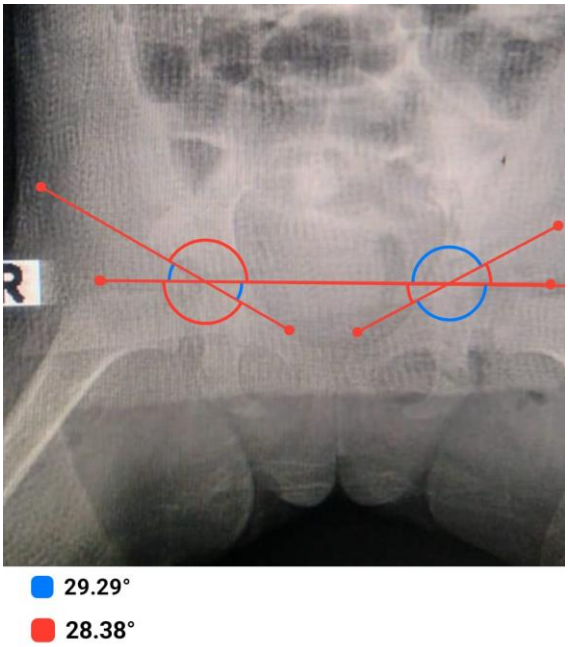

Figure 2.2

Immediate post operative AI was 29.5º (blue angle) and 28.5º (red angle) for right and left side, respectively.

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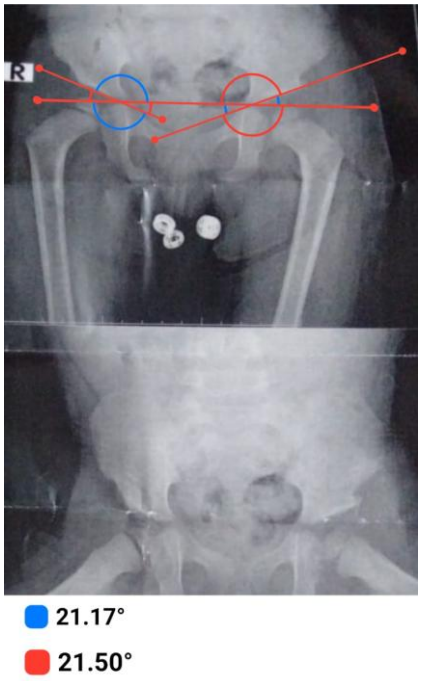

Figure 2.3

1 year post operative AI was 21.5º (red angle) and 21.17º (blue angle) for right and left side, respectively.

DISCUSSION

The current study found that patient age significantly affects early postoperative outcomes after DPO. Younger toddlers undergo more rapid acetabular remodeling and regain function faster, consistent with existing literature indicating that the immature acetabulum is more adaptable [11,12]. However, despite these advantages, our younger children experienced a higher incidence of osteotomy-site mechanical complications, consistent with earlier technical and clinical studies [10].

Our investigation showed that the length of surgical procedures and the healing time after osteotomy didn't seem to be affected by age, indicating that the surgical process and biological recovery are fairly similar across all toddlers. The recovery period was shorter in younger children, likely due to their greater neuromuscular plasticity.

Contemporary treatment protocols increasingly consider factors such as age, dysplasia severity, and bone quality [4,14]. Using pelvic osteotomy in children under 18 months remains controversial because of their dual potential for biological bone remodeling and mechanical fragility. Specialists caution that a thin iliac cortex, incomplete mineralization, and high cartilage content may lead to graft instability and deformation, even with proper correction [19, 20]. These issues are the reason many surgeons prefer to postpone reshaping osteotomies until after age two.

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Follow-up studies reported that remodeling depends on age, with younger children exhibiting greater remodeling due to higher cartilaginous potential and an open triradiate cartilage (21, 22). Terjesen observed that residual dysplasia after reduction often improves spontaneously when proper containment is achieved before age 3 (12).

Wang et al. conducted a meta-analysis comparing DPO and Salter osteotomies, noting that both procedures improve the acetabular index during the first year, with continued correction in younger patients over several additional years (9).

Our results align with these findings. In our cohort, the acetabular index decreased from approximately 41° pre-surgery to 17.6° in older toddlers and 13.1° in younger toddlers at follow-up. This shows immediate correction and early remodeling in children aged 11–24 months, supporting the idea that remodeling capacity depends on age, consistent with recent study emphasizing the benefits of early containment (21,22). El-Sayed et al. observed that the index improved after DPO, from 38° pre-surgery to 19° at the last follow-up, in children aged 2–8, with remodeling extending beyond 2 years (11).

Concerning the DPO, it effectively promotes remodeling by reshaping and preserving the posterior column hinge, allowing controlled redirection of the acetabular roof without complete pelvic disruption (7,20). Ghamdi et al. highlighted that the majority of corrections with DPO take place within the first postoperative year. (23). Amin et al. showed that Dega osteotomy reliably corrects the acetabular index in young children, comparable to HTIBO, confirming its status as a standard procedure for acetabular remodeling (13).

It has been reported that osteotomy complications, such as fragment crushing and graft migration, are more common in patients younger than 18 months and that aggressive redirection of the acetabular roof is not recommended in infants with thin iliac bones, regardless of osteotomy design (13,20). These findings align with the current study, which also reported that all mechanical osteotomy-site failures happened only in children younger than 18 months.

LIMITATIONS

The primary limitations include a small sample size, a brief follow-up period, and the absence of randomization. Long-term joint viability and degeneration could not be assessed. Future multicenter studies are required to define optimal age thresholds for pelvic osteotomy in early childhood. Nevertheless, the prospective study design and specific age stratification provide meaningful clinical insights.

CONCLUSION

Dega pelvic osteotomy is efficacious for both younger and older toddlers exhibiting severe Developmental Dysplasia of the Hip (DDH). Younger toddlers aged 11–24 months typically experience faster acetabular remodeling and earlier recovery; however, they are at an increased risk of mechanical complications at the osteotomy site compared to their older counterparts.

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ORIGINAL ARTICLE

DIAGNOSTIC VALUE OF TRU-CUT BIOPSY IN CLINICALLY SUSPICIOUS BREAST LESIONS.

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ABSTRACT

Background: Ultrasound became popular for diagnosing breast lesions due to its safety, efficiency, and real-time imaging without ionizing radiation. We aim to define the function of the tru-cut biopsy in the detection of malignant breast lesions in cases when the masses are not clinically palpable.

Methods: This cross-sectional investigation aims to evaluate the effectiveness of Tru-Cut Biopsy (TCB) in diagnosing breast lesions. The study was performed in the Radiology Department of Aswan University Hospitals, involving a sample size of 40 patients.

Results: Out of 40 patients, 26 (65%) had no discharge, 11 (27.5%) had bloody discharge, and 3 (7.5%) had yellowish discharge. Pain was reported by 23 patients (57.5%), with 15 (37.5%) having a left-side mass and 25 (62.5%) on the right side. All patients (100%) had impalpable masses. The mean tumor size was 19.25 ± 3.16 mm. Hypoechoic masses were found in 37 patients (92.5%), and 19 (47.5%) had irregular shapes. Biopsy samples were taken from the mass area in 24 patients (60%) and from non-mass areas in 16 (40%). Most patients (82.5%) had no complications. Ultrasound demonstrated 95% accuracy and strong agreement ($\kappa = 0.724$) with biopsy results, confirming its reliability for ruling out malignancy, though biopsy remains essential for definitive diagnosis.

Conclusion: Tru-cut biopsy is accurate, minimally invasive, and enhanced by imaging techniques, aiding early breast cancer detection.

Key words: Tru-Cut Biopsy; Breast Lesions; Malignant

INTRODUCTION

The use of ultrasound as part of the diagnostic process for breast lesions has grown in recent years. These treatments are risk-free and productive. And precise since there is no ionizing radiation and the ability to see changes in real time [1].

US guided biopsy can distinguish among benign, malignant, or grey zone lesions found in imaging investigations [2].

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A breast biopsy involves taking a small sample of tissue from an abnormal region of the breast and sending it for further analysis under a microscope. Only a highly trained radiologist employing a minimally invasive technique should do this.

This is helpful for lesions that are not palpable but can be detected using ultrasound guidance and sampled appropriately [3].

Clinical imaging and histological results must be correlated when dealing with a large breast lesion. A multidisciplinary open forum involving the doctor is the most effective way to accomplish this. working together as a team to choose the best course of action for each patient Applying established procedures. Using a trifecta of imaging, clinical diagnosis, and biopsies yields the most accurate diagnoses [4].

The goal of this investigation was to define the function of the tru-cut biopsy in the detection of malignant breast lesions in cases when the masses are not clinically palpable.

PATIENTS AND METHODS

Study design

This cross-sectional study aims to evaluate the effectiveness of Tru-Cut Biopsy (TCB) in diagnosing breast lesions. The study was conducted in the Radiology Department of Aswan University Hospitals, involving a sample size of 40 patients.

Patients' criteria selection

Inclusion criteria: All female cases above the age of twenty years with a clinically non palpable breast lump that is radiologically detected by sonomammography and classified as BI_RAD iv or v by ultrasonography.

Exclusion criteria: Patients who had Tru-Cut biopsy before and patients who have palpable breast mass.

Each subject was subjected to:

The pre-imaging process included recording the patient's history, age, symptoms, and conducting a clinical examination. Cases have been informed about the procedure, and their consent was obtained to ensure privacy and comfort. The process began with a thorough history assessment, clinical examination, radiological imaging, and performing a Tru-Cut biopsy. One milliliter of 2% lignocaine was injected around the target area, and the bulge was stabilized between the thumb and index finger before making a 5 mm skin incision. A Tru-Cut biopsy needle was inserted using an obturator, with the sheath advanced to trap tissue in the specimen notch. The needle was then discarded, and the sample was immersed in 10% formalin. Pressure was applied to the wound site to minimize bleeding. The procedure was repeated four times in different orientations to collect four biopsy fragments.

Statistical Analysis

A computer was used to analyze the data, with the help of IBM SPSS software package version 21.0. (New York: IBM Corp., Armonk) Numeric and percentage descriptions were provided for the qualitative data. The distribution was checked for normalcy using the

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Kolmogorov-Smirnov test. Minimum and maximum values, as well as the mean, standard deviation, median, and interquartile range (IQR), has been utilized to describe the quantitative data. At the 5% level, the results were considered significant.

RESULTS

Table 1 shows that, mean of age was 44.55 ± 8.85 years with range (30 – 60) years, mean of BMI was 28.06 ± 2.79 kg/m^2 with range (23.0 – 32.8) kg/m^2, 26 patients (65%) took Oral contraception, 5 patients (12.5%) had Diabetes, 10 patients (27.5%) had Hypertension, 25 patients (62.5%) had family history of breast cancer, and no patients had History of breast surgical.

Table 1: Distribution of the studied cases according to historical data.

	Cases (n = 40)	
Age		
Range.	30 – 60	
Mean ± SD.	44.55 ± 8.85	
BMI		
Range.	23.0 – 32.8	
Mean ± SD.	28.06 ± 2.79	
Historical data	**No.**	**%**
Oral contraception	26	65.0%
Diabetes	5	12.5%
Hypertension	11	27.5%
Family history of breast cancer	25	62.5%
History of breast surgical	0	0.0%

SD: standard deviation, BMI: Body Mass Index.

Table 2 shows that, 26 patients (65%) had no discharge, 11 patients (27.5%) had bloody discharge, 3 patients (7.5%) had yellowish discharge, 23 patients (57.5%) had pain, 15 patients (37.5%) had mass on the left side, while 25 patients (62.5%) had mass on the right side, and 40 patients (100%) had impalpable mass.

Table 2: Distribution of the studied cases according to symptoms and examinations

	Cases (n = 40)	
Discharge	**No.**	**%**
No	26	65.0%
Bloody	11	27.5%
Yellowish	3	7.5%
Pain	23	57.5%
Position	**No.**	**%**
Left	15	37.5%
Right	25	62.5%

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Examination	No.	%
Impalpable	40	100.0

Table 3 shows that, 1 patient (2.5%) had Hematoma, and Bleeding, 2 patients (5%) had Vasovagal reaction, and no patients had Bleeding requiring treatment, and Infection.

Table 3: Distribution of the studied cases according to complications.

	Cases (n = 40)	
Complications	**No.**	**%**
Hematoma	1	2.5%
Bleeding	1	2.5%
Bleeding requiring treatment	0	0.0%
Infection	0	0.0%
Vasovagal reaction	2	5%

Table 4 shows that, mean of size tumor was 19.25 ± 3.16 with range (15.0 – 25.0), according to Echogenicity of mass, 37 patients (92.5%) were Hypoechoic, while 3 patients (7.5%) were Mixed hyperechoic and hypoechoic, 13 patients (32.5%) had oval shape, 8 patients (20%) had round shape, 19 patients (47.5%) had irregular shape, 28 patients (70%) with non-speculated mass, while 12 patients (30%) with speculated mass, according to BIRADs, 5 patients (12.5%) with IV a, 9 patients (22.5%) with IV a, 16 patients (40%) with IV a, 7 patients (17.5%) with IV a, 3 patients (7.5%) with IV a, 36 patient (90%) with Calcification, 24 patients (60%) were taken their biopsy sample from Mass area, while 16 patients (40%) were taken their biopsy sample from Non-mass area, 33 patients (82.5%) had no complications, 5 patients (12.5%) had Bleeding, and 24 patients (60%) had infection.

Table 4: Distribution of the studied cases according to radiologic data

	Cases (n = 40)	
Echogenicity of mass	**No.**	**%**
Hypoechoic	37	92.5%
Mixed hyperechoic and hypoechoic	3	7.5%
Size (mm)		
Range.	15.0 – 25.0	
Mean ± SD.	19.25 ± 3.16	
Shape	**No.**	**%**
Oval	13	32.5%
Round	8	20.0%
Irregular	19	47.5%
Speculate (by US)	**No.**	**%**
Non speculated	28	70.0%

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Speculated	12	30.0%
BIRADs	**No.**	**%**
IV a	5	12.5%
IV b	9	22.5%
IV c	16	40.0%
V	7	17.5%
VI	3	7.5%
Calcification	**No.**	**%**
Absent	4	10.0%
Present	36	90.0%
Biopsy from	**No.**	**%**
Mass area	24	60.0%
Non-mass area	16	40.0%
Complications	**No.**	**%**
Non	33	82.5%
Bleeding	5	12.5%
Infection	2	5.0%

SD: standard deviation, BMI: Body Mass Index.

Table 5 shows that, the ultrasound is a very useful screening tool with high accuracy (95%) and is especially reliable for ruling out malignancy. Given the κ value of 0.724, it shows strong agreement with biopsy results, reinforcing its utility in clinical practice. However, a biopsy remains essential for a definitive diagnosis.

Table 5: Agreement between results by ultrasound and Tru-Cut Biopsy.

Results by US	**Results by TCB**		**κ**	**p**
	Benign	Malignant		
Benign	3 (7.5%)	0 (0.0%)	0.724	<0.001*
Malignant	2 (5.0%)	35 (87.5%)		

Sensitivity	**Specificity**	**PPV**	**NPV**	**Accuracy**
100.0%	60.0%	94.6%	100.0%	95.0%

DISCUSSION

Breast cancer is the 2nd most prevalent cancer diagnosed in women, exceeded only by non-melanoma skin cancer. It is the leading etiology of death from cancer in women worldwide. In the United States, breast cancer is the 2nd most prevalent cause of death from cancer in women, exceeded only by lung cancer, with approximately 316,000 cases diagnosed with breast cancer annually [5].

The majority of breast cancers are adenocarcinomas, with 85% of adenocarcinoma cases arising from the breast ducts and 15% from the lobular epithelium. The ductal pathology ranges from ductal carcinoma in situ, to invasive carcinomas which have spread beyond the basement membrane into adjacent breast parenchyma [6].

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Any lump in the breast that can be felt should be evaluated for indicators of cancer before surgery. Procedures for routine examination of breast lesions include a clinical breast examination, radiographic evaluation, and pathological analysis. There are numerous approaches to performing a pathological assessment. FNAC, core needle biopsy/Tru-Cut biopsy, and incisional/excisional biopsy are all examples of these procedures [7].

Tru-cut biopsy is now one of the useful means of obtaining early and accurate histopathological diagnosis. It is easy and may be conducted on an outpatient basis. It also avoids unnecessary excisional biopsy [8].

Our study aimed to determine if tru-cut biopsy is useful for diagnosing cancer in breast tumors that are not clinically palpable.

The current study conducted at Aswan University Hospital, conducted on 40 patients with a clinically non palpable breast lump.

Regarding distribution of the examined cases according to historical data we found that, the mean of age was 44.55 ± 8.85 years with range (30 – 60) years, mean of BMI was 28.06 ± 2.79 kg/m^2 with range (23.0 – 32.8) kg/m^2, 26 patients (65%) took oral contraception, 5 patients (12.5%) had diabetes, 10 patients (27.5%) had hypertension, 25 patients (62.5%) had family history of breast cancer, and no patients had history of breast surgical.

In agreement with our study Altintas and Bayrak [9] who aimed to evaluate the diagnostic utility of Tru-Cut biopsy in the diagnosis of breast mass in patients conducted on 472 patients. They showed that, the mean age of cases was 46.2 years old (range: 22 to 91 years) while 57 patients (12.1%) had family history of breast cancer.

In contrast with our study Abd ElRazik et al., [10] who aimed to evaluate ultrasound-guided Tru-cut needle biopsy in suspicious breast masses, analyzing procedure results, histopathological findings, and their correlation with imaging data conducted on 25 patients they reported that the mean age (years) was 50.9 ± 10.1 ranged (26 – 69) regarding to family history of malignancy 24 patients (96%) without malignancy while 1 patient (4%) with malignancy.

Accordance distribution of the studied cases according to symptoms and examinations demonstrated that, 26 patients (65%) had no discharge, 11 patients (27.5%) had bloody discharge, 3 patients (7.5%) had yellowish discharge, 23 patients (57.5%) had pain, 15 patients (37.5%) had mass on the left side, while 25 patients (62.5%) had mass on the right side, and 40 patients (100%) had impalpable mass.

In the same line agreed with our study Altintas and Bayrak [9] they reported that 268 patients (56.8%) had mass on the right side while 204 (23.2%) had mass on the left side, while 256 patients (54.2%) had palatable mass while 216 (45.8%) had unpalatable mass.

Also, agreed with our study Abd ElRazik et al.,[10] they showed that, 15 patients (60%) had mass on the right side while 10 patients (40%) had mass on the left side, while 24 patients (96%) with palpable mass while 1 patient (4%) with unpalatable mass,

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In our study we reported that distribution of complications among studied cases was 1 patient (2.5%) had hematoma, and bleeding, 2 patients (5%) had vasovagal reaction, and no patients had bleeding requiring treatment, and infection.

In supporting agreed with our study Altintas and Bayrak [9] they found that no complication has been observed in 97.7 percent of cases, ecchymosis was present in 1.4 percent of cases, and disappeared within a few days. Hematoma was detected in 0.9% of cases and subsided spontaneously, no superimposed infection has been observed.

Also, agreed with our study GONZALEZ et al., [11] they found that biopsy complications were limited to local pain or discomfort that rarely required analgesia. No cases of significant hemorrhage or hematomas were recorded. No infections were detected.

Regarding to distribution of the examined cases according to radiologic data we reported that mean of size tumor was 19.25 ± 3.16 with range (15.0 – 25.0), according to Echogenicity of mass, 37 patients (92.5%) were hypoechoic, while 3 patients (7.5%) were mixed hyperechoic and hypoechoic, 13 patients (32.5%) had oval shape, 8 patients (20%) had round shape, 19 patients (47.5%) had irregular shape, 28 patients (70%) with non-speculated mass, while 12 patients (30%) with speculated mass, according to BIRADs, 5 patients (12.5%) with IV a, 9 patients (22.5%) with IV a, 16 patients (40%) with IV a, 7 patients (17.5%) with IV a, 3 patients (7.5%) with IV a, 36 patient (90%) with calcification, 24 patients (60%) were taken their biopsy sample from mass area, while 16 patients (40%) were taken their biopsy sample from non-mass area, 33 patients (82.5%) had no complications, 5 patients (12.5%) had bleeding, and 24 patients (60%) had infection.

In agreement with our study Altintas and Bayrak [9] they reported that the mean of size tumor < 1 cm in 37 patients (7.8%), mean of size tumor 1 – 2 cm in 104 patients (22.0%), mean of size tumor 2 – 5 cm in 297 patients (62.9%) and mean of size tumor > 5 cm in 34 patients (7.3%). According to BIRADs, 338 patients (71.6%) with 3 a, 134 patients (28.4%) with 4 a. regarding sonographic findings; 28 patients (5.9%) with Cyst (complicated or thick wall cyst), 12 patients (2.5%) with inflammation, 53 patients (11.3%) with solid mass probably benign, 191 patients (11.3%) with Solid mass probably malignant.

As well, agreed with our study Abd ElRazik et al.,[10] they reported that borders were ill-defined in 16 patients (64%) and well-defined in 9 patients (36%) of cases, while echogenicity varied, with 16 patients (64%) hypoechoic, 2 patients (8%) hypo-to-isoechoic, and 7 patients (28%) isoechoic. Calcifications were present in 5 patients (20%) of cases. Mean ±SD of size was 16.5 ± 14.5 with range (3 – 72), Regarding BIRADs classification, 28% had BIRADs III, 4% had BIRADs IV, 8% had BIRADs IV a, 24% had BIRADs IV b, 20% had BIRADs IV c, and 16% had BIRADs V.

Agreement between results by ultrasound and Tru-Cut Biopsy we found that, the ultrasound is a very useful screening tool with high accuracy (95%) and is especially reliable for ruling out malignancy. Given the κ value of 0.724, it showed strong agreement with biopsy results, reinforcing its utility in clinical practice. However, a biopsy remains essential for a definitive diagnosis.

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In agreement with our study Abd ElRazik et al., [10] they reported that highly statistically significant (p-value > 0.05) concordance of US diagnosis in relation to pathology (k =0.89) as there were 6 patients (100%) true negative, 18 patients (94%) true positive, 1patient (5.3%) false negative with no patients with (0%) false positive. Thus, the U/S guided true cut had the sensitivity of 94.7%, specificity of 100%.

As well, our findings in line with Hossain et al., [12] reported that the reliability of the Tru-cut biopsy in identifying cancerous from benign breast cancers during screening. With a sensitivity of 98.1% and a specificity of 100.0%, Tru-cut biopsy was able to accurately distinguish among benign and malignant breast cancers. The test had a positive predictive value of 100% and a negative predictive value of 88.9%.

CONCLUSION

In conclusion, tru-cut biopsy is an effective and practical method for diagnosing non-palpable breast tumors, offering a balance between diagnostic accuracy, patient comfort, and minimal invasiveness. Its widespread use enhances early cancer detection and improves clinical decision-making, ultimately contributing to better case results. Furthermore, with the advancements in imaging-guided techniques such as ultrasound or stereotactic guidance, tru-cut biopsy can be performed with high accuracy, reducing the need for more invasive procedures.

RECOMMENDATION

Further investigations with larger sample sizes and longer monitoring periods are needed to confirm our findings and establish the role of tru-cut biopsy in diagnosing malignant breast lesions in non-palpable masses. Future research should include well-designed randomized controlled trials or large observational studies with representative patient samples, ensuring adequate control of confounding factors. Multicenter studies are also recommended to validate these results and provide meaningful conclusions.

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ORIGINAL ARTICLE

PRIMARY ENDOSCOPIC ULTRASOUND (EUS)-GUIDED BILIARY DRAINAGE VERSUS ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY (ERCP) IN DISTAL MALIGNANT BILIARY OBSTRUCTION: A RANDOMIZED CLINICAL TRIAL.

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ABSTRACT

Background: Endoscopic ultrasonography-guided biliary drainage (EUS-BD) presents promising outcomes as an alternative to endoscopic retrograde cholangiopancreatography (ERCP) in the management of malignant biliary obstruction (MBO), the aims of the current study are to compare between primary EUS- biliary drainage vs. ERCP in malignant obstruction of the distal bile duct: As regard success (technical and clinical), adverse events (AEs), timing and need for reintervention.

Methods: This prospective study evaluated two primary drainage procedures in 47 patients with malignant distal biliary stricture. Endoscopic retrograde cholangiopancreatography (ERCP) drainage was conducted on 24 patients, while endoscopic ultrasonography (EUS) drainage was executed on another 23 patients. Between 2022 and 2024, researchers from Shefaa Al Orman Hospital in Luxor and Theodor Bilharz Research Institute in Cairo engaged in collaboration. Furthermore, we documented technical and clinical success rates, duration of procedures, frequency of adverse events and re-interventions for both procedures.

Results: There were 57.4% males and 42.6% females among the examined patients, with an average age of 60.87 ± 10.44 years. There was no statistically significant difference between the groups with respect to age, gender, comorbidities, clinical and technical success, adverse event rates and re-intervention rates. The EUS group succeeded in managing to drastically shorten the operation time when compared to the ERCP group. Clinical success, adverse events, and re-intervention rates were not significantly different among the EUS-BD techniques; however, the procedure duration were significantly different, the least duration in the Choledocho-duodenostomy (CDS) group.

Conclusion: Our study demonstrates that EUS-BD serves as a viable option, offering safety and efficacy comparable to ERCP as a main palliative approach for malignant distal biliary obstruction, contingent upon the presence of a proficient team.

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Key words: Endoscopic ultrasound guided biliary drainage (EUS-BD), endoscopic retrograde cholangiopancreatography (ERCP), distal malignant biliary obstruction

INTRODUCTION

Although endoscopic retrograde cholangiopancreatography (ERCP) has been a safe and successful method for bile duct draining for more than 30 years, it is not risk-free [(1)]. Pancreatitis, bleeding, and perforation are the primary outcomes, occurring at rates ranging from 3% to 15% [(2)].

If ERCP fails, the next step is to refer the patient to a more proficient endoscopist [(3)]. Due to anatomical changes induced by tumor invasion or previous surgical therapies, even highly educated endoscopists may lack skill in biliary cannulation. Other options include palliative surgical intervention or undergoing percutaneous transhepatic biliary drainage (PTBD). Because of the possible negative effects of the therapies and the fact that patients dislike external drainage, these choices are not very appealing [(4)].

In recent years, EUS has transitioned from a diagnostic tool to a therapeutic modality [(5)]. The established criteria for EUS-BD include failed conventional ERCP with skilled endoscopist, anatomical abnormalities, tumor-related obstructions impeding biliary access, and contraindications to percutaneous drainage, such as significant ascites [(6)].

Due to its better safety profile, improved quality of life, and equivalent effectiveness, EUS-BD is highly recommended over PTBD in the 2022 recommendations of the European Society of Gastrointestinal Endoscopy (ESGE) [(7)].

One of the well-documented side effects of EUS-BD is bile leakage, which can have potentially fatal consequences [(8)], New research indicates that these occurrences have decreased as a result of practitioners' improved knowledge and shorter learning curve [(9)]. Recent studies suggest that EUS-BD may serve as a main drainage option for patients with MDBO [(9, 10)].

The current study aimed to compare between primary EUS- biliary drainage vs. ERCP in malignant obstruction of the distal bile duct: As regard success (technical and clinical), adverse events, timing and need for reintervention.

PATIENTS AND METHODS

Study design

This prospective comparative study included 47 patients diagnosed with malignant distal biliary stricture, who were randomly allocated into two groups: group 1 (n=23) had primary drainage by EUS, whereas group 2 (n=24) got primary drainage with ERCP. This study was conducted at two tertiary medical facilities: Shefaa Al Orman Hospital in Luxor, Egypt, and Theodor Bilharz Research Institute in Cairo, Egypt, from January 2022 to May 2024.

The inclusion criteria were patients aged over 18 years diagnosed with malignant distal biliary obstruction, hospitalized for primary biliary drainage, including both resectable and unresectable tumors and those with performance level A.

The exclusion criteria included patients with high up biliary obstruction, surgically altered anatomy, previous unsuccessful ERCP attempts, recurrent biliary obstruction after biliary stent placement (via ERCP or PTD), benign biliary strictures, uncorrected coagulopathy, and those exhibiting sepsis (as defined by the quick Sequential Organ Failure Assessment (SOFA) score,

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necessitating at least two of the following: a respiratory rate of 22 breaths per minute or greater, altered mental status, and a systolic blood pressure below 100 mmHg, with a life expectancy of less than one month).

Data was gathered from the individuals, including their medical history, such as age, sex, alcohol use, substance abuse, smoking habits, present symptoms, and prior abdominal surgery. The clinical assessment included a comprehensive physical examination, with a focus on the abdomen region, as well as diagnostic testing such as complete blood count (CBC), renal function tests, liver function tests, coagulation profile, tumor markers and computed tomography (CT) or magnetic resonance imaging (MRI).

Procedures: EUS-BD procedures were conducted by a single endoscopist skilled in ERCP and interventional EUS, overseeing more than 100 EUS patients each year. All procedures used the Fujifilm EG-580UT Curved Linear Endoscopic Ultrasound scope with SU-1 (Fujifilm Global, Tokyo, Japan) under fluoroscopic supervision. Patients undergoing EUS-BD were classified into three groups according to the used techniques, as shown in table (1).

Table (1) Parameters of EUS-BD of our study

Parameter	Category	(n=23)
Access Site	• Trans-gastric Intra-hepatic	10 (43.5%)
	• Trans-duodenal	13 (56.5%)
EUS-BD Technique	• Antegrade Stenting	3 (13%)
	• Choledocho-duodenostomy	14 (58%)
	• Hepatico-gastrostomy	6 (25%)
Dilatation	• Cystotome 6 Fr	22 (95.7%)
	• Mechanical Dilatation (balloon dilator)	1 (4.3%)
Stent Length	• 6 cm	14 (60.9%)
	• 8 cm	4 (17.4%)
	• 10 cm	5 (21.7%)

ERCP-BD procedure was conducted by endoscopists proficient in ERCP, each doing over 500 cases annually, according to pre-procedural guidelines aligned with those of EUS-BD. The procedure was conducted using a Fujifilm side-view duodenoscope. Biliary stenting was executed using self-expanding metallic stents (SEMS), including fifteen cases 6 cm stents (eleven

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partially covered and four uncovered), six cases 8 cm stents (three partially covered and three uncovered), and three cases 10 cm uncovered stents.

Patients were prescribed antibiotics (third-generation cephalosporins) before their procedures and were instructed to continue taking them for three to five days following the procedure.

The principal objectives of the research were to evaluate the efficacy of biliary drainage (BD) from both technical and clinical viewpoints. The procedure was classified as a technical success when the stent was precisely positioned, with one end in the biliary tree and the other in the alimentary canal. A reduction of total bilirubin by 50% or more two weeks post-endoscopy was classified as clinically successful, as was a decrease to below 3 mg/dl one month later, Procedure duration, occurrence of adverse events, and re-intervention rate within six months were the secondary outcomes [(11)].

We used the American Society for Gastrointestinal Endoscopy (ASGE) classification system to characterize and classify endoscopic adverse events (AEs). AEs are defined as occurrences that impair normal functioning and/or need medical consultation, hospitalization, or endoscopic or surgical procedures. AEs were classified as mild, moderate, severe, or fatal according to ASGE criteria. In cases where multiple adverse occurrences occurred, the most severe one was used for classification.

Follow up: The purpose of keeping all patients in the hospital for a minimum of one day after procedure was to identify any potential issues as early as possible. We assessed the late complication rate and clinical effectiveness at 1 week,1 month, and 6 months post-procedure, or as the situation required.

Statistical Analysis

The researcher validated, encoded, and analyzed the data using SPSS version 25(*). Descriptive statistics: Means, standard deviations, medians, and percentages were computed. Significance Evaluation: Chi-Square and Fisher's Exact Test Exact tests were used to analyze the variation in frequency distributions among several groups. An ANOVA test was conducted on continuous variables with many categories to assess mean differences in data according to a normal distribution, then followed by a post-hoc analysis using Bonferroni corrections. An independent T-test was used to compare two sets of parametric quantitative variables. The paired t-test was used to compare variables in the same group. A p-value below 0.05 was deemed significant.

RESULTS

There were no statistically significant differences between the EUS and ERCP groups in terms of gender, age, comorbidities, and cancer type. The evaluated patients' ages ranged from 33 to 86 years, with an average age of 60.87 ± 10.44 years. Of the total, there were 27 males (57.4% of the total) and 20 females (42.6%), as shown in table (2).

The evaluation of total bilirubin levels two weeks after endoscopy indicated no statistically significant difference between the two procedures (P-values = 0.21). The mean total bilirubin

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levels in the EUS-BD and ERCP-BD groups were 3.59 ± 1.7 mg/dL and 4.39 ± 2.22 mg/dL, respectively.

No statistically significant difference was seen between EUS and ERCP for technical success, clinical success, and duration of hospital stay. In contrast, the EUS group exhibited a significant decrease in procedure duration relative to the ERCP cohort (17.3 ± 5.75 min vs 23.75 ± 9.56 min, P-value = 0.008), as shown in table (4).

Evaluation of the rates of complications and re-intervention for EUS and ERCP showed that there was no statistically significant difference (P-values = 0.54, 0.38), as described in table (5 and 6).

The time required for each EUS technique to finish was significantly different between techniques (P-value < 0.001). Comparing EUS techniques did not reveal any statistically significant differences in re-intervention, adverse event, or clinical success rates (P-values = 0.65, 0.45, 0.47), as shown in table (7).

Table (2) Comparison between EUS and ERCP according to baseline characteristics

Variable		**Summary statistics (n=47)**			**P-Value**
		EUS-BD (n=23) No. (%)	**ERCP-BD (n=24) No. (%)**	**Total (n=47)**	
Age	**Mean ± SD**	61.08 ± 12.47	60.66 ± 8.32	60.87 ± 10.44	0.89
	Range (Min.-Max.)	(33-86)	(37-77)	(33-86)	
Gender	**Male**	13 (56.5%)	14 (58.3%)	27 (57.4%)	0.9
	Female	10 (43.5%)	10 (41.7%)	20 (42.6%)	
Comorbidities	**Yes** Hypertension Diabetes mellitus IHD Hypothyroidism Oncology	9 (39.1%)	11 (45.8%)	20 (42.6%)* 7 (14.9%) 12 (25.5%) 3 (6.4%) 1 (2.1%) 5 (16.6%)	0.64
	No	14 (60.9%)	13 (54.2%)	27 (57.4%)	
Type of malignancy	**PDAC**	19 (82.6%)	21 (87.4%)	40 (85.1%)	0.19
	Ampullary carcinoma	1 (4.3%)	1 (4.2%)	2 (4.3%)	

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	Cholangiocarcinoma	0 (0%)	1 (4.2%)	1 (2.1%)	
	Duodenal mass	2 (8.8%)	0 (0%)	2 (4.3%)	
	Porta hepatis L. N	0 (0%)	1 (4.2%)	1 (2.1%)	
	Retro-duodenal mass	1 (4.3%)	0 (0%)	1 (2.1%)	
Chemotherapy		20 (87%)	22 (91.7%)	42 (89.4%)	0.6
Surgery		2 (8.4%)	2 (8.4%)		0.51
Whipple operation		2 (8.4%)	1(4.2%)		
Gastric by-pass surgery		0 (0%)	1(4.2%)		

PDAC: Pancreatic ductal adenocarcinoma; IHD: Ischemic heart disease, *Many cases had more than one comorbidity

Table (3) Comparison between EUS and ERCP according to bilirubin level at different times.

Variable		**Summary statistics (n=47)**		**P-Value**
		EUS-BD (n=23) No. (%)	**ERCP-BD (n=24) No. (%)**	
Total bilirubin pre-endoscopy (mg/dL)	**Mean ± SD**	15.14 ± 7.23	16.16 ± 6.41	0.61
	Range (Min.-Max.)	(6-36)	(6-30)	
Total bilirubin 2 weeks post-endoscopy(mg/dL)	**Mean ± SD**	3.59 ± 1.7	4.39 ± 2.22	0.21
	Range (Min.-Max.)	(1-7)	(0.6-10)	
Total bilirubin 1-month post-endoscopy(mg/dL)	**Mean ± SD**	1.39 ± 0.51	1.2 ± 0.53	0.27
	Range (Min.-Max.)	(0.4-2)	(0.4-2)	

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Table (4) Comparison between the studied groups according to time of procedure, maneuver success and duration of hospital stay.

Variable		Summary statistics (n=47)		P-value
		EUS-BD (n=23) No. (%)	ERCP-BD (n=24) No. (%)	
Time procedure (min)	Mean ± SD	17.3 ± 5.75	23.75 ± 9.56	0.008*
	Range (Min.-Max.)	(10-28)	(8-40)	
Technical success	Yes	23 (100%)	22 (91.7%)	0.16
	No	0 (0%)	2 (8.3%): subjected to 2nd trial	
Clinical success	Yes	21 (91.3%)	24 (100%)	0.34
	No	1 (4.3%)	0 (0%)	
	Missed follow up	1 (4.3%)	0 (0%)	
Duration of hospital stay (days)	Mean ± SD	0.91 ± 0.59	0.79 ± 1.1	0.64
	Range (Min.-Max.)	(0-3)	(0-5)	

Table (5) Comparison between EUS and ERCP according to grades of adverse events according to the lexicon by American Society for Gastrointestinal Endoscopy

Variable	Summary statistics (n=47)		P-value
	EUS-BD (n=23) No. (%)	ERCP-BD (n=24) No. (%)	
Adverse events			
Yes	9 (39.1%)	7 (29.2%)	0.54
No	14 (60.9%)	17 (70.8%)	
Mild	**6 (25.2%)**	**2 (8.4%)**	**0.12**
- Hiccup	1 (4.2%)	0 (0%)	0.31
- Repeated vomiting (self-limited)	2 (8.4%)	0 (0%)	0.15
Abdominal pain	3 (12.6%)	2 (8.4%)	0.64
Moderate	**3 (12.6%)**	**4 (16.7%)**	**0.68**

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AKI	1 (4.2%)	0 (0%)	0.31
Cholangitis	2 (8.4%)	3 (12.5%)	0.15
Bleeding	0 (0%)	0 (0%)	---
Pancreatitis	0 (0%)	1 (4.2%)	0.31
Bile peritonitis	0 (0%)	0 (0%)	---
Severe	**0 (0%)**	**1 (4.2%)**	**0.31**
Perforation	0 (0%)	1 (4.2%)	0.31

Table (6) Comparison between EUS and ERCP according to reintervention rate.

Variable		**EUS-BD (n=23) No. (%)**	**ERCP-BD (n=24) No. (%)**	**P-Value**
Yes		**3 (13%)**	**1 (4.2%)**	0.38
1. **Biliary reintervention**		2 (8.6%)	1 (4.2%)	
Early (<30 days)	Slipped stent after 1 month	1 (4.3%)	0 (0%)	
Late (> 30 days)	Obstructed	1 (4.3%) (HGS)	1 (4.2%)	
	Causes	Impacted food and biliary sludge	Tumor growth	
	Re-intervention method	ERCP and plastic stent insertion	PTD	
2. **Others**				
GOO and duodenal stent insertion		1 (4.3%)	0 (0%)	
No		**20 (87%)**	**23 (95.8%)**	

GOO: Gastric Outlet Obstruction

Table (7) Comparison between techniques of EUS according to time of procedure and outcome

Variable	**CDS (n=14) No. (%)**	**HGS (n=6) No. (%)**	**Antegrade stenting (n=3) No. (%)**	**P-value**
Time of procedure (min)				
Mean ± SD	14.62 ± 4.27	23 ± 5.25	21.66 ± 2.88	P <0.001*
Range (Min.-Max.)	(10-22)	(15-28)	(20-25)	P1=<0.001* P2=0.016*

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				P3=0.84
Maneuver success				
Technical success	14 (100%)	6 (100%)	3 (100%)	---
Clinical success	13 (92.9%)	5 (83.3%)	3 (100%)	0.47
Adverse events				
Yes	7 (50%)	2 (33.4%)	0 (0%)	0.54
Mild	4 (28.6%)	2 (33.4%)	0 (0%)	0.12
Moderate	3 (21.4%)	0 (0%)	0 (0%)	0.68
Severe	0 (0%)	0 (0%)	0 (0%)	---
Re-intervention				
Yes	2 (14.3%)	1 (16.7%)	0 (0%)	0.65
No	12 (85.7%)	5 (83.3%)	3 (100%)	

P: among all groups, P1: CDS vs HGS, P2: CDS vs antegrade stenting, P3: HGS vs antegrade stenting.

Discussion

Underdeveloped countries have significant challenges when it comes to bile drainage and other advanced endoscopic procedures. All of these problems stem from three main sources: expensive costs, inadequate tools, and an absence of skilled workers. Despite these obstacles, the goal of improving healthcare delivery remains worthy, but the task at hand is enormous [(12)].

For a long time, the gold standard for treating malignant distal biliary obstruction was the implantation of stents using endoscopic retrograde cholangiopancreatography (ERCP) [(13)]. Despite the high success rate of ERCP, adverse consequences do occur in 5% to 9.8% of patients [(14)], notably severe pancreatitis [(15)].

The current ESGE recommendations from 2022 support EUS-BD over PTBD in case of ERCP failure because it improve quality of life and have a higher safety profile [(7)].

International acclaim, particularly in developing countries, has been bestowed to EUS-BD by the growing corpus of evidence proving its beneficial technical and clinical outcomes [(16)]. Thus, in our study we aim to evaluate the role of EUS- BD primarily as an alternative to ERCP in patients with malignant distal biliary obstruction (MDBO), as it seems to provide a higher success rate, a lower incidence of pancreatitis [(17)], and typically requires a shorter procedure time [(9)].

Forty-seven patients participated in the study, consisting of 27 males and 20 females. The ages of the patients ranged from 33 to 86 years. The predominant causes of malignant distal biliary obstruction were pancreatic cancer, followed by ampullary carcinoma, duodenal tumor, and cholangiocarcinoma. Diabetes mellitus and hypertension were the most common comorbidities among the participants, with no statistically significant differences in other comorbidities between

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the two groups. This aligns with the findings of Dhir et al., who reported no statistically significant differences in age, gender, or comorbidities between the two groups [18].

The current study reveals that both EUS-BD and ERCP are technically and clinically effective procedures, exhibiting a technical success rate of 100% versus 91.7%, and a clinical success rate of 91.3% compared to 100%, with no significant differences in feasibility or efficacy between the two techniques. This corresponds with the findings of Paik and Lee, which demonstrated comparable technical and clinical success rates across the EUS-BD and ERCP groups (93.8% vs 90.2% and 90.0% vs 94.5%, respectively), with no statistically significant difference seen [9]. Also, studies conducted by Park et al., Bange et al., and Ghoneem, Atalla et al. [12, 19, 20].

In comparison to the ERCP group, which took 23.75 minutes for the procedure, the EUS-BD group only took 17. 3 minutes. Consistent with the findings of Paik et al., the median duration of an EUS-BD was five minutes, but an ERCP took eleven minutes [9]. Also, with Teoh et al., who conducted a multicenter randomized controlled study which compared EUS-CDS employing LAMS with ERCP with a covered metallic stent in unresectable MDBO revealed that the entire procedure duration was dramatically shortened in the EUS-CDS group, averaging 10 minutes, compared to 25 minutes with ERCP [21].

According to Bang et al., there was no statistically significant difference in the total time required to finish the two procedures; ERCP and EUS-BD both took about the same amount of time, 21 and 25 minutes, respectively [19] and Ghoneem et al showed that the duration of procedure was nearly identical between EUS-CDS and ERCP (mean procedure time, 16 minutes vs 16 minutes) [12]. Our study shows that endoscopic teams have significantly improved their EUS-BD competency in the last several years, which is responsible for the dramatic decrease in procedure duration. The longer procedure duration in the ERCP group might be attributed to the complexity and progression of the patients' diseases.

The ERCP and EUS-BD groups did not vary significantly with respect to the amount of time patients stayed in the hospital after procedure. As a result of increased proficiency in EUS-BD operations, patients are now spending less time in the hospital than they did when this technology was first introduced, which may be attributed to the reduction in complication rate and continuous monitoring requirements. Paik et al. similarly found that patients receiving EUS-BD spent less time in the hospital overall compared to those getting ERCP, therefore our results are in line with theirs [9]

The current study indicates that the incidence of overall adverse events was similar between the EUS-BD and ERCP groups. Moderate adverse effects in the EUS group occurred in three instances (12.6%): two cases of cholangitis, which were treated with antibiotics, and one case of recurrent vomiting post-CDS, exacerbated by acute renal impairment and hypokalemia. The vomiting was attributed to friction between the metallic stent and the adjacent duodenal wall, leading to the placement of a pigtail stent, which alleviated the vomiting. This finding was also comparable to that of the ERCP cohort (16.7%). This aligns with the results of Bang et al., which revealed no significant difference in the frequency or severity of adverse events between the EUS-BD and

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ERCP groups, with overall adverse event rates of 21.2% and 14.7%, respectively, and moderate severity adverse events at 6.1% versus 5.9% [19].

Notably, pancreatitis was absent in cases utilizing EUS-BD, indicating a substantial advantage. This method completely avoids direct interaction with the papillary orifice of the pancreatic duct, unlike ERCP [17]. We used considerable caution in managing the incidence of post-ERCP pancreatitis (PEP) that was treated conservatively, given its impact on the patient. The 4.2% incidence of PEP in our cohort is likely attributable to pancreatic cancer, which accounts for 87.4% of obstruction causes. The reduction in the incidence of post-endoscopic retrograde cholangiopancreatography pancreatitis (PEP) due to trans papillary stenting in pancreatic cancer patients aligns with the results of Kawakubo et al. [22].

There was no statistically significant difference in stent patency and re-intervention rates between the EUS-BD and ERCP groups. In the EUS-BD cohort, thirteen percent of patients needed re-intervention, with eight percent of these patients having biliary re-intervention. The first patient had a stent replacement after one month owing to a displaced stent. After six months, the second patient with HGS returned with biliary sludge and food obstructing the metallic stent; a sweeping extraction balloon was used to remove the obstruction, and a plastic stent was inserted. Additionally, one patient had gastric outlet blockage due to tumor invasion, and the placement of a duodenal metal stent mitigated the patient's symptoms. After three months, one patient (4.2% of the total) in the ERCP cohort required a PTD implant due to blockage caused by tumor growth. The findings align with those of Bang et al., who also found that the ERCP and EUS-BD groups had comparable reintervention rates (3.0% vs. 2.9%) [19].

Nonetheless, additional research, including that by Paik et al., revealed that EUS-BD correlated with a statistically significant improvement in the six-month stent patency rate (85.1% versus 48.9%) and a statistically significant decrease in the reintervention rate (15.6% versus 42.6%) when compared to ERCP [9]. In contrast, A study by Nakai et al, reported that 10 out of 34 patients underwent EUS-CDS required re-intervention[17], and similarly, the study by Kuraoka et al found that 19 out of 92 cases with EUS-CDS needed re-intervention due to cholangitis. The heightened frequency of re-intervention may be attributed to the use of fully covered stents, which provide an elevated risk of stent migration. In the current study, both groups used partially covered or half-covered metal stents.

