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Functional Outcomes of Percutaneous Screw Fixation for Medial Malleolus Fractures

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Background: Medial malleolus fractures (MMF) are prevalent among middle-aged and elderly populations. Percutaneous screw fixation (PSF) has emerged as a contemporary surgical technique for the management of these fractures.

Material and methods: This prospective descriptive study was conducted at Erbil Teaching Hospital, West Erbil Emergency Hospital, and East Erbil Emergency Hospital in Erbil from April 1st to June 30th. The cohort comprised 32 adult patients diagnosed with MMF, who underwent PSF. Postoperative radiographs were obtained at 6 weeks to assess fracture union, with additional follow-ups at 12 weeks and as necessary thereafter.

Results: The mean age of the patients was 43.3 years, with a male predominance of 59.37%. The predominant cause of injury was falls from heights (53.1%). The fracture union rate was 100%, with a mean time to union of 9 weeks. Postoperative complications included tenderness due to hardware irritation (15.62%), malunion (6.25%), superficial infections (6.25%), and painful bursa (6.25%). An excellent functional rating was observed in 65.62% of patients postoperatively.

Conclusions: Percutaneous screw fixation of MMF demonstrates favorable outcomes in terms of union rates and soft tissue condition, effectively mitigating the impact of soft tissue interposition on fracture healing.

Keyword: Medial malleolus fracture, percutaneous screw fixation, fracture union, soft tissue status

Introduction

Ankle fractures represent a prevalent type of lower limb fracture, constituting approximately 9% of all fractures and significantly contributing to the trauma workload (1, 2). The annual incidence of ankle fractures reaches up to 184 per 100,000 individuals (3, 4), with open fractures comprising about 2% of these cases (5). Predominantly, these injuries affect young men and elderly women (6). Below the age of 50, men are more frequently afflicted, whereas women are more commonly affected thereafter. Contributing factors to one-third of these cases include alcohol consumption and slippery surfaces (7).

The primary etiologies of ankle fractures include falls, rotational injuries, and sports-related trauma (8). In middle-aged and older adults, conditions such as diabetes mellitus and obesity are associated with an increased risk of fractures. Most ankle fractures are accompanied by ligamentous injuries, with the type and severity of the fractures closely correlating with the magnitude and direction of the force applied to the joint (9).

Ankle fractures are among the most common fractures requiring surgical intervention (10). Open Reduction and Internal Fixation (ORIF) is typically advocated for unstable bimalleolar and trimalleolar fractures (11). For fractures involving the medial malleolus (MM), whether isolated or as part of a more complex fracture, optimal fixation methods are crucial, generally involving surgical stabilization (12).

The current discourse in the literature presents various opinions on the optimal constructs for the fixation of medial malleolar fractures. This includes the consideration of a typical supra collicular medial malleolar fracture, which commences at the shoulder of the medial tibial plafond and extends obliquely to the medial cortex (13, 14).

Various surgical techniques have been explored for the stabilization of medial malleolus fractures (MMF), including the use of 4.0 mm partially threaded lag screws, tension-band wiring, and bioabsorbable implants. Predominantly, the fixation involves placing 4.0 mm partially threaded, cancellous lag screws perpendicularly to the fracture line, initiating at the lowest part of the medial malleolus (15, 16) .

Biomechanical studies have demonstrated that neutralization plates might offer a mechanical advantage over screw-only fixation for specific fracture patterns, enhancing strength and durability (17). Moreover, percutaneous fixation using screws has been shown to reduce hospital stays and soft tissue complications, offering less invasive treatment options with satisfactory functional and radiological outcomes (18).

Despite generally positive results, operative stabilization of ankle fractures can lead to postoperative complications, such as pain or tenderness, which might lead to patient dissatisfaction. Soft tissue irritation from prominent hardware often contributes to this discomfort, occasionally necessitating hardware removal. The pain associated with hardware can stem from various factors, including subcutaneous positioning, bone impingement, or irritation of deeper soft tissue structures (19, 20). This study aims to evaluate the surgical outcomes of percutaneous screw fixation (PSF) of MMF, focusing on soft tissue integrity and union rates.

