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ORIGINAL ARTICLE

Minimally Invasive Percutaneous Anterolateral Plate Osteosynthesis for Distal Tibial Pilon Fracture

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ABSTRACT

Background: Distal tibia fracture surgery can be quite difficult and have a lot of problems. In order to successfully treat distal tibial fractures, soft tissue recovery is crucial. Because of the adequate soft tissue cover on the anterolateral distal tibia, the use of anterolateral plates is on an upward trend. The aim of the study is to assess the effectiveness and side effects of a minimally invasive anterolateral locking device in management of distal tibial Pilon fractures.

Methods: It was an observational prospective cohort research. After receiving the ethical permission for our study, we recruited and treated adult patients with distal tibial fractures of the AO 43C type who were hospitalized to our level I trauma center between March 2022 and August 2023. Following surgery, every patient was monitored for a minimum of 9 months. The mechanism of trauma, comorbidities, classifications, fracture-surgery interval, radiological exposure, surgery duration, complications, and the American Orthopedic Foot and Ankle Society (AOFAS) score were collected.

Results: The 25 patients were monitored for 9 to 18 months. The anatomic reduction was achieved in all cases. With the exception of one case, the majority of incisions healed well without necrosis two weeks following surgery. The healing time for the fractures was between 12 and 18 weeks (on average, 13.71.2 weeks). In the meantime, period of 4.95 months (3e12 months), full weight bearing was permitted. In any event, no significant local wound complication requiring revision surgery was observed. Five instances had minor problems, including two cases of delayed union, one case of a muscle hernia, one case of a superficial infection, and one case of sensory disturbance over the anterolateral foot. The average distance (6–8 cm) between the posterolateral and anteromedial incisions was 7 cm. At one year following surgery, the AOFAS scores were excellent in 15 patients and good in 10 patients (average: 86.5 points, with excellent and good rates of 100%).

Conclusions: The anterolateral plating is a good one-step treatment for tibial pilon fractures. Using locking plates and minimally invasive procedures can reduce issues with soft tissue and bone healing.

Keywords: pilon, tibia, anterolateral, plate.

INTRODUCTION

Fractures of the tibial pilon typically involve comminution, intra-articular extension, and serious soft tissue injury because they occur towards the distal end of the tibia. Incidence of tibial-pilon fracture only 5–7% of distal tibial fractures occur, making them uncommon [1]. Pilon fractures frequently feature an axial stress mechanism that damages the joint surface and continue to be difficult for the majority of orthopaedic surgeons to treat [2]. Fibular fractures occur in 75%-85% of cases, with the number of fracture fragments inversely related to the rotational force of trauma [3].

Because the distal tibial soft tissue covering is limited, pilon fractures are frequently accompanied by severe soft tissue damage, and tension blisters are typically seen. These patients may still experience postoperative wound dehiscence or infection, which can lead to complications like slowed wound healing, exposed hardware, fixation failure, or even amputation [4].

Open reduction and rigid internal fixation with plates and screws are the cornerstones of treatment for pilon fractures, as first reported by Ruedi and Allgower [5]. Medial, anterolateral, and lateral approaches have all been used to treat pilon fractures [6].

Open reduction and internal fixation, which is the conventional procedure for treating distal tibial fractures, necessitates considerable soft-tissue dissection and has a high rate of complications [7]. A small stab incision is made using the minimally invasive percutaneous plate osteosynthesis (MIPPO) technique, and the plate is then slid over the periosteum without damaging the vascular network [8]. Clinical results are good when locking plates are used to treat pilon fractures, by reducing the plate's contact with the bone, they preserve better periosteal blood flow [9]. Therefore, choosing the right surgical incision is crucial and can significantly lower postoperative problems [10]. To evaluate the efficacy and safety of a minimally invasive anterolateral locking device for distal tibial pilon fractures, we conducted this prospective study.

METHODS

Twenty-five distal tibial fracture cases that underwent Minimal Invasive anterolateral tibial plating at our University Hospitals were included in this prospective study. The AO classification method was used to classify the fractures. All selected individuals gave their informed consent in writing or had a family member sign off on their participation. The ethics of the current research as put by the Institutional Research Board (IRB) of Zagazig Faculty of Medicine, Zagazig University were followed up thoroughly with IRB number #9583/1212022. The Declaration of Helsinki, issued by the World Medical Association to ensure the protection of people participating in medical research, was strictly followed during this study.

Inclusion Criteria

Patients who had distal tibial fractures that extend into the joint surface AO43C1, 2, and 3, and patients above 18 years old who were surgically fit.