Moreover, every patient in each operational group had technical and clinical success, which in line with Uemura et al , a meta-analysis revealing that CDS and HGS exhibited comparable efficacy and safety, achieving high rates of both technical and clinical success. [23].

Regarding procedure duration across different EUS-BD modalities, our study observed the least duration in the CDS group (14.62 ± 4.27 minutes). This finding corresponds with Li et al., who indicated that CDS was somewhat more rapid than HGS [24]. Additionally, the study conducted by Ragab et al. supported our findings, since the median length of CDS was found to be 2 minutes shorter than HGS [16].

Limitation: Small sample size and short period of follow up.

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CONCLUSION

In conclusion, our study highlights that even in resource-limited settings, EUS-BD is a viable option and offers comparable safety and efficacy to ERCP as a primary palliative approach for malignant distal biliary obstruction, provided that an experienced team is available. Nevertheless, further large-scale randomized controlled trials with extended follow-up are essential to validate and strengthen these findings.

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ORIGINAL ARTICLE

MAST CELLS AS A PROGNOSTIC INDICATOR IN INVASIVE BREAST CARCINOMA MOLECULAR SUBTYPES

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ABSTRACT

Background: Breast cancer, which is the most common cancer in women worldwide, is a heterogeneous disease with surrounding microenvironment including Mast cells (MCs) that affects patient's outcomes as regard anti-tumorigenic host defense or tumor progression and metastatic probability. We aimed to determine MCs density (MCD) and their distribution using tryptase and toluidine blue staining and link them with the clinic-pathologic characteristics of breast cancer patients including molecular types.

Methodology: This was a retrospective analysis of 60 untreated invasive breast carcinoma cases from the Pathology Department's archived material between January 2020 and December 2023 at Aswan University Hospitals.

Results: Among cases, MCD was significantly increased when using Tryptase immunohistochemistry when compared with that of toluidine blue staining ($p < 0.001$) and also increase in luminal B and A tumors, whereas the least MCD was found in triple negative molecular subtype ($p < 0.001$). According to clinical parameters, MCD was significantly decreased in patients with only LVI ($p < 0.001$). Other clinicopathological variables showed no significant association with MCD ($p > 0.05$).

Conclusion: MCD suggests a good prognostic indication of breast cancer as regard molecular subtypes. Tryptase immunostaining is introduced to be preferred for accurate assessment of MCD in breast cancer studies.

Key words: breast cancer, mast cells, tryptase.

INTRODUCTION

Despite diagnostic and therapeutic efforts, breast cancer is the most common cancer among women worldwide, accounting for 11.7% of all cancer cases and it is the 5th leading cause of cancer mortality worldwide [1]**.** According to records from the Egyptians National Cancer Institute (NCI) 2017, breast cancer constituted 18.9% of total cancer cases among Egyptian women [2]**.**

Breast cancer is a heterogeneous disorder characterized by numerous subcategories of several cellular compositions, molecular alterations as well as clinical behavior. A Number of factors such as

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histological type, grade, and size of tumor, lymph node metastasis and molecular subtypes influence the prognosis and response to treatment of cancer [3].

Tumor microenvironment consists of fibroblasts, endothelial, and immune cells as well as extracellular matrix in the immediate peritumoral environment. It influences anti-tumor host defense, tumor development, and metastatic propensity, and may affect patient's outcome [4].

Mast cells (MCs) are immune cells of the myeloid lineage in the bone marrow and also present in connective tissues throughout the body. MCs play mainly a pro-inflammatory role in allergic reactions by degranulation and release of stored chemical mediators that appear after a mosquito bite up to a life-threatening full-blown anaphylaxis [5]. Currently, it is accepted that MCs have complex implications in many human pathological conditions such as infections up to tumor development. Consequently, they are one of the first cells to infiltrate cancer and other studies have shown that mast cells accumulate in a variety of malignant tumors, such as melanoma, Hodgkin's lymphoma, chronic lymphocytic leukemia, pancreatic, prostate and esophageal cancer [6].

MATREIAL AND METHODS

This retrospective study analyzed 60 formalin-fixed paraffin embedded tissue blocks related to 60 of untreated invasive breast carcinoma cases. they were retrieved from archived material at Pathology Department, Aswan University Hospitals during the period from January 2020 to December 2023.

The selected cases were obtained by breast mass tru-cut needle biopsies, modified radical mastectomy and conservative breast surgery either lumpectomy or wide excision for invasive breast carcinomas with full clinical data including patients' age and sex, tumor size, histological variant, immunophenotyping and pathological stage that were obtained from patients' clinical files.

Exclusion criteria encompassed patients with only *in situ* carcinoma without invasion, those who received neoadjuvant therapy, individuals with inadequate or incomplete tissue materials, those who lost follow-up and male patients.

Ethical consideration: Ethical approval to perform this work was obtained from the Institutional Research Ethical Committee at the Faculty of Medicine, Aswan University, and the privacy and confidentiality of all acquired information were maintained., IRB NUM: Asw. Uni/720/1/23.

Histological examination: Three 4µm-thick tissue sections were prepared from the tissue blocks and stained with standard Hematoxylin and Eosin (H&E) for histological assessment, while the other two sections were stained with special Toluidine blue staining and MC tryptase immunohistochemically (IHC) respectively.

All H&E slides were evaluated for the histopathologic type according to WHO recommendations, 2019 [7] and reviewed for *in situ* component, lympho-vascular invasion (LVI), Perineural invasion (PNI) and tumor necrosis according to the International Collaboration on Cancer Reporting (ICCR) published datasets for histological reporting of breast cancer. [8] Results of ER, PR, Her-2 and Ki-67 immunostaining were acquired by reassessing archived materials belonging to the cases.

For special staining: Toluidine blue stain (1.0%, aqueous; ScyTek, Logan Utah USA, 800-729-8350; Ref No: TQF125), was used to stain the tissue sections that were generated from the tissue blocks.

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During ten minutes, the slides were submerged in a solution of toluidine blue at a dilution of one to ten. After that, the slides were washed many times with water.

For IHC analysis, 4µm tissue sections were incubated with primary monoclonal antibodies: MC tryptase (Rabbit monoclonal antibody with Catalog number; A19801) at a dilution of 1:80. The negative control was established by omitting the main antibody, while colonic tissue functioned as a positive control. The streptavidin-biotin amplification technique was employed for immunostaining.

MCD detection and scoring: Histological examinations were performed on tissue sections that had been stained with toluidine blue and mast cell tryptase using a bright-field microscope equipped with an ocular grid that corresponded to an examination area of 0.2601 mm2 (Olympus BX53; 40x objective lens and 10x ocular lens; Working Distance = 0.51 mm; Olympus, Tokyo, Japan). First, the sections were first viewed at a magnification of ×100 to identify the hot spot areas. Then, the cells that were positively stained for toluidine blue and mast cell tryptase were then counted in five high-power fields (HPF), each measured 0.26mm2 to represent one millimeter squared. MCD measurements were made in two locations. The intratumoral MCD (MCDit) corresponds to positive cells found inside neoplastic tissue more than one high-power field away from the tumor edge while the peritumoral count (MCDpt) is related only to the fields of view situated at the interface between the lesion and its surrounding region which was seemed to be an invasive margin. The quantity of positive cells and fields were then noted. [9].

Statistical analysis: SPSS version 24 was used in order to do the analysis on the data. The frequency and percentage of occurrence were used to convey the qualitative data. The quantitative data were reported as the mean +/- SD. The center value of a discrete collection of numbers is referred to as the mean (average). A one-way analysis of variance (ANOVA) test was used when comparing between more than two groups. The Chi-square test was utilized to compare categorical data across various groups. Statistical significance was defined as $p < 0.05$, extremely significant as $p < 0.001$, and non-significant as $p > 0.05$.

RESULTS

This retrospective study was performed on 60 cases of IBC. These cases included those that underwent modified radical mastectomy and conservative breast surgery. Cases were collected as paraffin embedded blocks. Our patients' ages ranged from 28 to 85 years old, with an average age of 52 ± 12.07 years.

Using IHC anti-Mast cell tryptase labeling, we were able to identify a strong statistically significant difference ($p <0.001$) between the molecular sub-types and MCDit and MCDpt.

The luminal B subtype had the highest MCD values. The luminal A subtype came next. The Her-2 enriched subtype had lower MC values. However, triple negative molecular subtypes had the lowest density of MCs. **Table (1)**

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Table (1): Comparison of MCD by tryptase as regard molecular sub-types

		Molecular sub-types				F	P-value
		Luminal A (n = 16)	Luminal B (n = 20)	Triple negative (n = 14)	Her-2 enriched (n = 10)		
MCDit by tryptase	**Mean ±SD**	16.9 ± 7.1	20.5 ± 6.5	8.6 ± 6.5	12.7 ± 4.9	**10.17**	**<0.001 HS**
	Range	6 – 28	9 – 32	0 – 26	6 – 22		
MCDpt by tryptase	**Mean ±SD**	12.9 ± 8.1	13.7 ± 4.8	4.6 ± 3.9	12.7 ± 6.2	**7.67**	**<0.001 HS**
	Range	0 – 29	5 – 22	0 – 12	6 – 25		

F: Chi-square test. **S: p < 0.05 is considered significant.**

Tryptase evaluation of MCDit reveals that, in the patients under study, there is no significant correlation between intra-tumoral mast cell density and either PNI (P=0.228) or LVI (P=0.444). However, MCD peritumorally by tryptase revealed that, in all patients under study, MCDpt was considerably lower in individuals with only LVI than in those without LVI. **Table (2). Fig. 1, 2, 3.**

Table (2) Relation between MCDpt by tryptase with PNI and LVI

		MCDpt by tryptase Mean ±SD (Range)	T	P-value
PNI	**No (n = 44)**	**11.6 ± 6.8 (0 – 29)**	0.728	0.47 NS
	Yes (n = 16)	**10.1 ± 7.2 (0 – 25)**		
LVI	**No (n = 42)**	**12.4 ± 6.7 (0 – 29)**	**2.09**	**0.041 S**
	Yes (n = 18)	**8.4 ± 6.6 (0 – 22)**		

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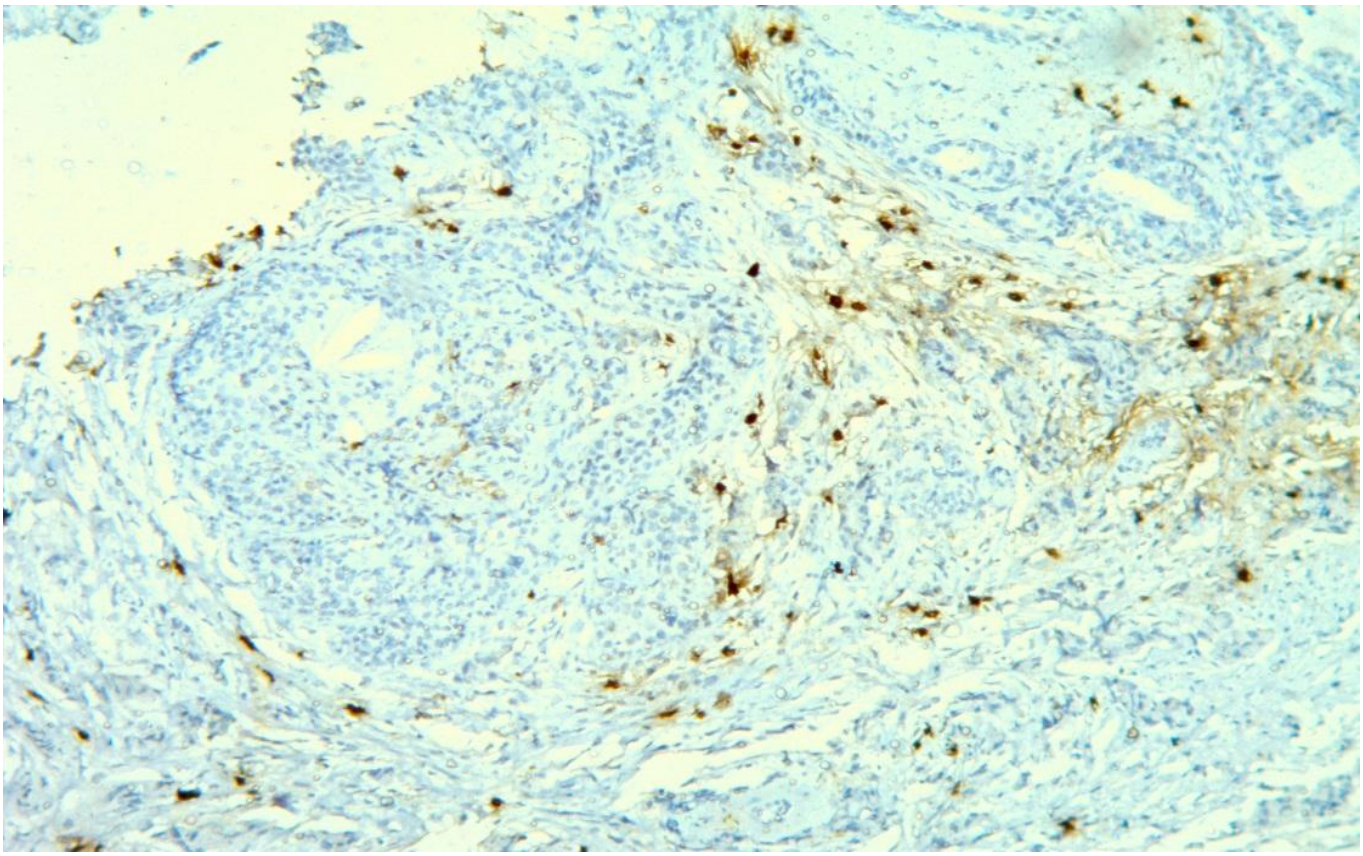

Fig. (1): IDC, grade II and luminal B immunophenotype showing peritumoral mast cells stained for antitryptase (IHC 100x)

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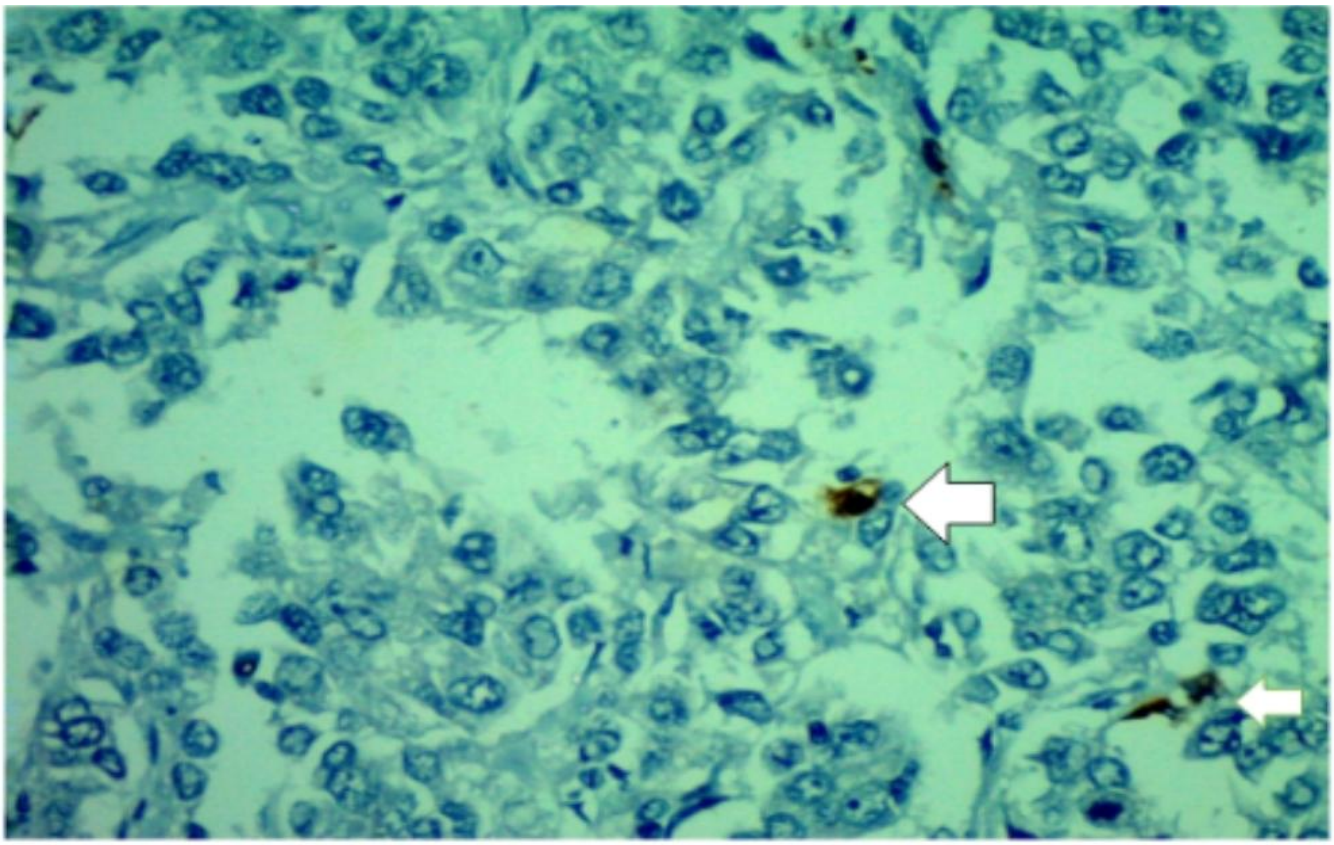

Fig. (2): Higher power of the previous case, showing high nuclear features with very low MCD (IHC 400x)

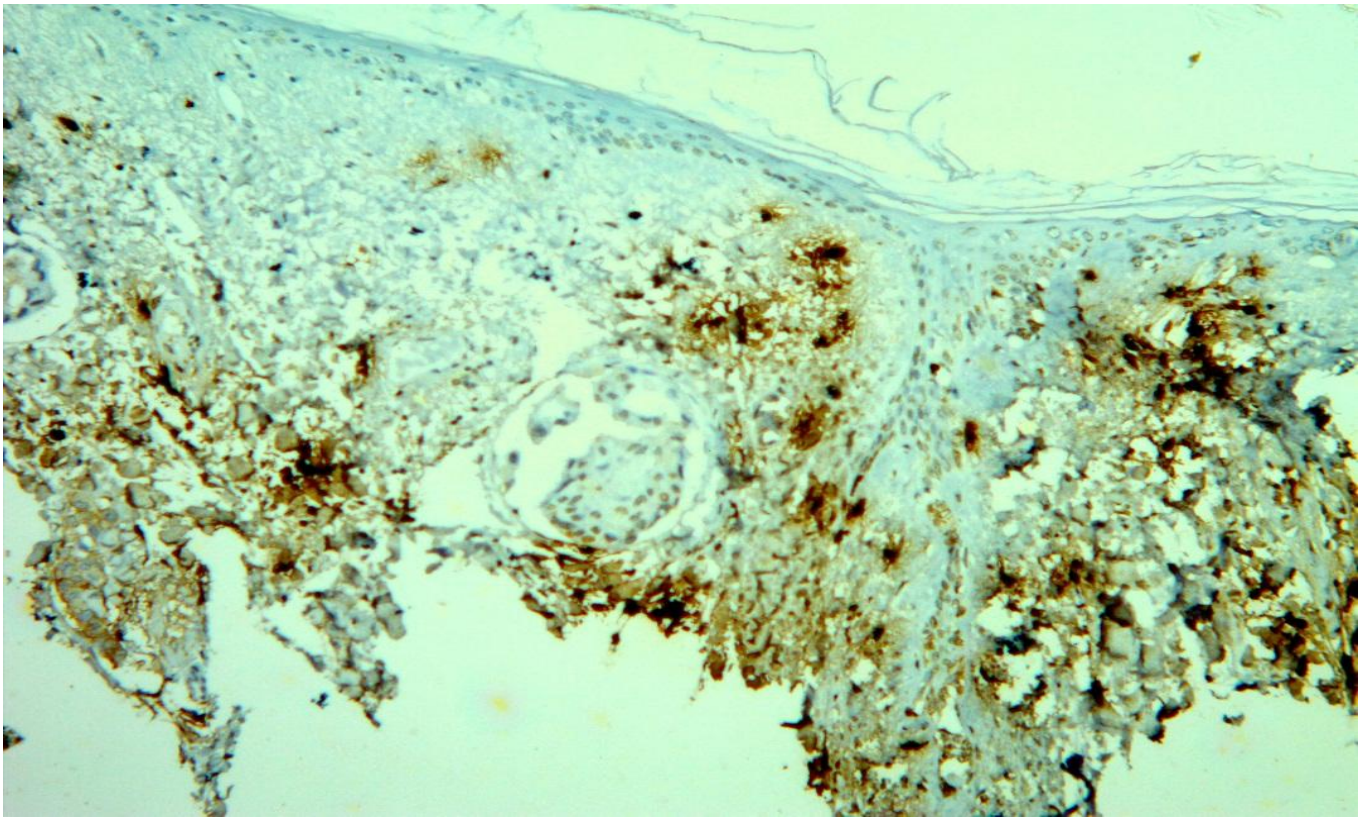

Fig. (3): MCs in proximity to lymphovascular tumor emboli (IHC 100x)

When comparing immunohistochemistry staining for Tryptase to toluidine blue staining, MCDpt and MCDit were considerably higher using Tryptase in all patients under study **(Table 3,4).**

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Table (3): Comparison between MCDpt by toluidine blue and by tryptase in all studied patients

Peritumoral		Toluidine blue (n= 60)	Tryptase (n= 60)	T	P-value
MCD	Mean ±SD Range	4.9 ± 4.2 0 – 16	11.2 ± 6.9 0 – 29	6.039	<0.001 HS

Table (4): Comparison between MCDit by toluidine blue and by tryptase in all studied patients

Intra-tumoral		Toluidine blue (n= 60)	Tryptase (n= 60)	T	P-value
MCD	Mean ±SD Range	6.7 ± 4.1 0 – 16	15.5 ±7.8 0 – 32	7.684	<0.001 HS

Patients with molecular subtype luminal A cells had a statistically significant (p=0.003) higher MCDpt by toluidine, followed by patients with luminal B molecular subtype. Patients with triple negative molecular subtype had the lowest density of MCs. However, when compared to patients with luminal A molecular subtype, patients with luminal B molecular subtype had a higher MCDit by toluidine, which was also the least in patients with triple negative molecular subtype, according to intratumoral location. This difference was statistically significant (p<0.001). **Table (5)**

Table (5): Comparison of MCDpt and MCDit-tumoral by toluidine blue as regard molecular sub-types

MCD by toluidine blue		Molecular sub-types				F	P-value
		Luminal A (n = 16)	Luminal B (n = 20)	Triple negative (n = 14)	Her-2 enriched (n = 10)		
Peritumoral	Mean ±SD Range	6.3 ± 5.2 0 – 16	5.9 ± 3.7 0 – 10	1.4 ± 1.6 0 – 5	5.8 ± 3.4 2 – 12	5.27	0.003 S
Intra-tumoral	Mean ±SD Range	7.6 ± 3.7 2 – 14	9.2 ± 3.8 4 – 16	2.9 ± 2.7 0 – 10	6 ± 2.7 3 – 12	10.08	<0.001 HS

F: ANOVA test **S: p < 0.05 is considered significant.**

HS: p < 0.001 is considered highly significant.

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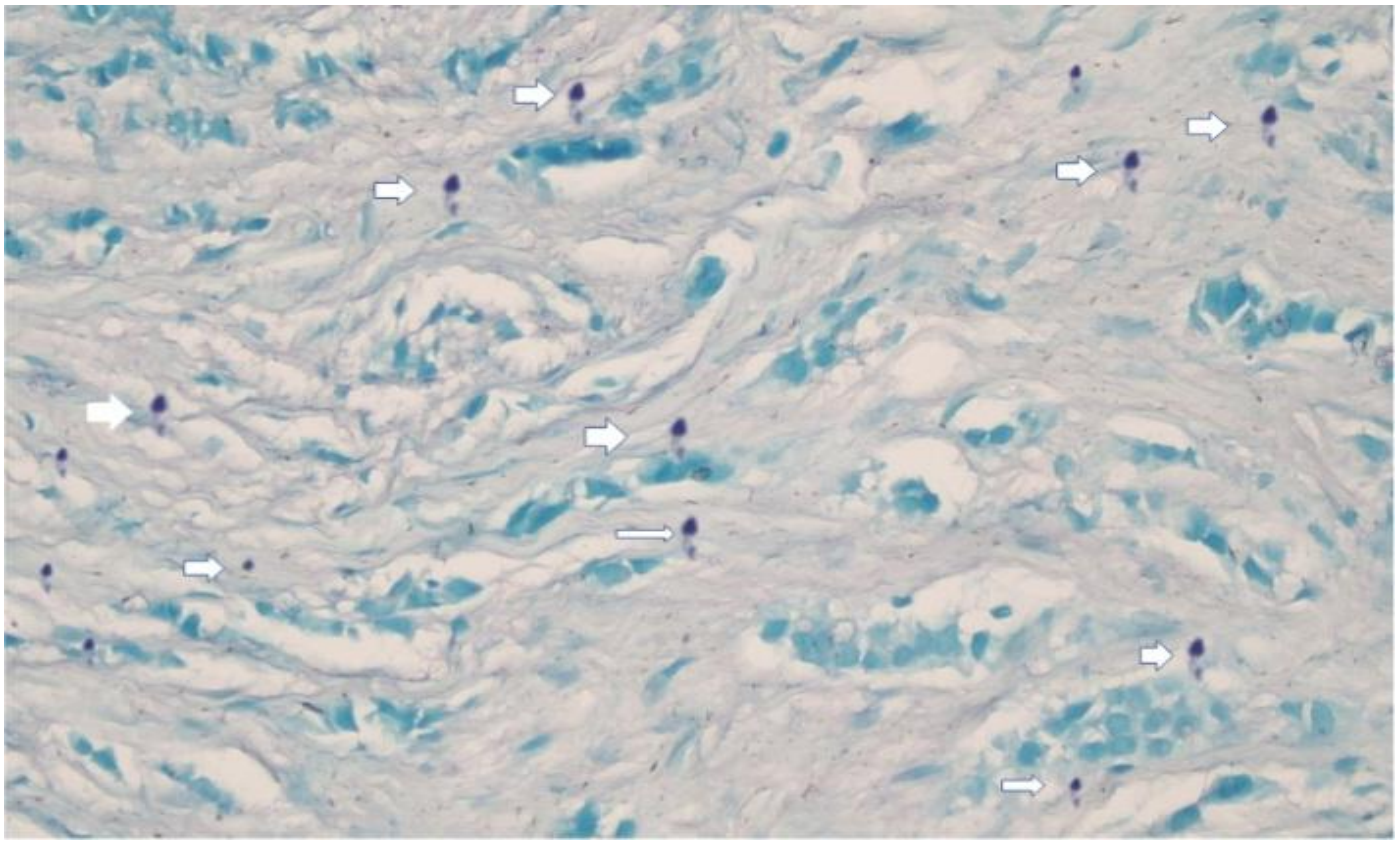

Fig. (4): Intratumoral MCs (white arrow; 200x) (toluidine blue)

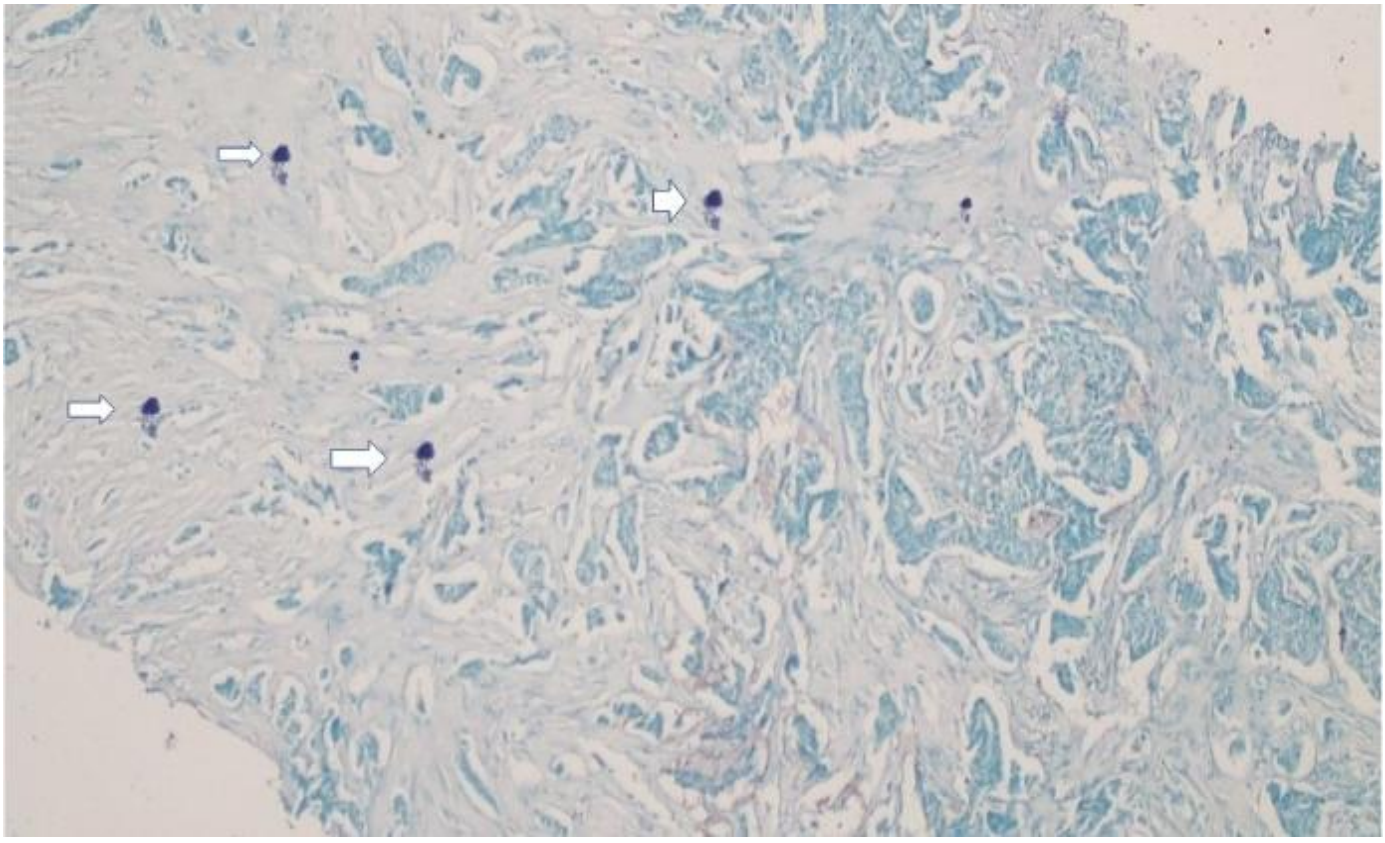

Fig. (5): Intratumoral MCs (white arrow; 100x) (toluidine blue)

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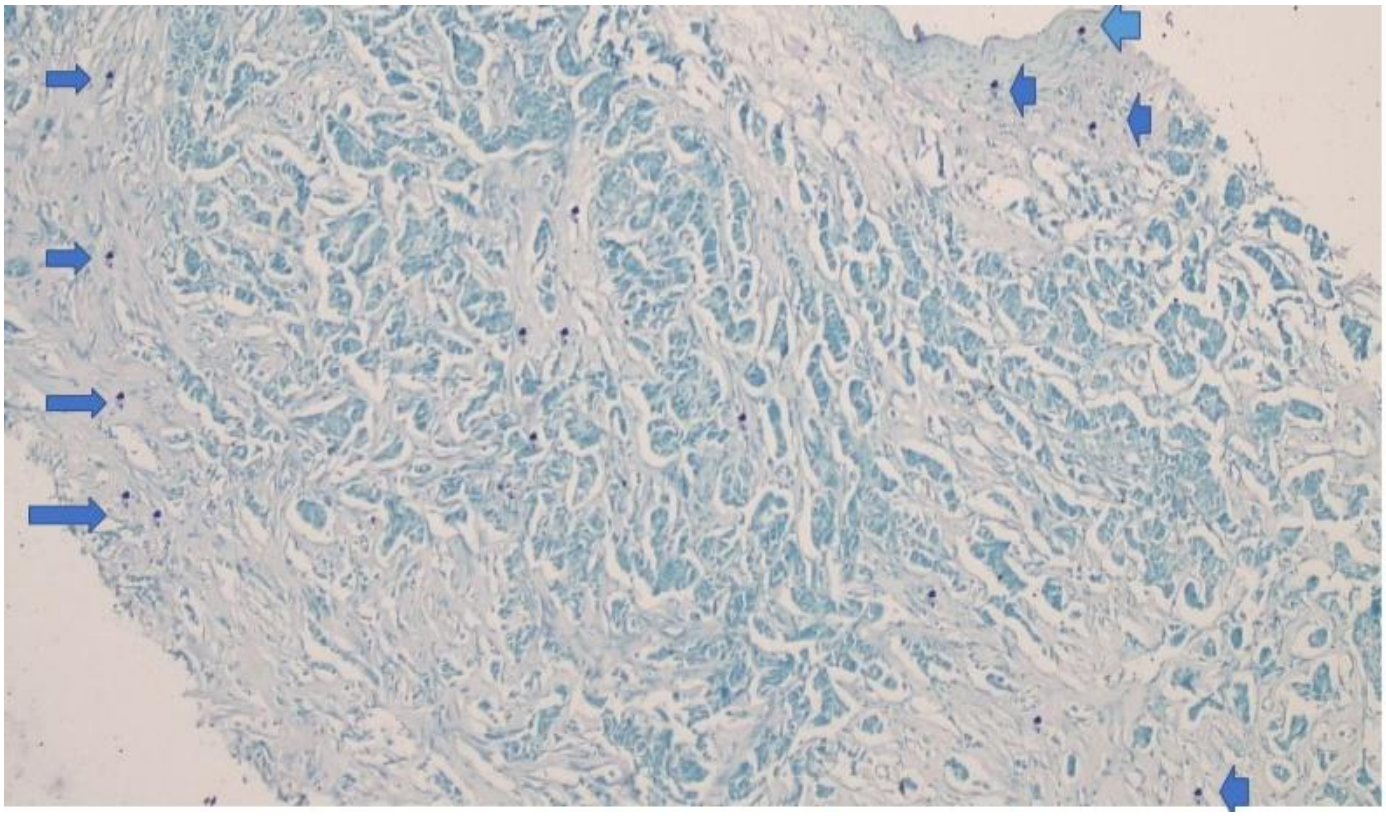

Fig. (6): Peritumoral MCs (Blue arrow; 100x) (toluidine blue)

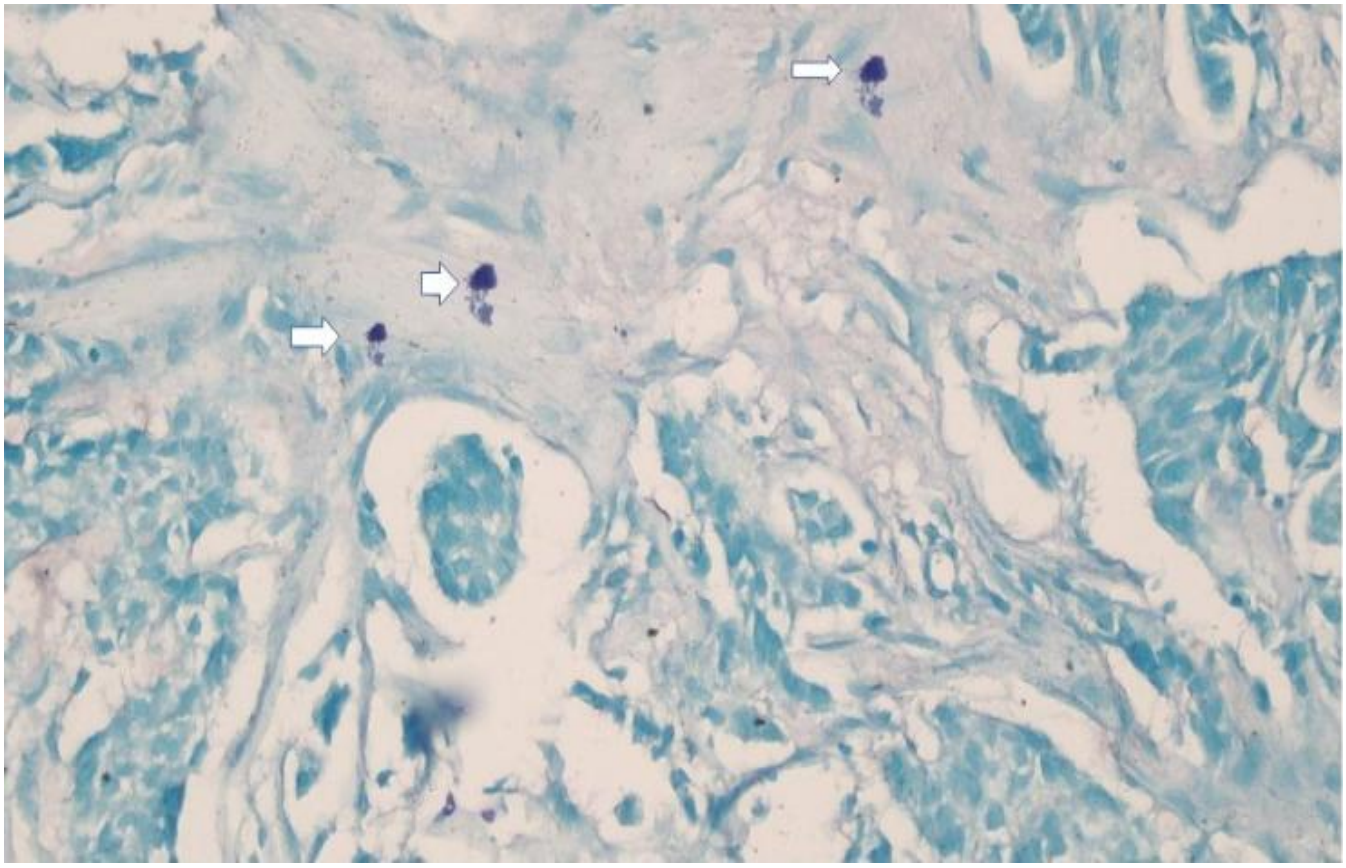

Fig. (7): Intratumoral MCs in proximity to lymphovascular tumor emboli, higher powers (400x)

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Discussion

Molecular classification has provided significant information leading to individualized therapies for breast cancer patients. It also identifies novel cancer driver genes and potentially targetable biomarkers. Our ability to predict a patient's prognosis with variable molecular subtypes has been remarkably enhanced [10].

In the present study, the molecular subtyping revealed that 26.7% of patients were Luminal A and 33.3% were Luminal B, followed by the Triple-Negative (23.3%) and HER2-enriched (16.7%) subtypes. These findings align with Mohamed et al. [11], who reported similar distributions (24.4% Luminal A, 34% Luminal B1). Conversely, Hagag et al. [12] reported a higher prevalence of the Triple-Negative subtype (28.7%) in Upper Egypt, a disparity that may be attributed to differences in cohort size, detection techniques, or geographic factors.

Less than 1/3 of the cases in the current study tested positive for both necrosis and the *in situ* component and this is aligned with **Rattanasalee** [13] who showed 12.7% of the breast cancer patients had *in situ* components; 10.8% of them are LCIS.

According to **Karak et al.,** [14]**,** PNI is a histological indicator of invasive breast cancer, which is ten times less common than LVI and is linked to higher tumor grade, stage, and lymph node invasion therefore they were estimated in the histological evaluation of the patients in this study, of 30% of cases had LVI, and 26.7% cases had PNI. Although our study's numbers are not much higher than those reported by **Karak et al.** [14], who showed that 12.9% of cases had LVI and 1.14% of patients had PNI. However, **Gürbüz et al.,** [15] showed significant outcomes, with 37% revealing PNI and 48% including LVI. Those differences in histopathological evaluation criteria and the extent of tissue sampling may potentially have an impact on detection rates [16].

In addition, the current study reported a statistically significant difference ($p = 0.008$) in LVI among the molecular subtypes of breast cancer, with the triple-negative subtype having the highest prevalence (64.3%). However, there was no statistically significant difference ($p=0.37$) in PNI between subtypes. These results are in line a study by **Morkavuk et al.,** [17] revealed a strong correlation between LVI and molecular subtypes, with higher frequencies of LVI observed in the basal-like (triple-negative) and luminal B subtypes.

Tumor growth and patient prognosis are impacted by the presence of MCs, essential elements of the tumor microenvironment, in breast cancer tissues at different densities [18]**.** In our investigation, MCs were identified by toluidine blue special staining and IHC employing tryptase antibody.

Regarding **Mast Cell Density (MCD)** detected by tryptase, we observed that nearly every case exhibited intratumoral mast cells (**MCDit**), with a mean of 15.5 ± 7.8 cells. Peritumoral mast cells (**MCDpt**) were identified in 55 out of 60 patients (mean 11.2 ± 6.9). Our data demonstrated a substantial variation in MCD among molecular subtypes ($p < 0.001$). The **Luminal B subtype** exhibited the highest mean MCDit (20.5 ± 6.5), while the **Triple-Negative subtype** showed the lowest (8.6 ± 6.5). This supports the findings of **Raica et al.,** [19] and **Glajcar et al.,** [9], who observed that Luminal A and B tumors possess significantly higher intratumoral MCD than basal-like (triple-negative) cancers.

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This was also supported by the findings of a study of 156 patients with breast cancer, which showed that basal-like carcinoma had the lowest MCD values but no correlation with the prognostic influence of the molecular type, whereas luminal A and Her-2 positive types had the highest MCD values [20].

The correlation between high MCD and **ER-positivity** (Luminal A and B) is noteworthy. Estrogen has been shown to activate mast cells in other conditions, such as ovarian endometriosis, and human uterine mast cells are known to express ER [21-22]**.** In our study, while MCD was significantly higher in hormone-receptor-positive subtypes, we found no significant association between MCD and other clinicopathologic criteria such as necrosis, T-stage, N-stage or PNI.

Similarly, MCD may not be a reliable predictive marker in this context, since **Ahmad et al.,** [23] found that stromal mast cell density in invasive breast cancer did not alter significantly among demographic and prognostic factor groups.

On the contrary, a study on colorectal carcinomas, for instance, found a positive relationship between the quantity of tryptase-positive mast cells and blood vessel or lymphatic invasion, demonstrating that mast cells may contribute to the invasiveness of tumors [24]**.** These differences could be explained by differences in MCD assessment techniques and the complex functions that mast cells play in various tumor microenvironments.

As regarding MCs assessment and detection, a high degree of statistical significance ($p < 0.001$) was found when comparing both the peritumoral and intratumoral MCD in breast cancer tissues assessed by tryptase staining to that was seen with toluidine blue staining which proved that tryptase is a specific marker for mast cells and believed to be a more sensitive and specific immunohistochemical method. In a similar vein, **Kim et al.,** [25] observed that tryptase immunohistochemistry staining significantly increased mast cell counts in comparison to toluidine blue staining ($p < 0.05$) in patients with bladder transitional cell carcinoma.

According MCD detection by using toluidine blue, we identified a statistical significance ($p=0.003$) in our study with molecular subtypes being higher in patients with the Luminal A (6.3 ± 5.2 cells) then patients with the Luminal B (mean = 5.9 ± 3.7 cells; range), triple negative (mean = 1.4 ± 1.6 cells), and HER-2-enriched subtypes (mean = 5.8 ± 3.4 cells). Similar to tryptase staining, no significant relation was observed with clinicopathologic parameters of studied cases and MCD detected with toluidine blue.

In conclusion, MCs infiltration has a good prognostic parameter in breast cancer, as it is over expressed in the majority of breast carcinoma, especially with luminal A and B molecular subtypes which are associated with ER and PR positive hormone receptor but has no significant relation with other clinicopathologic parameters such as age, histologic type, grade, tumor size, presence of necrosis, *in situ* component, pathological T stage or N stage.

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ORIGINAL ARTICLE

IMPACT OF SETON FISTULECTOMY VERSUS LASER FISTULECTOMY ON QUALITY OF LIFE

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ABSTRACT

Background: This randomized clinical open label study compares the impact of Seton fistulectomy and Laser fistulectomy on patients' quality of life (QoL) and continence in patients with cryptoglandular anal fistula (AF), using the short form -36 Quality of life, fecal incontinence quality of life (SF-36, FIQL) questionnaire and Wexner continence score.

Methods: Fifty patients, aged 18–65 years, with primary or recurrent cryptoglandular AF underwent surgical interventions, including Seton fistulectomy and Laser fistulectomy. Postoperative QoL and continence scores were collected at 1 week,1, 3, and 6 months postoperative and compared between the two groups. They were used to assess the impact of both surgical techniques on outcomes.

Results: Significant improvements in QoL were observed at all postoperative time points, with laser fistulectomy and showing greater improvements (average QoL changes of (83.00) compared to seton placement (55.00). The Postoperative continence scores also showed significant improvements, but weak correlations were found between continence and QoL scores.

Conclusion: While laser surgery offers faster recovery and reduced postoperative morbidity, open surgery (seton placement) remains the more definitive treatment option due to its superior long-term outcomes. Surgical decision making should be individualized based on fistula complexity and patient-specific factors. To validate these results, more research with larger sample sizes is required.

Key words: Anal fistula, laser fistulectomy, continence, quality of life.

INTRODUCTION

Anal fistula is a chronic and often debilitating condition characterized by an abnormal connection between the anal canal and perianal skin. It commonly arises after anorectal abscesses and can cause persistent pain, discharge, and recurrent infections [(1)].

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Because of its recurrent nature and discomfort, effective surgical management is essential not only for resolving the disease but also for restoring a patient's functional well-being. The choice of surgical technique significantly influences postoperative outcomes and long-term quality of life [(2)].

Traditionally, the seton fistulectomy has been a widely used method for treating complex anal fistulas. By placing a seton through the fistula tract, the procedure aims to gradually cut through infected tissue while preserving sphincter integrity [(3)].

Although effective, seton placement may be associated with prolonged healing time, persistent discomfort, and ongoing drainage, all of which can affect daily activities. These limitations have prompted interest in newer, less invasive alternatives [(4)].

Laser fistulectomy has emerged as a minimally invasive option that uses radially emitting laser energy to ablate the fistula tract. This technique is designed to minimize tissue damage, reduce postoperative pain, and allow quicker functional recovery. With quicker returns to regular activity and shorter hospital stays, laser therapy has gained popularity, especially among patients seeking less disruptive treatment options [(5)].

The significant differences in invasiveness, healing characteristics, and patient experience between the two procedures, comparative evaluation is necessary [(6)]. Clinical outcomes such as recurrence rates and complication profiles are important, but patients often place equal or greater value on comfort, ease of recovery, and preservation of continence. Consequently, quality of life has become a central focus in determining the overall effectiveness of fistula treatments.