Patients and Methods

This prospective study examined 32 patients with MMF treated surgically using PSF. The research was conducted across three hospitals in Erbil (Erbil Teaching, Erbil West Emergency, and Erbil East Emergency) from April 1 to June 30.

Inclusion Criteria: The study included adults over 18 years presenting with isolated malleolar fractures (bi- or tri-malleolar), closed fractures, and full skeletal maturity. Exclusion Criteria: Excluded were pregnant individuals, patients with non-displaced fractures (displacement <2-3 mm), mental health disorders, pediatric patients, those with polytrauma, vertical, comminuted, or open fractures, ankle dislocations, associated ligamentous injuries, or those presenting more than one week after injury.

Following a comprehensive history and examination, which included assessments of swelling, soft tissue condition, and distal pulse, patients underwent resuscitation per protocols as needed. A below-knee posterior slab or splint was applied before referring patients for anteroposterior and lateral radiographs, and CT scans if a plafond fracture was suspected.

Procedure

Patients received either spinal (12 patients) or general anesthesia (20 patients) in the supine position, with a pneumatic tourniquet applied over the mid-thigh. Surgical preparation included the arrangement of instruments, a fluoroscope, and implants. A single dose of Ceftriaxone (1 gm IV) was administered an hour before anesthesia induction.

The fracture reduction was achieved either manually or using a K-wire as a joystick. Subsequently, a guide wire was related to an electric power drill and inserted through a small port (1 cm incision length, 1 cm distal to the tip of the medial malleolus). Using a cannulated drill over the K-wire (4.5 or 5 mm based on the chosen screw size of 5 mm or 7.3 mm), the procedure was monitored regularly with a fluoroscope from lateral and anteroposterior views. After drilling, a partially threaded cancellous cannulated screw with a washer was inserted, ensuring the threads crossed the fracture and two cortices for optimal compression. Final verification was performed using a fluoroscope.

Following the surgical procedure, the port was shielded with sterile gauze, and a posterior slab was positioned below the knee. Elevation was recommended to mitigate swelling. The patient received an oral antibiotic, specifically cefixime, at a dosage of 400 mg daily for five days. Radiographic assessments were conducted at six weeks postoperatively to evaluate fracture union, and subsequently after more than 12 weeks. Partial weight-bearing was permitted starting two weeks post-surgery, contingent on the removal of the cast and patient compliance. Early initiation of physiotherapy was encouraged, beginning with active dorsiflexion and plantarflexion, followed by both active and passive stretching until the full range of motion was restored.

Clinical union is characterized by progressively increasing stiffness and strength, attributable to the mineralization process, rendering the fracture site stable and devoid of pain. Radiographic union is confirmed when plain radiographs reveal the crossing of bone trabeculae or cortical

bone at the fracture site. Malunion is diagnosed when the fracture heals with the fragments misaligned, potentially compromising function in several ways: 1) an irregular joint surface may lead to uneven weight distribution and subsequent joint arthritis, 2) rotation or angulation of fragments may affect balance or gait, 3) overlapping fragments or bone loss can cause noticeable limb shortening, and 4) mobility of adjacent joints may be restricted.

The functional rating scale was employed to assess ankle joint function post-surgery, categorizing outcomes as excellent (normal range of motion without pain or stiffness and normal resumption of activities), good (normal range of motion with occasional pain but without stiffness and normal activity resumption), fair (reduced range of motion with occasional pain post-activity), and poor (limited range of motion accompanied by pain and stiffness at rest). This study utilized the functional ankle score described by Latif et al. (Table 1) (21).

Table 1. Functional rating scale (20).

Ranks	Description
Excellent	Normal range of motion without pain or stiffness and return to previous activity level
Good	Normal range of motion without pain or stiffness, return to previous activity level with only occasional pain following activity
Fair	Decreased range of motion, frequent pain following activity
Poor	Decreased range of motion, pain and stiffness at rest

Ethical consideration:

The study received approval from the Scientific Council of Orthopedic Surgery of the Iraqi Board for Medical Specializations, and consent was secured from the Directorate of Health of Erbil (DOH). Informed oral consent was obtained from each participant before enrollment.