Exclusion Criteria

Open fractures, Pediatric fractures, Stress fractures, Pathological fractures, and vascular disease.

All subjects undergone the following

Careful history

Personal data: including name, age and sex. Co-morbidities include cerebral palsy (CP), diabetes mellitus (DM), heart disease, and asthma.

Clinical examination

General examination and local examination especially the skin condition and the neuro-vascular exam.

Radiological assessment

Plain x-ray anteroposterior (AP) & lateral to the affected tibia showing the knee and ankle joints. CT for articular fractures.

Implant used in internal fixation

The locked anatomical anterolateral distal tibial plate, measuring 4.5 mm.

Operative procedures

Anesthesia

Spinal anesthesia was done for all patients.

Operative technique

Position

On a translucent operating table, all patients were positioned supine and given tourniquets. On a pad, the leg is supported. This enabled rotation for improved access to the lateral and medial sides.

Incision

Anterolateral incision was used as a minimally invasive technique to make the incision. A 4-cm anterolateral incision was made centered over the anterolateral tubercle (Chaput) of the tibia and in line with the fourth metatarsal [11]. The superior extensor retinaculum was cut but the superficial peroneal nerve was protected. Another open incision of 2 cm was created over the proximal tibia for proximal locking **(Figure 1)**.

Fracture reduction and fixation

The fracture can be initially reduced by gentle traction and manipulation techniques, or by using percutaneously inserted pointed reduction forceps. When reduction proves challenging, a tiny incision is made, a Kirschner wire is used to help reduce the fracture, and a towel clip or reduction clamp is used to retain reduction. Anteroposterior angulation of less than 10° and varus valgus angulation of less than 5° are accepted standards for reduction.

For the purpose of placing the plate on the bone, a temporary non-locking screw is used. A non-locking screw was inserted distal to the fracture

site and then traction was done to maintain the reduction and a proximal non locking screw was inserted to maintain the compression of the plate against the bone before insertion of the locking screws. Those nonlocking screws were changed at the end of the operation into locking ones. Prior to inserting the proximal locking screws, 2 of the 5 distal locking screws were used. After removing the initial k-wires, all screws were firmly tightened once more before closing **(Figure 2)**.

Wound closure

All incisions were closed in layers. Sterile dressing and bandage were applied over the wound.

Follow up

At regular intervals of four weeks, X-rays were taken as part of follow-up visits to evaluate alignment and healing. Patients underwent clinical and radiological evaluation at every follow-up **(Figure 2)**.

Evaluation

At final follow up, all participants provided informed consent before enrollment, and all clinical examinations were completed at the hospital where the surgery was performed. Range of movement (ROM) of ankle joint was assessed with a goniometer, and the assessment of patients was generally done by the American Orthopedic Foot and Ankle Society Score (AOFAS). (AOFAS) is for patients who have suffered a severe ankle or hindfoot injury sometimes have their recovery. Pain, function, and alignment were the three primary categories used in the rating system. On this scale, the function receives 50 points, pain 40 points, and alignment 10 points. These are all scored together for a total of 100 points. Usually, a score between 90 and 100 is excellent, 75–89 good, 50–74 fair and <50 poor. The American Orthopaedic Foot and Ankle Society was intended for doctors to use in order to standardize their evaluations of patients who were suffering from foot or ankle diseases; hence, it is not a patient-reported outcome measure (PROM).

Statistical analysis:

Statistical analysis was done by SPSS version 28 (IBM Co., Armonk, NY, USA). Quantitative variables were presented as mean and standard deviation (SD), Categorical variables were presented as frequency and percentage (%).

RESULTS

This study was carried out on 25 patients with distal tibial fractures (19 males and 6 females) with ages ranged between 20 and 55 years and a mean age of 41. 5 ± 13.6 years. Out of 25 patients, 24% were smokers and 20% were diabetic as shown in **(Table 1).**

Twenty-five of the patients considered had closed complicated tibial Pilon fractures. The three leading causes of fractures were falls (19 cases), car accidents (3 cases), and industrial accidents (3 cases). The AO/OTA categorized four cases as type 43C1, ten as type 43C2, and eleven as type 43C3. 80% of the patients had concomitant fibular fractures, and surgery was performed 2 to 9 days after the fracture, with a mean of 5.55±2.03 days **(Table 2)**.