Therefore, this trial Aims to compare the impact of Seton fistulectomy and Laser fistulectomy on patients' quality of life.

PATIENTS AND METHODS

Study Context

This randomized clinical open label study was caried out on 50 patients who diagnosed with cryptoglandular anal fistula requiring surgical intervention at Alkarnak international Hospital in Egypt in the period between june 2024 & june 2025 after approval by The Research ethical committee of Elkarnak International Hospital Approval No (Lux med-071225-104).

Study population

After fulfilling the inclusion requirements, 50 patients regardless of gender with confirmed cryptoglandular anal fistula were involved in this work. Patients were treated in a stepwise manner, starting with MRI fistulograph and then moving on to elective surgery.

Inclusion criteria:

- Age from 18 to 65 years.
- Both sexes.
- Diagnosed with cryptoglandular anal fistula requiring surgical intervention.

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- Patients are eligible for either Seton fistulectomy or Laser fistulectomy based on clinical evaluation.

***Exclusion criteria**:*

- Patients with Crohn's disease, tuberculosis, or malignancy-related fistulas.
- Pregnant or lactating women.
- Multiple branched fistula proved in MRI fistulograph.
- Patients with severe comorbidities contraindicating surgery.
- Individuals unwilling or unable to complete follow-up assessments.

Randomization and blindness:

An online randomization program (http://www.randomizer.org) was used to generate a random list and each patient's code was kept in an opaque sealed envelope. Patients were divided into two groups in parallel at random using a 1:1 allocation ratio: Group A (n=25) (Seton Fistulectomy Group): Patients underwent a conventional surgical technique (seton placement). Group B (n=25) (Laser Fistulectomy Group): Patients underwent Laser fistulectomy using a 1470 nm radial-emitting laser fiber. This study was open label due to different techniques used.

All patients were subjected to the followings:

1) **Demographic data collection** (age, sex).
2) **Routine Labor history taking and dematory investigations:**
   - Complete Blood Count (CBC), virology, INR, liver function test, renal chemistry.
3) **Clinical Assessment**
   - Physical examination
   - Fistula classification (Park's classification)
   - Preoperative investigations including MRI or endoanal ultrasound if needed
4) **Quality-of-Life Assessment**
   - Quality of life will be estimated by validated instruments:
   - SF-36 Quality of Life Questionnaire (general health) [(7)].
   - Faecal Incontinence Quality of Life Scale (FIQL) if continence is affected [(8)].
   - Visual Analogue Scale (VAS) for postoperative pain [(9)].
   - Wexner Continence Score for sphincter function [(10)]

Interventions:

1-Seton Fistulectomy Procedure

In group A, patients will undergo seton fistulectomy under either regional (spinal) or general anesthesia depending on patient suitability and surgeon preference. After proper positioning—usually lithotomy or prone jack-knife—the external opening of the fistula is identified. A gentle probing instrument is inserted through the external opening to trace and confirm the path of the fistula tract toward the internal opening located inside the anal canal.

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Once the tract is clearly defined, a seton material (commonly silk, rubber band, or a specially designed cutting seton) is threaded through the tract. The seton is then tied externally, creating a loop. The purpose of the seton is to allow gradual, controlled cutting through infected tissue while minimizing damage to the anal sphincter muscle.

In cases where a cutting seton is used, the surgeon tightens it periodically during follow-up visits. Each tightening applies incremental pressure that slowly divides the tract and induces fibrosis behind the cut, thereby maintaining sphincter continuity. Over several weeks, the tract gradually transects and eventually heals with minimal risk of incontinence.

2-Laser Fistulectomy Procedure

In group B, patients will undergo Laser fistulectomy using a 1470 nm radial-emitting diode laser fiber, which targets water-rich tissue in the fistula tract while preserving surrounding sphincter structures. After administering regional or general anesthesia, the patient is positioned appropriately. The fistula tract is gently curetted to remove debris, granulation tissue, and epithelial lining. This prepares a clean channel for effective laser ablation.

The laser fiber is inserted into the full length of the fistula tract, beginning at the external opening and extending to the internal opening. Laser energy is then delivered in a controlled manner while the surgeon slowly withdraws the fiber. This technique applies uniform energy circumferentially, causing the walls of the tract to coagulate, collapse, and seal shut without physically cutting tissue.

- **Pain Intensity (VAS Score)**

Pain was measured using the Visual Analogue Scale (VAS), a validated tool ranging from 0 to 10: (0 = no pain, 10 = worst imaginable pain).

Patients were shown a straight 10-cm line and asked to mark the point that best represents their pain level at rest and during defecation. The distance from the zero point was recorded in centimeters and documented in the patient's follow-up record**.**

- **Postoperative Follow-Up**

  Participants were evaluated at 1 week, 1 month, 3 months, and 6 months after surgery. Each follow-up visit included both clinical examination and patient-reported outcome assessments, performed as follows:

- **Wound Healing and Discharge**

  Wound healing will be evaluated through physical examination by the attending surgeon:

  - Inspection of the surgical site for signs of granulation tissue, epithelialization, and closure of the tract.
  - Assessment for the presence and amount of serous, purulent, or bloody discharge.
  - Noting any signs of local infection such as redness, warmth, swelling, or tenderness.
  - In seton cases, additional evaluation of seton tension or need for adjustment may be performed.
  - Healing was categorized as complete, partial, or delayed based on standard postoperative criteria.

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- **Continence Level (Wexner Score)**

The Wexner Continence Score was used to evaluate sphincter function. Patients were answer a structured questionnaire covering:

- Frequency of incontinence to gas
- Incontinence to liquid stool
- Incontinence to solid stool
- Need for pads
- Lifestyle alterations due to incontinence

Each item is scored from 0 (never) to 4 (always). Total scores range from 0 (perfect continence) to 20 (complete incontinence).

- **Quality-of-Life Scores (SF-36, FIQL)**

Quality of life was measured by two validated questionnaires:

A. SF-36 (Short Form-36 Health Survey)

Patients will complete a self-administered questionnaire covering eight domains:

- Physical functioning
- Role limitations (physical)
- Role limitations (emotional)
- Vitality
- Mental health
- Social functioning
- Pain
- General health perception

Each domain is scored from 0 to 100, with higher scores indicating better quality of life.

B. FIQL (Fecal Incontinence Quality of Life Scale)

This questionnaire assesses quality of life specifically affected by incontinence:

- Lifestyle
- Coping/behavior
- Depression/self-perception
- Embarrassment

Each section uses a Likert-type scale, and scores were calculated according to the standard FIQL scoring manual.

Statistical Analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms was used to evaluate the normality of the distribution of data. Quantitative parametric variables were displayed as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's t- test. Quantitative non-parametric data was displayed as median and interquartile range (IQR) and will be analyzed by Mann Whitney-test. Qualitative

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variables were displayed as frequency and percentage and was analyzed by the Chi-square test or Fisher's exact test. A two tailed P value≤ 0.05 was considered statistically significant.

RESULTS

In randomized clinical open label study, 62 patients were assessed for eligibility, eight patients did not meet the criteria and four patients refused to participate in the study. The remaining patients were randomly divided into two equal groups (25 patients in each). All allocated patients were followed-up and analyzed statistically.

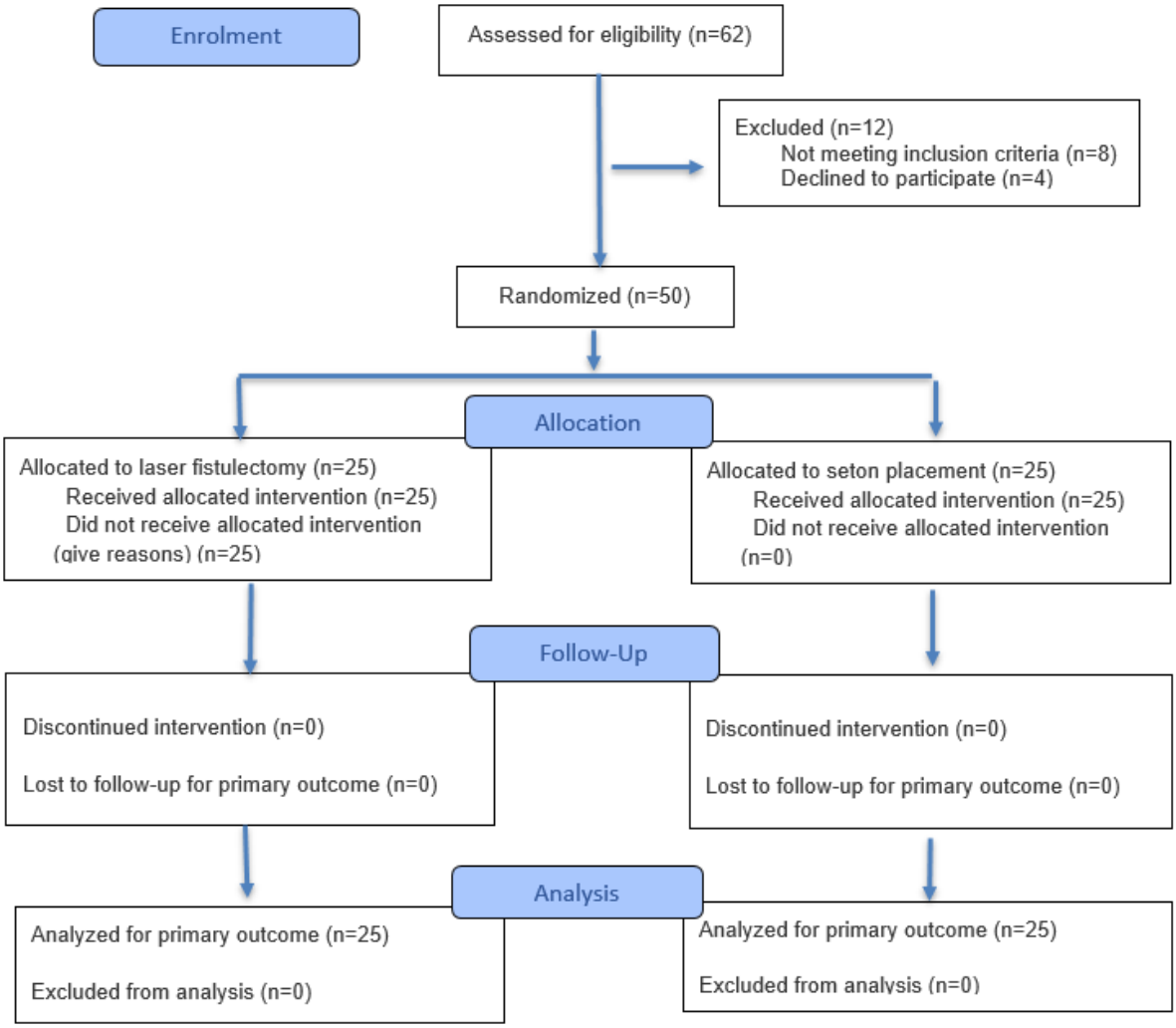

Figure 1: CONSORT Flow Diagram

The mean ± SD value of age was 49.27 ± 11.79. The majority of the patients were 40 (80%) males while were 10 (20%) females. Intersphincteric fistulas were the most prevalent form (76%). As

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regarding types of fistula presentation, it was primary fistula in 45 (90%) patients while it was recurrent fistula in 5 (10%) patients.

Table 1: Distribution of demographic data in the studied cases

		(n=50)
Age (years)		49.27 ± 11.97
Sex	**Male**	40 (80%)
	Female	10 (20%)
Type of fistula	**Intersphincteric**	38 (76%)
	Transsphencteric	8 (16%)
	Suprasphincteric	4 (8%)
Site of external opening	**6 o'clock**	30 (60%)
	12 o'clock	12 (24%)
	3 and 9 o'clock	8 (16%)
Type of presentation	**Primary presentation**	45 (90%)
	Recurrent presentation	5 (10%)

Data are represented as mean ± SD or frequency (%).

Figure 2: External opening of perianal fistula in one of our studied patients (blue arrow)

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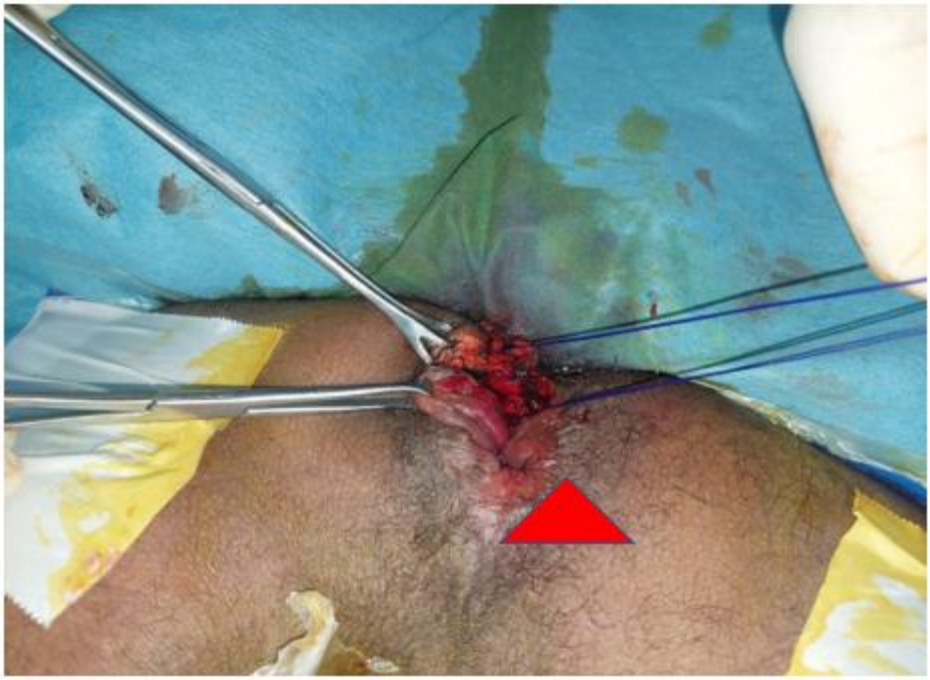

Figure 3: Intraoperative photograph ,seton placement in intersphincteric fistula in one of our studied patients(red triangle)

Figure 4: Intraoperative photograph of probe insertion during tracking of transsphencteric fistula in one of our studied patients (red arrow)

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Postoperative pain, hospital stay and return to work were better in the patients treated with laser technique than patients treated with seton placement as clarified in **Table (2).**

Table 2: Primary end points among the studied cases

Primary outcomes	Laser fistulectomy (N=25)	Seton placement (N=25)	P value
Mild pain (VAS 1-3)	18 (72%)	8 (32%)	0.005
Hospital stay (days)	1.5 ± 0.5	2.8 ± 1.2	<0.001
Return to work (days)	4.96 ± 0.91	9.96 ± 0.74	<0.001

Data are represented as mean ± SD or frequency (%). VAS: Visual Analogue Scale. Tests used was Chi-squared test and unpaired t test.

Healing outcomes

At three months postoperatively, complete healing was observed in 22 (88%) patients in the open surgery (seton placement) group and 20 (80%) patients in the laser surgery group. Although this difference did not reach significance (p = 0.702), it suggests a clinically meaningful trend favoring open surgery – likely attributable to more thorough tract excision and lower rates of residual disease.

Wound infection

The frequency of wound infection was notably lower in the laser group, affecting two (8%) patients, compared to nine (28%) patients in the open surgery group. This difference reached statistical significance (p = 0.037) and supports the minimally invasive nature of laser treatment in reducing postoperative morbidity.

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Figure 5: intraoperative photograph of laser anal fistula management in one of our studied cases

Anal incontinence

No cases of anal incontinence were reported in the laser surgery group (0 patients), whereas two (8%) patients in the open surgery group experienced mild fecal incontinence. Although this difference was not statistically significant (p = 0.489), it remains notable due to the potential impact on patients' quality of life.

Anal stenosis

No cases Anal stenosis was reportedin the laser surgery group, and one (4%) patient reported in the surgery group patients. Although this difference was not statistically significant (p= 1), it underscores the tissue-preserving advantage of laser treatment.

Recurrence rate

Recurrence occurred in 5 (20%) patients in the laser surgery group, and two (8%) patients in the open surgery group. While the difference approached statistical significance (p= 0.417), the trend suggests a higher likelihood of recurrence following lasertreatment, possibly due to limited excisional clearance of complex tracts.

Table 3: Secondary outcome in the studied patients

	Laser surgery (No=25)	**Seton placement (No=25)**	**P value**
Healing within 3 months	20(80%)	22(88%)	0.702
Wound infection	2(8%)	9(28%)	**0.037***
Incontinence	0(0%)	2(8%)	0.489
Anal stenosis	0(0%)	1(4%)	1
Recurrence rate	5(20%)	2(8%)	0.417

*: Significantly as P value≤0.05. Test used was Fisher's Exact Test.

Quality of life assessment:

Regarding quality of life score, psychological wellbeing, physical health and social well were significantly higher in laser surgery group than seton surgery group while body pain rating were markedly reduced in laser surgery group in contrast with seton surgery group (P<0.001).

Table 4: Descriptive analysis of quality of life in the studied patients (n=50)

	Laser surgery (n=25)	**Seton Surgery (n=25)**	**p**
Psychological wellbeing	85(80 - 90)	54(52 - 57)	**<0.001***
Physical health	86(77 - 90)	52(48 - 55)	**<0.001***
Social well being	81(79 - 87)	50(46 - 53)	**<0.001***
Body pain rating	51(46 - 57)	83(76 - 86)	**<0.001***

Data are presented as median (IQR). Test used was Kruskal–Wallis Test.

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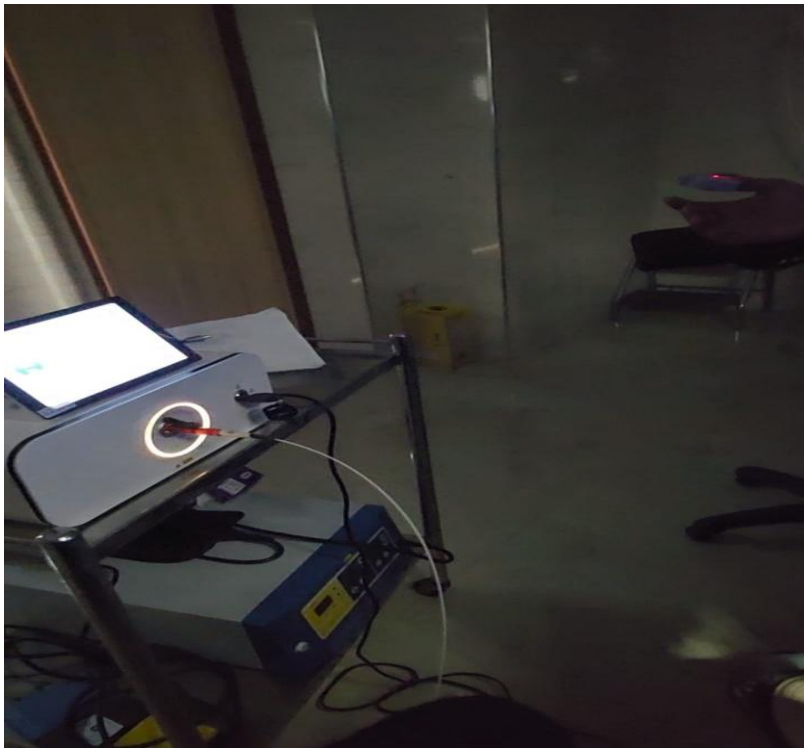

Figure 6: Laser equipment and laser fiber used in our study

Wexner score measurements were notably reduced in laser surgery group compared with seton surgery group (P<0.001).

Table 5: Analysis of incontinence score (wexner score) between the two studied groups

	Laser surgery (No=25)	**Seton placement (No=25)**	**P value**
1 week	8.04±1.65	11.92±1.8	**<0.001***
1 month	6.12±1.05	10±1.76	**<0.001***
3 months	3.56±1.42	7.08±1.22	**<0.001***
6 months	8.04±1.65	11.92±1.8	**<0.001***

Data are presented as mean±SD.Test used was unpaired t test.

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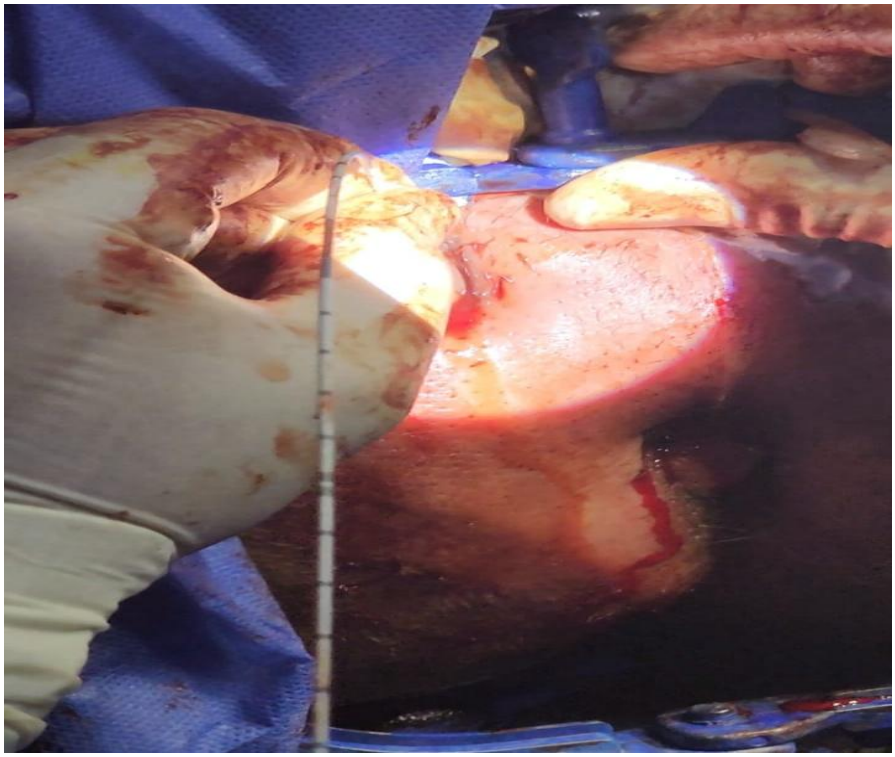

Figure 7: Intraoperative phograph of laser anal fistula ablation in one of our studied cases

Faecal incontinence quality of life scale including life style, coping, depression and embrassment was significantly higher in laser surgery group than seton surgery group (P<0.05).

Table 6: Analysis of faecal incontinence quality of life scale between the two studied groups

	Laser surgery (No=25)	**Seton placement (No=25)**	**p**
Life style	3.6(3.3 - 4)	2.8(2.6 - 3.7)	**<0.001***
Coping	3.7(3.3 - 4)	2.7(2.6 - 3.7)	**<0.001***
Depression	3.7(3.6 - 4)	2.9(2.6 - 3.8)	**0.006***
Embrassment	3.6(3.3 - 4)	3.1(2.7 - 3.4)	**<0.001***

Data are presented as median (IQR). Test used was Kruskal–Wallis Test.

DISCUSSION

AF is one of the most common anal condition in which the patient persistently suffers from pain and perianal discharge which makes patient's QoL impaired. Different methods have evolved to describe this effect; however, most commonly used tools were nonspecific for AF.

Ferrer-Marquez and colleagues developed an AF-specific questionnaire to assess the impact of AF. It is not surprising that, AF as a disease has an impact on QoL; furthermore, its surgery may improve or worsen this impact. Some authors correlated the QoL of the patient and incontinence, while others did not. This study aimed to compare the impact of Seton fistulectomy and Laser fistulectomy on patients' quality of life using the validated QoL-AF questionnaire and continence

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scores [11,12,13,14]. Our study compared endoscopic laser ablation with conventional open surgical technique (seton placement) in the management of fistula-in-ano. Laser surgery demonstrated early postoperative benefits such as shorter hospital stays (mean: 1.5±0.5 days) compared to open surgery (mean: 2.8±1.2 days), and lower postoperative pain scores - reported by 35 of 50 patients (70%) in the laser group, versus 15 of 50 patients (30%) in the open group.

Recurrence was observed in 15 patients (30%) undergoing laser surgery compared to nine patients (18%) in the open group, with reoperation rates mirroring these figures (30% vs. 18%). Earlier studies reported more favorable results for laser-based interventions. Tümer et al. [15] demonstrated better healing times and reduced postoperative morbidity with laser techniques. Lalhruaizela et al. [16] also noted favorable outcomes using endofistula laser ablation in low-complexity tracts. These reports underline the benefit of laser in early recovery phases, especially in simple fistulas.

However, anatomical complexity significantly influences surgical outcomes. The classification proposed by Parks et al. [17] continues to serve as a reliable framework for stratifying fistula types and guiding treatment strategies. In our study, laser treatment failed to provide adequate control in complex presentations, likely due to its limited ability to address secondary tracts and associated abscesses. This is agreed with Sluckin et al. [18] who, in a multicenter retrospective study, found no significant advantage of FiLaC™ over conventional methods, particularly in transsphincteric and suprasphincteric tracts.

First, a significant improvement in QoL was observed postoperatively, with patients showing marked improvements at all follow-up points (1 week 1, 3, and 6 months).

The **Kruskal–Wallis Test** demonstrated statistically significant improvement in QoL scores.

These results suggest that endoscopic laser interventions for cryptoglandular AF have a profound and sustained positive impact on patient QoL, highlighting the importance of timely and effective surgical treatment which coincides with the data reported by Kristo *et al.* [19] who reported significant improvement in the patients with loose seton and Litta *et al.* [13] who observed substantial improvement of QoL following laser fistulectomy.

Continence scores, as measured by the Wexner and FIQL scales, also showed non statistically significant improvements postoperatively between the two studied groups, which may be related to the improvement of soiling and decrease numbers of pads which worsen the incontinence scores. However, weak statistical correlations between continence scores and QoL scores imply that while continence is an important outcome, it may not be the sole determinant of patient-reported QoL. Other factors, such as pain, discomfort, and postoperative complications, maycontribute more significantly to patients' perceptions oftheir health and recovery.

LIMITATION OF THE STUDY

Laser Fistulectomy is more effective in improving QoL postoperatively compared toseton placement. Further studies with larger sample sizes, including larger numbers of patients who had endoscopic lasersurgery procedures done, may be required to validate these findings, particularly concerning the impact of fistula type and presentation on long-term outcomes.

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CONCLUSION

In conclusion, despite the impact of AF on patients' QoL, surgical interventions for cryptoglandular AF, particularly laser fistulectomy and seton, lead to significant improvements in QoL and continence. The choice of surgical technique appears to be a critical factor in optimizing patient outcomes, while the type and presentation of the fistula have less influence. These results support the continued use of laser fistulectomy and seton in the management of cryptoglandular AF and emphasize the need for individualized treatment plans that prioritize patient QoL. Further research with larger sample sizes is required to validate these findings and explore the long-term outcomes of different surgical approaches.

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ORIGINAL ARTICLE

DECOMPRESSION ALONE VERSUS DECOMPRESSION WITH FUSION FOR DEGENERATIVE LUMBAR SPINAL STENOSIS

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ABSTRACT

Background : Surgical management remains controversial for degenerative lumbar spinal stenosis regarding whether decompression alone is adequate or if additional fusion provides superior results. This study was conducted to Comparing clinical, functional, and operative outcomes between patients who underwent decompression alone versus decompression with fusion for DLSS.

Methods: A prospective comparative study was conducted on 30 patients diagnosed with single or multilevel DLSS, divided into two groups: Group A (n = 9) underwent decompression alone, and Group B (n = 21) underwent decompression with fusion. All patients were followed for 12 months. Pain and functional outcomes were assessed using Visual Analogue Scale (VAS) for back and leg pain and Oswestry Disability Index (ODI) preoperatively and at 3, 6, and 12 months postoperatively.

Results: Both groups demonstrated significant postoperative improvement in VAS and ODI at follow-up points compared to baseline . No significant difference was found between groups in the magnitude of improvement in VAS or ODI at any time point.

Conclusion: Decompression alone provides clinical and functional improvement equivalent to decompression with fusion in DLSS while significantly reducing operative time.

Keywords: Lumbar spinal stenosis, decompression, fusion, Visual Analogue Scale, Oswestry Disability Index.

Introduction

Degenerative lumbar spinal stenosis (DLSS), characterized by the narrowing of the spinal canal leading to compression of neural structures, is a predominant cause of spine surgery in the aging population [1, 2]. Symptoms, including back pain, leg pain, and neurogenic claudication, often necessitate surgical intervention when conservative measures fail [3].

Surgical decompression of neural structures is widely accepted as more effective for long-term outcomes compared to non-invasive treatments [1, 2]. However, a persistent controversy exists regarding the adequacy of decompression alone versus the potential superior outcomes associated with the addition of lumbar fusion [4, 5, 7]. Proponents of fusion argue it provides stability, particularly in cases of pre-existing or iatrogenically induced instability, such as in degenerative spondylolisthesis [6].

Conversely, critics highlight that fusion increases surgical complexity, operative time, and cost without conclusive evidence of superior long-term benefit for all patients [8].

This study aimed to evaluate the clinical and functional outcomes of decompression alone versus decompression with fusion in DLSS at our institution, using VAS and ODI as standardized outcome measures over 12 months of follow-up.

Methods

This prospective comparative study was conducted at Aswan University Hospital and included 30 patients with symptomatic degenerative lumbar spinal stenosis who were unresponsive to conservative management. Participants were divided into two groups based on the surgical procedure they received: one group underwent decompression alone (n=9), while the other underwent decompression with fusion (n=21). All operations were performed by the same surgical team using standard posterior approaches.

Patient selection was based on specific criteria, including an age of 40 years or older and MRI-confirmed DLSS without prior instrumentation. Individuals with stenosis from non-degenerative causes, severe deformity, or previous failed fusions were excluded. Pre-operative assessment involved evaluating clinical factors such as age, symptom duration, and comorbidities, as well as radiological factors including the affected spinal levels, the presence of spondylolisthesis, canal dimensions, and facet joint pathology.

Statistical analysis

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Normality was assessed using the Shapiro-Wilk test and histograms. Data were presented as medians with ranges for numerical variables and numbers with percentages for categorical variables. The Mann-Whitney U test was used for continuous variables and the Chi-square or Fisher's exact test for categorical variables to compare the two surgical groups. A p-value of <0.05 was considered statistically significant.

Results

The study included 30 patients divided into two groups, one group underwent decompression alone (n=9), while the other underwent decompression with fusion (n=21). The baseline characteristics of the two surgical groups were comparable, with no statistically significant differences observed (Table 1). The median age was 45 years in the decompression-alone group versus 49 years in the fusion group (p=0.821). A higher proportion of males was present in the decompression group (77.8%) compared to the fusion group (47.6%), though this difference was not significant (p=0.229). The median duration of symptoms was 24 months and 36 months in the decompression and fusion groups, respectively (p=0.629). Furthermore, the prevalence of prior spinal surgery and the distribution of comorbidities were similar between the two cohorts ($p>0.05$), establishing a foundation for comparative outcome analysis as shown in table (1)

The fusion group exhibited a trend toward a higher number of operated levels (median 2 vs. 1, p=0.088). Blood loss was comparable between the groups (median 500cc vs. 400cc, p=0.348). A significant difference was observed in operative time, with 71.4% of fusion cases exceeding 2 hours compared to only 11.1% in the decompression alone group (p=0.003) (Table 2).

The two groups are similar in post-operative functional recovery and there were no statistically significant differences between them. Walking improvement was reported by 66.7% in the

decompression group and 71.4% in the fusion group (p=0.794). Similarly, return to daily activities (66.7% vs. 71.4%, p=0.772) and patient satisfaction (66.7% vs. 76.2%, p=0.453) were comparable. The reoperation rate was 33.3% in the decompression group and 28.6% in the fusion group (p=0.559). Complication rates, including adjacent segment disease (ASD), infection, and recurrent disc herniation, were also not significantly different (Table 3).

Both surgical groups showed significant and progressive improvement in VAS and ODI scores from the pre-operative period to the 12-month follow-up ($p<0.001$ for both). Median VAS for back pain decreased from 5 to 1.5, and for leg pain from 8 to 1 (Table 4 , figure 1,2). ODI improved from a median of 3 (41%-60% disability) to 1 (0%-20% disability). Critically, when the groups were compared directly at each time point, there were no significant differences in VAS (back or leg) or ODI scores at any point during the 12-month follow-up (all $p > 0.05$) (Table 5,figure 3).

Discussion

In our prospective comparative study of 30 patients with degenerative lumbar spinal stenosis (DLSS), both decompression alone and decompression with fusion produced significant and progressive improvement in pain and functional disability over a 12-month period. VAS scores for back and leg pain, as well as ODI scores, improved markedly from baseline in both groups, confirming the effectiveness of surgical intervention for symptomatic DLSS. Importantly, when outcomes were directly compared between the two groups at each postoperative time point, no statistically significant differences were observed. This indicates that, in our cohort, adding fusion did not provide superior short-term functional or pain-relief benefits relative to decompression alone, supporting Amundsen et al. and Kurd et al. [9,10] who advocated that decompression alone provides equivalent outcomes to fusion for stable degenerative disease. While fusion should be reserved for specific indications; supporting Srinivas et al. [11] who advocated reserving fusion for instability or deformity.

Our findings align closely with several high-quality randomized trials and meta-analyses. Ghogawala et al. [6] reported no clinically meaningful advantages of fusion in most patients with DLSS except those with radiographic instability. Similarly, Austevoll et al. and Dijkerman et al. [3,5] found equivalent improvements in pain, functional scores, and patient satisfaction between decompression alone and decompression with fusion. These studies support the concept that neural decompression is the primary therapeutic component, and fusion should not be applied indiscriminately.

One of the most notable findings in our study was the significantly longer operative time associated with fusion. While 88.9% of decompression-only procedures were completed within 2 hours, only 28.6% of fusion cases met that benchmark ($p = 0.003$). This observation is clinically relevant because prolonged operative duration is associated with greater anesthetic exposure, higher intraoperative blood loss, increased infection risk, and higher overall perioperative morbidity, particularly in elderly or comorbid patients.

These findings are consistent with previous literature: Rajasekaran et al. and Hayashi K et al, [7,13] both reported increased operative times and levels involved in fusion surgeries, with the latter noting averages of 1.8 vs. 1.2 levels.

Similarly, the SPORT trial (Weinstein et al.,) [12] documented fusion procedures lasting significantly longer (3.1 vs. 1.5 hours), underscoring the technical complexity of fusion particularly in the setting of advanced or multilevel degenerative disease. The increased operative duration in fusion is attributable

to additional technical demands, including pedicle screw placement, interbody cage insertion, and bony decortication.

The similarity of blood loss, complication rates, length of hospital stay, and reoperation rates between the two groups corroborates the notion that fusion mainly increases surgical invasiveness, rather than improving outcomes. Though our sample size was limited, the absence of superior functional results with fusion suggests that its added surgical burden should be justified only when biomechanically necessary.

Postoperative parameters such as walking improvement, return to daily activities, satisfaction rates, and reoperation rates were comparable between the two groups. The decompression group did not show any meaningful short-term disadvantages- an important point given that decompression alone is simpler, faster, and more cost-effective.

Overall, our results demonstrate that decompression alone provides equivalent short-term clinical and functional outcomes compared with decompression with fusion in DLSS patients without instability. These findings further support a selective approach to fusion, reserving it for cases where structural support is required to maintain spinal stability.

Limitations: This study is limited by its small sample size, single-center design, and relatively short 12-month follow-up, which may not reflect long-term outcomes or complications. Some selection bias may also be present due to surgeon-based decision-making. Larger multicenter studies with extended follow-up are recommended.

Conclusion

Both decompression alone and decompression with fusion significantly improved pain and disability in patients with degenerative lumbar spinal stenosis. No meaningful differences in outcomes were found between the two techniques, while decompression alone required less operative time. Therefore, decompression alone is an effective primary option in cases without radiological instability, reserving fusion for clearly indicated situations.

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Tables

Table 1. Baseline characteristic data among different surgery groups.

Factor	Decompression alone (n=9)	Decompression with a fusion (n=21)	P-value
Age (y)	45 (40-70)	49 (34-85)	0.821
Gender			
male	7 (77.8%)	10 (47.6%)	0.229
female	2 (22.2%)	11 (52.4%)	
Duration of symptoms (mo.)	24 (12-84)	36 (6-120)	0.629
Past spinal surgery			
Yes	2 (22.2%)	3 (14.3%)	0.622
No	7 (77.8%)	18 (85.7%)	
Comorbidities			
Yes	3 (33.3%)	6 (28.6%)	0.704
DM	0	2 (9.5%)	
HTN	2 (22.2%)	2 (9.5%)	
DM+HTN	1 (11.1%)	1 (4.8%)	
HBV	0	1 (4.8%)	
NO	6 (66.7%)	15 (71.4%)	

*Categorical data presented as number and percentage, and numerical data presented as median (range).

Table 2. Operative Data among two surgery groups.

	Decompression alone (n=9)	Decompression with a fusion (n=21)	P-value
Number of levels operated	1 (1-2)	2 (1-3)	0.088
Blood loss during surgery (cc)	400 (300-900)	500 (200-800)	0.348
Operation time	No. (%)		
less than 2 hours	8 (88.9%)	6 (28.6%)	0.003
more than 2 hours	1 (11.1%)	15 (71.4%)	

*Categorical data presented as number and percentage, and numerical data presented as median (range).

Table 3. Post-Operative Data among two surgery groups.

		Decompression alone (n=9)	Decompression with a fusion (n=21)	P-value
Walking improvement		No. (%)	No. (%)	
	YES	6 (66.7%)	15 (71.4%)	

	NO	3 (33.3%)	6 (28.6%)	0.794
Return to daily activities				
	YES	6 (66.7%)	15 (71.4%)	0.772
	NO	3 (33.3%)	6 (28.6%)	
Satisfaction				
	Satisfied	6 (66.7%)	16 (76.2%)	0.453
	Not Satisfied	3 (33.3%)	5 (23.8%)	
Reoperation required				
	YES	3 (33.3%)	6 (28.6%)	0.559
	NO	6 (66.7%)	15 (71.4%)	
Complications				
	ASD	1 (11.1%)	2 (9.5%)	0.999
	Bedridden	1 (11.1%)	2 (9.5%)	
	Infection	0	1 (4.8%)	
	Recurrent disc	1 (11.1%)	2 (9.5%)	

*Categorical data presented as number and percentage. No. (%). ASD stands for adjacent segment disease.

Table 4. Visual Analogue Scale and Oswestry Disability Index at different time points.

	Pre-Op	3 mo. post-Op	6 mo. post-Op	12 mo. post-Op	P-value
VAS of Back pain	5 (3-9)	5 (3-7)	3 (1-7)	1.5 (0-7)	P-value <0.001
VAS of Leg pain	8 (6-9)	7 (4-9)	4 (2-7)	1 (0-7)	P-value <0.001
Oswestry Disability Index (ODI)	3 (3-5)	3 (1-4)	2 (1-4)	1(1-4)	P-value <0.001

*The numbers are median and range. VAS stands for Visual Analogue Scale; ODI stands for Oswestry Disability Index. ODI: 1 represents 0%-20%, 2 represents 21%-40%, 3 represents 41%-60%, 4 represents 61%-80%, 5 represents 81%-100%. Post hoc test with benforoni adjustment showed that the significance was found between 12 mo. post-Op and both of Pre-Op and 3 mo. post-Op, and between 6 mo. post-Op and Pre-Op and 3 mo. post-Op.

Table 5. Visual Analogue Scale and Oswestry Disability Index among different surgery groups at different time points.

	Decompression alone	Decompression with fusion	P-value
VAS of Back Pain Pre-op	5 (3-6)	5 (3-9)	0.32
VAS of Back pain 12 mo. post-op	2 (1-5)	1 (0-7)	0.533
VAS of Leg pain Pre-op	8 (7-9)	8 (6-9)	0.303
VAS of Leg pain 12 mo. post-op	1 (0-7)	1 (0-7)	0.516

ODI Pre-op	3 (3-4)	3 (3-5)	0.979
ODI 12 mo. post-op	1 (1-3)	1 (1-4)	0.719

*The numbers are median and range. VAS stands for Visual Analogue Scale; ODI stands for Oswestry Disability Index. ODI: 1 represents 0%-20%, 2 represents 21%-40%, 3 represents 41%-60%, 4 represents 61%-80%, 5 represents 81%-100%.

Figures

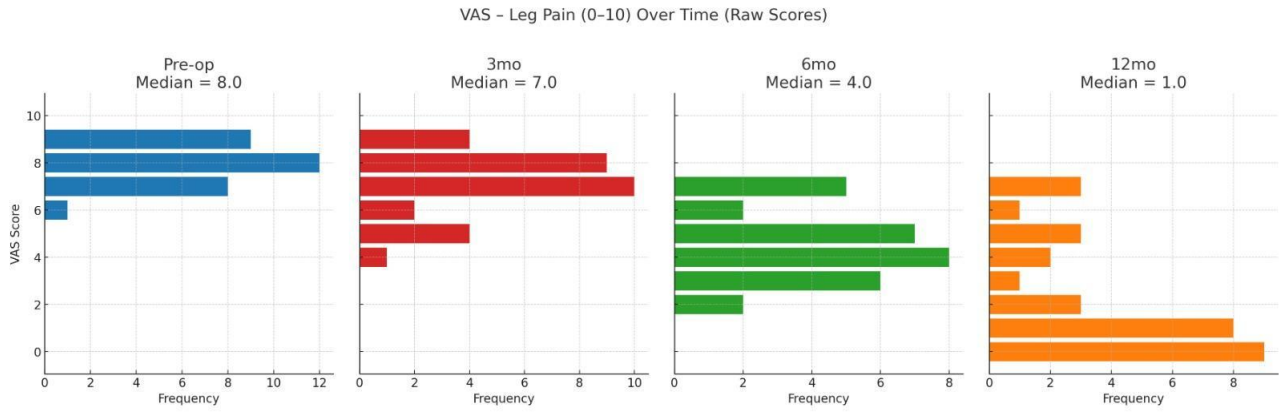

Figure 1. The improvement of VAS for Leg Pain.

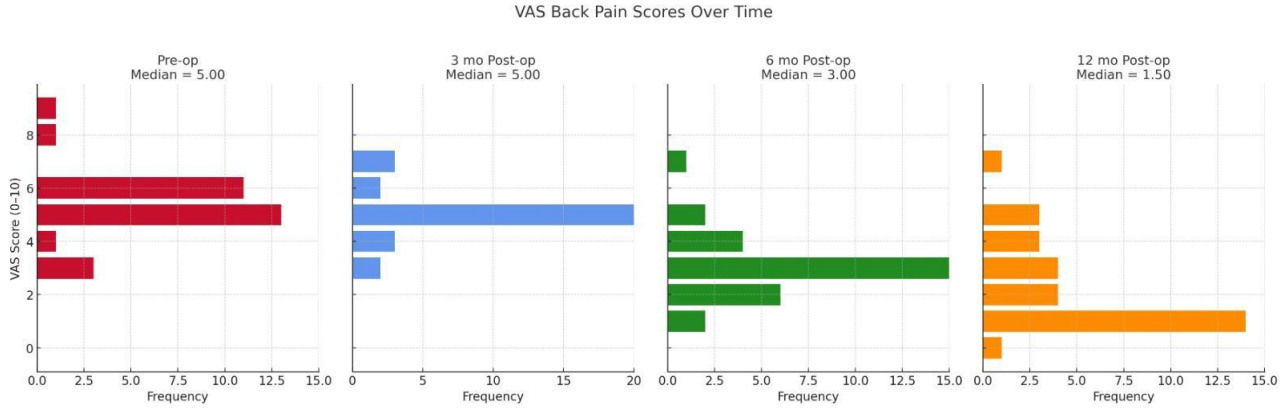

Figure 2. The improvement of VAS for Back Pain.

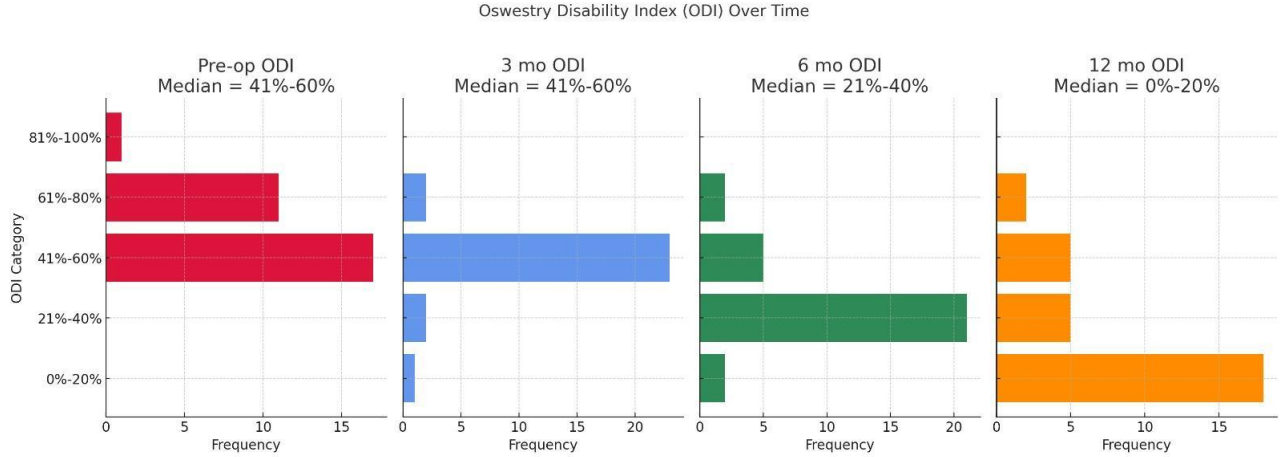

Figure 3. The improvement of Oswestry Disability Index.

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ORIGINAL ARTICLE

PERCUTANEOUS FIXATION OF TIBIAL PLATEAU FRACTURES

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ABSTRACT

Introduction: Tibial plateau fractures may induce long-term issues that might lower a person's standard of living. This work aimed to assess functional outcome related percutaneous fixation of tibial plateau fracture.

Methods: This prospective study included 31 adult patients with Tibial plateau fractures registered in Aswan University Hospital. The patients were evaluated with immediate assessment of the vital signs, full resuscitation, history taking from the patient relatives to detect mechanism of trauma and any medical comorbidities or chronic medications.

Results: the mean Rasmussen score was 27.03± 1.83. The mean time of full union was 3.68± 0.6 months, and the mean time of partial weight bearing was 1.81± 0.44 months. The range of motion was <90 in 2 (6.45%) patients, <120 in 18 (58.06%) patients, <140 in 9 (29.03%) patients, was > 90 in 1 (3.23%) patient and was 120 in 1 (3.23%) patient. Regarding complications, the infection occurred in 3 (9.68%) patients, and failure of fixation was not observed in any of the studied patients. Regarding the union, there were 31(100%) patients had full union.