Statistical analysis

Data analysis was conducted using IBM SPSS Statistics Version 27. Descriptive statistics were used to summarize categorical data, presented as frequencies and percentages, and continuous data, presented as means and standard deviations. P-values less than 0.05 were deemed statistically significant.

Result

The study included thirty-two patients with MMF, with a mean age of 43.3±14.6 years; 13 (40.62%) of these patients were aged 50 years or older. The patients were predominantly male, representing 19 (59.37%) of the sample. The most prevalent type of ankle fracture was Type A2, accounting for 13(40.62%), followed by Type A1 in 9 (28.12%) of the cases. The majority of

fractures, 21(65.62%), occurred on the right side. The primary causes of injury fell from heights 17 (53.12%), road traffic accidents 7 (21.87%), direct impacts 3(9.37%), and other mechanisms 5 (15.62%) (Table 2).

Table 2: General characteristics of MMF patients

Variable		No (%)
Age years		43.4±14.6*
	<30 years	7(22.87)
	30-39 years	3(9.37)
	40-49 years	9(28.12)
	≥50 years	13(40.62)
Sex		
	Male	19(59.37)
	female	13(40.62)
Fracture type		
	A1	9 (28.12)
	A2	13(40.62)
	A3	8 (25)
	A4	2 (6.25)
Fracture side		
	Right	21(65.62)
	Left	11 (34.38)
Mechanism of injury		
	FFH	17(53.12)
	Direct blow	3(9.37)
	RTA	7(21.87)
	Others	5(15.62)

* Mean±SD

Percutaneous fixation surgery for MMF was typically performed within 1-3 days for 17 (53.12%) of the patients, with the mean surgery duration being 29±8 minutes; 19 (59.37%) of the surgeries exceeded 25 minutes. The mean number of fluoroscopy C-arm shots was 30±13, with 22 (68.75%) patients receiving 30 shots or fewer. Fluoroscopic reduction was deemed satisfactory in 30 (93.8%) cases, as shown in Table 3.

Table 2: Surgical characteristics of medial malleolus fracture patients

Variable	No (%)
Surgery performed within 1-3 days	17(53.12)
Surgery duration (mean ± SD=29±8 minutes) >25 minutes	19(59.37)

Fluroscopy C-arm shoots (mean ± SD=30±13 shoots) 30 ≤	22(68.75)
Reduction on fluoroscopy Good	30(93.8)

Postoperatively, a gap of 2mm at the fracture site was observed in 4 patients (12.5%). The mean duration for partial and full weight-bearing were 5±1 weeks and 8±1 weeks, respectively. All patients commenced physiotherapy following surgery, with the mean time to resuming previous activities being 12±2 weeks. The mean time to union of the medial malleolus fracture post-surgery was 9±2 weeks, with a union rate of 100% and no occurrences of delayed union. The primary postoperative complications included hardware irritation pain (15.62%), malunion (6.25%), superficial infections (6.25%), and painful bursa (6.25%), but there were no issues related to the posterior tibial tendon in any patient. At six months post-surgery, the functional rating scale showed 65.62% of patients rated as excellent, 28.12% as good, and 6.25% as fair, with no poor outcomes reported (Tables 3, Figures 1 to 3).

Table 3: Outcome of percutaneous fixation of medial malleolus fracture patients

Variable	No (%)
Gap at fracture site Present	4(12.5)
Partial weight bearing (mean ± SD=5±1 weeks) <5 weeks	20(62.5)
Full weight bearing (mean ± SD=8±1 weeks) 8 weeks ≤	22(68.75)
Time to return to previous activity (mean ± SD=12+2 weeks) >9 weeks	27(84.37)
Postoperative physiotherapy (Yes)	32(100.0)
Union duration (mean ± SD=9+2 weeks) 9 weeks ≥	20(62.5)
Implant failure None	32(100.0)
Tenderness Yes	5(15.62)
Infection(superficial) Yes	2(6.25)
Painful bursa Yes	2(6.25)
Tibialis posterior tendon None	32(100.0)
Malunion None	2(6.25)

Nonunion	
None	32(100.0)
Delayed union	
None	32(100.0)
Conversion to internal fixation	
None	32(100.0)
Functional rating scale	
Excellent	21(65.62)
Good	9(28.12)
Fair	2(6.25)

Figure 1: A 43 years old female patient serial radiographs, A) Preoperative, B, C&D) Intraoperative guide wire insertion and screw placement, E&F) Follow up radiographs.