The study participants were followed up over a mean of 8.6±4. 9 months, ranging from 4 to 12 months. After the surgery, the Burwell-Charnley radiography criteria were used in conjunction with a picture archiving and communication system (PACS) workstation to assess the quality of the fracture reduction. According to the results, 19 cases had an anatomical reduction, 5 had a good reduction, 1 had a fair reduction, and no screws had entered the joint. In the weeks following surgery, imaging at follow-up showed that the fractures were united. No patients suffered internal fixation failure or malunion during the follow up period. Ankle dorsiflexion had a range of 7 to 16 degrees, with a mean of 14.05±2.8 degrees, and ankle plantarflexion had a range of 12 to 30 degrees, with a mean of 24.2±6.7 degrees, with recognized anatomical alignment in all patients, as shown in **(Table 3)**.

In addition to mild ankle discomfort (28% of cases), moderate pain (20% of cases), superficial infection (4% of cases), delayed union (8% of cases), muscle hernia (4% of cases), and sensory disturbance across the anterolateral foot (1% of cases), there was one case (4%) of sensory disturbance across the foot. At the final follow-up, no patients had suffered malunion, internal fixation failure, limb shortening, loss of fixation, removal of hardware and deep infection, or wound dehiscence **(Table 4).**

The postoperative function of the patient was evaluated using the AOFAS Ankle-Hindfoot Scale. The evaluation's findings show that the 25 cases received an average score of 88.4 (on a scale of 80 to 100), with 15 cases gaining excellent ratings, 10 good ratings, 0 fair ratings, and 0 poor ratings, for a 100% excellent and good rating rate **(Table5)**.

Table 1: Baseline characteristics of the studied patients

		Total patients (n=25)
Age (years)	Mean ± SD	41. 5 ± 13.6
	Range	20 – 55
Sex	Male	19 (76%)
	Female	6 (24%)
Comorbidities	Smoking	6 (24%)
	DM	5 (20%)
Side	Right	12(48%)
	Left	13(52%)

Table 2: Injury mechanism and fracture characteristics of the studied patients

		Total patients (n=25)
Injury mechanism	Fall from height	19 (76%)
	Motor vehicle crashes	3 (12%)
	workplace accidents	3 (12%)
Fracture type	43-C1	4 (16%)
	43-C2	10 (40%)
	43-C3	11 (44%)
Concomitant fibular fracture	No	5 (20%)
	Yes	20 (80%)
Time after trauma (day)	Mean ± SD	5.55 ± 2.03
	Range	2 - 9

Table 3: Postoperative follow-up of the studied patients

		Total patients (n=25)
Follow up time (months)	Mean ± SD	8.6 ± 4. 9
	Range	4 – 18
Time for union (weeks)	Mean ± SD	13.7 ± 2
	Range	12 - 18
Ankle dorsiflexion (°)	Mean ± SD	14.05 ± 2.8°
	Range	7 - 16
Ankle plantarflexion (°)	Mean ± SD	24.2 ± 6.7°
	Range	12 - 30
Anatomical alignment	Accepted	25 (100%)
	Unaccepted	0 (0%)

Table 4: The incidence of complications in the studied patients

		Total patients (n=25)
Limb shortening	**No**	25 (100%)
	Yes	0 (0%)
Ankle pain	**No pain**	13 (52%)
	Mild	7 (28%)
	Moderate	5 (20%)
Loss of fixation	**No**	25 (100%)
	Yes	0 (0%)
Hardware removal	**No**	25 (100%)
	Yes	0 (0%)
Infection	**No infection**	24 (96%)
	Superficial	1 (4%)
	Deep	0 (0%)
Wound dehiscence	**No**	25 (100%)
	Yes	0 (0%)

Table 5: AOFAS score of the studied patients

		Total patients (n=25)
AOFAS score	**Excellent**	15 (60%)
	Good	10 (40%)
	Fair	0 (0%)
	Mean ± SD	88.4 ± 8
	Range	80 - 100

Figure 1: Minimally invasive technique using anterolateral incision.