Conclusions: Our study demonstrates that percutaneous tibial plateau fractures fixation results in excellent functional outcomes with the minimum of complications. The results support the continued refinement and application of this technique in appropriate clinical scenarios.

Keywords: Percutaneous, Fixation, Tibial, Plateau, Fractures

Introduction

Typically, high-energy mechanisms are employed to sustain tibial plateau fractures, which comprise 1% of all fractures. The injury of nearby structures, such as the Tibial plateau fractures may be linked to contiguous compartments, nerves, ligaments, menisci, and vasculature. The preponderance of minimal tibial plateau fractures without concomitant injuries requires orthopedic consultation and surgical management, despite the fact that they can be securely managed without the need for surgery **(1)**.

The posterolateral aspect of the lateral platform is involved in 50.4% of lateral a prevalent type of

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an example of a tibial plateau fracture is a tibial plateau fracture. They are classified as Schatzker types I, II, and III, and fracture **(2)**. Six main categories were included in Schatzker's 1974 classification of tibial plateau fractures. Depending on the patient's age, the bone's condition, and the severity of the fracture, the categories were arranged in descending order of severity **(3)**. The schatzker classification was primarily derived from normal Six main categories were included in Schatzker's 1974 classification of tibial plateau fractures. The severity of the fracture is contingent upon the patient's age and the bone's condition acknowledging the significance of instability as a surgical indication **(4)**.

Kfuri and Schatzker **(3)** conducted a reevaluation of Tibial plateau fracture classification. Their primary focus was on the significance of the during the decision-making process, the three-dimensional position of the separated The optimal location for the buttress plate is determined by the wedge fragment. In addition to the surgical approach. The primary component responsible for the joint's stability was identified as the divided wedge fragment. This was particularly noteworthy.

Tibial plateau fractures may induce long-term issues that might lower a person's standard of living. Patients whose jobs involve a high level of movement may experience a considerable delay in returning to work following a tibial plateau fracture **(5)**. Over the course of numerous years, cast immobilization was the most frequently employed treatment. In conjunction with early mobilization, apley recommended the implementation of skeletal traction **(6)**.

The main emphasis of Tibial plateau fracture classification in 2018 was significance upon choosing the best surgical technique and buttress plate placement, the divided wedge fragment's three-dimensional location is assessed. The primary component responsible for the joint's stability was identified as the divided wedge fragment. But this was really significant **(7)**. Additionally, outstanding outcomes have been achieved through closed reduction through ligamentotaxis, elevation of the depressed plateau, stabilization with percutaneous screw fixation and through a variety of techniques, if necessary **(8)**.

The aim of this work was to assess functional outcome related percutaneous fixation of tibial plateau fracture.

Methods

This prospective study included 31 adult patients with tibial plateau fractures registered in Aswan University Hospital from Julie 2024 to October 2025. An Informed written consent was obtained from the patients. The study was done after approval from the Ethics Committee of the Faculty of Medicine, Orthopedics and Traumatology Department (approval code:).

Inclusion criteria were age from 18 to 65 years old, recent tibial plateau fracture within 20 days, tibial plateau fractures (schatzker type I II III IV V), non comminuted fractures, non pathological fractures, articular step <8mm and depression < 5mm.

Exclusion criteria were age less than 18 years old & more than 65 years old, pathological fractures, old neglected fracture tibial plateau fracture more than 1 month, comminuted fracture, articular > 8mm and depression > 5mm.

All patients were evaluated with immediate assessment of the vital signs, full resuscitation,

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history taking from the patient relatives to detect mechanism of trauma and any medical comorbidities or chronic medications. Clinical examination including general examination with a primary survey conducted according to ATLS protocol and local examination for the knee's general condition was evaluated as part of the secondary survey by inspection, palpation, range of motion and the vascular status which was assessed through the palpation of the pulses in the lower extremities and the examination of capillary refill. Neurological examination of the nerve supply to lower limb either related to trauma or related to chronic diseases affecting on peripheral nerves was performed.

All patients underwent radiological evaluation including plain X ray (standard AP and lateral views) and CT scan of knee joint.

Surgical technique:

For lateral tibial plateau fracture: preferably, under general anesthesia, the patient was placed supine on a radiolucent table, the knee is slightly flexed. The percutaneous reduction techniques could be summarized as the following:

For Schatzker I, ligarotaxis was employed to minimize the separation, and K-wires or a fastener were employed to percutaneously stabilize the fragment. A joystick was used to reduce a fracture with a posterolateral separation using a steinmann pin. For schatzker II which is a combination of melancholy and separation fractures, the initial phase involved ligamentotaxis, which reduces the separation and simplifies the fracture, resulting in (Schatzker, III) a pure depression type. For Schatzker type III, the use of a spatula can ameliorate melancholy following the creation of a minor cortical perforation in the secure zone, which was situated in the superlateral quadrant of the proximal tibia. Into the depression's centre was inserted a K-wire. Immediately following an anterior corticectomy, the K-wire, a spatula, or a cannulated bone were utilized press are used to progressively lift the object. For Schatzker type IV, ligarotaxis was employed to minimize the separation and K-wires or a fastener were employed to percutaneously stabilize the fragment. In the event that the fracture had a posteromedial separation, for reduction, a Steinmann pin was used as a joystick. For Schatzker type V, ligamentotaxis was the most effective method for simplifying complex structures. An appropriate quantity of traction was applied to realign the limb and reduce the metaphysis. A Schatzker III fracture was used to reduce any residual depression. After fragment reduced internal fixation was completed with a cortical screw from the anterior to the posterior, in addition to or absent two subchondral screws from the lateral to the medial.

Postoperative care:

Managing pain Proper postoperative pain management was crucial for facilitating rehabilitation and preventing delirium, patients seeking treatment for lower limb fractures should undergo deep vein prophylaxis, risk stratification for VTE determined the kind and length of treatment, every patient were examined for neurovascular status, pain killers and anti-edematous medications were prescribed and postoperative plain x-rays for Knee (AP, lateral).

Follow up:

At the final visit, six months after the surgical intervention, the Rasmussen knee Score was employed to ascertain the outcome, the following scoring instrument comprises functional and

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anatomical (radiological) grading, five parameters were utilized to evaluate the knee's functionality (degree of stabilization, the degree of extension, range of motion, pain, and walking capacity through functional grading), if the points ranged from 27 to 30, the functional score was deemed to be outstanding. Results were classified as good if the range was 20-27 points, middling if the range was 10-20 points and poor if the range was less than 10, patients underwent postoperative evaluations at two, six, and twelve weeks, and thereafter, on a monthly basis until radiological union and the removal of sutures and wound care **(9)**.

A follow-up X-ray of knee (AP and lateral view) was conducted to evaluate stability of fixation and fracture union, neurovascular assessment, examine the patient was examined for bedsores and DVT and other recumbence complications and ROM.

The Rasmussen Radiological score for tibial plateau fractures is based on the following criteria: Fracture displacement refered to the extent to which the fractured bone fragments have been displaced, involvement of the joint surface and comminution (Fracture fragmentation). The Rasmussen score was the sum of the scores from the three components **(Table 5).** Total score range from 0 to 7, and fractures were categorized as follows (0–2 points: Mild tibial plateau fracture, 3–4 points: Moderate tibial plateau fracture and 5–7 points: Severe tibial plateau fracture **(9)**.

Statistical analysis:

A code document was generated subsequent to the compilation of data. The data was organized, tabulated, presented, and analysed implemented through the utilization of SPSS (IBM©, Armonk, NY, USA). Mean value (X): divided by number of observations and sum of all observations and standard deviations (SD.): Measures the extent to which individual varieties deviate from their norm.

Case presentation

Case 1: Case male patient 40 years old with no comorbidities came to ER by acute right knee pain and inability to weight bearing. X ray and Ct revealed head fibula fracture Neurovascular intact and right tibial plateau fracture schatzker type I. Patient had been operated by percutaneous canulated screws time of operation was 1hour and no intraoberative blood loss tourniquet had been applied. The patient started weight bearing 1.5 months post-operative he could walk using a single cane at 1.5 months post-operative. He could 140< range of motion. Rasmussen score at 6 months post-operative was 28.pt now have mild degree of osteoarthritis. **Figure 1**

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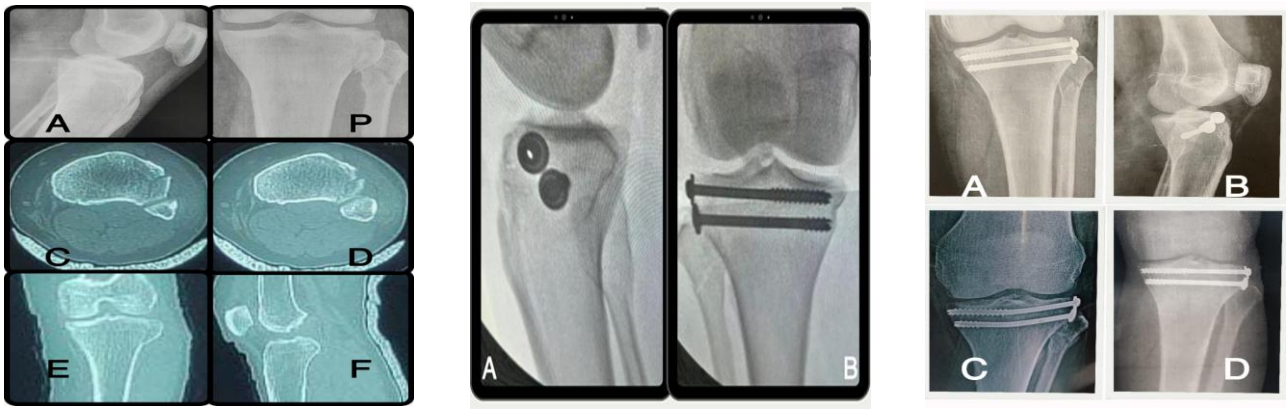

(1) (2) (3)

Figure 1: (1) show pre-operative x-ray & & Ct type I schatzker tibial plateau fracture, (2) show intraoberative x rays AP and lateral views and (3) show post-operative x ray AP and lateral during 6 months

Case 2: Male patient, 50 years old presented to ER with the inability to sustain weight and left knee discomfort. X ray and CT revealed tibial plateau type III by schatzker classification. The patient started weight bearing 1.5 months post-operative he could walk using a single cane at 1.5 months post-operative. He could 120< range of motion. Rasmussen score at 6 months post-operative was 27.pt now have mild degree of osteoarthritis. **Figure 2**

(1) (2) (3)

Figure 2: (1) show pre oberative x ray and Ct tibial plateau type III schatzker classification", (2)show intraoberative images AP and lateral knee with 2 rafting cannulated screw" and (3) "show post-operative Ct knee patient started weight bearing 1.5 month range of motion>120

Case 3:

Case male patient 40 years old presented to ER by acute right knee pain and inability to weight bearing. X ray and Ct revealed right tibial plateau fracture split fracture Neurovascular intact. Pt is started weight bearing 1.5 months ago range of motion 120< mild degree of osteoarthritis Pt. is 29 Rasmussen score". **Figure 3**

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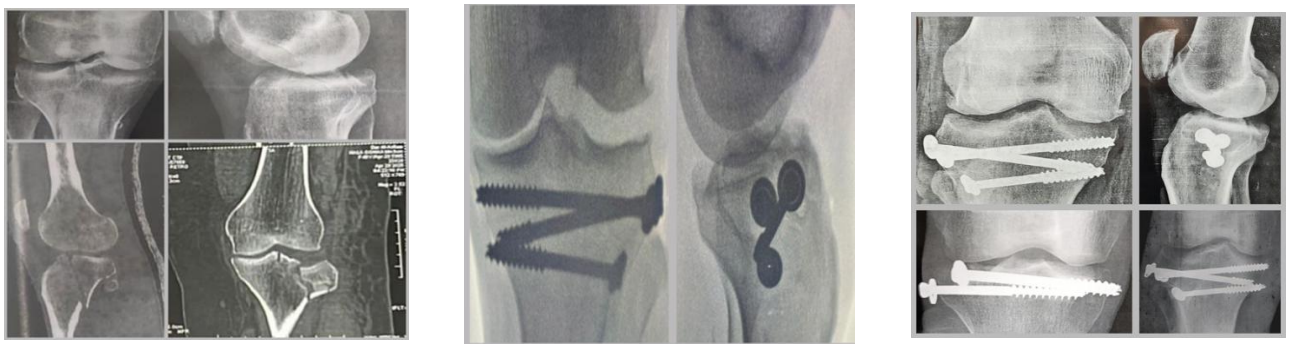

(1) (2) (3)

Figure 3: (1) show pre-operative Ct and x ray split fracture type I tibial plateau", (2)show intraoperative C arm AP/Lateral" and (3) show post-operative x rays during 6 month

Results

Table 1 shows the baseline characteristics, comorbidities, side and mode of trauma, associated other LL fracture, type of fracture and time interval till operation of the studied patients.

			Total (n= 31)
Baseline characteristics	**Age (years)**		39.03± 10.73
	Gender	**Male**	23 (74.19%)
		Female	6 (19.35%)
	Smoking	**Smoker**	12 (38.71%)
		Non-smoker	19 (61.29%)
Comorbidities	**Comorbidity**	**HTN**	1 (3.23%)
		DM	5 (16.13%)
		Obesity	3 (9.68%)
		Cardiac disease	21 (67.74%)
		No	1 (3.23%)
Side and mode of trauma	**Side of trauma**	**Right**	14 (45.16%)
		Left	17 (54.84%)
	Mode of trauma	**CA**	14 (45.16%)
		FOG	16 (51.61%)
		FFH	1 (3.23%)
Associated other LL fracture		**Distal tibia fracture**	2 (6.45%)
		5th metatarsal fracture	1 (3.23%)
		SCIC femur	1 (3.23%)
		No	27 (87.1%)
Type of fracture		**Schatzker type I**	13 (41.94%)
		Schatzker type II	5 (16.13%)
		Schatzker type III	5 (16.13%)
		Schatzker type IV	4 (12.9%)
		Schatzker type V	4 (12.9%)
Time interval (hrs.)			53.42± 26.8

Data was presented as mean±SD or frequency(%). HTN: Hypertension, DM: Diabetes mellitus, CA: car accident, FOG:fall over ground , FFH: fall from height, SCIC:

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All the studied patients were operated by percutaneous cannulated screws and were in supine position during surgery. The type of anesthesia was spinal in 30 (96.77%) patients and was general in 1 (3.23%) patient. The operation time ranged from 1 to 3 hours with a mean of 1.24± 0.43 hours. The time of C arm exposure ranged from 5 to 60 min with a mean of 29.67± 13.45 min. Among the studied patients, 3 (9.68%) patients had intraoperative blood loss. **Table 2**.

Table (2): Operative data of the studied patients

		Total (n= 31)
Type of operation	**Percutaneous cannulated screws**	31(100%)
Anesthesia	**Spinal**	30 (96.77%)
	General	1 (3.23%)
Position	**Supine**	31 (100%)
Operation time (hrs.)		1.24± 0.43
C-arm exposure (min)		29.67± 13.45
Blood loss		3 (9.68%)

Data was presented as mean±SD or frequency(%).

Regarding the walking capacity, 25 (80.65%) patients can walk outdoor for at least one hour, 4 (12.9%) patients can walk outdoor for at least 15 min and the majority of patients 2 (6.45%) patients had normal walking capacity. The functional outcome, the mean Rasmussen score was 27.03± 1.83. The mean time of full union was 3.68± 0.6 months and the mean time of partial weight bearing was 1.81± 0.44 months. The range of motion was <90 in 2 (6.45%) patients, <120 in 18 (58.06%) patients, <140 in 9 (29.03%) patients, was > 90 in 1 (3.23%) patient and was 120 in 1 (3.23%) patient. Stability, 25 (80.65%) patients were normal in extension 20o flexion, 2 (6.45%) patients were instable in 20o flexion, and 4 (12.9%) patients had Instability in 10 o extension. The extension lag was normal in the majority of the studied patients 28 (90.32%), while was 0-10 in 3 (9.68%) patients. Concerning pain, 2 (6.45%) patients had occasional pain, 12 (38.71%) patients had throbbing pain, 4 (12.9%) patients had constant pain after activity pain, whereas 13 (41.94%) patients had no pain. None needed revision among the studied patients in the current study. Regarding the union, there were 31(100%) patients had full union.

Table 3*: Outcome of the studied patients*

		Total (n=31)
Can walk outdoor for at least one hour		25 (80.65%)
Can walk outdoor for at least 15 min		4 (12.9%)
Normal		2 (6.45%)
Rasmussen score		27.03± 1.83
Time of full union (months)		3.68± 0.6
Time of partial weight bearing (months)		1.81± 0.44
Range of motion (degree)	**<90**	2 (6.45%)
	<120	18 (58.06%)
	<140	9 (29.03%)
	> 90	1 (3.23%)
	120	1 (3.23%)

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Stability	**Normal in extension 20 ° flexion**	25 (80.65%)
	Instability in 20 ° flexion	2 (6.45%)
	Instability in 10 ° extension	4 (12.9%)
Extension lag	**0-10**	3 (9.68%)
	Normal	28 (90.32%)
Pain	**Occasional**	2 (6.45%)
	Throbbing	12 (38.71%)
	Constant pain after activity	4 (12.9%)
	No pain	13 (41.94%)
Revision		0 (0%)
United		31(100%)

Data was presented as mean±SD or frequency(%)

Regarding complications, the infection occurred in 3 (9.68%) patients, and failure of fixation was not observed in any of the studied patients.

Table 4*: Complications of the studied patients*

	Total (n= 31)
Infection	3 (9.68%)
Failure of fixation	0 (0%)

Data was presented as frequency(%).

Radiological signs
Time full union averge 3 months in all patients
Depression articular surface 1‹mm in all patients

Discussion

Tibial plateau fractures accounted for one percent of all fractures. The repercussions may be severe and have a substantial social influence. If not addressed appropriately. The management of the fracture is contingent upon a a variety of criteria, including the patient's age, bone condition, and activity level, concomitant soft tissue injury, and fracture configuration **(10)**.

The demographic profile of our study population revealed a mean age of 39.03± 10.73 years, with a predominance of male patients (74.19%).

This aligns with findings by El-Gyoshi et al. **(11)** reported that the tibial condyle fractures are typically observed around the age of forty. However, in this study, they were observed to occur below the age of 35. This can be attributed due to the elevated level of activity observed in this demographic. In upper Egypt, the female population is primarily employed indoors and is not typically involved in sporting activities or road traffic incidents, which is the reason for the sex disparity in the incidence of fractures between males and females (65% versus 35%).

While, Delmarter and Hohl, **(12)** reported that the incidence of tibial plateau fractures was equal between

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men and women.

Regarding the associated comorbidities, 1 (3.23%) patient had hypertension, 5 (16.13%) patients had diabetes mellitus, 3 (9.68%) patients were obese, 21 (67.74%) patients had cardiac disease. Whereas 1 (3.23%) patient were free from any comorbidities.

This rate is comparable to Henkelmann et al. **(13)**, who reported comorbidities in 30% of patients with tibial plateau fractures, noting that these conditions can potentially affect healing outcomes.

Our study found that the mode of trauma was through CA in 14 (45.16%) patients, FOG in 16 (51.61%) patients and FFH in 1 (3.23%) patient.

These findings correspond with Srivastava and Vijay **(6)** showed that physical assault (5%), road traffic accidents (86%), and falls from a height (9%), were the most frequently reported modes of injury.

In our study, regarding the associated other LL fracture, 2 (6.45%) patients had distal tibia fracture, 1 (3.23%) patient had 5th metatarsal fracture and 1 (3.23%) patients had SCIC femur. While 27 (87.1%) patients had no associated other LL fracture.

El-Gyoshi et al. **(11)** reported that two patients (10%) had associated fibulae head fractures. The remaining patients (5%) had Colles' fractures, 5% had femoral shaft fractures, and 5% had tibia fractures.

In our study, the type of fracture was Schatzker type I in 13 (41.94%) patients, Schatzker type II in 5 (16.13%) patients, was Schatzker type III in 5 (16.13%) patients, was Schatzker type IV in 4 (12.9%) patients and was Schatzker type V in 4 (12.9%) patients.

This distribution differs somewhat from He et al. **(14)**, who reported type II as the most common fracture pattern (54.74%) in their series. Also Bormann et al. **(15)** reported that the most common type of fracture was Schatzker II (26%). This variance might be attributed to differences in regional trauma patterns or selection criteria, as our study specifically focused on cases amenable to percutaneous fixation.

In our study, the mean time interval from injury to surgery was 53.42± 26.8 hours, with a range of 24 to 168 hours.

This is consistent with El-Gyoshi et al. **(11)** who reported that the duration until the operation varied from two to five days; however, the majority of cases were completed within the first two to three days of admission.

In our study, the functional outcomes demonstrated excellent results, with a mean Rasmussen score of 27.03± 1.83.

Comparable to the findings of Siegler et al. **(16)**, who reported a mean score of 25.5 in their series of percutaneously treated tibial plateau fractures.

Regarding ROM, <90 in 2 (6.45%) patients, <120 in 18 (58.06%) patients, <140 in 9 (29.03%) patients, was > 90 in 1 (3.23%) patient and was 120 in 1 (3.23%) patient

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A few patients experienced a decrease in knee range of motion as a consequence of delayed knee mobilization in 22 patients with closed tibial plateau fractures who were treated with percutaneous cancellous screws and washers **(17)**.

In our study, regarding stability, 25 (80.65%) patients were normal in extension 20o flexion, 2 (6.45%) patients were instable in 20o flexion, and 4 (12.9%) patients had Instability in 10 o extension.

These results are comparable to El-Gyoshi et al. [**(11)** the initial assessment of ligamentous instability was conducted under anaesthesia. 4 of the cases were discovered to have a concomitant ligamentous injury.

In our study, extension lag was minimal, with 90% of patients showing normal extension, similar to findings by Lo et al. **(18)**, who reported normal extension in 88% of patients following minimally invasive fixation.

In our study, regarding pain, 41.9% of patients reported no pain, while 6.45% experienced only occasional discomfort. The low incidence of pain in our series underscores the benefit of minimally invasive techniques in reducing post-operative discomfort. The complication rate in our study was notably low, with superficial infection occurring in 9.68% of patients, while no cases of non-union or fixation failure were observed. Importantly, the absence of non-union and fixation failure in our series. The absence of revision surgeries in our cohort further attests to the efficacy and durability of percutaneous fixation for appropriately selected tibial plateau fractures.

Abdelkareem et al. **(19)** reported that none of the patients experienced infection or wound dehiscence as a result of closed reduction and percutaneous screw fixation for tibial plateau fractures.

The excellent functional outcomes and low rates of complications that were observed in our study provide evidence in favour of the use of percutaneous fixation techniques for Schatzker type I-III tibial plateau fractures. The preservation of joint motion and stability, coupled with minimal pain and high union rates, suggests that this approach offers significant advantages over more invasive techniques for suitable fracture patterns.

The limitation of the study was that it was relatively small sample size inevitably lowered the statistical power of the analysis, the results are less generalizable due to the single-center study and a small sample quantity.

Conclusion

Our study demonstrates that percutaneous tibial plateau fractures fixation results in excellent functional outcomes with the minimum of complications. The results support the continued refinement and application of this technique in appropriate clinical scenarios. Future studies should focus on longer-term outcomes and potential refinements to surgical technique to further reduce radiation exposure and operative time.

Therefore, the study recommends that it was further investigations with larger and stratified sample size for more accurate results and multi-center study.

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Conflict of interests: None to be declared.

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ORIGINAL ARTICLE

FUNCTIONAL AND KNEE RANGE OF MOTION IN TIBIAL PLATEAU FRACTURES TREATED WITH PERCUTANEOUS SCREW FIXATION

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ABSTRACT

Introduction: Fractures of the tibia plateau comprise about one percent of all fractures and they are at risk of potential functional disability, and post-traumatic osteoarthritis unless treated accordingly. Percutaneous screw fixation is a minimally invasive alternative to traditional open fixation and is designed to provide stable fixation with preservation of soft tissue integrity. This is a prospective study which assessed the functional and radiological outcomes of tibia plateau fractures in the use of percutaneous screw fixation. **Methods:** A prospective single-centre study of 31 adult patients with Schatzker type I -IV tibial plateau fractures were carried out at Aswan University Hospital between July 2024 and October 2025. Percutaneous screw fixation was done on the patients with or without bone grafting and the patients were followed up to six months. Clinical assessment was in terms of range of motion (ROM) and Rasmussen clinical scoring, radiological outcome was measured by Rasmussen radiological score. These included complications, union rates and reoperations. **Results:** The study cohort comprised individuals with a mean age of 43.9 years (standard deviation, 10.2 years; range, 21–63 years), including 71.0% men and 29.0% women. Rehabilitation was initiated, on average, 6.0 days following the index procedure, with partial weight bearing permitted at 7.0 weeks and full weight bearing at 11.0 weeks postoperatively. At final follow-up, mean knee flexion measured 115.7° (standard deviation, 4.5°), accompanied by a mean extension lag of 1.3° (standard deviation, 1.2°). Bony union was observed in 90.3% of cases, whereas delayed union occurred in 6.5% and nonunion in 3.2%. Adverse events were noted in 19.4% of participants, encompassing stiffness (9.7%), hardware-related irritation (6.5%), and superficial infection (3.2%); notably, reoperation proved necessary in a single instance (3.2%). Functional assessment via the Rasmussen clinical score yielded a mean of 24.8 (standard deviation, 3.0) at the six-month mark, complemented by a mean radiological score of 5.3 (standard deviation, 1.1), findings that collectively suggest favorable to superior clinical results. **Conclusion:** Percutaneous screw fixation of tibial plateau fractures is a safe and effective treatment option with high union rates, satisfactory knee functioning and low complication and reoperation rates. These results confirm its use as a least invasive intervention in the case of selected fractures.

Tibial plateau fractures are complicated intra-articular injuries that are estimated to contribute to more or less 1 percent of all fractures and about 8 percent of the fractures in the older group of people. The causes are typically the high energy traumas among young people and the low energy falls among the elderly who have osteoporotic bones. The main aims of the treatment include regaining the congruence of the articular surface, ensuring stable fixation, and early mobilization; they should provide the preservation of knee functions and avoid long-term disability **(1, 2).**

Conventional DVT treatment and cure of displaced tibial plateau fractures consist of open reduction and internal fixation (ORIF) using plateaus and screws. Nevertheless, this technique can require a great deal of soft tissue resection, which is more likely to cause infection, wound dehiscence and slow rehabilitation. These complications can have adverse consequences on functional performance, especially knee range of motion, one of the most important patient satisfactions and back to activity determinants **(3, 4)**.

Less invasive surgery, such as closed reduction, and percutaneous screw fixation has become popular as a substitute to traditional ORIF. Such techniques are intended to preserve the soft tissue damage to the minimal extent possible, whilst ensuring sufficient stability of the fracture fragments. Percutaneous fixation is thought to decrease complication and facilitate early rehabilitation through maintenance of periosteal blood supply and minimization of surgical trauma **(5, 6)**.

Percutaneous screw fixation is the most appropriate in simple split or depression fractures which are in line with lower-grade Schatzker types (I to III). They are normally minimally comminuted injuries that can be stabilized with cannulated cancellous screws with the help of fluoroscopy. Other studies have found that patients receiving percutaneous screws have satisfactory union rates, good functional outcomes, and acceptable ranges of knee motions with the initiation of early physiotherapy **(7, 8)**.

The standardised scoring systems like the Rasmussen score, the Knee Society Score and the Lysholm Knee Score are commonly used to measure the functional outcome of managing tibial plateau fracture. These scales use the pain, stability, walking ability and range of motion as significant elements. These include knee flexion and knee extension which are said to be the most sensitive measures of long-term quality of life and recovery to normal activities. Poor restoration of motion is commonly related to stiffness, persistent pain and the risk of post traumatic osteoarthritis **(3, 9)**.

Mobilization in the early phases is highly associated with good postoperative knee range of motion. Comparisons between early and late weight-bearing programs have shown that early onset of movement following surgery is associated with superior flexion results without a decline

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in fracture stability. This shows the significance of the fixation method as well as the rehabilitation program after the operation in dictating the ultimate functional outcomes **(10, 11)**.

Although percutaneous screw fixation has the potential to be advantageous, it is common in the literature to consider radiological results like articular step-off and alignment, whereas functional recovery and range of motion are not as highly valued. In addition, most studies reported in the literature have a limited number of study participants and a brief duration of follow-ups, which restrict the applicability of their results. Thus, a research gap is still present concerning the need to conduct well-planned studies that directly compare knee motion and functional recovery after percutaneous screw fixation **(5, 12)**.

The aim of this study is to evaluate the functional outcomes and knee range of motion in patients with tibial plateau fractures treated using percutaneous screw fixation, with a focus on determining whether this minimally invasive technique provides adequate stability to allow early mobilization, satisfactory joint motion, and improved overall functional recovery.

Methods

This prospective study included 31 adult patients with tibial plateau fractures registered in Aswan University Hospital from July 2024 to October 2025. Informed written consent was obtained from all patients before enrollment. The study was conducted after approval from the Ethics Committee of the Faculty of Medicine, Orthopedics and Traumatology Department, Aswan University.

Inclusion criteria: patients, between 18 and 65 years of age, recent fracture of the tibial plateau within 20 days, Schatzker type I-V fracture, non-comminuted fragment, non-comminuted fracture, an articular step of less than 8 mm and a depression of less than 5 mm.

Exclusion criteria: patients under the age of 18 years or over the age of 65 years, pathological fractures, neglected fractures (> 1 month), highly comminuted fractures, articular step > 8 mm, depression > 5 mm, or patients not fit to undergo anesthesia.

Sample Size

The sample size was calculated using the formula for comparing means, considering a standard deviation of knee range of motion of approximately 12° from previous studies and a minimal clinically significant difference of 8°. With a 95% confidence level ($\alpha = 0.05$) and 80% power ($\beta = 0.20$), the required number of patients was estimated to be **31 cases,** which will provide adequate statistical power to detect meaningful differences in functional outcome and knee motion following percutaneous screw fixation **(11, 13)**.

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All patients underwent immediate trauma assessment with stabilization of vital signs, full resuscitation when indicated, and history taking to document mechanism of trauma, comorbidities, and medications. Clinical examination will follow the ATLS protocol, including general and local examination of the knee for swelling, deformity, range of motion, vascular status (pulses, capillary refill), and neurological function of the affected limb.

Radiological assessment included plain radiographs of the knee (AP and lateral views) and computed tomography (CT) when needed to assess fracture configuration, displacement, and articular depression.

Surgical Technique

All surgery was under spinal or general anesthesia with the patient lying on radiolucent table in the supine position with the knee flexed slightly. Ligamentotaxis will be used to realize a closed reduction that will be confirmed with the help of fluoroscopy.

- **Schatzker I:** reduced by traction, stabilized with percutaneous cannulated cancellous screws.
- **Schatzker II:** split reduced by traction; depression elevated using a cortical window and bone tamp; fixation with subchondral screws.
- **Schatzker III:** depression elevated with a spatula/K-wire through a cortical window; stabilized with screws.
- **Schatzker IV:** reduced using ligamentotaxis or Steinmann pin joystick; fixed with anterior–posterior cortical screws.
- **Schatzker V:** traction employed to simplify alignment, reduction confirmed, and fixation achieved with cortical and subchondral screws.

Postoperative Care

All the patients provided Postoperative analgesia, thromboprophylaxis and neurovascular monitoring. Active-assisted knee mobilization and passive started during the first week of operation. Until evidence of callus formation (typically following 68 weeks) partial weight-bearing was delayed. Radiographic follow-up (AP and lateral knee) was taken as early as possible after surgery, 2 weeks, 6 weeks, 3 months and monthly until the union.

Outcome Evaluation

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At 6 months follow-up, functional results were evaluated using the **Rasmussen clinical score (14)** (pain, walking capacity, stability, extension lag, and range of motion). Radiological outcomes will be assessed using the **Rasmussen radiological score (15)** (articular depression, condylar widening, malalignment).

- Clinical score: excellent (27–30), good (20–26), fair (10–19), poor (<10).
- Radiological score: mild (0–2), moderate (3–4), severe (5–7).

Statistical Analysis

A code document was generated subsequent to the compilation of data. The data was organized, tabulated, presented, and analysed implemented through the utilization of SPSS (IBM©, Armonk, NY, USA). Mean value (X): divided by number of observations and sum of all observations and standard deviations (SD.): Measures the extent to which individual varieties deviate from their norm.

Results

The study included 31 patients with tibial plateau fractures treated by percutaneous screw fixation. The mean age of the cohort was 43.9 years (range 21–63 years). Males constituted the majority (71%) compared with females (29%). The mean body mass index (BMI) of the patients was 26.5 kg/m².

Table 1: Baseline Demographic and Clinical Characteristics

Age (years)	Mean (SD)	43.9 (±10.2)
	Range	21.0 - 63.0
Gender	Male	22 (71.0%)
	Female	9 (29.0%)
BMI (kg/m²)	Mean (SD)	26.5 (±2.8)
	Range	22.0 - 32.0

Regarding fracture patterns, the most frequent was type II (38.7%), type III (29.0%), type IV (19.4%), and type I (12.9 percent). The mean articular depression was 3.4 ± 1.0 mm (2-5 mm) and the mean step-off was 4.0 ± 1.2 mm (2-7 mm). The mean condylar widening was 2.7 ±0.8mm (1-4mm).

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Table 2: Fracture characteristics of the study population

Schatzker Type	I	4 (12.9%)
	II	12 (38.7%)
	III	9 (29.0%)
	IV	6 (19.4%)
Articular Depression (mm)	Mean (SD)	3.4 (±1.0)
	Range	2.0 - 5.0
Articular Step-off (mm)	Mean (SD)	4.0 (±1.2)
	Range	2.0 - 7.0
Condylar Widening (mm)	Mean (SD)	2.7 (±0.8)
	Range	1.0 - 4.0

Mean injury to surgery was 5.3 days with a range of 2 to 11 days. The vast majority of fractures were fixed with two screws (51.6%) or three screws (48.4%), and most of them had the parallel configuration (61.3%). In 22.6% of cases bone grafting was employed. The most common intraoperative adjunct technique was fluoroscopy (83.9%), followed by 16.1% using arthroscopy.

Table 3: Treatment details of the study population

Time from Injury to Surgery (days)	Mean (SD)	5.3 (±2.5)
	Range	2.0 - 11.0
Number of Screws	2	16 (51.6%)
	3	15 (48.4%)
Screw Configuration	Parallel	19 (61.3%)

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	Crossed	8 (25.8%)
	Anteroposterior	4 (12.9%)
Bone Graft Used	Yes	7 (22.6%)
	No	24 (77.4%)
Intraoperative Adjuncts	Fluoroscopy	26 (83.9%)
	Arthroscopy	5 (16.1%)

Postoperative rehabilitation began with range-of-motion exercises at a mean of 6.0 ± 2.0 days (range 3–9 days). Partial weight bearing commenced at 7.0 ± 0.8 weeks, and full weight bearing at 11.0 ± 1.0 weeks. The mean final knee flexion was 115.7 ± 4.5° (range 108–123°), with a mean extension lag of 1.3 ± 1.2°. Union was achieved in 90.3% of cases, with only 6.5% delayed unions and 3.2% nonunion. Complications occurred in 19.4% of patients, most commonly stiffness (9.7%), while infection and hardware issues were rare. Only one patient (3.2%) required reoperation. At six months, the mean final Rasmussen clinical score was 24.8 ± 3.0, and the radiological score was 5.3 ± 1.1, indicating overall good to excellent outcomes.

Table 4: Postoperative rehabilitation and outcomes

Time to Start ROM (days)	Mean (SD)	6.0 (±2.0)
	Range	3.0 - 9.0
Partial Weight Bearing (weeks)	Mean (SD)	7.0 (±0.8)
	Range	6.0 - 8.0
Full Weight Bearing (weeks)	Mean (SD)	11.0 (±1.0)
	Range	10.0 - 13.0
Final Knee Flexion (°)	Mean (SD)	115.7 (±4.5)
	Range	108.0 - 123.0
Final Extension Lag (°)	Mean (SD)	1.3 (±1.2)
	Range	0 - 5.0

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Union Status	United	28 (90.3%)
	Delayed union	2 (6.5%)
	Nonunion	1 (3.2%)
Complications	None	25 (80.6%)
	Stiffness	3 (9.7%)
	Hardware issues	2 (6.5%)
	Infection	1 (3.2%)
Reoperation	Yes	1 (3.2%)
	No	30 (96.8%)
Final Rasmussen Clinical Score	Mean (SD)	24.8 (±3.0)
	Range	20.0 - 30.0
Final Rasmussen Radiological Score	Mean (SD)	5.3 (±1.1)
	Range	3.0 - 7.0

At follow-up, the mean knee ROM improved steadily over time. At 2 weeks, flexion averaged 52.0 ± 6.5° (range 40–64°), increasing to 82.0 ± 7.0° (range 70–94°) at 6 weeks. By 3 months, patients achieved a mean ROM of 103.0 ± 6.8° (range 90–114°), with further improvement to 116.0 ± 4.5° (range 108–123°) at 6 months.

Table 5: Follow-up knee range of motion (ROM) at different time points

ROM at 2 weeks (°)	Mean (SD)	52.0 (±6.5)
	Range	40.0 - 64.0
ROM at 6 weeks (°)	Mean (SD)	82.0 (±7.0)
	Range	70.0 - 94.0
ROM at 3 months (°)	Mean (SD)	103.0 (±6.8)

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	Range	90.0 - 114.0
ROM at 6 months (°)	Mean (SD)	116.0 (±4.5)
	Range	108.0 - 123.0

Discussion

Fractures of the tibial plateau comprise approximately one percent of all fractures, yet their ramifications can be devastating, and the sufferer may end up with debilitating effects and may create a significant social and economic burden unless addressed appropriately. The complexity of these injuries is stipulated by the fact that they are related to the weight bearing articular surface of the knee joint and inappropriate treatment may result in chronic pain, instability, stiffness and post-traumatic osteoarthritis. Management strategy choice depends on them depending upon various factors including patient age, bone quality, and activity, presence of concomitant soft tissue injury and fracture specificity.

Our prospective study compared 31 patients with Schatzker type I-IV fracture treated with percutaneous screws fixation, a minimally invasive procedure that works to achieve stable reduction of fractures and maintenance of soft tissue integrity. These were 6 months follow-ups with serial functional and radiographic assessments, which allowed evaluating the knee range of motion, union rates, and complications in terms of established scoring systems.

In the present study, the cohort was 31 patients, and the mean age was 43.9 ± 10.2 years (21-63 years), which represents a relatively young to middle aged population field of patients with trauma based injuries. The extensive spread implies that even younger patients, who may be exposed to high-energy processes, e.g., road traffic accidents, and older patients, who are more inclined to have low-energy processes, were represented. The males were more at 71.0% (n = 22) and the females 29.0% (n = 9) which is in line with the overall pattern in orthopedic trauma where men are more often affected because of occupational risks and recreation. The average body mass index (BMI) of the research population was 26.5 ± 2.8 kg/m 2 (minimum 22 and maximum 32), which situates the average patient in the overweight category, but with a small range that omits the extremes of obesity. This also applies, because morbid obesity has been linked with rehabilitation lag time and wounds, which had not been common in the current series.

Comparable demographic patterns have been reported in the literature evaluating percutaneous or minimally invasive fixation techniques. Chen et al. **(16),** in a methodical review of 12 studies involving 353 patients, the mean ages reported were between 36 and 72 years with most of the patients having mean ages of between 41 and 49 years closely resembling the mean age in this study of 43.9 years. A majority of male patients in 7 of 12 studies, with male proportions ranging between 10.0% and 75.6, was also noted in that review, which is consistent with the 71.0%

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predominance of males here, although some cohorts were more balanced or even predominantly female.

The patterns of fractures in this report were categorized as per the Schatzker system, Type II, most common at 38.7% (n = 12), Type III, 29.0% (n = 9), Type IV, 19.4% (n = 6), and Type I, 12.9% (n = 4). This distribution emphasizes the prevalence of split-depression (Type II) and pure depression (Type III) fractures that tend to be percutaneous-friendly, owing to their comparatively small comminution and better reduction potential. The articular depression had a mean of 3.4 ± 1.0 mm (range 2.0-5.0 mm) which was considered moderate articular surface involvement that required surgical intervention to curb the incidence of long-term post-traumatic arthritis. Likewise, the average articular step-off was 4.0 ± 1.2 mm (range 2.07.0 mm), and the upper range indicated that some cases exhibited significant incongruity that might question the validity of percutaneous reduction. Condylar widening mean was 2.7 ± 0.8 mm (range 1.0-4.0 mm), a small but clinically meaningful value, as even slight widening has been linked to changes in the load distribution and knee stability.

These findings are consistent with the prevailing literature, which has demonstrated a predominance of Schatzker Types I–III in patient cohorts undergoing percutaneous or arthroscopically assisted fixation, as such patterns are less complex than higher-grade fractures. Chen et al. **(16)**, in a systematic review involving 353 patients, stated that Type I-III injuries predominate among surgically treated tibial plateau fractures, and that only a small number of series reported Type IV-VI injuries, indicating the increased complexity of those types of patterns that may require open reduction and internal fixation. Similarly, Siegler et al. **(17)**, when exploring the use of arthroscopically directed percutaneous fixation, limited their sample to Schatzker Type I-III, thus agreeing with the existing distribution that focuses on patterns of reducibility.

In another series, Chowdhury et al. **(18)** tested 37 patients treated with internal fixation (screws in 29.7% cases) and found a preponderance of Type I (37.8) and Type II (27.0), with fewer higher-type fractures, but did not measure step-off and condylar widening, the authors reported an operative threshold of over 3 mm articular depression, which is comparable to the mean articular depression in the present study.

Likewise, Nguyen et al **.(19)** studied AO/OTA Type 41.B1-B3 fractures, which are monocondylar lateral fractures, similar to Schatzker Type I-III, and they did not report depression or step-off values but the focus on reducible fracture morphology is consistent with the moderate displacement in this study, with up to 7 mm maximum step-off.

The present cohort commenced treatment at an average of 5.3 ± 2.5 days after injury (2.0 to 11.0 days), which is the compromise between sufficient time to stabilize the soft tissue, and the time spent on surgical waiting that may make the procedure more complicated. The fixation was done

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using two screws (51.6% n =16) and three screws (48.4% n=15), mostly parallel (61.3% n=19) with crossed (25.8% n=8) and anteroposterior (12.9% n=4) setups. This distribution reflects a definite biomechanical advantage to parallel constructs, which are commonly preferred to support subchondral constructs in depression pattern. The bone grafting was used in 22.6 (n = 7) cases when there was a gap left behind, usually in a case where the depressed fragments were lifted, and most (77.4, n = 24) cases were stable but not augmented, indicating that most reductions were stable with screw fixation. Fluoroscopic guidance dominated intraoperative adjuncts in 83.9% (n = 26) and arthroscopy was selectively used in 16.1% (n = 5) reflecting a pragmatic compromise between increased visualization and efficiency in the procedure.

Similar results have been reported in the literature comparing percutaneous fixation and minimally invasive fixation. Chen et al. **(16)**, in systematic review of 12 studies, screw fixation is reported to have been the most widely used technique (8/12 of studies) often along with autogenous or synthetic grafts, but no combined usage rate is given, making the present rate of 22.6% graft placement in the current series more conservative, implying a more cautious approach to augmentation.

Similarly, Elsøe and Larsen **(20)** presented results of 56 patients who received intraoperative fixation without specifying when it was done, how many screws used, or how they were configured, which makes it more challenging to compare the results directly but indicates the broader use of screw-based fixation plans.

In contrast, Chowdhury et al. **(18)** also indicated a significant increased bone grafting (64.9%) rate in their 37-patient series, and cancellous screw fixation in 29.7, which could be explained by the higher number of cases of more complex types of fractures that needed such support. Their activities were planned according to soft tissue preparedness, which was in line with the 5.3 days mean period in this case.

Finally, Nguyen et al. **(19)**, of 33 patients, arthroscopically (10 cases) versus fluoroscopically (23 cases) percutaneous fixation, although no specific reference was made to screws or grafts, and their shift to more frequent fluoroscopy usage matched the 83.9% fluoroscopic dependence in the current series, suggesting just how efficient and popular it is.

The current cohort began rehabilitation with range of movement (ROM) exercises with a mean of 6.0 ± 2.0 days (range 3.0–9.0 days), which is grounded on early mobilization as a preventative approach to avoid stiffness. Partial weight bearing commenced at an average of 7.0 ± 0.8 weeks (range 6.0–8.0 weeks), and full weight bearing at 11.0 ± 1.0 weeks (range 10.0–13.0 weeks), which is a conservative protocol to balance between fracture healing and functional recovery. Final follow-up showed an average knee flexion of 115.7 ± 4.5 (108.0-123.0) and an average extension lag of 1.3 + 1.2 (0-5.0) which represents an almost complete restoration of motion with just slight

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residual deficits. Radiological union occurred in 90.3% (n = 28), delayed in 6.5 (n = 2), and nonunion in 3.2 (n = 1) indicating that percutaneous screw fixation has a high healing potential when used in the right fracture patterns. None had complications (80.6% n = 25), superficial infection (3.2% n = 1), stiffness (9.7% n = 3), and hardware-related irritation (6.5% n = 2) were the most common adverse events. Only 3.2% (n = 1) had to be reoperated. Six months, the average Rasmussen clinical score was 24.83, standard deviation 3.0 (20.0-30.0) and the average radiological score was 5.26, standard deviation 1.1 (3.0-7.0), which indicated overall good to excellent results.

These results are broadly consistent with previous reports. Chen et al. **(16)**, in a systematic review of 12 studies comprising 353 patients, reported mean clinical Rasmussen scores of 25.5 to 28.4 were reported in 12 studies with 353 patients, 3 of which were rated excellent or good, but with longer follow-up (24-87 months) times, which could have raised the scores. Of the review, radiological outcomes were 8.0-16.1 with ≥63% being reported as excellent or good compared to the lower mean of 5.3 in this study, which may be explained by scoring differences or more strict criteria being used at six months. During a succession of arthroscopically aided percutaneous fixations, Siegler et al. **(17)**, reported mean clinical and radiological Rasmussen scores of 25.5 and 8.0 at 59.5 months with 47.6% showing early osteoarthritic changes, which are comparable to the current functional scores but indicate the potential risks of long-term effects at six months.

In the 56-patient cohort described by Elsoe and Larsen **(20),** complicated rates of 9% were reported which compares to the 19.4% complication rate found at this location including stiffness and hardware irritation; their average KOOS score of 75.5 at three years was a sign of sustained functioning even though the Rasmussen scores were not reported to be compared directly.

Similarly, Chowdhury et al. **(18)** reported good outcomes in 35.1% and excellent results in 51.4% of 37 patients, and stiffness in 10.8% and a partial weight bearing usually introduced between 10 and 12 weeks, time schedule and complicationIllegate results which are similar to the current results, although with a less timely introduction of weight bearing.