Figure 2: A 37 years old male patient serial radiographs, A) Preoperative, B&C) Follow up radiographs

Figure 3: A39 years old patient serial radiographs, A&B) Preoperative, C&D) Postoperative fixation

Discussion

The surgical stabilization of medial malleolar fractures using either a partially threaded cannulated cancellous screw or two partially threaded cancellous screws is a widely recognized clinical practice (22). Prior literature on the surgical technique for inserting hardware into medial malleolar fractures has generally not included specific recommendations by Femino et al. to mitigate potential risks to the posterior tibial tendon, which runs directly posterior and inferior to the medial malleolus (23). In the present study, all patients were operated on following these guidelines.

Posterior tibial tendon dysfunction following ankle trauma is well-documented. Bubra et al. suggested that previous ankle trauma might be a contributing factor in the development of posterior tibial tendon insufficiency, which can lead to acquired flatfoot. Notably, no injuries to the tibialis posterior tendon were reported in the present study (24).

Ziegler et al. advocated for the use of closed or percutaneous fixation methods in ankle fractures, highlighting the benefits of these approaches in preserving blood supply and minimizing soft tissue dissection (25). A study by Singh et al. in the UK indicated that ankle fractures are prevalent among the elderly due to factors such as obesity and diabetes mellitus, along with a high incidence of postoperative complications. In the current study, 40.62% of the patients were over 50 years of age (2).

The current study observed a higher incidence of MMF in males than females, aligning with findings by Vosoughi et al., which noted a predominance of male patients suffering from ankle fractures. However, males under 50 were the most frequently affected group (26).

Over half of the medial malleolus fracture cases in this study resulted from falls from height, accounting for 53.12% of cases, which underscores the violent nature of injuries more common among males. Elmosrati noted that falls from height are the predominant cause of ankle fractures (27).

The mean time for bone union following percutaneous fixation of MMF in the current study was nine weeks, which is more favorable compared to the 11.8 weeks reported by Mohammed et al. for tension band wiring and 9.4 weeks for screw fixation. The timeline for returning to physical activity was 12 weeks, with partial and full weight bearing at five and eight weeks, respectively (28).

The union rate in this study aligns with that reported by Wang et al., who used PSF in 34 cases and observed effective reductions and bone union. They suggested that PSF minimizes surgical trauma, potentially lowering infection rates and facilitating quicker functional recovery of the ankle joint, Additionally, the postoperative complications noted in the present study included tenderness (15.62%), malunion (6.25%), and superficial infection (6.25%). In contrast, Wang et al. reported no infections or poor reductions with percutaneous fixation (29).

Khachariya et al. compared outcomes between ORIF using a cannulated screw and tension band wiring in 40 patients. They reported a 5% rate of delayed union and a 10% rate of wound infection, both of which are higher than the rates observed in the present study (30).

At last, Smith et al. emphasized that PSF is an excellent method for the fixation of ankle fractures, particularly in cases with poor soft tissue, and is associated with a low incidence of postoperative complications (18).

Conclusions and Recommendations

This study demonstrates that flexible intramedullary nailing is an effective and physiologically appropriate method for treating most pediatric femoral shaft fractures in children aged 4 years and older with open growth plates. The ESIN is a safe, straightforward, and dependable treatment option for femoral fractures in children aged 4-14 years. It promotes early mobility, decreases the length of hospital stays, minimizes complications, and enhances satisfaction among families and children. Additionally, the ease of use of ESIN facilitates quicker parental return to work. This technique is particularly suitable for treating mid-diaphyseal transverse, short oblique, or short spiral femur fractures with minimal comminution in children eligible for surgical stabilization.

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Conflict of interest: We extend our heartfelt thanks to all contributors for their dedicated efforts and expertise in this study.

Data availability: Data from this study can be provided by the corresponding author upon reasonable request.

Consent for publications: The authors reviewed and gave their approval to the published version of the study.

Ethics approval and consent to participate: The Helsinki Declaration was followed in the conduct of this investigation. The Local Ethics Committee approved the study and participants provided informed permission.

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