Finally, Nguyen et al. **(19)**, recorded good to excellent Rasmussen results in 90% of arthroscopically assisted cases and 94% of fluoroscopically guided cases with only one reoperation (total knee arthroplasty), which is similar to the low reoperation rate (3.2) and high union rate (90.3) in this cohort.

Follow-up in the present study demonstrated progressive improvement in knee ROM. At two weeks, the mean flexion was 52.0 ± 6.5° (range 40.0–64.0°), which increased to 82.0 ± 7.0° (range 70.0–94.0°) at six weeks. By three months, the mean flexion reached 103.0 ± 6.8° (range 90.0–114.0°), and at six months it improved further to 116.0 ± 4.5° (range 108.0–123.0°). This steady progression, from limited early flexion to near-normal mobility by six months, highlights the

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effectiveness of the rehabilitation protocol applied in this cohort. The relatively narrow standard deviations across time points indicate consistent recovery among patients, with minimal outliers.

Few studies provide timed ROM data for direct comparison, which limits precise benchmarking, but available evidence supports a similar recovery trajectory. Chen et al. **(16)**, in a systematic review, made no mention of ROM values in particular but have reported a general good to excellent functional outcome using Rasmussen scoring indicating a similar improvement in the functional outcome of the cohorts in which the arthroscopy was performed.

In the 37-patient series described by Chowdhury et al. **(18),** ROM values were not published at any given time, but six week, three-month, six-month, and one-year follow-ups were, the results reported show a trend of gradual increase as per the current results.

Furthermore, meta-analytic data on arthroscopically assisted fixation by Evola et al. **(21)** reported final ROM values averaging 124–127° across subgroups, which is higher than the 116° observed at six months in this study, a difference that may be attributable to longer follow-up durations or variations in surgical and rehabilitation protocols.

The study was also limited by the fact that it was a relatively small sample size that automatically reduced the statistical power of the study and that the findings are less generalizable since it is a single-center study with a small number of patients.

Conclusion

This prospective study revealed that tibial plateau fractures treated with percutaneous screw fixation are a valid minimally invasive procedure, which offers good functional and radiological results at six months. Most of the patients scored good to excellent on the Rasmussen score, and a steady increase in the knee range of motion to near-normal levels coupled with a high rate of union. It is important to note that the rate of complications was also minimal and re-operation was hardly necessary, which confirms the safety of this method. The results reinforce the utility of percutaneous screw fixation as a secure intervention against a subset of tibial plateau fractures and contribute some useful information to the current evidence base on minimally invasive interventions of periarticular knee injuries.

Recommendations

These findings should be confirmed in future research using larger multicenter randomized cohort studies with extended follow-up to confirm whether the positive short-term outcomes associated

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with the treatment result in lasting functional improvements and decreased risk of post-traumatic osteoarthritis. Subgroup analyses in terms of fracture-type, patient age, comorbidities are suggested to narrow the patient sample used to select patients undergoing percutaneous fixation. Moreover, standard rehabilitation protocols and patient-reported outcome measures such as quality of life, and return-to-function measures, should be included to give a better assessment of the recovery. To further establish the relative merits of screw fixation, comparative studies with other forms of fixation including, plating or arthroscopically assisted reduction are required.

Limitations

There are a number of limitations to this research. It was also designed as a one-center study, which can be a limitation to the study as it may not generalize its findings to other organizations and practice environments. The analysis had a very low statistical power by virtue of the relatively small sample (31 patients). The six-month follow-up was considered to be sufficient in the evaluation of the union and early function, but it might fail to detect long-term complications like the post-traumatic osteoarthritis or the problems with the hardware. Lastly, there was no cost-effectiveness analysis or detailed patient-reported outcomes, and they should be considered in future research.

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ORIGINAL ARTICLE

Role of Transcranial Ultrasound in The Assessment of Perinatal Hypoxic Ischemic Encephalopathy

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ABSTRACT

Background: Hypoxic-ischemic encephalopathy (HIE) remains a major cause of neonatal morbidity and mortality worldwide. Early diagnosis is crucial for initiating timely management and improving long-term neurodevelopmental outcomes.

Objective: To evaluate the role of transcranial ultrasonography (TCUS) as a diagnostic tool in detecting early brain changes and in monitoring neonates with HIE.

Methods: A cross-sectional study was conducted on 50 neonates admitted to the neonatal intensive care unit with a history of birth asphyxia. All enrolled infants underwent detailed history and clinical assessment, including Apgar scores, need for resuscitation, and HIE staging. Transcranial ultrasound, including grayscale and Doppler evaluation, was performed in all cases.

Results: Of the 50 neonates, 58% were males, with 52% preterm. The majority were delivered by cesarean section (86%). The most common clinical features included apnea (82%), cyanosis (72%), and respiratory distress (38%). On ultrasound, cerebral edema (30%) and hyperechoic thalami (16%) were the most frequent findings, while 38% showed normal scans. Doppler abnormalities were present in 48% of cases. No significant association was found between Doppler indices and clinical staging.

Conclusion: Transcranial ultrasonography is a valuable, safe, and accessible bedside tool for the early detection of hypoxic-ischemic brain injury in neonates. Although MRI remains the gold standard, TCUS provides rapid and practical information for diagnosis and follow-up in resource-limited settings.

Keywords: Hypoxic-ischemic encephalopathy, Transcranial ultrasound, Doppler ultrasonography.

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INTRODUCTION

Perinatal asphyxia refers to impaired blood flow or gas exchange occurring before, during, or immediately after birth. This condition can result in profound systemic and neurological consequences due to inadequate oxygen delivery to vital organs. In severe cases, oxygen deprivation leads to hypoxemia, hypercapnia, acidosis, and subsequent neuronal injury. Hypoxic-ischemic encephalopathy (HIE) is the most serious neurological consequence of perinatal asphyxia and remains a leading cause of neonatal morbidity and mortality. Early identification of brain injury is critical for guiding clinical management and preventing long-term neurodevelopmental complications **(Gillam-Krakauer & Gowen, 2017).**

Several neuroimaging modalities are available for the evaluation of neonates with suspected HIE. Magnetic resonance imaging (MRI) provides detailed information and early biomarkers of brain injury but has limitations in accessibility, cost, and feasibility in critically ill neonates. Computed tomography (CT) offers structural assessment but exposes infants to radiation. Transcranial ultrasonography (TCUS) is a non-invasive, bedside, and relatively inexpensive technique that can detect parenchymal, vascular, and structural abnormalities in neonates. It allows evaluation of brain echogenicity, ventricular size, and cerebral blood flow, thereby providing early prognostic information **(Liu Lu., 2023).**

The present study aimed to determine the diagnostic role of TCUS in detecting early brain abnormalities in neonates with hypoxic-ischemic encephalopathy and to evaluate its usefulness compared with clinical findings.

PATIENTS AND METHODS

Study design and setting:

This cross-sectional study was conducted over 12 months in the neonatal intensive care unit (NICU) and radiology departments of Aswan University Hospital.

Study population:

Fifty neonates admitted with a history of birth asphyxia were included. Asphyxia was considered likely if any of the following were present:

- Prolonged antenatal acidosis (>1 hour)
- Fetal heart rate <60 beats per minute
- Apgar score ≤3 at ≥10 minutes
- Delayed first cry >5 minutes or need for positive-pressure ventilation
- Seizures within the first 24 hours of life

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Inclusion criteria:

- Full-term or preterm neonates (≥35 week gestation) with a history of birth asphyxia
- Presence of neurological manifestations such as seizures, hypotonia, coma, or lethargy
- Evidence of multi-organ involvement (brain, liver, lungs, heart, kidneys, intestines)
- Difficult labor with poor or absent crying immediately after birth

Exclusion criteria:

- Major congenital malformations
- Chromosomal abnormalities
- Metabolic disorders

Methods:

All neonates in this study were subjected to a detailed perinatal history, including age at enrollment, need for resuscitation, Apgar score documentation, and need for mechanical ventilation. A complete physical examination was done. Ultrasound was examined with a sector or microconvex probe (2–4 MHz). Scanning was done via the anterior fontanelle in coronal and sagittal planes, with additional axial views through the mastoid fontanelle. Doppler assessment of the anterior cerebral, middle cerebral, internal carotid, and basilar arteries was included and peak systolic velocity (PSV), pulsatility index (PI), and the systolic/diastolic (S/D) ratio, in addition to the resistive index (RI) were evaluated. All were examined with neonates in the supine position.

Statistical analysis:

Data were analyzed using SPSS version 26. Continuous variables are expressed as mean ± SD and categorical data as frequencies and percentages. Comparisons were made using chi-square or Fisher's exact test for categorical data and appropriate parametric or non-parametric tests for continuous variables. A p-value <0.05 was considered statistically significant.

Ethical considerations:

The study was approved by the Ethics Committee of the Faculty of Medicine, Aswan University. Informed consent was obtained from the parents or legal guardians of all participants.

RESULTS

The demographic data of the studied cases showed that 76% of cases were presented in the first week, 12% in the 2nd week, 58% of cases were males, and 52% were pre-term patients; most of the cases (86%) were delivered by CS. 60% of cases need resuscitation, and the mean APGAR score was 2.76 ± 2.2 as shown in table (1).

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Figure (1) showed the most common peri-natal risk factors in the studied cases were pre-eclampsia in 22% of cases and obstructed labor in 16%, followed by PROM and diabetes mellitus, while the least common peri-natal risk factor was hypertension in one case only. There were no perinatal risk factors in 38% of cases.

Figure (2) showed the most common clinical features in the studied patients were apnea in 82% of cases and cyanosis (72%), followed by respiratory distress (38%) and hypotonia (32%), while the least common clinical feature was convulsions in 18% of cases.

Figure (3) showed the most common US findings in the cases were cerebral edema in 30% of cases and hyperechoic thalami in 16% of cases, followed by germinal matrix hemorrhage (GMH) in 12% and periventricular leukomalacia (PVL) in 12%, while the least common US findings were infarctions in only one case and intraventricular hemorrhage in one patient. The US was normal in 38% of cases. Doppler results in the studied cases were normal in 52% of cases, < 0.6 in 44%, and > 0.8 in 4% of cases, as shown in figure (4).

Table (2) showed no statistically significant difference **(p-value = 0.102)** in Doppler results as regards clinical staging. In patients with mild staging, there were 39.1% of cases with a value < 0.6. In moderate patients, 31.3% of cases are < 0.6 and 6.3% of them are > 0.8. In severe cases, 72.7% of cases are < 0.6 and 9.1% of them are > 0.8.

Table (1): Demographic data of the studied cases.

		Studied patients (N = 50)	
Age at time of enrollment	**1st week**	38	76%
	2nd week	6	12%
	3rd week	5	10%
	4th week	1	2%
Gestational age	**Pre-term**	26	52%
	Full term	24	48%
Sex	**Male**	29	58%
	Female	21	42%
Mode of delivery	**VD**	7	14%
	CS	43	86%

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Resuscitation	**No**	20	40%
	Yes	30	60%
APGAR score	**Mean ±SD**	2.76 ± 2.2	
	Min - Max	0 –5	

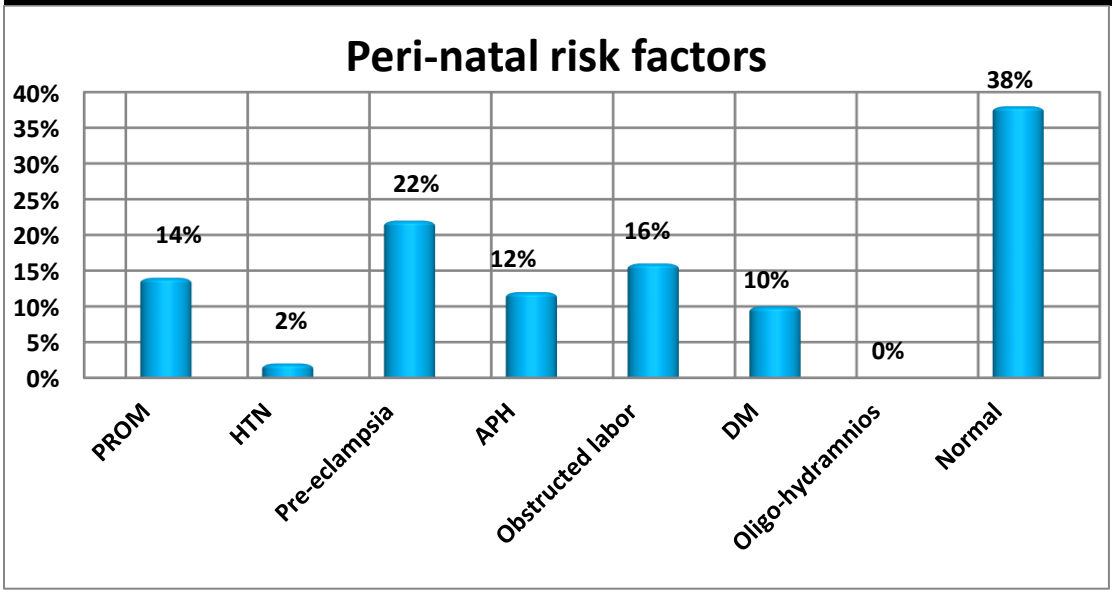

Figure (1): Peri-natal risk factors in the studied cases.

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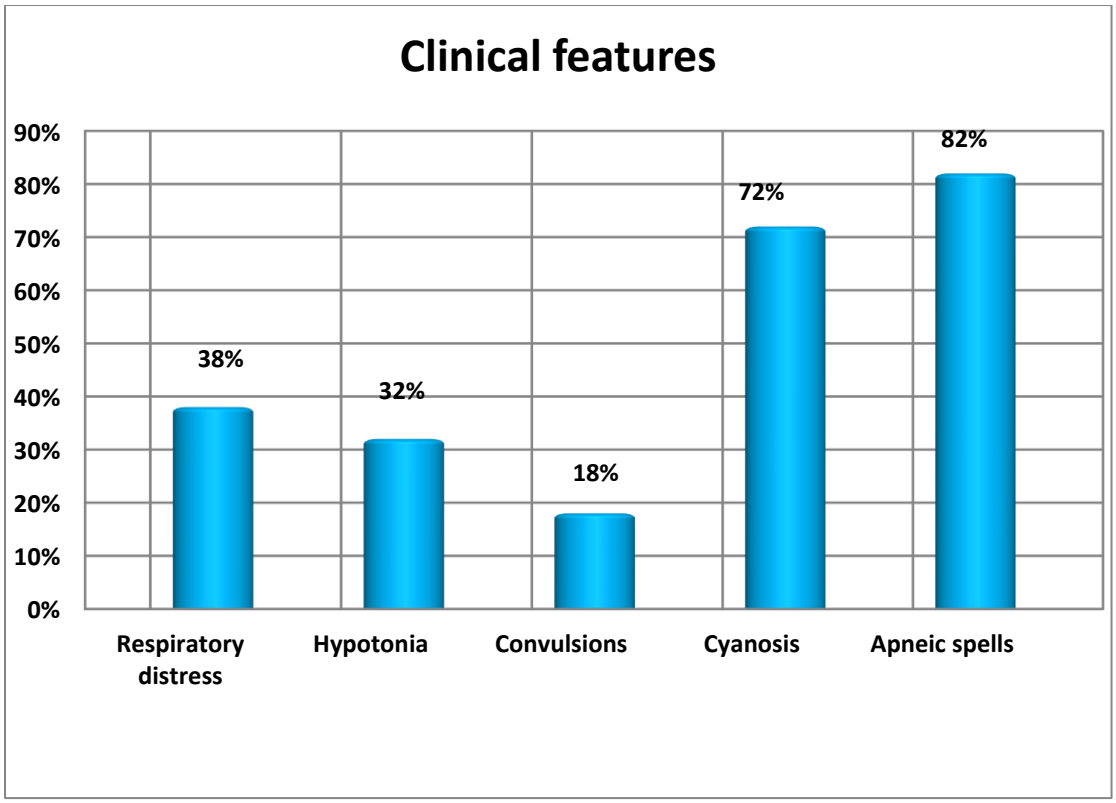

Figure (1): Clinical features in the studied cases.

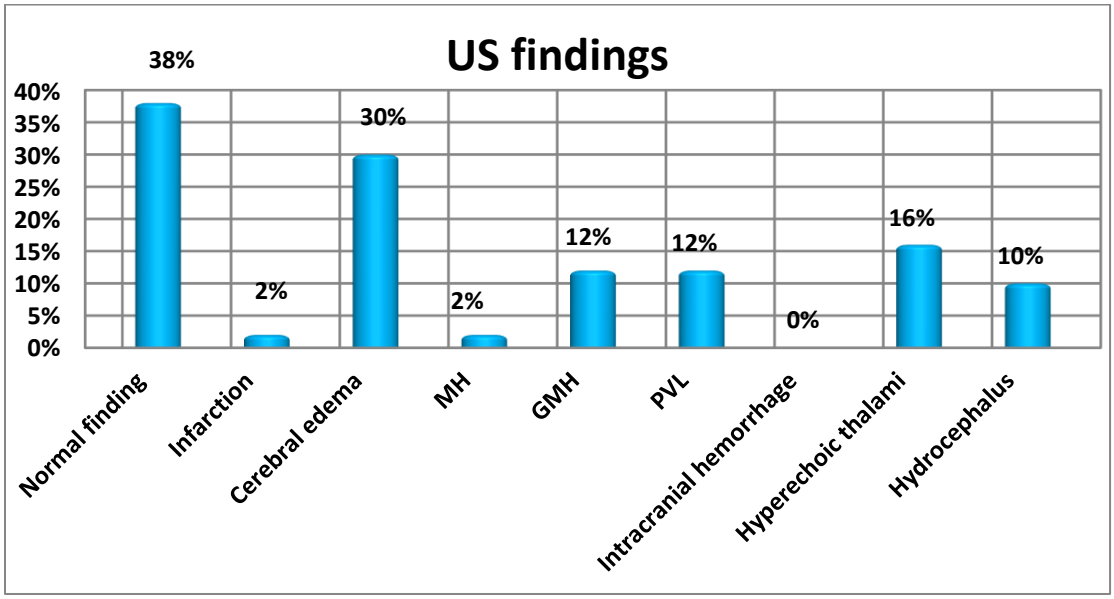

Figure (3): US findings of the studied cases.

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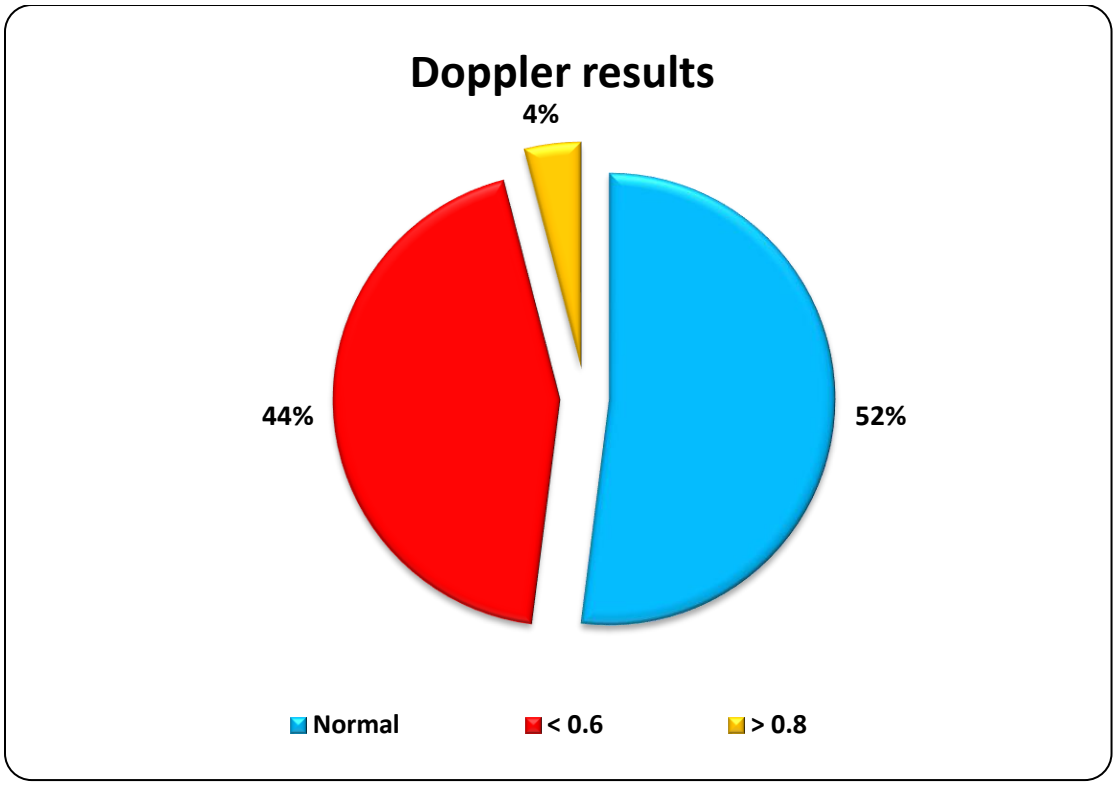

Figure (4): Doppler results in the studied cases.

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Table (2): Correlation between clinical staging and Doppler results.

		Clinical staging						Stat. test	P-value
		Mild (n = 23)		Moderate (n = 16)		Severe (n = 11)			
Doppler	**Normal**	14	60.9%	10	62.5%	2	18.2%	X^2 = 7.7	0.102 NS
	< 0.6	9	39.1%	5	31.3%	8	72.7%		
	> 0.8	0	0%	1	6.3%	1	9.1%		

X^2: Chi-square test. NS: p-value > 0.05 is considered non-significant.

DISCUSSION

Hypoxic–ischemic injury in preterm infants remains a major clinical challenge, contributing substantially to neonatal mortality and long-term morbidity. It continues to be a leading cause of chronic central nervous system damage, cerebral palsy, and cognitive impairment. Several imaging modalities, including TCUS, CT, and MRI, are employed in the evaluation of HIE and cerebral hemorrhage **(Fan et al., 2021).**

Among these, TCUS offers important advantages: being bedside, radiation-free, widely accessible, and cost-effective, making it particularly suitable for screening and follow-up. Conversely, MRI provides superior soft tissue contrast and precise delineation of the extent and location of injury but is limited by high cost, prolonged acquisition time, and the need for transporting critically ill neonates. CT, while valuable in detecting hemorrhage, carries the drawback of radiation exposure **(Mrelashvili et al., 2025).**

In this study, we sought to evaluate the diagnostic utility of TCUS in full-term and preterm infants (>35 weeks of gestation) with perinatal asphyxia. A total of 50 neonates admitted to the NICU with a history of birth asphyxia for over 12 months were included. Clinically, the most common presentations were apnea (82%) and cyanosis (72%), followed by respiratory distress (38%) and hypotonia (32%), while seizures were observed in 18% of cases.

These findings are consistent with previous reports**. Aly and Al-Ghannam (2022)** described symptomatic seizures in approximately one-third of cases, while **Yasmin et al. (2016) noted** respiratory distress in 75%, seizures in 42%, cyanosis in 40%, and apnea in 30%. Similar clinical patterns have also been reported in earlier studies **(Thomson & Teele, 2001; Barr, 1999; Hill et al., 1983; D'Souza et al., 1981).**

With respect to ultrasonographic findings, the most frequent abnormalities were cerebral edema (30%) and hyperechoic thalami (16%), followed by germinal matrix hemorrhage (12%) and

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periventricular leukomalacia (12%). Less common findings included infarction (2%) and intraventricular hemorrhage (2%). Notably, 38% of patients showed no abnormalities.

Similar trends have been described by **Aly and Al-Ghannam (2022**), who observed abnormal findings in more than 90% of neonates with HIE, with periventricular leukomalacia, intraventricular hemorrhage, and cerebral edema being prominent. **Bundi et al. (2020**) also reported that over half of neonates with HIE demonstrated abnormal cranial ultrasound results, predominantly moderate to severe forms.

Other studies (**Thakkar et al., 2019; Yasmin et al., 2016; Martinez-Biarge et al., 2011)** confirm that periventricular and thalamic involvement is strongly associated with adverse neurodevelopmental outcomes, including motor impairment.

Our Doppler evaluation revealed normal resistive index (RI) values in 52% of patients, values <0.6 in 44%, and >0.8 in 4%. Very low RI (<0.5) in the first 48 hours of neonatal life has been strongly associated with poor neurologic outcomes. After 48 hours, the RI generally normalizes, indicating recovery of normal brain perfusion. However, if significant cerebral edema develops, the RI may increase. A significant variability in the measured RI values with and without compression also indicates inadequate cerebral autoregulation ***(Orman, Gunes, et al., 2015).***

These findings align with **Aly and Al-Ghannam (2022),** who found abnormal RI values in the anterior, middle, and internal carotid arteries in nearly 60% of cases. **Bundi et al. (2020**) further demonstrated that aberrant RI values (<0.5 or 0.8) were strongly correlated with the severity of HIE, highlighting the prognostic value of Doppler in grading injury.

Similarly, **Kirimi et al. (2002), Barseem et al. (2016),** and **Kudrevičienė et al. (2014**) all reported that abnormal cerebral Doppler indices within the first 24 hours of life predicted later neurodevelopmental deficits.

In terms of clinical staging, nearly half of our patients presented with mild HIE (46%), followed by moderate (32%) and severe cases (22%). These proportions are comparable to those reported in earlier studies, with **Tann et al. (2016)** and **Ugwu et al. (2012)** emphasizing the predominance of moderate to severe cases. Other studies, such as **Hadžimuratović et al. (2022),** have also confirmed the correlation between HIE severity and Apgar scores, umbilical cord blood gases, and Doppler indices, further supporting the prognostic relevance of cerebrovascular flow assessment.

Taken together, our findings suggest that transcranial ultrasound, when combined with Doppler assessment, provides valuable insights into both the presence and severity of HIE. Although MRI remains the gold standard for structural characterization, the bedside availability and safety of ultrasound make it an indispensable first-line tool for screening, monitoring progression, and predicting outcomes. Consistent with **Guan et al. (2017),** our study supports the use of serial ultrasound follow-up as a practical and prognostic tool in neonatal HIE.

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CONCLUSION

Transcranial ultrasound is a valuable, non-invasive, and readily available imaging modality for assessing perinatal asphyxia in neonates. Its portability, safety, and ability to provide real-time evaluation make it particularly useful in neonatal intensive care units, especially in resource-limited settings. When integrated with clinical evaluation, TCUS can contribute significantly to early diagnosis, monitoring of disease progression, and follow-up of patients with HIE. Future advances in high-resolution ultrasound techniques and quantitative approaches may further enhance its diagnostic accuracy and clinical applicability.

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ORIGINAL ARTICLE

SERUM IRISIN LEVELS AND THEIR ASSOCIATION WITH DIABETIC NEPHROPATHY IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Background: Type 2 diabetes–related hyperglycemia drives diabetic nephropathy, and circulating irisin, which declines with kidney dysfunction, may represent an early biomarker for detecting disease and risk assessment. Objectives: To evaluate circulating irisin level and its correlation with diabetic nephropathy in individuals affected by type 2 diabetes.

Methodology: A case-control study was conducted at Aswan University Hospital, including 93 participants divided into two groups: 31 healthy persons (Group I) and 62 patients with Type 2 Diabetes (Group II), further subdivided into 31 diabetic patients without nephropathy (Group IIA) and 31 diabetic nephropathy patients (Group IIB). Demographic data, blood pressure, glycemic indices, lipid profile, renal function parameters, and serum irisin levels were assessed.

Results: Mean circulating irisin levels progressively decreased with increasing albuminuria severity, from controls (305.34 ± 119.89 ng/mL) to diabetic patients without nephropathy (189.79 ± 44.08 ng/mL), and diabetic nephropathy patients (82.69 ± 35.09 ng/mL).

Conclusion: Circulating irisin levels progressively decline with worsening diabetic nephropathy and increasing albuminuria in type 2 diabetes patients.

Key words: Circulating irisin, Type 2 diabetes mellitus, Diabetic nephropathy

INTRODUCTION

Globally, type 2 diabetes mellitus represents the predominant form of diabetes. and demonstrating a steady global increase. (1).

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Persistent hyperglycemia is fundamentally involved in the development of diabetic kidney disease (DKD). (2).

It is proposed that metabolic disturbances triggered by hyperglycemia lead to glomerulosclerosis, tubulointerstitial inflammation, and fibrosis, ultimately contributing to the development of diabetic nephropathy (3).

DKD is associated with substantial morbidity and mortality between individuals with diabetes and is identified clinically through evidence of albuminuria and/or impaired estimated glomerular filtration rate (eGFR) in patients with either form of diabetes. (4).

According to the American clinical practice guidelines, albuminuria is defined based on the albumin to creatinine ratio (ACR), where values below 30 mg/g are considered normal whereas urinary albumin excretion values equal to or exceeding 30 mg/day indicate abnormal albuminuria (5).

Circulating Irisin generated from fibronectin type III domain containing protein 5, through proteolytic cleavage of its extracellular domain, after which it is released into the peripheral circulation (6).

Serum irisin levels show a marked decline as chronic kidney disease (CKD) progresses, with the lowest concentrations observed in individuals with stage 5 CKD (7).

Although albuminuria and eGFR currently serve as the primary diagnostic and prognostic markers for DKD, both parameters have some limitations. so, there is an increasing need for novel biomarkers that can enhance risk assessment and enable earlier detection of the disease (8).

This study aims to assess circulating irisin level and its association with diabetic nephropathy in individuals with type 2 diabetes.

PATIENTS AND METHODS

Study design:

A Case control Study was conducted in Aswan University Hospital, included 93 participants and divided into two groups: Group I: included 31 healthy persons, group II: The patient group included 62 patients with Type 2 Diabetes (T2D) and patients with T2D were further subdivided into two groups as the following: 31 diabetic patients without nephropathy (group IIA), 31 diabetic nephropathy patients (group IIB).

Patients' criteria selection:

Inclusion criteria: Individuals with T2D aged between 40 and 70 years.

Exclusion criteria: Type 1 diabetes, pregnancy, acute infection, and impaired liver function.

Sample size:

The required sample size was performed using the G*Power statistical package program Version 3.1.9.7 (Franz Faul, Universitat Kiel, Germany) using two population means formula for this study design. using F test (ANOVA, fixed effect, one way) and the following assumptions: Confidence level=99%; Power (1-β): 80%; Effect size=0.4 (large); Two tail.

Methods:

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All participants underwent detailed history taking, including diabetes duration and medication history, followed by a full clinical examination with vital sign assessment, anthropometric measurements, BMI calculation, and chest, cardiac, fundus, and neurological evaluations.

Laboratory investigations: Fasting blood glucose (FBG), postprandial blood glucose (PP), urea, creatinine, glycosylated haemoglobin (HbA1c), renal function test (serum creatinine, urea) and lipid profile (Serum triglycerides, Total cholesterol), ACR, urinary albumin (mg), and creatinine (g), eGFR was calculated by the CKD-EPI equations, serum irisin was measured by enzyme-linked immunosorbent assay (ELISA) kits. (SinoGeneClon Biotech -Cat. No: 11594) and diabetic patients were identified based on the American Diabetes Association diagnostic criteria, which include elevated A1C levels (≥ 6.5%), increased FBG (≥ 126 mg/dL), abnormal 2 hour PP glucose values (≥ 200 mg/dL) during a 75 g OGTT, or a random plasma glucose concentration ≥ 200 mg/dL accompanied by classic symptoms of hyperglycemia.

Ethical considerations:

The research protocol was approved by the relevant Scientific and Ethical Committees at the Faculty of Medicine, Aswan University. Informed written consent was secured from all participants, who were advised of their right to discontinue participation at any stage without affecting their medical care.

Statistical Analysis

The collected data were coded, tabulated, and analyzed using SPSS (Statistical Package for the Social Sciences), version 29 (IBM Corp., Armonk, NY, USA) on an IBM-compatible computer. Descriptive statistics included frequencies and percentages for qualitative variables and mean ± standard deviation for quantitative measures.

The statistical tests used in this study included Chi-square test (χ^2), Student's t-test, Mann–Whitney U test, one-way ANOVA (F-test), Kruskal–Wallis test, and Pearson's correlation coefficient. Differences were considered significant when $p < 0.05$ and highly significant when $p < 0.001$.

RESULTS

This was a case-control study, conducted at Aswan University Hospital. Overall, 93 individuals participated in the present study.

The study shows that there was no statistically significant difference in gender distribution among the studied groups ($\chi^2 = 1.667$, $p = 0.435$). **Table (1)**

Table (1): Comparative analysis of the study groups according to gender

Gende	Groups						Total		χ^2	P-value
	Group I		Group IIA		Group IIB					
	N	%	N	%	N	%	N	%		
Male	13	41.9%	11	35.5%	16	51.6%	40	43.0%	1.667	0.435
Female	18	58.1%	20	64.5%	15	48.4%	53	57.0%		

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Mean age showed a gradual increase across groups, from controls (56.87 ± 8.16 years) to diabetics (58.45 ± 7.55 years) and diabetic nephropathy patients (60.94±6.92 years), with no statistically significant difference ($p > 0.05$). Mean BMI was comparable between controls (26.84 ± 5.44 kg/m²), diabetics (28.19 ± 4.22 kg/m²), and diabetic nephropathy patients (29.03 ± 3.92 kg/m²), with ($p > 0.05$). (**Table 2)**. Mean duration of diabetes was significantly longer in diabetic nephropathy patients (13.35 ± 3.47 years) compared with diabetics without nephropathy (7.16 ± 2.27 years) ($p < 0.001$). (**Table 2 and Figure 1)**. Mean SBP increased significantly across groups, from controls (116.77 ± 8.32 mmHg) to diabetics (128.71 ± 7.18 mmHg) and diabetic nephropathy patients (157.58 ± 12.84 mmHg) ($p < 0.001$). Mean DBP showed a significant progressive rise, being lowest in controls (76.77 ± 8.32 mmHg), higher in diabetics (83.87 ± 6.15 mmHg), and highest in diabetic nephropathy patients (102.26 ± 11.68 mmHg) ($p < 0.001$). (**Table 2).**

Table (2): Demographic and biochemical parameters of the studied groups

	Group I N=31	**Group IIA N=31**	**Group IIB N=31**	**P-value**
Age (Year)				
Mean±SD	56.87 ± 8.16	58.45 ± 7.55	60.94 ± 6.92	0.109
Min.-Max.	45 - 70	45 - 70	46 - 70	
BMI				
Mean±SD	26.84 ± 5.44	28.19 ± 4.22	29.03 ± 3.92	0.171
Min.-Max.	19.20 - 37.18	18.81 - 37.95	21.71 - 35.46	
Duration (Year)				
Mean±SD		7.16 ± 2.27	13.35b ± 3.47	<0.001**
Min.-Max.		4 - 14	7 - 18	
SBP				
Mean±SD	116.77 ± 8.32	128.71a ± 7.18	157.58 a,b ± 12.84	<0.001**
Min.-Max.	100 - 130	120 - 140	120 - 180	
DBP				
Mean±SD	76.77 ± 8.32	83.87 a ± 6.15	102.26 a,b ± 11.68	<0.001**

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Min.-Max.	60 - 90	70 - 90	80 - 130	

BMI: body mass index; **SBP:** systolic blood pressure; **DBP:** diastolic blood pressure;
a < 0.05 vs. Group I; **b** < 0.05 vs. Group IIA

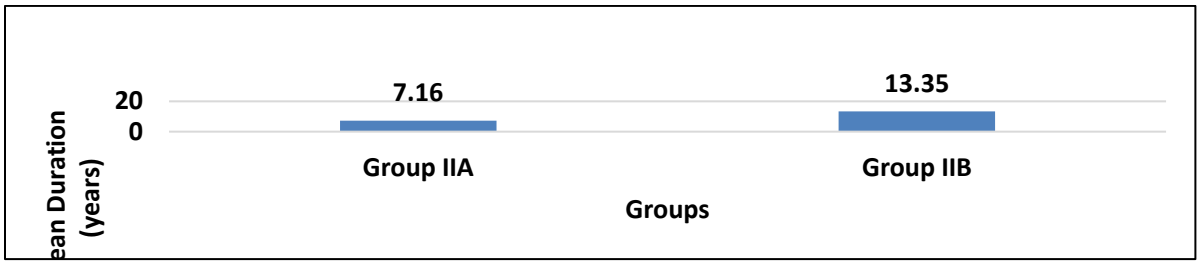

Figure (1): Comparison between groups as regards duration of diabetes

Mean HbA1c levels differed significantly among groups, increasing from controls (4.85 ± 0.57%) to diabetics (6.45 ± 0.44%) and markedly to diabetic nephropathy patients (9.98 ± 1.71%) ($p < 0.001$). (**Table 3)**

Mean FPG was significantly elevated in diabetics (146.61 ± 13.99 mg/dL) and diabetic nephropathy patients (180.03 ± 20.23 mg/dL) compared with controls (92.84 ± 11.28 mg/dL) ($p < 0.001$). Mean PPBG increased significantly across groups, from controls (110.35 ± 11.18 mg/dL) to diabetics (212.55 ± 17.19 mg/dL) and diabetic nephropathy patients (306.32 ± 46.70 mg/dL) ($p < 0.001$). (**Table 3)**

Mean TC levels were significantly higher in diabetics (219.87 ± 64.37 mg/dL) and markedly elevated in diabetic nephropathy patients (254.58 ± 63.3 mg/dL) compared with controls (159.71 ± 24.79 mg/dL) ($p < 0.001$). Mean TG levels increased significantly from controls (108.06 ± 17.78 mg/dL) to diabetics (149.35 ± 39.15 mg/dL) and diabetic nephropathy patients (208.58 ± 47.71 mg/dL) ($p < 0.001$). (**Table 3 and Figure 2)**

Mean Serum urea levels were significantly elevated in diabetics (29.90 ± 5.08 mg/dL) and markedly higher in diabetic nephropathy patients (107.06 ± 38.35 mg/dL) compared with controls (18.10 ± 8.59 mg/dL) ($p < 0.001$). Mean serum creatinine increased significantly from controls (0.81 ± 0.11 mg/dL) to diabetics (1.10 ± 0.11 mg/dL) and was markedly elevated in diabetic nephropathy patients (3.65 ± 1.12 mg/dL) ($p < 0.001$). (**Table 3)**

Table (3): Biochemical parameters across the study groups

	Group I N=31	**Group IIA N=31**	**Group IIB N=31**	**P-value**
HBA1C				
Mean±SD	4.85 ± 0.57	6.45a ± 0.44	9.98a,b ± 1.71	<0.001**

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Min.-Max.	4.0 - 5.6	5.9 - 7.9	7.2 - 14.0	
FPG				
Mean±SD	92.84 ± 11.28	146.61a ± 13.99	180.03a,b ± 20.23	<0.001**
Min.-Max.	70 - 109	92 - 160	120 - 220	
PPBG				
Mean±SD	110.35 ± 11.18	212.55a ± 17.19	306.32a,b ± 46.70	<0.001**
Min.-Max.	91 - 130	159 - 240	200 - 396	
TC				
Mean±SD	159.71 ± 24.79	219.87a ± 64.37	254.58a,b ± 63.30	<0.001**
Min.-Max.	120 - 200	120 - 345	140 - 390	
TG				
Mean±SD	108.06 ± 17.78	149.35a ± 39.15	208.58a,b ± 47.71	<0.001**
Min.-Max.	80 - 130	90 - 220	100 - 310	
S. urea				
Mean±SD	18.10 ± 8.59	29.90a ± 5.08	107.06a,b ± 38.35	<0.001**
Min.-Max.	7 - 35	22 - 38	53 - 190	
S. Cr				
Mean±SD	0.81 ± 0.11	1.10 ± 0.11	3.65a,b ± 1.12	<0.001**
Min.-Max.	0.7 - 1.0	0.9 - 1.3	1.9 - 6.0	

FPG: fasting plasma glucose; **PPBG:** Postprandial Blood Glucose; **TC:** total cholesterol; **TG:** triglycerides; **S. Cr:** Serum creatinine; **a** < 0.05 vs. Group I; **b** < 0.05 vs. Group IIA

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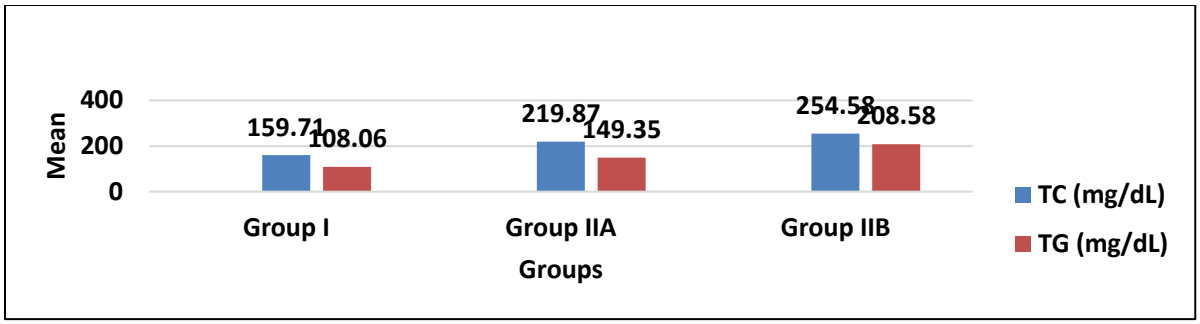

Figure (2): Comparison between groups as regards TC and TG levels

Mean ACR showed a significant increase across groups, being lowest in controls (16.61 ± 3.77 mg/gm), higher in diabetics (20.74 ± 5.02 mg/gm), and markedly elevated in diabetic nephropathy patients (480.32 ± 226.88 mg/gm) ($p < 0.001$). (**Table 4 and Figure 3)**

Mean eGFR declined significantly from controls (118.12 ± 21.35 mL/min/1.73 m²) to diabetics (74.29 ± 10.21 mL/min/1.73 m²) and further to diabetic nephropathy patients (28.97 ± 8.08 mL/min/1.73 m²) ($p < 0.001$). (**Table 4 and Figure 4)**

Mean Serum irisin levels were highest in controls (305.34 ± 119.89 ng/mL), significantly reduced in diabetics (189.79 ± 44.08 ng/mL), and markedly decreased in diabetic nephropathy patients (82.69 ± 35.09 ng/mL) ($p < 0.001$). (**Table 4 and Figure 5)**

Table (4): Biochemical parameters across the study groups

	Group I N=31	**Group IIA N=31**	**Group IIB N=31**	**P-value**
ACR (mg/g)				
Mean±SD	16.61 ± 3.77	20.74 ± 5.02	480.32 a,b ± 226.88	<0.001**
Min.-Max.	11.00 - 27.00	12.00 - 29.00	125 - 900	
eGFR				
Mean±SD	118.12 ± 21.35	74.29 a ± 10.21	28.97 a,b ± 8.08	<0.001**
Min.-Max.	92.93 - 166.91	60.35 - 96.36	18.68 - 55.12	
Irisin				
Mean±SD	305.34 ± 119.89	189.79a ± 44.08	82.69 a,b ± 35.09	<0.001**
Min.-Max.	203.01 - 639.26	150.37 - 272.94	21.18 - 140.22	

a < 0.05 vs. Group I; **b** < 0.05 vs. Group IIA

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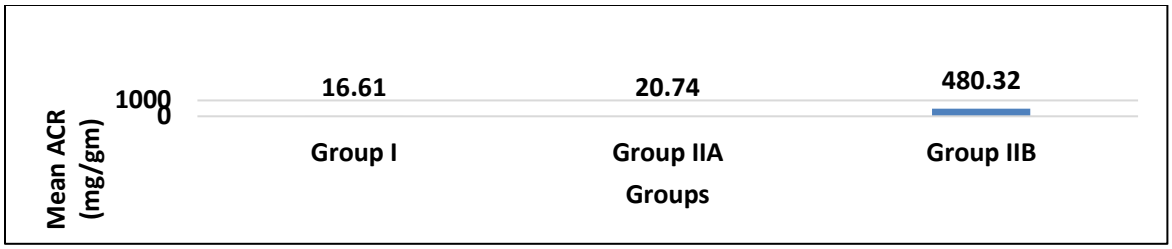

Figure (3): Comparison of the studied groups regarding ACR

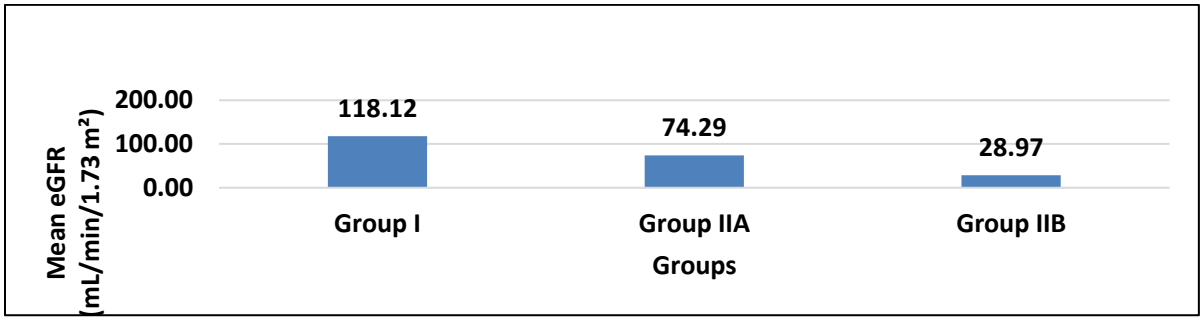

Figure (4): Comparison of the studied groups as regard eGFR

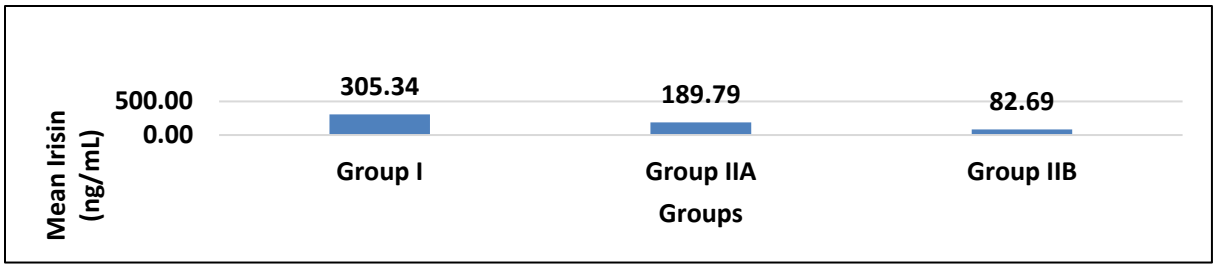

Figure (5): Comparison of the studied groups regarding Irisin levels

DISCUSSION

In this study, mean age showed a gradual increase across groups, from controls to diabetics and diabetic nephropathy patients, however, no significant difference was detected ($p > 0.05$).

These results are in agreement with **Liu et al. (2014) (9),** who described similar age distributions across diabetic patients with varying degrees of renal function, with no significant intergroup differences.

Similarly**, Hu et al. (2016) (10)** documented comparable ages between diabetics with nephropathy (59.1 ± 7.2 years) and those without nephropathy (57.8 ± 8.0 years), with ($p > 0.05$).

Our study showed that mean duration of diabetes was significantly longer in diabetic nephropathy patients compared with diabetics without nephropathy ($p < 0.001$).

Our results align with **Elesawy et al. (2025) (11)** who found that patients with micro- and macro-albuminuria had significantly longer diabetes duration (8.85 and 10.3 years, respectively) than diabetic individuals with normoalbuminuria, whose mean duration was 6.6 years.

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These observations are supported by **Shelbaya et al. (2018) (12)** who documented a significantly longer mean duration of diabetes in DN patients (10.93 ± 2.36 years) compared with non-nephropathic diabetics (5.0 ± 2.19 years, $p < 0.001$).

Our findings showed that mean SBP increased significantly across groups, from controls to diabetics and diabetic nephropathy patients ($P<0.001$). Mean DBP showed a significant progressive rise, being lowest in controls, higher in diabetics, and highest in diabetic nephropathy patients. ($P<0.001$).

Similar observations have been documented by **Shelbaya et al. (2018) (12),** who also reported that mean SBP increased significantly across groups, from controls (112.66 ± 11.12 mmHg) to diabetics (121.16 ± 7.39 mmHg) and diabetic nephropathy patients (128.66 ± 8.99 mmHg) ($p < 0.001$), also mean DBP showed a significant progressive rise, from controls to diabetics and highest in diabetic nephropathy patients ($p < 0.001$). Their results further showed a Highly statistically significant negative correlation between irisin , SBP ($r = -0.493$) and DBP ($r = -0.625$), (P-value <0.001) indicating that higher blood pressure is closely linked to reduced irisin levels in T2DM patient.

Our findings indicate progressively worsening glycemic control with advancing disease severity. Mean HbA1c levels differed significantly among groups, increasing from controls to diabetics and markedly to diabetic nephropathy patients ($p < 0.001$). Mean FPG levels were significantly increased in diabetic individuals, particularly those with nephropathy, compared with healthy controls. ($p < 0.001$). Mean PPBG increased significantly across groups, from controls to diabetics and diabetic nephropathy patients ($p < 0.001$).

Circulating irisin was significantly and negatively correlated with HbA1c ($r = -0.680$), FPG ($r = -0.694$), PPBG ($r = -0.595$), ($p < 0.001$).

Our results align with **El Haddad et al. (2019) (13),** who reported significant negative correlations between irisin and major glycemic markers, including FPG ($r = -0.419$) (P-value=0.001), HbA1c ($r = -0.528$) (P-value<0.001), and urinary albumin excretion, ($r = -0.439$) (P-value=0.001) indicating that poorer glycemic control is associated with lower irisin levels.

Shelbaya et al. (2018) (12) also, reported higher mean HbA1c levels in DN patients compared with diabetics without nephropathy, with no statistically significant difference as regard HbA1c (p=0.063) and FBS (p= 0.689) between groups, but also reported significant statistical negative correlation was found between irisin and HbA1c ($r = -0.365$) (P-value=0.048) and between irisin and FBS. ($r = -0.495$) (P-value= 0.005) in diabetic nephropathy patients.

In the present study, total cholesterol (TC) and triglyceride (TG) levels showed a clear and statistically significant upward trend across the study groups ($p < 0.001$). In our study, circulating irisin also demonstrated significant negative correlations with total cholesterol ($r = -0.473$) and triglycerides ($r = -0.604$) ($p < 0.001$). These findings reflect the well-established pattern of progressive dyslipidemia accompanying worsening glycemic control and renal involvement in T2D associated with declining irisin levels.

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These findings are comparable to those reported by **Elesawy et al. (2025) (11),** who reported a similar progressive rise in lipid parameters across different stages of albuminuria. In their cohort, Mean TC increased from 148.72 ± 14.46 mg/dL in controls to 227.24 ± 10.23 mg/dL in normo-albuminuric diabetics, 265.95 ± 11.13 mg/dL in micro-albuminuric patients, and reached 288.30 ± 57.76 mg/dL in those with macro-albuminuria. Mean TG levels followed the same pattern, rising from 120.52 ± 11.19 mg/dL in controls to 206.30 ± 18.85 mg/dL, 277.22 ± 9.45 mg/dL, and 286.69 ± 21.93 mg/dL in normo-, micro-, and macro-albuminuric diabetic subjects respectively.

The present study demonstrated a marked deterioration of renal function across the groups. Mean serum urea increased progressively from controls to diabetics without nephropathy and peaked in diabetic nephropathy patients ($p < 0.001$). Similarly, Mean serum creatinine rose from controls to diabetics and DN patients ($p < 0.001$), reflecting a progressive decline in renal function associated with diabetes severity and duration. In our study, circulating irisin also demonstrated significant negative correlations with serum urea ($r = -0.596$), serum creatinine ($r = -0.652$). ($p < 0.001$).

Hu et al. (2016) (10) found that diabetic patients with more advanced microvascular complications including nephropathy had significantly higher creatinine and blood urea nitrogen levels, accompanied by markedly lower irisin concentrations. Their results showed an inverse relationship between irisin and renal impairment markers, supporting the concept that renal dysfunction contributes to irisin decline.

In agreement with these findings, **Liu et al. (2014) (9)** demonstrated a marked reduction in circulating irisin levels among diabetic patients with renal impairment when compared with individuals maintaining preserved renal function . The reduction in irisin was most pronounced in patients with severe impairment, highlighting a clear relationship between renal decline and irisin reduction.

In this study, Mean ACR showed a significant increase across groups, being lowest in controls, higher in diabetics, and markedly elevated in diabetic nephropathy patients ($p < 0.001$). circulating irisin also demonstrated significant negative correlations with ACR ($r = -0.604$), ($p < 0.001$).

Our results are in agreement with **Khairallah et al. (2025) (14)** who showed that mean ACR values were markedly increased in diabetics compared with controls (430.12 ± 1179.31 vs. 13.64 ± 7.36 mg/g), confirming the same pattern seen in our study.

In our study, Mean eGFR declined significantly from controls to diabetics and further to diabetic nephropathy patients ($p < 0.001$). circulating irisin showed a strong positive correlation with eGFR ($r = 0.793$, $p < 0.001$), indicating higher irisin levels in association with better renal function.

This pattern is consistent with **Liu et al. (2014) (9)** who showed that patients with reduced renal function (eGFR < 60 mL/min/1.73 m²) had significantly lower serum irisin levels compared with those with preserved renal function, with the decline being most evident in advanced renal insufficiency (stage 5 CKD patients).

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Further supporting these findings, **Deng et al. (2025) (15)** reported that T2D patients with eGFR ≤ 60 mL/min/1.73 m² had lower irisin levels when compared with patients with preserved renal function, but without statistical significance.

In our study, Serum irisin levels were highest in controls, significantly reduced in diabetics, and markedly decreased in diabetic nephropathy patients ($p < 0.001$).

These findings indicate a clear inverse relationship between albuminuria severity and circulating irisin, consistent with worsening renal function and metabolic dysregulation.

Zhang et al. (2016) (16) found lower serum irisin levels in newly diagnosed T2D relative to healthy individuals, highlighting the early decline in irisin associated with metabolic dysfunction in T2DM.

Also, **Khidr et al. (2017) (17)** reported that patients with type 2 diabetes mellitus had significantly lower serum irisin levels compared with healthy controls. Furthermore, their findings showed a progressive decline in irisin concentrations with increasing albuminuria severity.

CONCLUSION

Our findings show that circulating irisin levels progressively decline with worsening diabetic nephropathy and increasing albuminuria in individuals with T2D. Lower irisin levels were strongly associated with poor glycemic control, dyslipidemia, elevated blood pressure, and impaired renal function, supporting its role as a biomarker for nephropathy severity. These findings suggest that irisin may reflect underlying metabolic and inflammatory disturbances contributing to renal injury.

RECOMMENDATION

Further longitudinal studies are needed to establish causality and to evaluate whether modulation of irisin could have therapeutic implications in the prevention or deterioration of diabetic nephropathy.

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ORIGINAL ARTICLE

DISTAL SENSORY NEUROTIZATION IN CASES WITH HIGH SCIATIC NERVE INJURY

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ABSTRACT

Background: Sciatic nerve injuries are highly disabling injuries because of lower limb muscles palsy, altered gait, and insensate foot. Early sensory recovery of the sole of the foot which is very crucial to avoid serious skin complications.

Methods: This is a prospective case series on 10 patients with sciatic nerve injuries associated with insensate foot presented between June 2023 to June 2024. Patients more than 60 years old or younger than 12 years old or with psychiatric disorders or with neuromuscular disorders were excluded from this study. Sensory transfer of distal saphenous nerve above ankle to distal tibial nerve at tarsal tunnel was done to all patients.

Results: In this study we included 10 patients with insensate sole of the foot following sciatic nerve injury with mean ± SD age 46 ± 6 years, and the body mass index 29 ± 3, of them 60% were males, and 26.7% were smokers.Sensory recovery according to medical research council grading system (MRC scale) was 4 cases S3+ , 2 cases S3 and 4 cases S2. Pain and deep touch sensation were recovered in all cases at variable degrees.

Conclusion: : Nerve transfer is a good alternative to classic nerve repair specially in large nerves in which long recovery time is expected. Distal saphenous nerve is a good donor to neurotize distal tibial nerve with hopeful optimistic results.

Keywords: Sciatic nerve injury , Nerve transfer ,Saphenous nerve.

INTRODUCTION

Sensory information provided by muscle and cutaneous afferents in the foot play a crucial rule in our ability to stand upright and maintain adequate balance. The intrinsic muscles of the foot and sensation of the glabrous skin of the sole are supplied by the tibial nerve. The tibial nerve is a mixed nerve that extends from the arcade of the soleus muscle to the calcaneal canal as it travels along the posteromedial aspect of the ankle. Distally, it bifurcates into the lateral plantar nerve and medial plantar nerve which supply the majority of the cutaneous innervation of the plan tar surface of the foot. Tibial nerve also provide motor innervation for the foot including plater flexion of the ankle and toes as well as intrinsic muscles innervation (11)

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So, Sciatic nerve injuries are highly disabling injuries because of lower limb muscles palsy, altered gait, and loss of foot sensation.(3)

Management of sciatic nerve injuries properly can strongly avoid motor and sensory disability. Complete high sciatic nerve injuries proximal to the hamstring branch can lead to difficulty with knee flexion and a flail foot caused by loss of dorsiflexion and plantar flexion. There is also loss of function of the tibialis posterior foot invertors and the peroneus longus and brevis foot evertors. Sensory loss involves the posterior thigh, lower lateral leg, and the entire foot which may lead to serious skin complications, pressure sores, infections, claw toes, and in some instances to eventual limb amputation. (2)

Burks et al described the challenges in sciatic nerve repair. Various management options including autologous nerve grafting which is the most common reconstructive technique, especially when there is a considerable gap, the sural nerve being the most common source. Direct repair can be facilitated with limb flexion or shortening procedures.(3)

Now, nerve transfers techniques are considered a good option ensuring adequate fast recovery especially after optimistic results in upper limb nerve injuries. Unfortunately, lower limb has very limited donor options suitable for transfer.(5)

Limited previous trials of sensory transfer to sole sensation, Amy M. Moore et al, described 2 staged sensory transfer to sole of the foot, 1st stage proximal saphenous nerve to sural nerve transfer followed by 2nd stage sural nerve to distal sensory tibial nerve transfer after about 18 months. she reported recovery of adequate contact surface sensation. (9)

Gordon L, et al ., described transfer of superficial peroneal nerve supplying dorsum of the foot to injured sural nerve suppling lateral border of the sole of the foot . he reported adequate recovery of resistant contact ulcer at the lateral border of the sole after recovery of sensation. (4)

Recovery of sensation or at least protective sensation of anesthetic areas supplied by damaged nerve enhances limb function and promotes healing of contact ulcers. (4)

The saphenous nerve runs posterior to the greater saphenous vein in the leg and divides into an anterior and posterior branch approximately 3 cm proximal to the tip of the medial malleolus. These branches terminate in the integument proximal to the tip of the medial malleolus, while the vein continues into the foot. The anterior branch ends at the anterior aspect of the medial malleolus near the posterior edge of the greater saphenous vein. The posterior branch ends near the posterior aspect of the medial malleolus. (4)

PATIENTS AND METHODS

This is a prospective case series on 10 patients with sciatic nerve injuries associated with insensate foot presented between June 2023 to June 2024. Sensory transfer of distal saphenous nerve above ankle to distal tibial nerve at tarsal tunnel was done to all patients. The protocol of the study was approved by IRP, Faculty of Medicine, Aswan University. Patients more than 60 years old or

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younger than 12 years old or with psychiatric disorders or with neuromuscular disorders were excluded from this study. All patients underwent full clinical neurological evaluation. Preoperative nerve conduction velocity was done to all cases .

Surgical technique

Under spinal anesthesia and the patient is in supine position, skin incision was done at the medial aspect of the distal leg extending from behind medial malleolus. Tibial nerve was identified and dissected inside tarsal tunnel. Intra-fascicular dissection till calcaneal branch start to exit from tibial nerve. This part of the tibial nerve was divided proximally for maximum length. Distal sensory saphenous nerve was identified accompanying saphenous vein, divided distally and transposed posteriorly to directly coaptate with tibial nerve.(Fig 1.1)

A tension-free direct nerve coaptation was performed under the operating microscope using 9-0 nylon micro sutures. (Fig 1.2)

Postoperative posterior slab was done to secure the repair for 3weeks. Rehabilitation protocol started after 3 weeks. Physiotherapist followed rehabilitation strategy based on the donor activation focused rehabilitation approach (DAFRA). This protocol is used to reinforce the new neural pathway altered by nerve transfer. We followed the patient at 1, 3, 6 and 12 months postoperatively. (Fig 1.3)

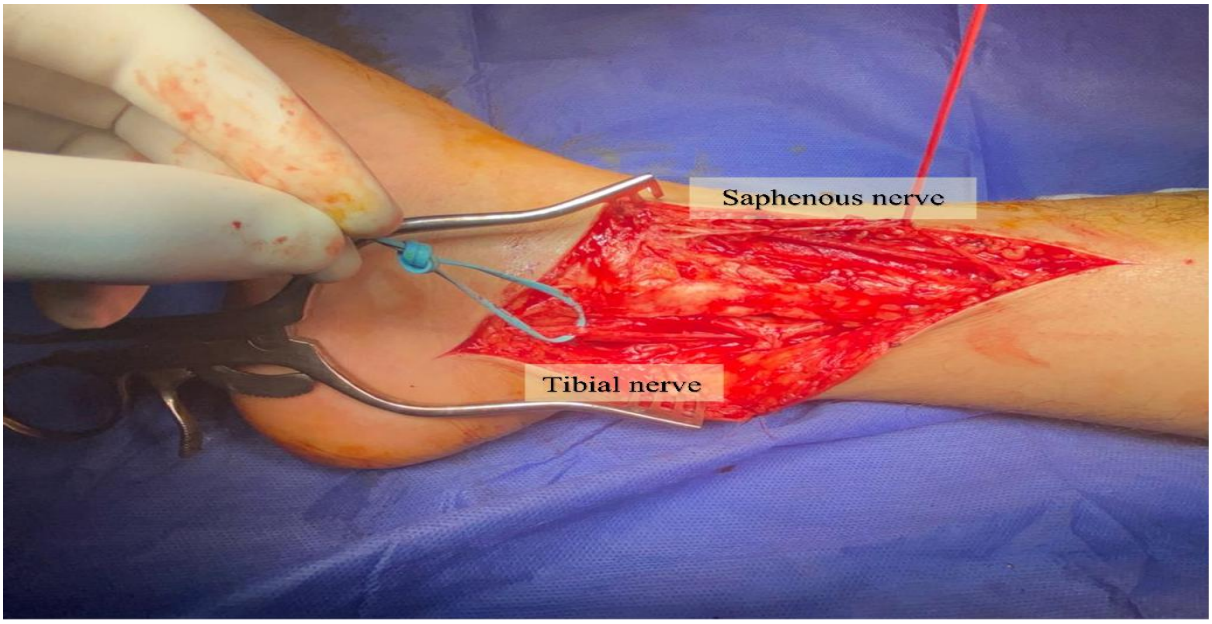

Fig (1.1) Distal incision showing saphenous nerve (donor) and distal tibial nerve (recipient)

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Fig (1.2) Direct coaptation between saphenous nerve and distal tibial nerve.

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Fig (1.3) 8 -month postoperative follow up visit showing sensory recovery of the *sole of the foot.*

(MRC grade S3+ 2PD 13mm)

(MRC grade S3 2PD 20mm)

(MRC grade S1 deep pain sensation)

Table (1) surgical outcome according to MRC grade.

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Variable	*No. of cases*	
MRC grade	4 cases S3+	Pain and touch sensation with 2PD 7-15mm
	2 cases S3	Pain and touch sensation with 2PD 15-20mm
	4 cases S2	Pain and touch sensation with no 2PD

Results

In this study we included 10 patients with insensate sole of the foot following sciatic nerve injury with mean ± SD age 46 ± 6 years, and the body mass index 29 ± 3, of them 60% were males, and 26.7% were smokers. There were 3 patients that have hypertension, and one patient with hypothyroidism, while 60 % of participants didn't have any comorbidities. Mean time passed since injury was 5± 2 months. 3 cases had high level sciatic nerve injury (buttock and proximal third thigh) while 7 cases had low sciatic nerve injury (middle and lower thirds of the thigh). Mean follow up time of the study group was 16.8± 5 months. Sensory recovery according to medical research council grading system (MRC scale) was 4 cases S3+, 2 cases S3 and 4 cases S2. Pain and deep touch sensation were recovered in all cases at variable degrees. (table 1)

DISCUSSION

Sciatic nerve injuries remain one of highly disabling lesions in lower limb. So, many different treatment modalities were used trying to ensure satisfactory recovery. According to Aydin A, et al., poor functional outcomes after sciatic nerve repair in the past are now being rapidly replaced by a more optimistic approach. Advances in microsurgery and use of treatment algorithms based on scientific research account for this significant improvement in outcomes after sciatic nerve surgery.

Kim DH et al., reported in his study which included 353 of surgically treated sciatic nerve injuries that best functional outcomes at high injuries observed after neurolysis (80%), followed by direct nerve repair(51%) then graft repair (43%). Furthermore, they concluded that high lesions have poor functional recovery than distal lesions because of the long regeneration distance.

Amy moore et al., described first clinical trial of utilizing distal femoral nerve branches as donor nerves to neurotize sciatic nerve .This study includes 2 cases managed with staged surgery of transferring (vastus medialis nerve branch VMN , vastus lateralis nerve branch VLN and saphenous nerve (SN)) to (medial gastrocnemius nerve branch MGN , lateral gastrocnemius nerve branch LGN and sural nerve ,respectively) using interposed nerve graft (7-8 cm long) followed by 2nd stage sensory transfer of sural nerve to tibial nerve at the medial ankle after about 16 months. Patients had a good functional motor and sensory recovery.

Our new technique is an innovative technique. it has the advantage of being a single stage surgery with very hopeful results. All of our cases had recovered pain and touch sensation at variable degrees. Distal saphenous nerve has nearly constant anatomical course and an adequate size

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making it a good donor option to neurotize distal sensory tibial nerve directly. Unlike Amy Moore's technique, our technique ensures early sensory recovery of the sole of the foot which is very crucial to avoid serious skin complications. Mean recovery time was 4±2 months.

This study has some potential limitations. Sample size allowed us to discuss the anatomic feasibility of this novel single stage triple neurotization efficiently but a larger sample size is needed to optimize discussion of the functional outcomes. Also, a comparative study is needed to compare our results with outcomes of ordinary sciatic nerve repair or grafting.

CONCLUSION

Nerve transfer is a good alternative to classic nerve repair specially in large nerves in which long recovery time is expected. Distal saphenous nerve is a good donor to neurotize distal tibial nerve with hopeful optimistic results

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ORIGINAL ARTICLE

Safety of Intra-Operative Aspiration for Distended Gallbladder in Laparoscopic Cholecystectomy, A pilot study

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is the standard treatment for symptomatic gallbladder disease, but distended gallbladders pose technical challenges and increase the risk of complications such as perforation and bile spillage. Intraoperative gallbladder aspiration has been proposed to reduce these risks, yet evidence regarding its safety in diverse pathological conditions remains limited. We aimed to evaluate the safety of intraoperative gallbladder aspiration in patients with distended gallbladders undergoing LC.

Methods: we included 20 patients with distended gallbladders scheduled for LC. Patients were randomly assigned to aspiration (Group A, n=10) or non-aspiration (Group B, n=10) groups. Outcomes included biliary injury, conversion to open surgery, and postoperative complications over 30 days.

Results: No significant differences were observed between groups in major safety outcomes, including biliary tree injury, conversion to open surgery, or serious postoperative complications. Gallbladder perforation occurred in both groups with comparable stone spillage (20% each) and mucus spillage (30% vs. 20%), with significant reduction in operative time in aspiration group (p-value 0.02).

Conclusion: Intraoperative gallbladder aspiration appears to be a safe technique in distended gallbladders, with a complication profile comparable to non-aspiration.

Keywords: Laparoscopic cholecystectomy, gallbladder aspiration, distended gallbladder, safety, complications.

Introduction

Laparoscopic cholecystectomy (LC) has become the gold standard treatment for symptomatic gallbladder disease, offering advantages of reduced postoperative pain, shorter hospital stay, and faster recovery compared to open surgery (1). However, the procedure is not without technical challenges, particularly when dealing with a "difficult gallbladder," a scenario often encountered with acute cholecystitis, empyema, or mucocele (2,3). A distended gallbladder presents specific difficulties in grasping, manipulating, and dissecting, potentially

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increasing the risk of complications such as gallbladder perforation, bile spillage, and stone loss (4,5). The inability to safely grasp the gallbladder wall is a key contributor to operative difficulty and can lead to iatrogenic injury (6).

Gallbladder perforation during LC occurs in a significant percentage of cases, with subsequent bile and stone spillage potentially leading to postoperative complications including surgical site infections, intra-abdominal abscesses, adhesions, and rarely, distant abscess formation or fistulae (7,8). The prevention of bile duct injury (BDI) remains the paramount concern in cholecystectomy, as it is associated with significant morbidity and long-term sequelae (9,10). In an attempt to mitigate the risks associated with a distended, tense gallbladder, intraoperative aspiration of gallbladder content has been proposed as a technical modification. This maneuver is intended to decompress the organ, thereby reducing wall tension, improving the ability to grasp the wall, and facilitating dissection of Calot's triangle (11,12). For a mucocele filled with tenacious mucus, aspiration is considered critical for safe manipulation (13).

Previous studies evaluating gallbladder aspiration have reported conflicting results. While some investigators found reduced perforation rates and operative times (7,13,14), others reported no significant benefits in routine elective cases (8). A meta-analysis by Siddiqui et al. (2011) (4) suggested that aspiration might reduce gallbladder perforation but did not translate into decreased stone loss or infection rates. More recent systematic reviews and meta-analyses have echoed these findings, indicating that while aspiration is safe, its impact on major clinical outcomes remains unclear (5,15). The procedure may be most beneficial in the context of a "difficult" or "impossible" gallbladder, potentially serving as an alternative to conversion or a bailout subtotal cholecystectomy (6,16).

The existing literature primarily focuses on elective cholecystectomy or specific conditions like mucocele. There remains a gap in evidence regarding the safety profile of aspiration specifically for distended gallbladders in a broader clinical context including various pathologies such as acute calcular cholecystitis, pyocele, and impacted stones. Furthermore, in high-risk surgical patients with acute cholecystitis, percutaneous or endoscopic gallbladder drainage is often preferred over emergency surgery (17–19), but the role of intraoperative aspiration in this population is less defined.

This pilot study aims to evaluate the safety of intraoperative gallbladder aspiration in patients with distended gallbladders undergoing LC, with particular focus on major biliary injuries, conversion rates, and postoperative complications. By providing preliminary data, this study seeks to inform the design of a larger definitive trial.

Methods

This pilot study was conducted at the General Surgery Department, Aswan University Hospital.

Patients with preoperative or intraoperative distended gallbladder (shiny, over-distended, long, difficult to grasp and manipulate) presenting for laparoscopic cholecystectomy were considered for inclusion, with no restriction on age or gender, all calcular cholecystitis (Acute or chronic), gallbladder mucocele, or gallbladder empyema.

Patients with Obstructive jaundice, non-distended gallbladder, Previous upper abdominal operations or pregnant were excluded.

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- Sample Size and Randomization

As a pilot study, 10 patients were included in each group (total N=20). Randomization was performed using computer-generated numbers placed in opaque, sequentially numbered sealed envelopes. Group allocation was disclosed to the operating surgeon by an independent nurse not involved in the study.

- **Group A:** Aspiration group (n=10)
- **Group B:** Non-aspiration group (n=10)
- Surgical Technique

All procedures were performed under general anesthesia with pneumoperitoneum at 12–14 mmHg. Standard four-port technique was used. In Group A, gallbladder aspiration was performed using a laparoscopic needle inserted through the xiphoid or right subcostal port. In Group B, no aspiration was performed. Gallbladder dissection was performed using blunt dissection and monopolar cautery. Extraction was performed through the xiphoid port.

Primary safety outcomes included: Biliary tree injury, Conversion to open surgery, Postoperative complications (wound infection, bleeding, collection, peritonitis) and 30-day mortality

- Statistical Analysis

Data were analyzed using R version 4.5.2 and SPSS version 25. Continuous variables were expressed as mean ± SD and compared using t-test or Mann–Whitney U test. Categorical variables were expressed as frequencies (%) and compared using chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant; values between 0.05 and 0.15 were noted as trends.

Results

This pilot study enrolled and analyzed 20 patients with a pre- or intra-operative diagnosis of a distended gallbladder who underwent classic laparoscopic cholecystectomy. Participants were prospectively allocated into either an aspiration group (Group A, n=10) or a non-aspiration group (Group B, n=10).

Table 1: Baseline Demographic and Clinical Characteristics

		Aspiration N=10	Non-Aspiration N=10	p-value
Age (years)		**41.5 ± 7.2**	**38.7 ± 7.8**	**0.38**
Gender (Female)		**6 (60.0%)**	**4 (40.0%)**	**0.66**
Smoker		**0 (0.0%)**	**0 (0.0%)**	**1.00**
Co-morbidities	**• DM**	**1 (10.0%)**	**0 (0.0%)**	**1.00**
	• HTN	**0 (0.0%)**	**1 (10.0%)**	**1.00**
Clinical findings	**• Positive Murfy**	**8 (80.0%)**	**10 (100.0%)**	**0.47**
	• Palpable GB	**4 (40.0%)**	**4 (40.0%)**	**1.00**
ASA classification	**• I**	**2 (20.0%)**	**3 (30.0%)**	**0.89**
	• II	**6 (60.0%)**	**5 (50.0%)**	
	• III	**2 (20.0%)**	**2 (20.0%)**	

The demographic and clinical characteristics of the two study groups were well-balanced at baseline, with no statistically significant differences observed in age, gender distribution, smoking status, comorbidities, or clinical presentation (Murphy's sign, palpable

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gallbladder). This baseline comparability between the aspiration and non-aspiration groups supports the internal validity of our pilot study, suggesting that any observed differences in intraoperative or postoperative outcomes are more likely attributable to the intervention rather than confounding patient factors. The ASA classification distribution was also similar between groups, indicating comparable anesthetic risk profiles.

Table 2: Intraoperative Outcomes

		Aspiration N=10	*Non-Aspiration N=10*	*p-value*
Operative time		***50.2 ± 6.6***	***59.9 ± 10.9***	***0.02***
Hospital stay (hours)		***20.9 ± 3.0***	***25.4 ± 4.8***	***0.02***
Distension type	***• Acute calcular***	***3 (30.0%)***	***4 (40.0%)***	***0.63***
	• Impacted stone	***4 (40.0%)***	***3 (30.0%)***	
	• Mucocele	***0 (0.0%)***	***1 (10.0%)***	
	• Pyocele	***3 (30.0%)***	***2 (20.0%)***	
Conversion to open		***0 (0.0%)***	***0 (0.0%)***	***1.00***
Intra-operative Loss of stone		***2 (20.0%)***	***2 (20.0%)***	***1.00***
Intra-operative Bleeding		***1 (10.0%)***	***1 (10.0%)***	***1.00***

There was a statistically significant reduction in operative time in the aspiration group (50.2 vs. 59.9 minutes, p=0.02), representing a mean reduction of 9.7 minutes (16.2% reduction). This supports our hypothesis that gallbladder decompression facilitates dissection and manipulation during laparoscopic cholecystectomy.

There were no conversions to open surgery in either group, and the distribution of gallbladder pathology types (acute calcular, impacted stone, mucocele, pyocele) was similar between groups. Rates of intraoperative stone loss (20% in both groups) and intraoperative bleeding (10% in both groups) were comparable. No statistically significant differences were observed in these intraoperative safety parameters.

Table 3: Intraoperative and Postoperative Complications

		Aspiration N=10	**Non-Aspiration N=10**	**p-value**
Intraoperative complications	**Biliary tree injury**	**0 (0.0%)**	**0 (0.0%)**	**1.00**
	Stone spillage	**2 (20.0%)**	**2 (20.0%)**	**1.00**
	Mucus spillage	**3 (30.0%)**	**2 (20.0%)**	**1.00**
	Drain	**10 (100.0%)**	**10 (100.0%)**	**1.00**
	Duodenal perforation	**0 (0.0%)**	**0 (0.0%)**	**1.00**
Postoperative complications	**Jaundice**	**0 (0.0%)**	**0 (0.0%)**	**1.00**
	Cholangitis	**0 (0.0%)**	**0 (0.0%)**	**1.00**
	Pancreatitis	**0 (0.0%)**	**0 (0.0%)**	**1.00**
	SSI	**1 (10.0%)**	**1 (10.0%)**	**1.00**
	bile leakage	**0 (0.0%)**	**0 (0.0%)**	**1.00**
	Hospital stay (hours)	**20.9 ± 3.0**	**25.4 ± 4.8**	**0.02**
	Readmission	**0 (0.0%)**	**0 (0.0%)**	**1.00**

The complication profile in this pilot study showed no statistically significant differences between groups for any of the measured safety outcomes. Reassuringly, there were no instances of major biliary injury, duodenal perforation, postoperative jaundice, cholangitis, pancreatitis, bile leakage, or readmissions in either group. Gallbladder perforation occurred

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with comparable rates between groups, with stone spillage occurring in 2 patients (20%) in each group and mucus spillage in 3 patients (30%) in the aspiration group versus 2 patients (20%) in the non-aspiration group.

Postoperative surgical site infection occurred in one patient in each group (10%), demonstrating comparable wound complication rates. The universal use of drains in both groups reflects our institutional protocol for distended gallbladder cases.

Hospital stay was significantly shorter in the aspiration group (20.9 vs. 25.4 hours, p=0.02), indicating potential benefits for postoperative recovery and healthcare resource utilization.

Discussion

Our pilot study involving 20 patients with distended gallbladders demonstrates that intraoperative aspiration appears to be a safe technical modification during laparoscopic cholecystectomy. The absence of major biliary injuries, conversions to open surgery, and serious postoperative complications in both aspiration and non-aspiration groups is reassuring, albeit limited by the small sample size. This safety profile is consistent with the broader literature, which confirms that aspiration is a harmless maneuver that does not introduce additional risk (5,15).

The comparable complication profiles between groups in our study align with findings from Ezer et al. (2008) (8), who reported no significant differences in gallbladder perforation, stone spillage, or wound infection rates in a larger randomized trial of 160 elective cases. However, our findings contrast with those of Calik et al. (2007)(7), who demonstrated significantly reduced gallbladder perforation rates (7% vs. 26%, p=0.0003) but was similar regrading operative times. This discrepancy may be explained by differences in patient populations; while our study specifically enrolled patients with distended gallbladders, Calik et al.'s study included a broader range of elective cases where the benefits of aspiration might be more pronounced in the subset with gallbladder distension. Other studies, such as that by Bhandari et al. (2014) (2), have also reported benefits of aspiration specifically in the context of difficult laparoscopic cholecystectomy, supporting the notion that patient selection is key.

The 30% gallbladder perforation rate in our aspiration group is higher than the 16.3% reported by Ezer et al. (2008) (8) but comparable to the baseline rates in distended gallbladder populations described elsewhere. This suggests that while aspiration may offer benefits, it does not completely eliminate the risk of perforation in technically challenging cases. Importantly, the comparable rates of stone spillage (20% in both groups) suggest that when perforation does occur in aspirated gallbladders, it may not necessarily result in more extensive spillage, though our study was not powered to detect such differences. Sajid et al. (2008) similarly found no significant difference in stone spillage rates in their study (14).

Our findings regarding the safety of aspiration in various gallbladder pathologies (acute calcular, impacted stone, mucocele, pyocele) extend the evidence from Shirah et al. (2018), who specifically demonstrated benefits of aspiration in gallbladder mucocele (13). Their study of 57 patients showed significantly reduced morbidity (0% vs. 16.2%, p=0.02) and shorter hospital stays with aspiration. They concluded that "collapsing of the gallbladder wall was a keystone in the non-complicated laparoscopic procedure," a finding that directly supports the rationale for our intervention. In the context of gallbladder empyema, achieving decompression

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may be particularly valuable in reducing the inflammatory burden and facilitating dissection (3).

The absence of any biliary tree injuries in both groups is particularly noteworthy given that distended gallbladders are often considered more technically challenging. Prevention of BDI remains the central goal of safe cholecystectomy (9). Maneuvers that improve exposure of the critical view of safety, such as gallbladder decompression, are therefore valuable (16). While aspiration is a simpler technique compared to a bailout subtotal cholecystectomy, it may serve a similar purpose in selected patients by creating a less hazardous field (6). Our findings align with the safety profile established in the meta-analysis by Siddiqui et al. (2011), which concluded that safety of aspiration in mucocele (4). The more recent meta-analysis by Kumar et al. (2021) corroborates this, showing no increase in operative time or complications with aspiration (5).

Our study's limitations include the small sample size inherent to its pilot design, which limits statistical power to detect differences in complication rates. The single-center design and short-term follow-up may also limit generalizability and miss late complications. Furthermore, we did not stratify patients by gallbladder pathology or degree of distension, which may have influenced the outcomes. Larger, multicenter studies with standardized definitions of "distended gallbladder" and longer follow-up are needed to definitively establish the role of this technique.

Conclusion:

This pilot study provides preliminary evidence that intraoperative aspiration of distended gallbladder during laparoscopic cholecystectomy appears to be a safe technique, with comparable complication profiles to the non-aspiration approach. While no significant differences were observed in major safety outcomes, the absence of biliary injuries, conversions, and serious complications in both groups is reassuring.

Future research should focus on larger multicenter randomized trials with longer follow-up to definitively establish the safety and efficacy of this technique across different gallbladder pathologies and surgeon experience levels.

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ORIGINAL ARTICLE

Dynamic Hematological Shifts Before and After Hemodialysis: Correlation Analysis and Clinical Implications

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ABSTRACT

Background: Hemodialysis induces acute hematological alterations; however, intra-session stability of parameters and their prognostic relevance remain incompletely defined.

Methods: This cross-sectional study included 200 end-stage renal disease patients undergoing maintenance hemodialysis. Paired pre- and post-dialysis measurements were obtained for mean corpuscular volume (MCV), platelet count, total white blood cell count, neutrophil count, lymphocyte count, and neutrophil-to-lymphocyte ratio (NLR). Clinical data included bleeding time, heparin use, vascular access type, left ventricular ejection fraction (LVEF), and mortality outcomes. Logistic regression was used to identify mortality predictors.

Results: Significant post-dialysis reductions were observed in platelet, WBC, neutrophil, and lymphocyte counts, while NLR remained stable. MCV demonstrated the highest stability ($r = 0.852$, $R^2 = 0.726$). neutrophil count showed the greatest variability. Bleeding time was prolonged , did not differ significantly between patients with and without bleeding history ($p = 0.612$). Heparin use was associated with fewer bleeding events, ($p < 0.001$). Overall mortality was 22%, predominantly cardiovascular and infectious.

Conclusion: : MCV and NLR are stable during hemodialysis, whereas neutrophil count is more time-sensitive. LVEF and NLR are simple independent predictors of mortality, supporting their use in risk stratification.

Keywords: chronic kidney disease; neutrophil-to-lymphocyte ratio; mortality; hematological variability.

Introduction

Chronic kidney disease (CKD) represents a major global public health problem characterized by progressive and irreversible decline in renal function.[1] The global burden of CKD is substantial, affecting approximately 8–10% of the adult population, with a higher prevalence in developing countries.[2] In Egypt, CKD has emerged as a leading cause of mortality, with its overall burden increasing markedly in recent years.[3]

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Hematological abnormalities are highly prevalent among patients with advanced CKD, particularly those receiving maintenance hemodialysis. Among these complications, anemia is the most common and clinically important disorder.[4,5] The pathogenesis of anemia in CKD is multifactorial, primarily driven by reduced erythropoietin production, iron deficiency, chronic inflammation, and uremic toxin accumulation.[6,8] Additional mechanisms include impaired iron utilization due to elevated hepcidin, bone marrow suppression, shortened red blood cell survival, and chronic blood loss associated with dialysis procedures and repeated venipuncture.[6,9,10].

Beyond anemia, CKD is associated with complex hematological alterations driven by chronic inflammation, malnutrition, and accelerated atherosclerosis, resulting in neutrophilia, lymphopenia, and immune dysregulation.[11] This has increased interest in the neutrophil-to-lymphocyte ratio (NLR) as a simple inflammatory marker.[12] Elevated NLR has been linked to increased mortality in cardiovascular disease.[13]

Platelet dysfunction and thrombocytopenia are also frequently observed in CKD, particularly in patients exposed to less biocompatible dialysis membranes.[14] Importantly, bleeding tendency in CKD is not fully explained by platelet count alone, as qualitative platelet dysfunction plays a major role.[15]

Hemodialysis itself induces acute hematological changes due to blood-membrane interaction, mechanical stress, and anticoagulation[16,17,18] .

Despite these known effects, the intra-dialytic stability of hematological parameters and their relationship with clinical outcomes remain insufficiently characterized. Therefore, this study aimed to evaluate intra-session hematological variability, bleeding risk indicators, heparin-associated bleeding patterns, and independent predictors of mortality in hemodialysis patients.

Patients and Methods

Study Design and Setting

This cross-sectional study was conducted in the hemodialysis unit of Aswan University Hospital, Aswan, Egypt, from December 2023 to June 2025.

Patients

A total of 200 adult patients diagnosed with end-stage renal disease (ESRD) and receiving regular hemodialysis were enrolled in the study.

Inclusion criteria

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Patients aged ≥18 years who had been undergoing maintenance hemodialysis (MHD) for at least three consecutive months were eligible for participation, regardless of sex.

Exclusion criteria

Patients were excluded if they were pregnant or breastfeeding, or had polycystic kidney disease, autoimmune disorders, malignancy, inherited or acquired hematological diseases, acute or chronic inflammatory conditions, connective tissue disorders, clinically significant dehydration, or a recent history of hemorrhagic events. These criteria were applied to minimize potential confounding factors that could independently affect hematological parameters.

Data Collection

Demographic and clinical data were systematically collected for each participant. Recorded variables included age, sex, body weight, primary etiology of chronic kidney disease, current medications, type of vascular access used for dialysis, history of previous bleeding episodes, administration of heparin during dialysis sessions, symptoms suggestive of anemia (such as cognitive impairment and decreased exercise tolerance), survival status, and documented cause of death when applicable.

Laboratory and Clinical Assessments

All laboratory investigations were performed in the Clinical Pathology Department of Aswan University Hospital using standardized laboratory procedures and quality control protocols.

Hematological parameters

Complete blood count (CBC) analysis was performed using an automated hematology analyzer. Paired venous blood samples were obtained immediately before initiation of hemodialysis (pre-dialysis) and immediately after completion of a single dialysis session (post-dialysis).

The following hematological indices were measured: mean corpuscular volume (MCV), platelet count, total white blood cell (WBC) count, neutrophil count, lymphocyte count, and neutrophil-to-lymphocyte ratio (NLR).

Bleeding time

Bleeding time was measured using the standardized template method in accordance with established clinical guidelines and laboratory protocols.

Renal and mineral metabolism markers

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Serum creatinine, blood urea nitrogen (BUN), parathyroid hormone (PTH), serum calcium, and serum phosphate levels were measured using routine laboratory methods based on standardized analytical techniques.

Echocardiography

Transthoracic echocardiography was performed for all participants to evaluate left ventricular ejection fraction (EF) and to assess the presence and severity of left ventricular hypertrophy (LVH).

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 29 (SPSS Inc., Chicago, IL, USA). The normality of continuous variables was assessed using both the Kolmogorov–Smirnov test and the Shapiro–Wilk test.

The following statistical methods were applied:

- Paired t-tests were used to compare pre-dialysis and post-dialysis measurements of platelet count, total WBC count, neutrophil count, lymphocyte count, and NLR.
- Pearson correlation analysis was performed to assess relationships between serum creatinine and other study variables, as well as correlations between pre-dialysis and post-dialysis hematological parameters. The coefficient of determination (R^2) was derived from correlation coefficients.
- The Mann–Whitney U test was used to compare bleeding time between patients with and without a history of bleeding.
- The chi-square test was applied to compare bleeding rates between patients who received heparin and those who did not receive anticoagulation.
- Mortality predictors were evaluated using univariate and multivariate logistic regression analyses. Variables with $p < 0.10$ in univariate analysis were entered into multivariate models. Results are reported as odds ratios (OR) and adjusted odds ratios (AOR) with corresponding 95% confidence intervals (CI).
- A p-value < 0.05 was considered statistically significant. All tests were two-tailed.

Ethical Considerations

The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Aswan University, Egypt (Approval No. Asw.uni./523/3/21). Written informed consent was obtained from all participants prior to enrollment. Strict confidentiality and data pr

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Discussion

Baseline Cohort Summary

A total of 200 adult patients receiving regular hemodialysis were enrolled in the study. The mean age of the cohort was 49.68 ± 15.535 years, with an approximately equal sex distribution and a slight predominance of females (50.5% female vs. 49.5% male). Body weight ranged widely from 15 to 130 kg, with a mean value of 70.43 ± 17.28 kg. Hypertension represented the most common underlying cause of chronic kidney disease, accounting for 59% of cases, followed by idiopathic causes (17%) and diabetes mellitus (14%) (Table 1).

Regarding vascular access, arteriovenous (AV) shunts constituted the predominant modality, used in 93% of patients, while temporary catheters and permanent catheters were used in 6.5% and 0.5% of patients, respectively. A prior history of clinically significant bleeding was documented in 19% of participants. The majority of patients (98%) received heparin anticoagulation during dialysis sessions. The overall mortality rate during the study period was 22%.

Correlation Between Serum Creatinine and Other Parameters

Serum creatinine demonstrated statistically significant positive correlations with blood urea nitrogen ($r = 0.290$, $p < 0.001$), parathyroid hormone ($r = 0.208$, $p = 0.003$), and pre-dialysis mean corpuscular volume (MCV) ($r = 0.184$, $p = 0.009$). In contrast, a significant inverse correlation was observed between serum creatinine and serum calcium ($r = -0.268$, $p < 0.001$) (Table 2).

The positive associations with blood urea nitrogen and parathyroid hormone are physiologically consistent with progressive renal dysfunction. The inverse relationship with serum calcium likely reflects hypocalcemia secondary to reduced calcitriol synthesis in advanced CKD. However, the modest strength of these correlations suggests that serum creatinine alone is insufficient to predict these biochemical disturbances, which are likely influenced by additional factors including systemic inflammation, nutritional status, mineral–bone disorder, and dialysis adequacy.

Dynamic Changes Across a Single Dialysis Session

Significant reductions were observed in platelet count, total white blood cell count, neutrophil count, and lymphocyte count following a single hemodialysis session. In contrast, the neutrophil-to-lymphocyte ratio (NLR) remained stable, with no statistically significant difference between pre-dialysis and post-dialysis measurements (Table 3).

The stability of NLR despite simultaneous reductions in neutrophil and lymphocyte counts suggests proportional changes in both cell populations, preserving the ratio. This relative stability supports the reliability of NLR as an inflammatory biomarker that can be measured either pre- or post-dialysis without materially affecting clinical interpretation.

Bleeding Time and Clinical Bleeding

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Bleeding time was markedly prolonged in the study cohort, with a median duration of 35 minutes (interquartile range [IQR]: 20–50.75). When stratified by bleeding history, no statistically significant difference was observed between patients with and without prior bleeding episodes. Specifically, median bleeding time was 32.5 minutes (IQR: 20–45) in patients with a documented bleeding history compared with 35 minutes (IQR: 20–52) in those without such history ($p = 0.612$) (Table 4).

Although bleeding time was frequently prolonged in uremic patients, it failed to discriminate individuals with a clinical history of bleeding. This finding suggests that bleeding time has limited predictive value in this population, and that detailed clinical history remains more informative for bleeding risk assessment in hemodialysis patients.

Heparin Administration During Dialysis

Heparin administration during dialysis was associated with a significantly lower frequency of bleeding events. Specifically, 17.3% of patients receiving heparin experienced bleeding complications, whereas 100% of patients not receiving heparin developed bleeding episodes ($p < 0.001$) (Table 5).

Although this result appears paradoxical given the anticoagulant properties of heparin, it is most likely explained by confounding by indication. Patients in whom heparin was withheld likely had a higher baseline bleeding risk, including active hemorrhage, recent major bleeding, or severe thrombocytopenia. Thus, the observed higher bleeding rate in the non-heparin group reflects underlying clinical severity rather than a protective effect of heparin. Overall, these findings support the safety of heparin use when appropriately indicated in hemodialysis patients.

Access Type and Infection Risk

To evaluate inflammatory burden according to vascular access type, neutrophil-to-lymphocyte ratio (NLR) and total white blood cell (WBC) counts were compared among patients using arteriovenous (AV) shunts, temporary catheters, and permanent catheters.

NLR was significantly higher in patients with permanent catheters compared with those using temporary catheters and AV shunts (4.69 [4.69–4.69] vs. 2.89 [2.41–4.77] and 2.26 [1.45–3.16], respectively; $p = 0.049$). In contrast, total WBC count showed no significant difference across access groups ($p = 0.634$) (Table 6).

The elevated NLR observed in permanent catheter users suggests increased inflammatory burden, potentially reflecting subclinical infection, chronic immune activation, or biofilm formation. These findings are consistent with the known association between central venous catheters and increased risk of bloodstream infection.

Stability Hierarchy of Hematological Parameters

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Scatter plot analyses comparing pre-dialysis and post-dialysis values for six hematological parameters demonstrated statistically significant correlations for all variables ($p < 0.001$), with varying degrees of stability.

Top of the Hierarchy: MCV (Figure 1A)

Mean corpuscular volume (MCV) demonstrated the strongest correlation ($r = 0.852$, $R^2 = 0.726$), with minimal dispersion. This reflects its intrinsic stability as a red blood cell index unaffected by acute dialysis-related physiological changes.

Middle of the Hierarchy: Platelets and WBC Counts (Figures 1B and 1C)

Platelet count ($r = 0.629$, $R^2 = 0.396$) and total WBC count ($r = 0.628$, $R^2 = 0.394$) showed moderate stability. Both parameters are influenced by cellular activation and transient sequestration during dialysis, supporting the preference for pre-dialysis sampling in clinical assessment.

The Unique Case: NLR (Figure 1D)

NLR demonstrated intermediate stability ($r = 0.583$, $R^2 = 0.340$). Importantly, it was more stable than its individual components—lymphocytes ($R^2 = 0.325$) and neutrophils ($R^2 = 0.316$)—likely due to proportional reductions in both cell lines during dialysis.

Bottom of the Hierarchy: Lymphocytes and Neutrophils (Figures 1E and 1F)

Lymphocytes ($r = 0.570$, $R^2 = 0.325$) and neutrophils ($r = 0.562$, $R^2 = 0.316$) exhibited the lowest stability, with neutrophils identified as the most variable parameter. This variability is consistent with complement activation and transient pulmonary sequestration during dialysis, supporting pre-dialysis sampling for accurate interpretation.

Mortality Predictors and Clinical Outcomes

The overall mortality rate was 22% (44/200 patients). Cardiovascular disease was the leading cause of death (40.9%, n = 18), followed by septic shock (13.6%, n = 6), infective endocarditis (11.4%, n = 5), pneumonia (9.1%, n = 4), and cerebrovascular events (6.8%, n = 3) (Table 8).

Overview and Novel Contributions

This study provides a comprehensive evaluation of acute hematological changes during hemodialysis in a cohort of 200 patients with end-stage renal disease (ESRD). Beyond confirming known short-term hematological alterations, the study introduces a **practical stability hierarchy of blood parameters**, offering clinically relevant guidance for laboratory timing and interpretation in routine hemodialysis practice.

Baseline Hematological Profile and Clinical Context

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The cohort demonstrated a high prevalence of anemia (92.5%), predominantly normocytic normochromic, consistent with CKD pathophysiology driven by reduced erythropoietin production and chronic inflammation.[19] Elevated serum ferritin with low-normal iron indices supported functional iron deficiency in inflammatory states.[20] Secondary hyperparathyroidism and hyperphosphatemia were also highly prevalent, reflecting the significant burden of mineral and bone disorder in ESRD and highlighting the complex hematologic–metabolic derangements in maintenance hemodialysis patients.

Dynamic Hematological Shifts and Stability Hierarchy

Hemodialysis induced significant reductions in platelet count, WBC count, neutrophils, and lymphocytes, consistent with prior studies.[16,17] These changes are attributed to cellular activation, membrane interaction, complement activation, and transient sequestration in pulmonary and splenic circulation.[16,18,21] Hemoglobin and mean corpuscular volume (MCV) showed modest post-dialysis increases, likely reflecting hemoconcentration due to ultrafiltration.

A key contribution of this work is the **stability hierarchy of hematological parameters**. MCV demonstrated the highest stability with minimal intra-dialytic variation, supporting reliable interpretation regardless of sampling time. In contrast, neutrophil count showed the greatest variability, suggesting post-dialysis values may not reflect baseline inflammatory status. Platelet count and total WBC count exhibited intermediate stability, supporting preferential pre-dialysis sampling when evaluating thrombocytopenia or infection.

Neutrophil-to-Lymphocyte Ratio (NLR) as a Biomarker

Despite significant reductions in neutrophils and lymphocytes, the neutrophil-to-lymphocyte ratio (NLR) remained stable across dialysis sessions. This reflects proportional declines in both cell populations, preserving the ratio despite absolute changes. These findings support NLR as a **robust and practical inflammatory biomarker**, consistent with prior evidence linking elevated NLR to systemic inflammation and adverse outcomes in CKD.[12,13,22] Its stability is particularly valuable in routine clinical settings where sampling timing may vary.

Bleeding Risk and Heparin Use

Patients exhibited prolonged bleeding time consistent with uremic platelet dysfunction.[23,24] However, bleeding time did not differ significantly between patients with and without prior bleeding history, indicating limited predictive value for clinical bleeding risk. Clinical assessment remains essential, incorporating vascular access type, anticoagulation, and anemia severity.[25]

Heparin use was associated with a lower incidence of bleeding (17.3% vs. 100%, $p < 0.001$). This paradox is most likely explained by **confounding by indication**, as patients not receiving heparin

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had higher baseline bleeding risk. These findings support the safety of heparin when appropriately indicated.

Vascular Access and Inflammatory Burden

Patients with permanent catheters showed higher NLR compared with those using temporary catheters and AV shunts (4.69 [4.69–4.69] vs. 2.89 [2.41–4.77] and 2.26 [1.45–3.16], p = 0.049), while WBC count did not differ significantly (p = 0.634). This suggests increased inflammatory burden in catheter-dependent patients, likely due to subclinical infection, biofilm formation, or chronic foreign-body response. These findings support preference for AV fistulas due to lower infectious and inflammatory complications.

Independent Predictors of Mortality

The overall mortality rate was 22%, with cardiovascular disease (40.9%) and infections (34.1%) as leading causes of death, reflecting combined cardiovascular and immune dysfunction burden in ESRD.[13,26]

Multivariate analysis identified **reduced left ventricular ejection fraction (<50%)** and **elevated NLR (>4)** as independent predictors of mortality, emphasizing the central role of cardiac dysfunction and systemic inflammation in survival outcomes. Anemia-related variables and leukocyte abnormalities were not independently associated with mortality, suggesting that inflammation and cardiac dysfunction are stronger prognostic determinants than hemoglobin levels. This aligns with concerns regarding overly aggressive anemia correction using erythropoiesis-stimulating agents.[27]

Strengths and Limitations

Strengths include a relatively large sample size, paired pre-/post-dialysis measurements enabling dynamic assessment, and comprehensive evaluation of clinical variables, including mortality predictors. Limitations include the single-center design, limiting generalizability; cross-sectional elements limiting causal inference; and inherent variability and limited reproducibility of bleeding time.

Conclusion

MCV and NLR are the most stable hematological markers during hemodialysis, while neutrophils show the highest variability and should be measured pre-dialysis. Bleeding time has limited clinical predictive value. Reduced left ventricular ejection fraction and elevated NLR are independent predictors of mortality.

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Table 1: Baseline characteristics and causes of chronic kidney disease among hemodialysis patients (n = 200)

Parameter	Category	Number	Percentage (%)
Age (years)	**Mean ± SD**	**49.68 ± 15.535**	
Gender	**Male**	**99**	**49.5%**
	Female	**101**	**50.5%**
Weight (Kg)	**Mean ± SD**	**70.43 ± 17.28**	
Causes of CKD	**Diabetes Mellitus**	**28**	**14%**
	Hypertension	**118**	**59%**
	Idiopathic	**34**	**17%**
	Glomerulonephritis	**10**	**5%**
	Obstructive uropathy	**9**	**4.5%**
	Analgesics overuse	**8**	**4%**
	Congenital	**8**	**4%**
	Pyelonephritis	**6**	**3%**
Medication	**Anti-hypertensive**	**98**	**49%**
	Anti-hypertensive and anti-diabetic	**20**	**10%**
	NSAIDs	**8**	**4%**
	Anti-diabetics	**7**	**3.5%**
	Anti-ischemic	**2**	**1%**
	Anti-asthmatics	**1**	**0.5%**
	Addiction	**1**	**0.5%**

Table 2: Pearson correlation between serum creatinine and hematological parameters

Parameter	r	p-value
Blood urea (mg/dL)	**0.290**	**<0.001**
Serum calcium (mg/dL)	**-0.268**	**<0.001**
Parathyroid hormone (pg/mL)	**0.208**	**0.003**
MCV pre-dialysis (fL)	**0.184**	**0.009**

Table 3: Comparison of hematological parameters before and after hemodialysis

Parameter	Pre-dialysis (Mean ± SD)	Post-dialysis (Mean ± SD)	p-value
Hemoglobin (g/dL)	**9.59 ± 1.77**	**10.015 ± 2.09**	**<0.001**
MCV (fL)	**84.24 ± 7.97**	**84.94 ± 7.77**	**0.022**
Platelets (×10³/µL)	**234.86 ± 75.012**	**220.089 ± 78.18**	**0.001**
WBCs (×10³/µL)	**7.103 ± 2.714**	**6.28 ± 2.71**	**<0.001**

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Neutrophils (×10³/µL)	**4.14 ± 2.06**	**3.67 ± 2.37**	**0.002**
Lymphocytes (×10³/µL)	**1.84 ± 1.123**	**1.56 ± 0.74**	**<0.001**
NLR	**2.56 ± 1.58**	**2.79 ± 2.65**	**0.126**

Table 4: Bleeding time comparison between patients with and without history of bleeding

Group	n	Median bleeding time (minutes)	IQR	p-value
History of bleeding	**38**	**32.5**	**20-45**	**0.612**
No history of bleeding	**162**	**35**	**20-52**	

Table 5: Association between heparin administration and bleeding

Heparin administration	Bleeding (n, %)	No bleeding (n, %)	p-value
Yes (n = 196)	**34 (17.3%)**	**162 (82.7%)**	**<0.001**
No (n = 4)	**4 (100%)**	**0 (0%)**	

Table 6: Relation between type of access and infection

Type of access	WBC count (normal)	WBC count (leucopenia)	WBC count (leukocytosis)	NLR post-dialysis (median [IQR])
AV shunt (n = 186)	**152 (81.7%)**	**18 (9.7%)**	**16 (8.6%)**	**2.26 [1.45-3.16]**
Temporary catheter (n = 13)	**9 (69.2%)**	**3 (23.1%)**	**1 (7.7%)**	**2.89 [2.41-4.77]**
Permanent catheter (n = 1)	**1 (100%)**	**0 (0%)**	**0 (0%)**	**4.69 [4.69-4.69]**
p-value	**0.634**	**0.634**	**0.634**	**0.049***

*Significant; NLR: Neutrophil-lymphocyte ratio parameters (Table 7).

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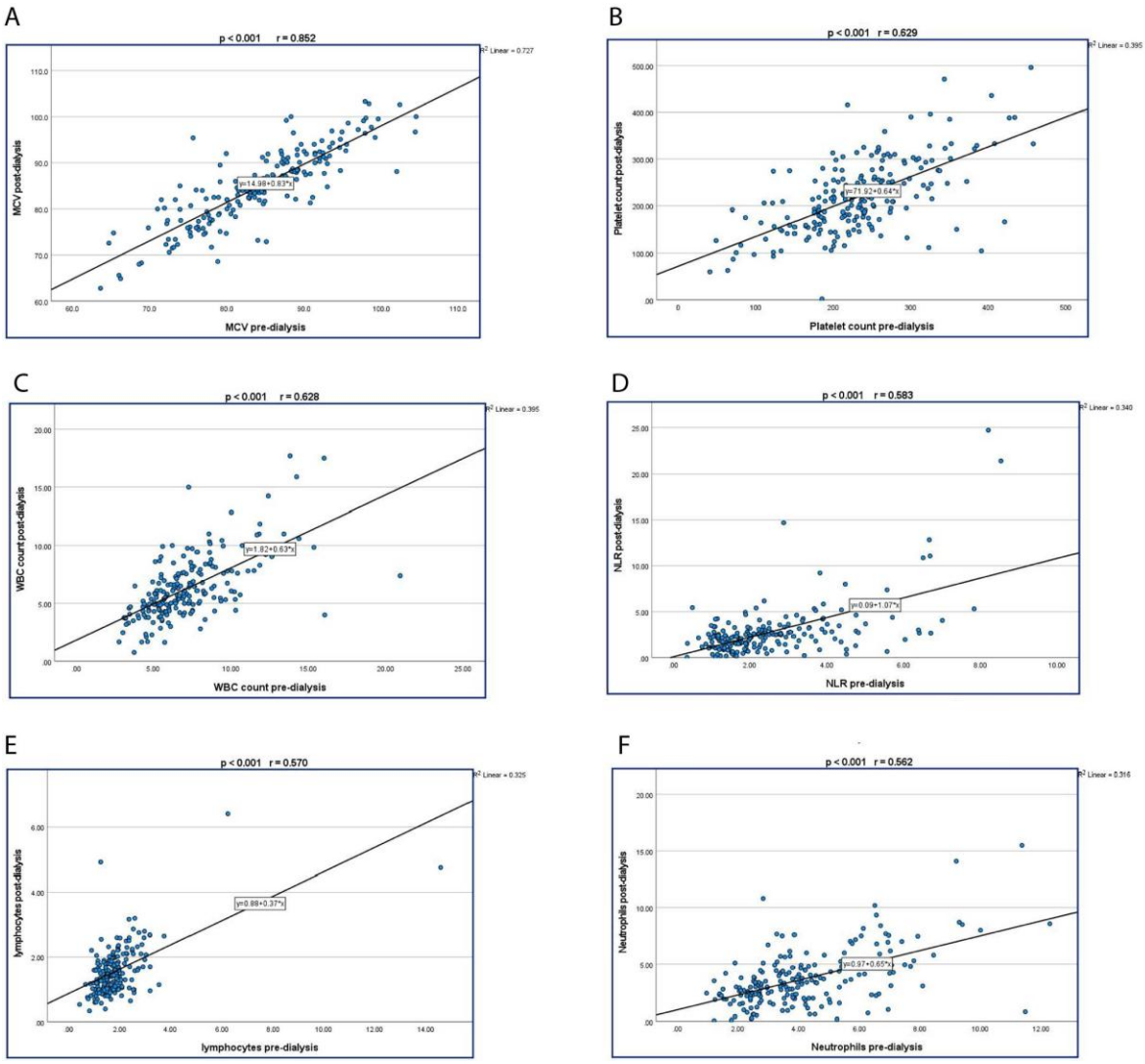

Figure 1 A–F: Pre- versus post-dialysis correlations for six hematological parameters

Scatter plots (pre- vs. post-dialysis) for MCV (A), platelets (B), WBC (C), NLR (D), lymphocytes (E), and neutrophils (F) in 200 hemodialysis patients. All correlations $p < 0.001$. Stability hierarchy: MCV > platelets ≈ WBC > NLR > lymphocytes > neutrophils.

Table 8: Causes of death among hemodialysis patients

Cause of death	n	Percentage (%)
Cardiovascular diseases	**18**	**40.9%**
Septic shock	**6**	**13.6%**

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Infective endocarditis	**5**	**11.4%**
Pneumonia	**4**	**9.1%**
Pulmonary edema	**3**	**6.8%**
Cerebral hemorrhage or stroke	**3**	**6.8%**
Pulmonary embolism	**2**	**4.5%**
Melena and shock	**2**	**4.5%**
Rupture shunt	**1**	**2.3%**

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ORIGINAL ARTICLE

Clinical and Functional Outcomes of Unreamed Intramedullary Nailing for Open Diaphyseal Long-Bone Fractures in Adults: A Prospective Single-Center Study

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ABSTRACT

Background and aim: Open fractures of long bones pose challenges due to soft tissue injury, infection risk, and nonunion. This study assessed unreamed intramedullary nailing for Gustilo-Anderson type I and II tibial and femoral shaft fractures, aiming for healed, pain-free weight-bearing, well-aligned fractures, and functional knee/ankle motion.

Methods: Prospective study of 30 patients treated at Aswan University Hospitals (March 2024–2025) with type I/II open diaphyseal femur/tibia fractures undergoing unreamed nailing. Outcomes included time to partial weight-bearing (days), union (months), foot-floor contact (days), and functional recovery via Olerud-Molander and Thorsen scores at 12 months.

Results: Mean age was 31.4 years (86.7% male); most were mid-shaft fractures. Partial weight-bearing averaged 22.9 days: union, 3.3 months. Functional scores showed good-to-excellent recovery. Complications: nonunion (13.3%), infection (3.3%); no implant failures.

Conclusion: Unreamed nailing yields reliable union, minimal complications, and satisfactory function, supporting its use as first-line treatment for these fractures.

Keywords: Open long-bone fractures; Unreamed intramedullary nailing; Gustilo–Anderson type I and II; Tibial and femoral shaft fractures; Fracture union and functional outcome

Introduction

Open fracture is a type of bone break where the broken bone penetrates the soft tissue like the muscles, skin, and other connective tissues, increasing the risk of contamination and infection. The skin doesn't have to be directly over the fracture; it could be expressed at any site distant to it. So, any fraction with a wound is treated as an open fracture until proven otherwise. Open

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fractures happen because of trauma. They happen due to high-energy injuries, low-velocity trauma when the sharp ends of the fractured bones penetrate through the skin. Open fractures are associated with life-threatening complications such as neurovascular injuries, soft tissue crushing, wound contamination and skin deglove. **(1) (2)**

Open fractures represent 2.6% of all fractures, mostly in the lower limb and especially the tibia. Tibia and femur represent 98% of all open long bone fractures, mostly from high-energy trauma like motor-vehicle crashes or explosions. A five-year retrospective cohort study showed out of 138 openly fractured bones, 84.8% happened in men. The mean age of patients was 25.6 ± 15.6 years. Injuries of the lower extremities were the most common 76.8%. Among them, Injuries of the forefoot were the most common 31.2%. The foreman was the most likely to be injured in the upper limbs 10.2%. Many fractures happened due to motorbike accidents, 28.47%, followed by motor vehicle accidents 27.01% and falling from a height because of suicide or work-related risks 18.96%. Gustilo-Anderson type II was the most common type of fracture, which happened in 59.1% of the patients. **(3–5)**

The management of open fractures requires systemic manners to prevent infection and ensure optimal bone union and recovery. The treatment begins with intravenous antibiotic administration, within 1–3 hours of injury. Gustilo-Anderson Type I and II fractures are treated with First-generation cephalosporins, while Type III fractures require additional gram-negative coverage with aminoglycosides or broad-spectrum medications. Many surficial procedures are used for open fractures including intramedullary nailing (both reamed and unreamed), external fixation, and plate fixation, depending on fracture severity, soft tissue condition, and associated injuries. **(6–8)**

Unreamed nailing is recommended for open fractures with compromised soft tissues as it reduces endosteal disruption and shortens operative time with less blood loss. Reamed nailing is accompanied by stronger fixation, faster bone healing, but more surgical time and heat generation and potentially higher initial infection risk. **(5,9,10)**

An Indian observational study showed proper union, reduced complications, and satisfactory functional outcomes across different Gustilo-Anderson types of patients treated with unreamed interlocking nails. Intra-medullary nailing is considered as the preferred method for most open fractures, especially Type I-IIIA. **(11,12)**

We therefore aimed to assess the effects of unreamed nailing in open type I and type II Tibia and Femur shaft fractures to obtain a healed, pain-free weight-bearing, well-aligned fracture, and functional range of motion of the knee and ankle joints.

Methods

This is a prospective study conducted in Aswan university Hospitals, Faculty of Medicine Aswan University from March 2024 and March 2025 to assess the effects of unreamed

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intramedullary nailing in patients presenting with open type I and type II tibia and femur shaft fractures following our inclusion criteria.

Patients were eligible for inclusion if they were older than 18 years and had open diaphyseal fractures of the femur or tibia classified as Gustilo–Anderson type I or II. Patients were excluded if they had closed fractures, open diaphyseal fractures classified as Gustilo–Anderson type III, pathological fractures, or non-diaphyseal fractures. Additional exclusion criteria included a history of previous bony surgery involving the same femur or tibia, the presence of a stiff knee, coagulation disorders, or associated head injuries.

Fracture Classification

Fractures were classified according Tscherne classification for Closed tibial fractures **(13)** and Gustilo and Anderson classification and for open tibial fractures **(14).** AO/OTA Classification was used for the both groups.

In closed tibial fractures group (15 cases): (6) cases of (C 0), (6) cases of (C 1), (3) cases of (C 2) according to Tscherne classification. (9) cases type A simple fractures, (3) cases type B wedge fractures, (3) cases type C complex fractures according to AO/OTA Classification. Out of the 15 cases: (3) cases were due to motor car accident, (2) cases due to motorbike accidents, (2) cases were due to fall from height, (3) cases were due to direct trauma and (5) cases were due to sports injury.

In Open tibial fractures group (5 cases): type I (3) cases and type II (2) cases according to Gustilo and Anderson classification, (4) cases type A simple fractures and (1) case type C complex segmental fracture according to AO/OTA Classification. Out of the 5 cases: (3) cases were due to motor car accident and (2) cases were due to motorbike accidents.

Preoperative Management

All patients underwent evaluations, including medical history taking and physical examination. Sterile wound coverage and initial stabilization were performed. Time from injury to the surgical procedure ranged from eight to twenty-four hours. We take plain lateral and anteroposterior radiographs that cover the ankle and knee. Radiographs taken at a 45-degree angle may be necessary to identify a non-displaced spiral fracture in certain cases.

Surgical Technique for Tibial Fractures

Patients with tibial fractures were positioned supine on a fracture table with the affected knee flexed. A longitudinal incision was made from the inferior pole of the patella to the tibial tubercle. Nail length and diameter were determined preoperatively, with 9–10 mm being the most common diameters. The entry point was located approximately 2 cm anterior to the tibial plateau, and the metaphysis was reamed to a depth of 6–8 cm. Nail diameter was selected based on the narrowest diaphyseal diameter on AP and lateral radiographs. A guide wire was advanced under fluoroscopic guidance, followed by insertion of the unreamed nail over the guide wire.

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Surgical Technique for Femoral fractures

Patients with femoral fractures were treated using antegrade nailing with the patient positioned supine on a fracture table or in lateral decubitus position. A longitudinal incision was made over the greater trochanter to identify the entry point at the piriformis fossa or lateral greater trochanter, depending on the nail system. The nail was inserted under fluoroscopic guidance.

Postoperative care

Intravenous antibiotics were administered to all patients within one to three days following surgery. Starting on day 4, the medicine was taken orally until the patient's temperature returned to normal. One dressing change was applied the day following surgery, and then every three days after that. We removed the sutures fourteen days after the procedure. We start with basic range-of-motion exercises. From the first six months after surgery to the first year, every case was checked once every two months. An X-ray and measurements of the patient's hip, knee, and ankle range of motion were part of the examination. A patellar tendon bearing brace or orthosis is used to stabilize fracture fixation in patients who are not compliant or who have not healed sufficiently. Patients with axially stable patterns (i.e., transverse diaphyseal) can be allowed to bear weight freely.

Outcome measures

Primary outcomes measures

Time to partial weight bearing (days)

Time to full fracture union (months)

Time to foot-floor contact (days)

Clinical Evaluation

A functional analysis was part of the clinical examination along with a neurovascular exam, evaluation of axial alignment, and other physical examination procedures using the Olerud-Molander score (0–100 points) for tibial fractures and the Thorsen score (0–50 points) for femoral fractures.

Radiographic assessment

AP and Lat radiographs were taken after the operation and at every subsequent appointment. On each of these radiographs, the orientation of the fracture was established. The deformities in the coronal plane (varus and valgus) were identified using AP radiographs, whereas the deformities in the sagittal plane (flexion and extension) were determined using Lat. Radiographs.

Statistical Analysis

Software developed by IBM and published in Armonk, New York, USA, SPSS v26 was used for that purpose. The normality of the data distribution was assessed using the Shapiro-Wilks

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test and histograms. The statistics were shown as the mean with standard deviation (SD) for quantitative parametric data. To display quantitative non-parametric data, the IQR and median were used. The frequency and percentage (%) of qualitative characteristics were depicted.

Results

A total of 30 patients with open diaphyseal fractures were enrolled in this prospective study at Orthopedic Department, Aswan University Hospitals. The mean age of patients was 31.4± 15.8years. There were 26 (86.67%) males and 4 (13.33%) females. Among the patients studied, 6 (20%) patients were smokers **(Table 1).**

Table (1): Baseline characteristics of the participants.

		Total (n=30)
Age (years)	**Mean± SD**	31.4± 15.8
	Range	18-84
Gender	**Male**	26 (86.67%)
	Female	4 (13.33%)
Smoking	**Yes**	6 (20%)
	No	24 (80%)

Regarding comorbidities, most of the studied patients 22 (73.33%) had no associated comorbidities, while 1 (3.33%) patient had asthma, 1 (3.33%) patient had IPF, 1 (3.33%) patient had DCL, 1 (3.33%) patient had renal impairment, 1 (3.33%) patient had pneumothorax, 1 (3.33%) patient had lung contusion, 1 (3.33%) patient had DM and 1 (3.33%) patient had extradural hemorrhage **(Table 2)**

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Table (2): Comorbidities of the participants

	Total (n=30)
Asthma	1 (3.33%)
IPF	1 (3.33%)
DCL	1 (3.33%)
Renal impairment	1 (3.33%)
Pneumothorax	1 (3.33%)
Lung contusion	1 (3.33%)
DM	1 (3.33%)
Extradural hemorrhage	1 (3.33%)
No	22 (73.33%)

DM: Diabetes mellitus, IPF: Idiopathic pulmonary fibrosis, DCL: Diffuse cutaneous leishmaniasis.

Regarding the trauma location, injury was on the right side in 12 patients (40%) and on the left side in 18 patients (60%). The mechanism of trauma was motor car accident (MCA) in 16 patients (53.33%), road traffic accident (RTA) in 9 patients (30%), direct trauma in 3 patients (10%), and assault in 2 patients (6.67%) **(Table 3).**

Table (3): Mode of trauma of the participants

		Total (n=30)
Mode of trauma	**MCA**	16 (53.33%)
	Direct trauma	3 (10%)
	RTA	9 (30%)
	Assault	2 (6.67%)

MCA: motorcycle accident,

Regarding the type of fracture, 8 (26.67%) patients had fracture at the mid-shaft tibia, 7 (23.33%) patients had fracture at the distal tibia, 1 (3.33%) patient had fracture at the proximal tibia, 13 (43.33%) patients had fracture at the mid-shaft femur, and 1 (3.33%) patient had fracture at the proximal femur.

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According to Gustilo-Anderson classification, 13 (43.33%) patients had OG I fracture, and 17 (56.67%) patients had OG II fracture. The time interval till intervention was less than 24 hrs. in 21 (70%) patients, while was more than 24 hrs. in 8 (26.67%) patients.

Table (4): Outcome of the participants

		Total (n=30)
Time of partial weight bearing (days)	**Mean± SD**	22.87± 8.99
	Range	14-42
Time of full union (months)	**Mean± SD**	3.27± 1.13
	Range	2-6
Foot to floor (days)	**Mean± SD**	7± 8.03
	Range	2-28
	Median (IQR)	2.5 (2 – 7)

Regarding the operative data, 19 (63.33%) patients were operated in the supine position while 11 (36.67%) patients were operated in the lateral position, and all the studied patients 30 (100%) were operated under spinal anesthesia. The C-arm exposure time ranged from 25 to 75 seconds with a mean of 42.33± 11.72 seconds. The operation time ranged from 1 to 2 hours with a mean of 1.33± 0.39 hours. The intraoperative blood loss had been occurred only in patients with femur fracture 14 (46.67%), and ranged from 150 to 400 ml with a mean of 232.14± 72.34 ml. **(Table 5)**

Table (5): Functional outcome in patients with femur fracture

		Total (n=14)
Thorsen score	**Mean± SD**	39.64± 5.34
	Range	28-47

Regarding the outcome, the time of partial weight bearing ranged from 14 to 42 days with a mean of 22.87± 8.99 days. The time of full union ranged from 2 to 6 months with a mean of 3.27± 1.13 months. The foot to floor time ranged from 2 to 28 days with a mean of 7± 8.03 days.

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Functional outcomes were assessed according to the fracture site. In patients with tibial fractures, the Olerud and Molander score ranged from 60 to 95, with a mean of 84.06 ± 9.87 **(Table 6).** In patients with femoral fractures, the Thorsen score ranged from 28 to 47, with a mean of 39.64 ± 5.34 **(Table 5).**

Table (6): Functional outcome in patients with tibial fracture

		Total (n=16)
Olerud and Molander score	**Mean± SD**	84.06± 9.87
	Range	60-95

Concerning the incidence of complications, non-union occurred in 4 (13.33%) patients and infection occurred in 1 (3.33%) patient. None of the patients studied showed failure or needed revision. **(Table 7)**

Table (7): Complications of the participants

	Total (n=30)
Non-union	4 (13.33%)
Failure	0 (0%)
Revision	0 (0%)
Infection	1 (3.33%)

Discussion

This prospective study assessed the outcomes of un reamed intramedullary nailing in open diaphyseal fractures of the femur and tibia for adult patients with Gustilo-Anderson type I and II injuries. The findings showed positive outcomes related to the un reamed nailing: favorable union rates, low complication incidence, and satisfactory functional recovery for this patient population.

Our finding comes in agreement with another study conducted in Pakistan. It reported lower infection rates and satisfactory union rates with reamed nailing but also found unreamed nailing safe with minimal complications for Gustilo Type II and IIIA open tibial fractures. **(12)**

Another prospective cohort comparing Reamed Versus Unreamed Intramedullary Interlocking Nail for Gustilo and Anderson Type I, Type II and IIIA reported unreamed nailing as effective for Grade I and II open tibial fractures with minimal complications and excellent functional outcomes, which aligns with our study finding and strengthen our evidence. **(15)**

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On the other hand, a few studies contradicted our results. One in five patients who undergo intramedullary nailing of traumatic tibial fractures is affected by anterior knee pain. After receiving intramedullary nailing for severe tibial fractures, 18% of patients go on to have one or more further surgeries. A 2022 meta-analysis found unreamed nailing has significantly higher rates of nonunion, malunion, and secondary procedures compared to reamed nailing, along with longer healing times. **(16,17)**

Conclusion

Our study demonstrates that unreamed intramedullary nailing is a safe and effective treatment modality for Gustilo type I and II open diaphyseal fractures, with favorable union rates, good functional outcomes, and a low complication profile. These findings support the continued use of this technique in the management of open diaphyseal fractures, particularly in resource-limited settings where the biological advantages of unreamed nailing may outweigh the biomechanical benefits of reamed techniques.

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ORIGINAL ARTICLE

LEARNING CURVE OF MINIMALLY INVASIVE ACETABULAR COLUMNS SCREW FIXATION: A PROSPECTIVE COMPARATIVE STUDY

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ABSTRACT

Background:

Minimally invasive column screw for fixation of acetabular fractures necessitates a learning curve to prevent complications such as screw intraarticular penetration, neurovascular injury, non-union, and metal failure. We aimed to assess the learning curve of minimally invasive acetabular column screw fixation by comparing perioperative and short-term clinical outcomes in early versus later cases

Methods:

Between January 2024 and June 2025, 22 patients presented with acetabulum column fractures in a prospective comparative study at Aswan University Hospital.. Patients were categorized into two groups: Group A was in the first nine months, and Group B was in the subsequent nine months, with a standardized perioperative protocol. At least six months of follow-up. Quality of reduction, radiographic union, radiation dose, intraoperative bleeding, time, functional outcome and complications are among the outcomes.

Results:

Mean operative time was 100.91 ± 27.73 minutes in Group A and 79.09 ± 27.73 minutes in Group B. Anatomical reduction was obtained in 63.6% of Group A and 72.7% of Group B. Mean blood loss was 55.45 ± 17.53 cc and 50.91 ± 13.00 cc, respectively. Mean radiation exposure was 3.54 ± 0.57 mSv in Group A and 3.07 ± 0.79 mSv in Group B.. Functional scores were 16.18 ± 1.08 and 16.36 ± 1.03. one case of a broken guide wire tip reported without clinical consequence in Group A.

Conclusions:

Minimally invasive column screw necessitates learning curve and surgeon experience to avoid perioperative complications.

Keywords: Hypoxic-ischemic encephalopathy, Transcranial ultrasound, Doppler ultrasonography.

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INTRODUCTION

Acetabular fractures are among the most complex injuries in orthopaedic trauma and are usually caused by high-energy mechanisms such as road traffic accidents or falls from height. These fractures are common among young, economically active people and are associated with significant morbidity if not treated appropriately. Long-term hip joint function and the prevention of post-traumatic arthritis depend heavily on anatomical reduction and stable fixation, and therefore surgery is considered the standard treatment for displaced fractures. (1, 2).

The standard management of acetabular fractures was open reduction and internal fixation (ORIF). Nonetheless, ORIF requires a wide surgical exposure, which is associated with significant blood loss, soft-tissue injury, wound complications, heterotopic ossification, and neurological damage. (3, 4).

Percutaneous and minimally invasive screw fixation techniques have emerged as options for treating certain acetabular fractures, especially minimally displaced and non-displaced acetabular column fractures. These approaches focus on maintaining soft tissue integrity, reducing operation duration, lowering blood loss, and decreasing infection risk without sacrificing fracture stability. Enhancements in the safety and precision of percutaneous column screw placement have been made possible by advancements in fluoroscopic imaging, preoperative CT planning, and intraoperative navigation. (5).

Improvements in intraoperative navigation are primarily aimed at reducing complications and increasing the safety of minimally invasive procedures (11). In developing countries such as Egypt, navigation systems are not accessible in all centers. Therefore, our goal is to standardize intraoperative fluoroscopic views and minimize radiation exposure.

Recent work has improved fluoroscopic techniques and confirmed that percutaneous acetabular screw fixation is safe and effective in selected cases, but it mainly emphasises imaging optimisation, navigation, and screw accuracy rather than how junior surgeons learn the procedure. There is still almost no prospective evidence tracking the early learning curve, radiation exposure, and clinical outcomes for a single junior surgeon using fluoroscopy alone and no navigation in a resource-limited setting (20).

We aimed to assess the learning curve of a junior orthopedic trauma surgeon performing minimally invasive acetabular column screw fixation without navigation. This involved comparing early and late cases in a prospective cohort, focusing on screw intraarticular penetration, neurovascular injury, high radiation exposure, prolonged operative time, and postoperative complications such as non-union, metal failure, and loss of reduction.

We hypothesize that gaining more surgical experience would enhance the efficiency of fluoroscopy-guided minimally invasive acetabular column screw fixation.

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PATIENTS AND METHODS

This prospective comparative cohort study included 22 patients who presented with minimally displaced or nondisplaced acetabular column fractures and were treated by the same surgeon with fluoroscopy-guided minimally invasive acetabular column screw fixation between January 2024 and June 2025 at Aswan University Hospital.

Patients were divided based on the date of operation into two groups: Group A, consisting of 11 patients treated in the first nine months, and Group B, with 11 patients in the following period.

Eligible patients were aged 16 to 65 years old with minimal or no displacement (<2 mm) anterior or posterior column or transverse acetabular fractures without posterior wall involvement. The fractures were closed within 3 weeks of injury. Patients were excluded if they had haemodynamic instability, open fractures, injuries older than 3 weeks, comminuted or markedly displaced acetabular column fractures, or associated posterior wall fractures or marginal impaction

All patients signed an informed consent written form, and the Ethics Committee of the Faculty of Medicine, Aswan University Hospital approved the study.

Preoperative preparations:

The patients were admitted to the trauma unit, Aswan University Hospital. The patient's evaluation began with an immediate assessment of vital signs and full resuscitation. History taking from the patient /relatives to detect the mechanism of trauma and any medical comorbidities or chronic medications.

Preoperatively all patient underwent 1ry survey and 2ry seurvey according to ATLS protocol. Local examination of the hip to exclude any swelling, deformity, bruising, deep wounds, and assessment of hip range of motion. Neurovascular status was assessed in all patients. Radiologically, routin anteroposterior, judet views, and CT scan for all patients.

Outcomes

The primary outcomes were operative time and radiation exposure. Operative time was defined as the time from skin incision to wound-closure (minutes), and radiation exposure was measured intraoperatively using the fluoroscopy unit (mSv) for each case.

Secondary outcomes were intraoperative blood loss, reduction quality, time to initiation of weight bearing, functional outcome, radiographic union, and complications. reduction quality was graded as anatomical or congruent on immediate postoperative radiographs; functional outcome was measured at 6 months using the modified Merle d'Aubigné hip score by an independent surgeon (21). Complications included intra-articular screw penetration, neurovascular injury, infection, loss of reduction, non-union, implant failure, and guidewire-related problems.

Follow-up:

All patients were followed for a minimum of 6 months after surgery. "The mean follow-up duration was 11.86 ±3.31 (range 6-18) months overall, including 15.27± 1.86 months in Group A and 9.54 ±2.34 months in Group B."

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Surgical technique:

Minimally invasive percutaneous column screw fixation was performed in all patients in both study groups under general or spinal anaesthesia by the experienced orthopaedic trauma surgeon. The patients were placed flat on a radiolucent operating table, allowing clear fluoroscopic visualisation. Preoperative intravenous antibiotics were administered in line with the institutional guideline, and aseptic measures were strictly followed during the procedure.

Fracture reduction was initiated by gentle traction and manipulation under fluoroscopic guidance and performed as a closed or indirect procedure. This preoperative planning was based on computed tomography (CT), which determined the fracture structures and helped identify the most suitable screw entry point, path, and screw length to be placed within safe osseous margins of the acetabular columns.

The predetermined entry point was punctured with a small percutaneous skin incision, and a guidewire was inserted under constant fluoroscopic monitoring of the endpoint using anteroposterior, iliac oblique, and obturator oblique views. The guidewire was advanced cautiously along the intended route to avoid temporary intra-articular penetration and to protect neurovascular structures. Once the correct location of the guidewire was verified, cannulated drilling was performed, and a 6.5-mm cannulated cancellous screw of the corresponding size was placed in an antegrade or retrograde position, according to the column and fracture pattern involved.

Retrograde posterior column percutaneous fixation using retrograde posterior column screws was first demonstrated in 1996 by Starr et al. Several authors have since published clinical and cadaveric studies on the topic. (12,13)

To reduce pressure on the sciatic nerve, the patient may lie prone, on the side, or on the back, but flexing the hips and knees tends to be the most comfortable position (14).

The retrograde acetabular posterior column screw entry point is situated in the midline between the medial and lateral edges of the ischial tuberosity, approximately 1.3 cm from its distal end. If the fracture of the acetabular posterior column occurs less than 4 cm above the femoral head's center, the screw should be oriented roughly 10° longitudinally and 15° anteriorly to promote proper healing. (15)

For AP pelvis, the iliac oblique view is used to guide anteroposterior placement anterior to the greater sciatic notch and behind the acetabulum (16). Use an outlet view to direct medial-lateral wire placement. The obturator-outlet oblique view should be directed towards the bone corridor

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connecting the anterior-inferior iliac spine (AIIS) to the posterior-superior iliac spine (PSIS) (17). Figure (1)

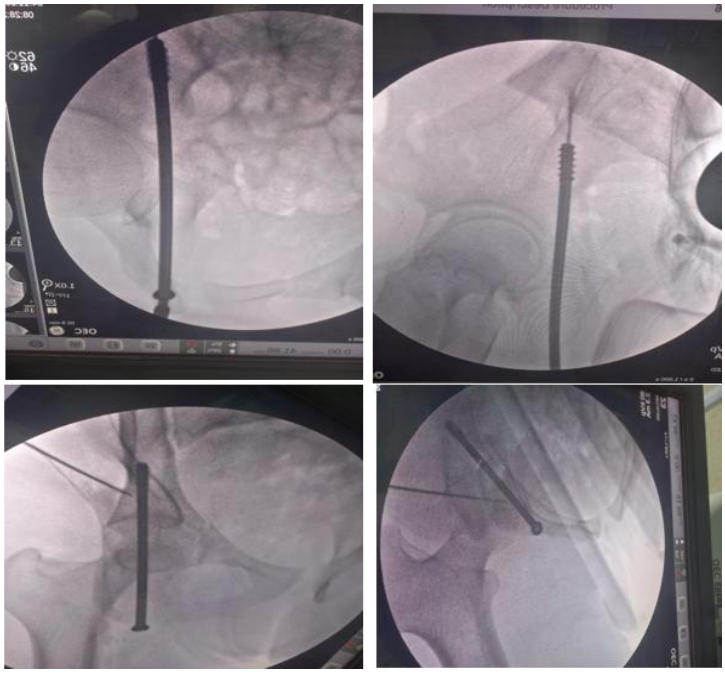

Figure (1): Retrograde posterior column screw intraoperative fluoroscopy in AP, Iliac oblique, inlet and obturator outlet views.

Magic screw: Position the patient supine, and access the body 1 cm above the acetabular ring and 2 cm behind the AIIS. Insert the fastener at a 10-degree angle medially and a 20-degree angle superiorly. The obturator oblique view shows the wire descending into the tuberosity, preventing medial or lateral extrusion. The iliac oblique view confirms that the wire lies outside the joint along the posterior column and avoids the sciatic grooves (18). Figure (2)

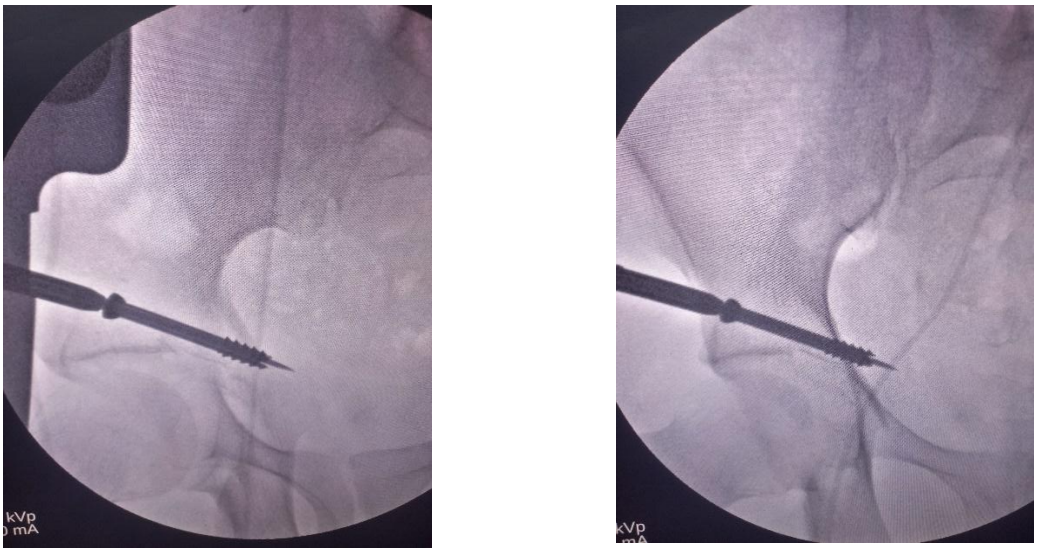

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Figure (2) Intraoperative fluoroscopy of Magic screw in AP and Iliac oblique views.

Anterior column screw Obturator outlet and iliac inlet views ensure that the wire does not inadvertently exit the superior pubic ramus or cut out on its inner surface to a point just above the acetabulum. (19)

Axial fluoroscopic imaging for the anterior column, as described by Feng et al. in 2017, was not applicable for intraoperative use. Figure (3)

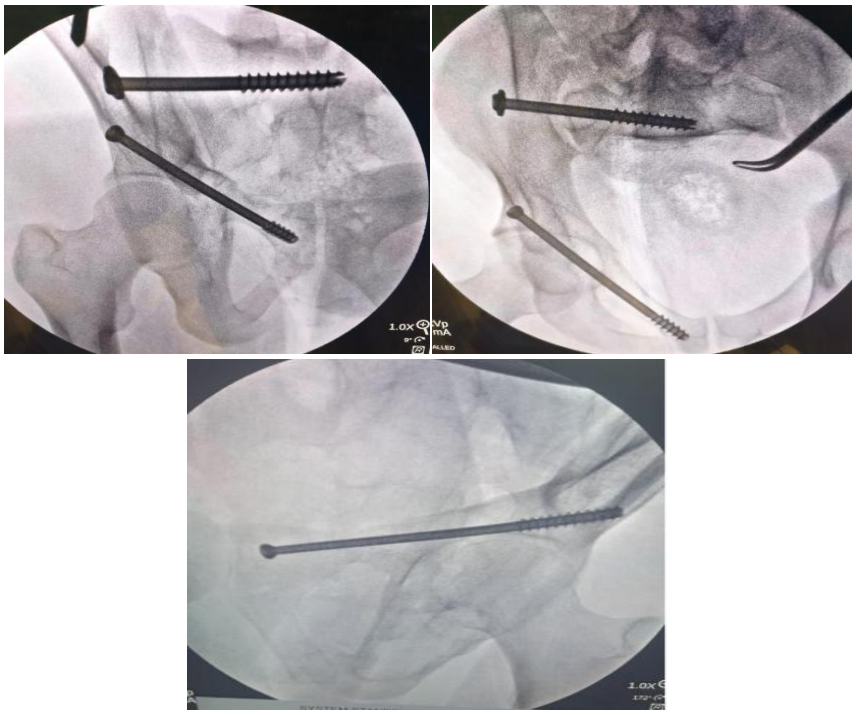

Figure (3) Intraoperative fluoroscopy of Anterior column screw Retrograde and Antegrade.

The end result of the fluoroscopic procedure was to establish adequate reduction of the fracture, proper screw placement and maintenance of hip joint congruity. The wound was irrigated and layered up without surgical drainage.

Postoperative Management:

All patients followed a standardized postoperative rehabilitation protocol. Active and passive range-of-motion exercises began as early as possible. During the initial postoperative phase, patients maintained partial or non-weight-bearing status, with a gradual transition to full weight-bearing based on clinical assessment and radiographic evidence of fracture healing. Patients were monitored regularly, with evaluations of functional and radiographic outcomes compared across both groups.

Statistical analysis

Data were analysed with SPSS v29 (IBM Corp., Armonk, NY, USA). Quantitative variables are shown as means and standard deviations and were compared between groups using unpaired Student's t-tests. Qualitative variables are expressed as frequencies and percentages and were compared using Chi-square or Fisher's exact tests, as appropriate. A two-tailed P value < 0.05 was deemed statistically significant.

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Sample size justification: all eligible patients treated consecutively over the 18-month study period were prospectively enrolled (22 cases). The study was designed as an exploratory, real-world single-surgeon series and is underpowered to detect small between-group differences.

Learning-curve assessment

Cases were ordered chronologically from 1 to 22 by date of surgery. Operative time, radiation exposure, and complications were plotted against case number to explore trends in performance across successive procedures, with any reduction in operative time or radiation exposure interpreted as evidence of increasing procedural efficiency. Given the limited sample size, this learning-curve analysis was descriptive rather than inferential

RESULTS

Patient demographics

A total of twenty-two patients participated, with 11 in Group A (first period) and 11 in Group B (second period). The average age was 25.91 ± 6.98 years for Group A and 27.18 ± 7.80 years for Group B (P = 0.691). Both groups were predominantly male: 10 of 11 (90.9%) in Group A and all 11 (100%) in Group B were male; this difference was not statistically significant (P = 1.000).

Injury and fracture characteristics:

Fracture patterns were similar across both groups. In Group A, there were 6 transverse fractures (54.5%), 3 anterior column fractures (27.3%), 1 posterior column fracture (9.1%), and 1 T-shaped fracture (9.1%). In Group B, the counts were 5 (45.5%) transverse, 4 (36.4%) anterior column, 1 (9.1%) posterior column, and 1 (9.1%) T-shaped fractures (P = 0.972). Most fractures showed minimal displacement in both groups (10/11, or 90.9%), with one case (9.1%) exhibiting moderate displacement in each group (P = 1.000). Associated injuries were observed in 2 patients (18.2%) in Group A and 3 patients (27.3%) in Group B, with no significant difference (P = 1.000).

Operative details

All fractures were treated with closed reduction and percutaneous screw fixation while the patients were in the supine position. Spinal anesthesia was administered to 4 patients (36.4%) in Group A and 5 patients (45.5%) in Group B. General anesthesia was used for 7 patients (63.6%) in Group A and 6 patients (54.5%) in Group B (P = 1.000).

Antegrade anterior column screw fixation was performed in 8 patients (72.7%) in Group A and 6 (54.5%) in Group B (P = 0.659). Retrograde posterior column screws were used in 3 patients (27.3%) in each group (P = 1.000), and “magic” screws in 4 patients (36.4%) in both groups (P = 1.000). Additional anterior column screws were used in 0 patients (0.0%) in Group A and 3 (27.3%) in Group B (P = 0.214). Retrograde anterior column screws were used in 1 patient (9.1%) in each group (P = 1.000), and supracetabular screws in 2 patients (18.2%) in Group A compared to 1 patient (9.1%) in Group B (P = 1.000).

The immediate postoperative radiographs showed an anatomical reduction in 7 patients (63.6%) in Group A and 8 patients (72.7%) in Group B. Congruent reductions were observed in 4 patients (36.4%) of Group A and 3 patients (27.3%) of Group B (P = 0.198).

Perioperative quantitative outcomes

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The mean operative time was 100.91 ± 27.73 minutes in Group A and 79.09 ± 27.73 minutes in Group B, with a non-significant trend towards shorter procedures in the subsequent period (P = 0.080). The mean intraoperative blood loss was minimal in both groups, recorded at 55.45 ± 17.53 mL in Group A and 50.91 ± 13.00 mL in Group B (P = 0.498). The mean radiation exposure was 3.54 ± 0.57 mSv in Group A, compared to 3.07 ± 0.79 mSv in Group B, again indicating a non-significant tendency towards reduced exposure in the later cases (P = 0.133).

Postoperative course and functional outcomes

All patients were followed for a minimum of 6 months after surgery. The mean follow-up duration was 11.86 ± 3.31 (range 6-18) months overall, including 15.27± 1.86 months (range 12-18 months) in Group A and 9.54 ±2.34 months (range 6-13 months) in Group B.

The mean time to initiation of weight bearing was 2.64 ± 1.29 months for Group A and 2.27 ± 0.47 months for Group B (P = 0.395).

Functional outcome at final follow-up was satisfactory in both groups. The mean functional score was 16.18 ± 1.08 points in Group A and 16.36 ± 1.03 points in Group B (P = 0.690).

Radiographic union and complications

Radiographic union was achieved in all patients, No instances of postoperative loss of reduction, intra-articular screw penetration, or implant failure were observed during follow-up.

Complications were infrequent. In Group A, there was one case (9.1%) of a broken guidewire tip that did not lead to any clinical consequences, while Group B had no complications (0.0%) (P = 1.000). Neither group experienced deep infections, clinically evident neurovascular injuries, symptomatic non-unions, or reoperations.

Table 1. Baseline demographic and injury characteristics

Variable	Group A (n=11)	Group B (n=11)	P value
Age (years), mean ± SD	25.91 ± 6.98	27.18 ± 7.80	0.691
Sex, male	10 (90.9%)	11 (100.0%)	1.000
Sex, female	1 (9.1%)	0 (0.0%)	
Transverse fracture	6 (54.5%)	5 (45.5%)	0.972
Anterior column fracture	3 (27.3%)	4 (36.4%)	
Posterior column fracture	1 (9.1%)	1 (9.1%)	
T-shaped fracture	1 (9.1%)	1 (9.1%)	
Minimal displacement	10 (90.9%)	10 (90.9%)	1.000
Moderate displacement	1 (9.1%)	1 (9.1%)	
Associated injuries present	2 (18.2%)	3 (27.3%)	1.000
Follow-up (months), mean ± SD	15.27± 1.86	9.54 ±2.34	0.00042

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Table 2. Operative details and perioperative outcome

Variable	Group A (n=11)	Group B (n=11)	P value
Closed reduction	11 (100.0%)	11 (100.0%)	1.000
Supine position	11 (100.0%)	11 (100.0%)	1.000
Spinal anaesthesia	4 (36.4%)	5 (45.5%)	1.000
General anaesthesia	7 (63.6%)	6 (54.5%)	
Antegrade anterior column screw	8 (72.7%)	6 (54.5%)	0.659
Retrograde posterior column screw	3 (27.3%)	3 (27.3%)	1.000
Magic screw	4 (36.4%)	4 (36.4%)	1.000
Additional anterior column screw	0 (0.0%)	3 (27.3%)	0.214
Retrograde anterior column screw	1 (9.1%)	1 (9.1%)	1.000
Supracetabular screw	2 (18.2%)	1 (9.1%)	1.000
Anatomical reduction	7 (63.6%)	8 (72.7%)	0.198
Congruent reduction	4 (36.4%)	3 (27.3%)	
Operative time (min), mean ± SD	100.91 ± 27.73	79.09 ± 27.73	0.080
Blood loss (cc), mean ± SD	55.45 ± 17.53	50.91 ± 13.00	0.498
Radiation exposure (mSv), mean ± SD	3.54 ± 0.57	3.07 ± 0.79	0.133
Start weight bearing, mean ± SD	2.64 ± 1.29	2.27 ± 0.47	0.395
Modified Merle d'Aubigné score, mean ± SD	16.18 ± 1.08	16.36 ± 1.03	0.690
No complication	10 (90.9%)	11 (100.0%)	1.000

DISCUSSION

This prospective series included 22 eligible patients, divided into early (Group A) and late (Group B) categories. All patients underwent fluoroscopy-guided minimally invasive acetabular column screw fixation, performed by the same junior trauma surgeon under senior supervision. The results aligned with the hypothesis that experience improves the learning curve, with mean operative time

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decreasing from 100.91 ± 27.73 minutes in the early cases to 79.09 ± 27.73 minutes in the later cases, and mean radiation exposure decreasing from 3.54 ± 0.57 mSv to 3.07 ± 0.79 mSv. Short-term outcomes in both groups were satisfactory. Fracture reduction was anatomical in 63.6% of Group A and 72.7% of Group B, while functional scores were comparable at 16.18 ± 1.08 and 16.36 ± 1.03, respectively (P = 0.690). Blood loss was low in both groups, at 55.45 ± 17.53 cc in Group A and 50.91 ± 13.00 cc in Group B (P = 0.498). Complications were uncommon, with one broken guidewire tip in Group A and none in Group B. Nonetheless, because these differences were not statistically significant (P = 0.080 and P = 0.133), the data suggest a trend towards increased efficiency rather than definitive evidence of skill mastery. Later cases required less operative time and lower radiation exposure while maintaining similar reduction quality and functional outcomes. This indicates that the learning curve is reflected mainly in technical efficiency rather than in reduction quality, function, or complication rate, suggesting that progressive familiarity with fluoroscopic views, screw trajectories, and intraoperative decision-making improved performance over time. At the same time, the absence of major deterioration in early cases suggests that careful patient selection and adherence to a standardised technique may allow this learning process to occur without compromising short-term results.

In comparison with the literature, our results are comparable. Agroudy et al. reported that operative times and blood loss were similar to those observed in the current cohort. They observed comparable functional outcomes, with a mean functional score of 15.72 ± 1.6, and noted a low complication rate following percutaneous acetabular fixation. (9)

Liu et al. reported a comparable level of radiation exposure in their studies of fluoroscopy-guided percutaneous fixation and robot-assisted procedures. (3)

Einhorn et al. also noted low blood loss levels associated with percutaneous methods, which can serve as a reference pattern for perioperative level measures in this study.(10)

Tripathy et al. reported data on early mobilisation features and observed low complication rates among patients undergoing percutaneous procedures. (4)

Einhorn et al. also observed consistent outcomes and reported similar functional results with a low complication rate in cases of low-invasion acetabular fixation. (10)

In the current study, the complication rate was 4.5%: one case of a broken guidewire tip in Group A and none in Group B. Neither group experienced infections, metal failures, intra-articular penetration, or other major adverse events during follow-up. With low blood loss in both groups (55.45 ± 17.53 vs 50.91 ± 13.00 cc, P = 0.498), these results suggest that fluoroscopy-guided minimally invasive column screw fixation is safe for selected fracture patterns, even during a surgeon's early experience, provided there is careful planning and fluoroscopic oversight.

This study has several limitations. First, the small sample size of 22 patients, divided into two groups of 11, limited statistical power and may explain why reductions in operative time and radiation exposure did not reach significance. Second, the experience of a single surgeon at one

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centre improves consistency but limits external validity. Third, the inclusion of different fracture patterns and fixation methods may have affected operative simplicity, regardless of the surgeon's experience. Lastly, the follow-up of at least 6 months prevented evaluation of long-term outcomes such as post-traumatic arthritis, late implant problems, and conversion to total hip arthroplasty.

CONCLUSION

Operative time and radiation exposure reduced in subsequent instances within this single-surgeon prospective series, suggesting a better learning curve with experience. However, due to the small sample size, these differences were not statistically significant. Larger, multi-centre studies with formal learning-curve analysis are needed to determine the number of cases required to achieve proficiency and to compare this technique with open reduction and internal fixation.

Conflict of interest: None.

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ORIGINAL ARTICLE

HISTOLOGICAL EFFECTS OF CCL4 ON LUNG AND THE POSSIBLE AMELIORATING ROLE OF METFORMIN

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ABSTRACT

Background: Lung fibrosis is a fibrotic change of the lung architecture that leading to respiratory failure and death. Exposure to high concentrations of carbon tetrachloride, especially vapor, can cause lung destruction. Recent research suggests that metformin may provide protection against a variety of lung ailments to Evaluate how metformin protects against lung damage caused by carbon tetrachloride.

Methods Thirty adult male albino rats (10 rats each) were divided into three equal groups. One group served as the control. Group 2: received **CCl4** 1.5 mg/kg twice weekly S.C. for a duration of 12 weeks. Group 3: Oral Metformin and **CCl4** were administered for 12 weeks at a dose of 100 mg/kg/day and 1.5 mg/kg twice weekly S.C. After the animal sacrificed, the lungs were taken out of each group and studied under light microscope.

Results: The histological abnormalities in the lung tissue caused by the administration of CCl4 included areas of tissue destruction, congestion, and fibrosis. Concurrent metformin and CCl4 treatment resulted in improvements.

Conclusion: : the histological and biochemical effects of CCl4 on lung tissue can be modulated by administration of metformin.

Keywords: CCl4, Metformin, pulmonary fibrosis.

INTRODUCTION

Fibrosis is a pathological condition that arises from an ineffective repair response to tissue damage. [1]Idiopathic pulmonary fibrosis (IPF), a type of lung fibrosis is a chronic and progressive disorder occurring primarily in elderly subjects.[2] Researchers have become more interested in metformin, one of the most widely used anti-diabetic drugs, recently as they examine its more pharmacological effects. Various tissues or diseases were implicated in these, according to **Kaur et al.** [3]

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Metformin's pharmacological impact has been linked to autophagy, a crucial biological mechanism that mediates numerous physiologies and diseases. Metformin's many effects have even been linked to autophagy [4]Metformin has been demonstrated to have anti-aging properties in addition to its effects on diabetes [5]; act as a prophylaxis in some pathologies such as metabolic disorders, cardiovascular, neurological diseases , inflammation, cancer and modulation of the microbiome [6].Metformin has numerous pharmacological effects in the gastrointestinal system that complement its hypoglycemic mechanisms. [7]

Aim : to demonstrate effects of Metformin in CCl4 induced lung fibrosis via light microscopic assessment.

PATIENTS AND METHODS

I. Chemicals: Cidophage, CID.Co., El-Haram, Giza, Egypt, was the supplier of metformin. The carbon tetrachloride solution was supplied by Sigma Co. located in St. Louis, USA.

II. Animals Thirty adult male albino rats, weighing approximately 135 to 195 grams, were obtained from the Assiut University animal house and housed in spacious, clean cages that could accommodate up to four rats each. They were housed in an air-conditioned room with a natural light-dark cycle of 12 hours, at a temperature of 25 ± 5˚C. They also had unrestricted access to water and standard rat pellets for food. The experimental protocol was approved by the Institutional Animal Research Committee of the Aswan Faculty of Medicine. It was conducted in accordance with the relevant ethical issues.

Experimental Groups: rats were randomly assigned to one of three groups, ten animals each as follows:

Group 1 (control group): rats were given intragastric tubes containing 0.5 mg/kg of distilled water orally every day.

Group 2 (CCl4 group): rats were given 1.5 mg/kg of dissolved **CCl4** S.C. twice a week for 12 weeks, diluted in 50:50 olive oil. [17]

Group 3 (CCl4 and Metformin group): rats were given 100 mg/kg/daily of Metformin orally for 12 weeks, and 1.5 mg/kg of CCL4 S.C. dissolved in olive oil twice a week for 12 weeks, Metformin pills are administered by nasopharyngeal tube after being broken up and diluted in distilled water.

All of the animals were sacrificed throughout the experiment under general anesthesia, and their lungs were removed from each group by decapitating them through a median abdominal incision. The organs were then prepared for light microscopy.

Light microscopy:

Lungs of all groups' specimens were obtained, fixed in 10% formalin, cleaned in 70% alcohol, dried using increasing alcohol grades, embedded in paraffin, sectioned using a microtome at a thickness of 5µm, and stained with the following dyes: [8]

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I. Use the universal H&E stain to do a general histological examination.
II. Collagen fibers are visible when using Masson's trichrome. Bancroft and Layton claim that every staining method was employed.

physiological study:

Pulse oximetry type (purier spo2: 70-100%, pulse : 30-250 bpm Model 30) was used to measure peripheral oxygen saturation (spo2) and heart rate (HR) in rats , measuring was done in the resting condition in the end of the experiment in Assuit University animal house .

Results

Results of Light Microscopy:

A. Results of Hematoxylin and Eosin-stained sections:

Group (I) (control group) : shows a normal lung structure with lung alveoli have thin alveolar wall lined by simple squamous epithelium connected together through alveolar pores which open into alveolar sacs, alveolar ducts , respiratory bronchioles and thin interalveolar septa(fig. 1a,b). Bronchioles are highly folded lined by simple columnar ciliated epithelium , have no goblet cells nor cartilage but only circular muscle layers which gradually become thinner in terminal bronchioles, respiratory bronchioles, alveolar ducts and finally disappear in alveolar sacs .The lung alveoli are bordered by a large number of flat, elongated cells (pneumocytes type I), and a small number of cuboidal cells, (pneumocytes type II).
Group II (CCl4 treated group) : shows thickening of the interalveolar septum, lymphocytic infiltration, necrotic material inside the bronchioles and congested blood vessels with thickened wall (figure 1c,d).

Group III (CCl4 and metformin treated group): shows more or less normal appearance, The lung shows some collapsed alveoli, other alveoli are dilated with thin alveolar wall and lined by flattened cells separated by alternating areas of thin and thick interalveolar septa with inflammatory cell infiltrate. and blood vessels with minimal congestion (fig. 1e, f).

B. Sections stained with Masson's trichrome:

Group I (control group) shows sparse collagen fibers between alveoli. (figure 2a).

Group II (CCl4 treated group) shows increased collagen fiber deposition and clogged blood vessels. (fig. 2b)

Group III (CCl4 and metformin treated group): shows bronchioles with low surrounding collagen fibers deposition. (fig.2c).

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Physiological Results:

Table (1): Descriptive Statistics of Vital Signs in study Groups

Parameter	Control	CCl_4	CCl_4 + Metformin
SpO_2 (%)			
Mean ± SD	91.5 ± 6.4	79.9 ± 25.7	83.6 ± 19.4
Median (IQR)	91.5 (87.0-96.0)	96.0 (62.0-99.0)	90.0 (76.0-98.0)
Range (Min - Max)	87 - 96	37 - 99	34 - 98
HR (bpm)			
Mean ± SD	82.0 ± 2.8	100.6 ± 43.7	63.4 ± 33.5
Median (IQR)	82.0 (80.0-84.0)	81.0 (60.0-137.0)	50.0 (29.0-83.5)
Range (Min - Max)	80 - 84	51 - 160	27 - 124

CCl_4: ; SpO_2: ; HR SD: IQR:Interquartile Range ;

Table (2): Vital Signs Analysis Across Study Treatment Groups

Parameter	Control	CCl_4	CCl_4 + Metformin	p-value
SpO_2 (%)				
Mean ± SD	91.5 ± 6.4[a]	79.9 ± 25.7[b]	83.6 ± 19.4[b]	**0.038***
HR (bpm)				
Mean ± SD	82.0 ± 2.8[a]	103.6 ± 43.7[b]	63.4 ± 33.5[c]	**0.013***

Non-parametric Kruskal-Wallis test followed by Mann-Whitney U tests with Bonferroni correction for multiple comparisons. Data presented as mean ± SD. ***Superscript letters****: Groups sharing the same letter (a, b, c) are not statistically different (p > 0.05) based on post-hoc Mann-Whitney U pairwise comparisons with Bonferroni correction." **SpO_2**: The control group ([a]) exhibited significantly higher oxygen saturation than both CCl_4-treated groups ([b]), which did not differ from each other (p=0.298)2.**HR**: All groups differed significantly ([a], [b], [c]), with metformin countering CCl_4-induced tachycardia (p=0.009 vs. CCl_4 group)*

Table (3): Post-hoc Pairwise Comparisons Between Study Groups

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Comparison	SpO_2 (p-value)	HR (p-value)	Clinical Significance
Kruskal-Wallis	**0.038***	**0.013***	Overall Groups Differences
Control vs CCl4	**0.028***	0.158	CCl4 induces hypoxemia
Control vs CCl4+Met	0.083	**0.045***	Metformin protects HR
CCl4 vs CCl4+Met	0.298	**0.009****	Strong HR modulation

**p<0.05, **p<0.01 (Mann-Whitney U test with Bonferroni correction); The Bonferroni-corrected non-parametric analysis accounts for multiple comparisons (3) and non-normal distributions (Shapiro-Wilk p<0.05) ; Effect sizes calculated (SpO_2: r=0.62; HR: r=0.71)*

Tables 1 and 2 display the analysis of vital signs across treatment groups revealed significant differences in both oxygen saturation (SpO_2) and heart rate (HR). The Kruskal-Wallis test shows overall group differences for SpO_2 (p=0.038) and HR (p=0.013), with post-hoc Mann-Whitney U tests demonstrating distinct patterns.

SpO_2 Outcomes:

The control group (91.5% ± 6.4) shows significantly higher oxygen saturation than both CCl_4-treated groups (a vs b superscripts). While CCl_4 alone (79.9% ± 25.7) and CCl_4+Metformin (83.6% ± 19.4) share the same statistical grouping (b), pairwise comparisons reveal CCl_4-induced hypoxemia compared to controls (p=0.028). The metformin group does not show statistically significant SpO_2 improvement over CCl_4 alone (p=0.298).

HR Modulation:

All groups differ significantly in heart rate except for control vs CCl4 groups as p=0.158. . The CCl_4 group exhibits tachycardia (103.6 ± 43.7 bpm) versus controls (82.0 ± 2.8 bpm, p=0.158 NS), while metformin co-treatment paradoxically reduces HR to 63.4 ± 33.5 bpm (vs control p=0.045, vs CCl_4 p=0.009). This suggests metformin exerts strong bradycardic effects that counteract CCl_4-induced cardiovascular stress.

These findings clinically indicate that while CCl_4 primarily impacts oxygenation, metformin shows specific cardioprotective properties independent of respiratory parameters.

The data in Chart 1, is displaying both SpO_2 (%) and heart rate (HR, bpm) across the three study groups: Control, CCl_4, and CCl_4 + Metformin. The bars represent mean values with error

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bars indicating standard deviations. Superscript letters above each bar denote statistical groupings from post-hoc analysis: groups sharing the same letter are not significantly different ($p > 0.05$), while different letters indicate significant differences.

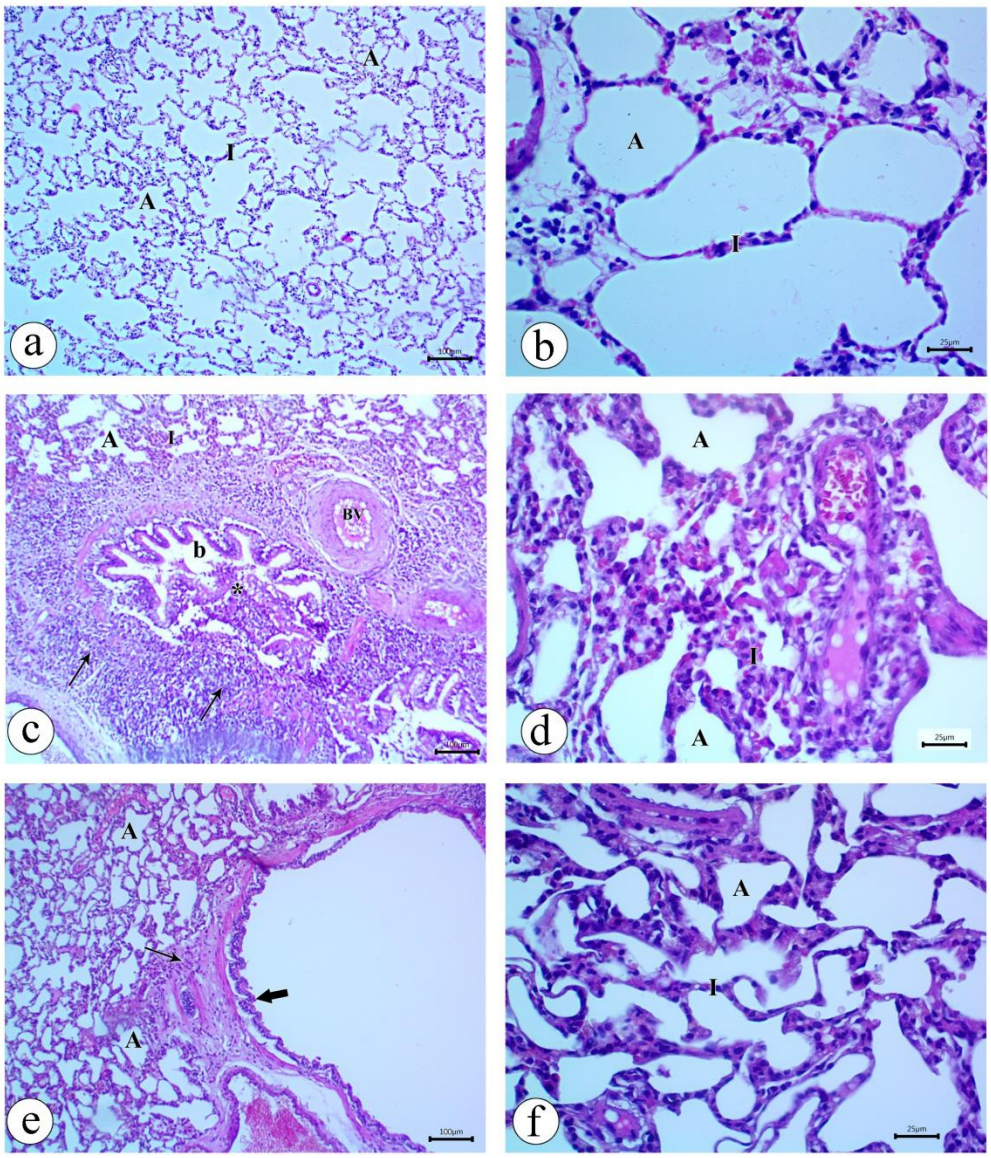

Fig. 1 Photomicrographs of lung sections stained with hematoxylin-eosin . a,b control group (a) showing patent lung alveoli (A) which are thin walled sac like structures , thin interalveolar septa (I) .(H&E x 100). (b) showing normal histological architecture of the rat lung showing patent lung alveoli (A) and thin interalveolar septa (I) (H&E x 400). . c , d CCl4 treated group (c) showing thickening of interalveolar septum (I) between the alveoli (A) ,lymphocytic infiltration (arrows), necrotic material (star) inside bronchioles (b) and a blood vessel with vascular congestion(BV) (H&E x 100) . (d) showing thickening of interalveolar septum (I) between the alveoli (A) (H&E x 400) . e ,f metformin and CCl4 treated group (e) showing: patent bronchiole lined with cuboidal cells(thick arrow) with few lymphocytic infiltrations around the bronchiole (arrow), lung alveoli

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which are patent thin walled saclike structures (A) (H&E x 100). (f) Showing: alveolar sacs formed of lung alveoli which are patent thin-walled sac like structures (A), with thin interalveolar septa (I) (H&E x 400).

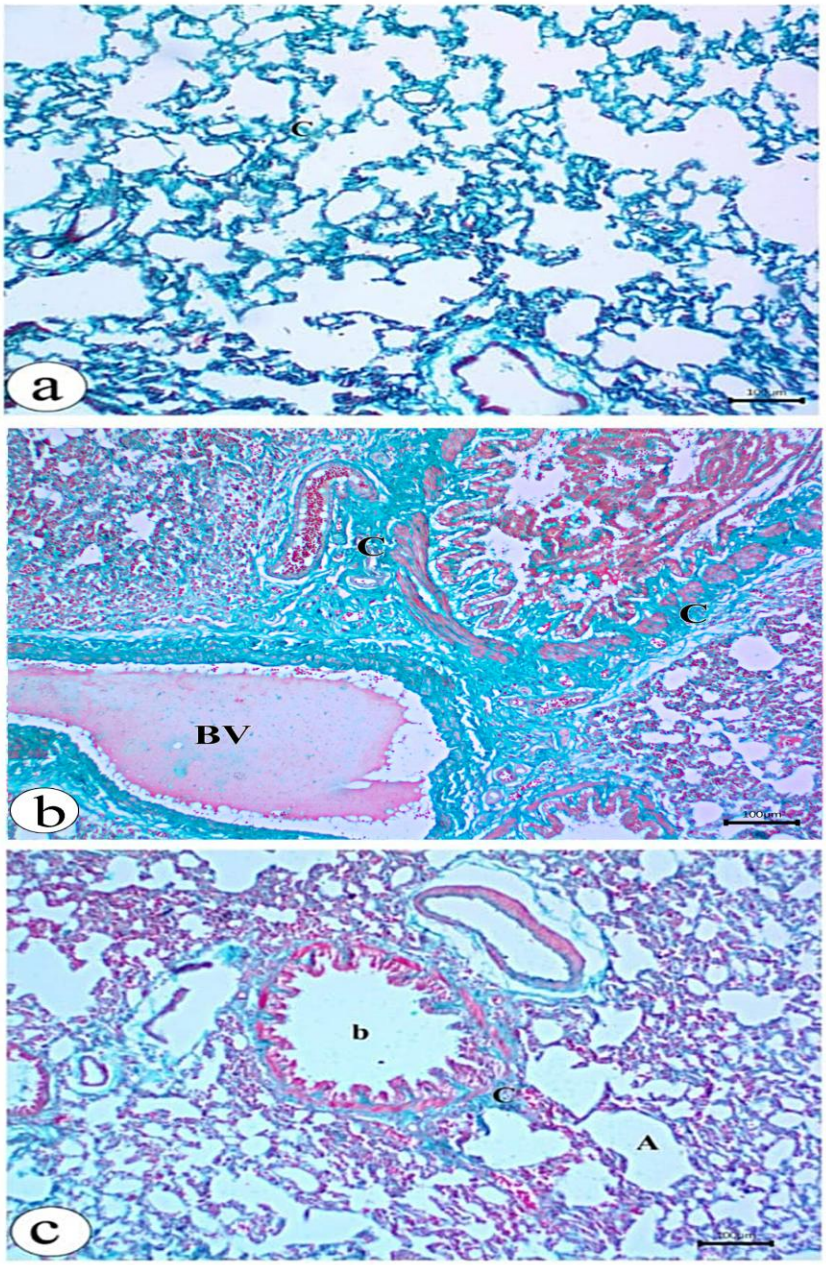

Fig 2 Masson trichrome stained sections showing control group (a) alveoli with patent alveolar walls and normal collagen fibers distribution (masson trichrome x 100) .(b) CCl4 treated rats with increased collagen fibers distribution(C) and a congested blood vessel (BV) (masson trichrome x 100).(C) metformin and CCl4 treated group showing bronchiole (b) with little surrounding collagen fibers deposition (C) (masson trichrome x 100) .

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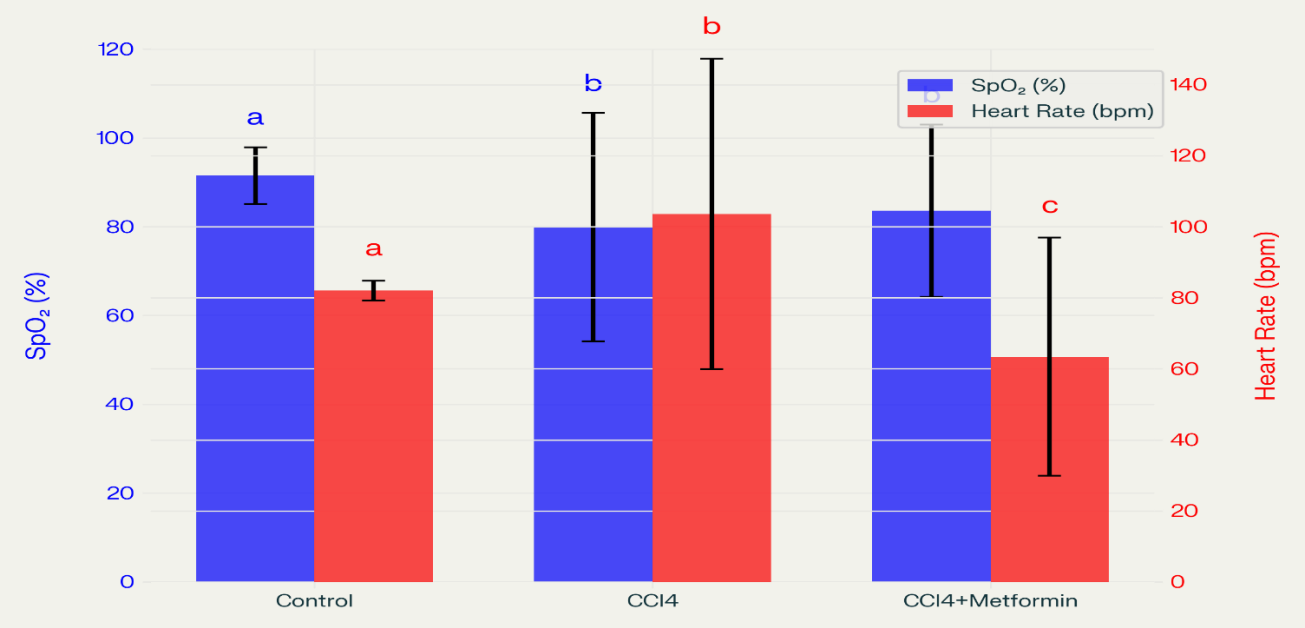

Note: SpO2 superscripts are shown in blue, and HR superscripts in red, matching the respective axes and bar

Chart (1)showing Oxygen Saturation and Heart Rate Measurements Across Control, CCl_4, and CCl_4+Metformin Treatment Groups

DISCUSSION

The goal of the current study in rats was to determine the effect of metformin in lung fibrosis induced by CCl4. The study revealed that the group receiving CCl4 treatment exhibited histological alterations in the lung, including thickening of the interalveolar septum, infiltration of lymphocytes, necrotic material within the bronchioles, and congested blood vessels. This is in line with **Kurt et al.** findings, which indicate that acute CCl4 toxicity induces lung tissue damage through the intense release of TNF-α and NO, which in turn produces ROS and peroxynitrite radicals. Additionally, they discovered that acute CCl4 toxicity may increase the accumulation of alveolar macrophages and stimulate the production of TNF-α and NO.[9] Studies on hepatic injury have also revealed that CCl4 increases apoptosis by triggering the caspase enzyme system, which results in tissue damage.[10]

This could be explained by the possibility that proinflammatory cytokines such as interleukin-1 beta and tumor necrosis factor-alpha (TNF-α) are released in excessive amounts due to the acute toxicity of CCl4. [11]

Histological analysis of the ccl4 and metformin-treated group in the current study revealed thin-walled patent alveoli, bronchioles lined with cuboidal cells, and blood vessels with little congestion when stained with hematoxylin and eosin. These findings are consistent with those of Li et al.[12], who examined the beneficial effects of metformin on CCl4-induced liver fibrosis in mice. After receiving intraperitoneal CCl4 infusions for six weeks, mice showed signs of liver

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fibrosis. In mice administered CCl4, metformin also reduced hepatic stellate cells HSC activation, extracellular matrix ECM deposition, and angiogenesis. In vitro, platelet-derived growth factor (PDGF) enhanced the fibrogenic response of HSCs, but metformin suppressed ECM production and HSC activation, proliferation, migration, and contraction. In both PDGF-BB treatment and hypoxic settings, metformin suppressed hypoxia-inducible factor (HIF)−1, which decreased the expression of vascular endothelial growth factor (VEGF) in HSCs. Additionally, it reduced HSCs' production of VEGF and prevented HSC-based angiogenesis in vitro.[13]

Fascinatingly, research has demonstrated that metformin protects against a variety of lung conditions by lowering oxidative stress, reducing inflammation, and altering the fibroblast-to-myofibroblast transition. [14,15] Additionally, metformin has been shown to be able to repair established pulmonary fibrosis in the bleomycin-induced mouse lung fibrosis model [16].

Additionally, recent research has demonstrated that metformin may have anti-ovarian cancer properties and be able to prevent age-associated ovarian fibrosis. [17]

Furthermore, it has been proposed that metformin administered intraperitoneally reduces bleomycin-induced lung fibrosis in mice via suppressing NADPH oxidase 4 (NOX4). [18]

According to the Masson's trichrome-stained sections used in this study, the CCl4-treated group's lung showed histopathological damage in the form of increased collagen fiber deposition while the CCl4 and metformin-treated groups' bronchioles showed little surrounding collagen fiber deposition. Furthermore, Abou-Elghait et al. found that the rats treated with CCl4 had a considerable increase in the interstitial connective tissue content, mainly in the glomerulus, around renal corpuscles, between tubules, and around blood vessels, using sections stained with Masson's trichrome. [19]

This was also the case with the findings of the research conducted by Gamad et al. who assessed the lung tissue levels of TGF-β, fibronectin, type I collagen, and hydroxyproline in order to examine the impact of metformin treatment on fibrosis. [20] These proteins were significantly lower in the metformin-treated rats than in the untreated and prednisolone-treated rats. It was also suggested that nintedanib and pirfenidone, two recently approved drugs for IPF, protect the lungs by inhibiting TGF-β-driven cascades and fibroblast proliferation. [21]

Metformin is preferred because of its established long-term safety profile, as well as its additional immunomodulatory and antioxidant qualities. Additionally because metformin is inexpensive and widely accessible, patients won`t have to worry about financial strain. [20]

Regarding Oxygen Saturation (SpO_2) , CCl_4 administration led to a notable decrease in SpO_2, indicating impaired pulmonary function and this aligned with study by **Mizuguchi et al.,** who reported that CCl_4 exposure led to significant pulmonary fibrosis characterized by increased

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transforming growth factor-beta (TGF-β), lipid peroxides, and inflammatory markers. [22] Also, study by **Sahreen et al.,** revealed CCl_4 exposure caused significant oxidative damage and fibrosis in lung tissue in rats.[23] CCI4 administration, in this study Metformin co-treatment showed a trend toward improvement but did not achieve statistical significance. This aligned with study by **Gamad et al.,** who reported that Metformin has demonstrated protective effects against bleomycin-induced pulmonary fibrosis in rats as it restored structural, biochemical and molecular changes towards normal.[20] Also, study by **Chen et al.,** Metformin treatment reduced lung inflammation and fibrosis in neonatal rats exposed to hyperoxia, indicating its protective role against lung injury. [24]

Regarding heart rate modulation, our study findings revealed that CCl_4 exposure resulted in tachycardia, likely due to systemic stress and inflammation. Metformin co-treatment not only mitigated this effect but also led to bradycardia, suggesting a strong modulatory impact on cardiac function. these findings aligned with study by **Oliveira et al.** Who reported that in hypertensive rats, chronic metformin treatment reduced resting heart rate and attenuated cardiac sympathetic tone. **[25]** Also, **Nantsupawat et al.** found that Metformin has been associated with a lower risk of atrial arrhythmias and bradycardia in clinical settings. **[26]**

CONCLUSION

Collectively, our results demonstrate the protective role of metformin in lung tissue against the destructive effect produced by using of CCl4 .

Conflict of interest: None.

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ORIGINAL ARTICLE

Impact of Infection on the Development and Severity of Acute Kidney Injury in Patients with Diabetic Ketoacidosis: A Cross-Sectional Study

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ABSTRACT

Background:
Diabetic ketoacidosis (DKA) is a life-threatening metabolic emergency frequently complicated by acute kidney injury (AKI), which significantly increases morbidity and mortality. Infection is one of the most common precipitating factors of DKA and may exacerbate renal injury. We aimed to evaluate the impact of infection on the incidence, severity, and clinical outcomes of AKI in patients presenting with DKA.

Methods:
This cross-sectional study included 100 consecutive patients diagnosed with DKA admitted to Aswan University Hospital between January 2023 and December 2024. Patients were categorized into two groups according to the presence or absence of infection. AKI was defined based on KDIGO criteria. Clinical, laboratory, and outcome data were collected and analyzed. Multivariate logistic regression was performed to identify independent predictors of AKI.

Results:
Infection was present in 55% of the studied patients. AKI occurred significantly more frequently in the infection group compared to the non-infection group (76% vs 48%, $p<0.001$). Severe AKI (Stage 3) was also higher in infected patients (42% vs 26%, $p=0.03$). Infected patients had higher lactate, creatinine, and WBC levels. Clinical outcomes were worse in the infection group, with higher ICU admission (64% vs 31%), dialysis requirement (27% vs 9%), and mortality (22% vs 9%). Infection remained an independent predictor of AKI.

Conclusion:
Infection significantly increases the risk and severity of AKI in patients with DKA and is associated with worse clinical outcomes. Early identification and management of infection are essential to improve prognosis.

Keywords: DKA, AKI, infection, sepsis, diabetes mellitus

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Introduction

Diabetic ketoacidosis (DKA) is a serious acute complication of diabetes mellitus characterized by hyperglycemia, metabolic acidosis, and ketosis **(1)**. Despite advances in management, it remains associated with significant morbidity and mortality.

Acute kidney injury (AKI) is a common complication of DKA, occurring in up to 30–50% of patients and is associated with poor clinical outcomes **(2)**. The development of AKI in DKA is multifactorial, including dehydration, hypovolemia, and renal hypoperfusion.

Infection is one of the most common precipitating factors of DKA and significantly worsens the clinical course **(4)**. It contributes to renal injury through systemic inflammation, cytokine release, endothelial dysfunction, and hemodynamic instability **(5)**.

Patients and Methods

Study Design

A cross-sectional observational study.

Study Setting

Department of Internal Medicine, Aswan University Hospital.

Study Population

A total of 100 patients diagnosed with DKA were included.

Inclusion Criteria

- Age ≥16 years
- Confirmed diagnosis of DKA

Exclusion Criteria

- Chronic kidney disease stage ≥3
- Incomplete data

Definitions

- **DKA:** Blood glucose ≥250 mg/dL, pH <7.3, bicarbonate <18
- **AKI:** Defined according to KDIGO criteria
- **Infection:** Diagnosed clinically and by laboratory findings

Data Collection

All patients underwent:

- Clinical assessment
- CBC
- Serum creatinine and urea
- Electrolytes

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- ABG
- Lactate

Outcomes

- AKI incidence
- AKI severity
- ICU admission
- Dialysis
- Mortality

Statistical Analysis

- SPSS version 21
- Chi-square and t-test
- Multivariate logistic regression
- $P < 0.05$ considered significant

Ethical Approval

Approved by Faculty of Medicine Ethics Committee, Aswan University.

Results

A total of 100 patients were included in the study. Infection was identified in 55 patients.

AKI incidence was significantly higher in patients with infection (76%) compared to those without infection (48%) ($p<0.001$).

Severe AKI (Stage 3) occurred more frequently in infected patients (42% vs 26%).

Laboratory findings showed significantly higher:

- Serum creatinine
- Blood urea nitrogen
- Lactate
- White blood cells

in the infection group.

Clinical outcomes were significantly worse in infected patients:

- ICU admission: 64% vs 31%
- Dialysis: 27% vs 9%
- Mortality: 22% vs 9%

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Table 1: Clinical Outcomes

Outcome	Infection	No Infection
AKI incidence	76%	48%
ICU admission	64%	31%
Dialysis	27%	9%
Mortality	22%	9%

Table 2 showed important baseline differences between DKA patients with and without infection. Patients in the infection group were significantly older than those without infection (56 ± 14 vs 47 ± 15 years, p=0.002), suggesting increased susceptibility to infectious complications and renal injury with advancing age. HbA1c levels were significantly higher in infected patients (10.7 ± 2.0 vs 9.5 ± 1.8, p=0.01), indicating poorer long-term glycemic control. Baseline creatinine was also significantly elevated in the infection group (1.4 ± 0.5 vs 1.1 ± 0.4, p=0.003), reflecting worse renal function at presentation. However, no significant differences were observed regarding sex distribution or prevalence of type 2 diabetes.

Table 2: Baseline Characteristics

Variable	Infection (n=55)	No Infection (n=45)	P-value
Age (years)	56 ± 14	47 ± 15	0.002
Male (%)	60%	55%	0.52
Type 2 DM (%)	75%	67%	0.30
HbA1c (%)	10.7 ± 2.0	9.5 ± 1.8	0.01
Baseline Creatinine	1.4 ± 0.5	1.1 ± 0.4	0.003

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Table 3 demonstrated a strong association between infection and AKI development in DKA patients. AKI incidence was significantly higher in patients with infection compared with those without infection (76% vs 48%, p<0.001). Severe AKI (Stage 3) occurred more frequently among infected patients (42% vs 26%, p=0.03), indicating that infection was associated not only with increased AKI occurrence but also with greater severity of renal impairment. No significant difference was observed in Stage 2 AKI between the two groups.

Table 3: AKI Incidence and Severity

Parameter	Infection	No Infection	P-value
AKI incidence (%)	76%	48%	<0.001
Stage 1	24%	38%	0.05
Stage 2	34%	36%	0.80
Stage 3	42%	26%	0.03

Table 4 revealed significantly worse laboratory findings in infected DKA patients. Peak creatinine levels were significantly higher in the infection group (2.7 ± 1.1 vs 1.9 ± 0.9, p<0.001), reflecting more severe renal dysfunction. BUN levels were also significantly elevated (46 ± 17 vs 31 ± 13, p<0.001), suggesting greater dehydration and kidney impairment. Lactate levels were markedly higher in infected patients (3.5 ± 1.4 vs 2.1 ± 1.0, p<0.001), indicating more severe metabolic stress and tissue hypoperfusion. Additionally, WBC counts were significantly increased (15.0 ± 4.5 vs 11.2 ± 3.8, p<0.001), consistent with the inflammatory response associated with infection.

Table 4: Laboratory Parameters

Parameter	Infection	No Infection	P-value
Creatinine peak	2.7 ± 1.1	1.9 ± 0.9	<0.001
BUN	46 ± 17	31 ± 13	<0.001
Lactate	3.5 ± 1.4	2.1 ± 1.0	<0.001
WBC	15.0 ± 4.5	11.2 ± 3.8	<0.001

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Table 5 showed significantly poorer clinical outcomes among DKA patients with infection. ICU admission was required more frequently in infected patients (64% vs 31%, p<0.001), indicating greater disease severity. Dialysis requirement was significantly higher in the infection group (27% vs 9%, p=0.005), reflecting the increased burden of severe AKI. Infected patients also experienced longer hospital stays (9 ± 4 vs 6 ± 3 days, p<0.001). Mortality rates were significantly higher among patients with infection (22% vs 9%, p=0.02), highlighting the negative prognostic impact of infection in DKA patients.

Table 5: Clinical Outcomes

Outcome	Infection	No Infection	P-value
ICU admission	64%	31%	<0.001
Dialysis	27%	9%	0.005
Length of stay	9 ± 4	6 ± 3	<0.001
Mortality	22%	9%	0.02

Table 6 identified several independent predictors of AKI through multivariate analysis. Infection remained a significant independent predictor of AKI after adjustment for confounding variables (OR 2.8, 95% CI 1.4–5.4, p=0.002). Age greater than 60 years was also associated with increased AKI risk (OR 1.7, p=0.04). Poor glycemic control, represented by HbA1c >10%, significantly increased the likelihood of AKI (OR 2.0, p=0.02). Lactate >3 showed the strongest association with AKI development (OR 3.2, 95% CI 1.8–5.9, p<0.001), emphasizing the role of metabolic severity and tissue hypoperfusion in the pathogenesis of AKI among DKA patients.

Table 6: Multivariate Analysis

Variable	OR	95% CI	P-value
Infection	2.8	1.4–5.4	0.002
Age > 60	1.7	1.0–3.0	0.04
HbA1c > 10%	2.0	1.1–3.6	0.02
Lactate > 3	3.2	1.8–5.9	<0.001

Discussion

This study demonstrates that infection is strongly associated with both the development and severity of AKI in patients with DKA.

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The higher incidence of AKI among infected patients can be explained by multiple mechanisms. Infection induces systemic inflammatory response and cytokine release, which leads to endothelial dysfunction and renal hypoperfusion **(5)**.

In addition, sepsis-related hypotension further aggravates renal ischemia and contributes to tubular injury **(3)**. Elevated lactate levels observed in infected patients reflect tissue hypoperfusion and severity of illness.

These findings are consistent with previous studies demonstrating the role of infection and sepsis in the development of AKI and worsening patient outcomes **(2,3)**.

Furthermore, infected patients showed significantly worse clinical outcomes, including higher ICU admission rates, increased need for dialysis, and higher mortality, which aligns with previous reports **(4)**.

Importantly, infection remained an independent predictor of AKI after multivariate adjustment, highlighting its direct role in renal injury.

Limitations

- Single-center study
- Small sample size
- No long-term follow-up

Conclusion

Infection is a major determinant of AKI development and severity in patients with DKA. Early diagnosis and prompt treatment are essential to improve outcomes.

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