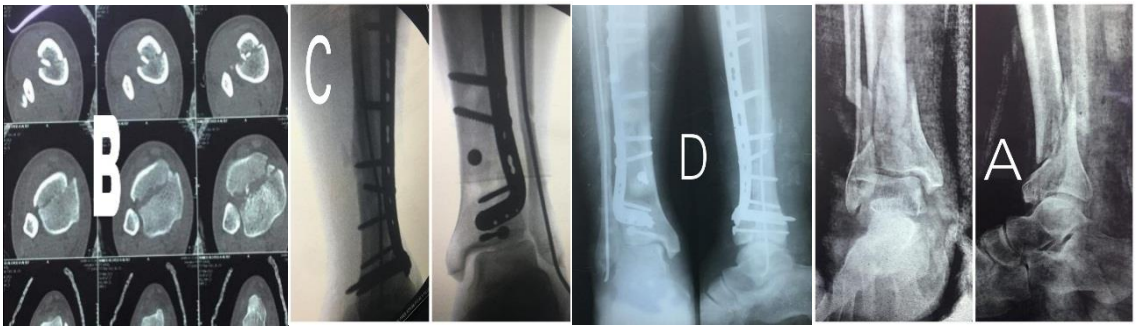

Figure 2: Anteroposterior and lateral views of the tibia before surgery (A), CT image showing intra-articular extension (B), intraoperative image (C), postoperative image during follow up period (D).

DISCUSSION

Distal tibial Pilon fractures frequently end in tension blisters and severe soft tissue injuries as the distal tibial soft tissue covering is constrained. Even after surgery, these individuals may still develop postoperative wound dehiscence or infection, which might hinder wound healing, expose the hardware, resulting in fixation failure, or even demand amputation. Therefore, it is crucial to have adequate pre-operative planning and achieve the optimal management of the soft tissue coverage intra-operative [4].

Treatment options for tibial Pilon fractures include six main surgical approaches; medial, anteromedial, anterolateral, lateral, posterolateral, and posteromedial [12]. Each surgical method has its own unique exposure window and defining features. The anteromedial technique is the one that is most frequently used, although one of its main drawbacks is the possibility of wound breakdown and implant exposure. Anteromedial plating and implant prominence may require removal as a revision procedure This method also fails to adequately expose the Chaput fragment, which is located on the distal tibia's anterolateral side. The distal tibia's anterolateral region showed enhanced soft tissue coverage and direct exposure to the anterolateral fragment. The anterior side and Chaput fragment of the distal tibia are well exposed during anterolateral surgical methods utilized to treat fibular fractures, while the medial side is not. Locking plates lessen the likelihood of a delayed union, nonunion, or loss of fixation by decreasing the pressure on the periosteum [13].

This study examined the functional, radiological outcomes, and comorbidities related to anterolateral plate treatment of distal tibial pilon fractures utilizing the MIPO approach.

In this prospective investigation of 25 patients, the majority of fractures occurred between the ages of 22 and 55, with a mean age of 41. 5 ± 13.6 years. sex women (24%) and 19 men (76%) were enrolled in the study. In this investigation, a distal locking tibial plate was present in every participant. A prospective study was carried out by Guan et al. [14]. with 13 participants. 6 men and 7 women participated in the research study, with an average age of 46 years.

In this study, falls from height occurred in 19 patients (76%), road traffic collisions occurred in 3 instances (12%), and workplace accidents occurred in 3 patients (12%). This was consistent with the findings of most of the literature, which showed that most cases with pilon fracture had a high-energy trauma [2.3].

In order to treat distal tibia fractures, Minimally Invasive Techniques are now generally recognized [8,13,17]. The literature [7] states that there is a possibility that open reduction internal fixation will obstruct blood flow and hinder soft tissue healing. With our technique, we stabilized fractures with the least possible sacrifice to soft tissue and with the least periosteal damage. We did postpone the treatment till the distal tibia's lines faded and the edema subsided. In order to keep the size of the wound incisions as small as possible, we made an effort to reduce the amount of dissection along the fibula [17].

Historically, twin incisions have been utilized to treat pilon fractures that also have fibular fractures; however, to prevent soft tissue necrosis, the skin bridge must be at least 7 cm wide. However, because to their high suture tension, substantial soft tissue injury, and slow incision healing rate, twin wounds may cause serious infection of the bone and soft tissue. Despite the substantial exposure provided by the medial and lateral incisions, it is still difficult to see the Chaput bone block and the repaired anterolateral column fractures [18].In our study, the skin bridge between the two incisions was 6 to 8 cm (on

average 7 cm) from the posterolateral incision to give this bridge a better blood supply and lower the incidence of soft tissue and incision wound problems [13]. However, some cases with fibular fractures were managed with percutaneous Kirsch wire.

The thirteen (AO/OTA 43-C3) instances of pilon fracture that Guan et al. [14] retrospectively investigated showed a mean bone union time of around 3.6 months (range, 2.6-5 months), with step off less than 2 mm in over 92% of the cases. These results were comparable to ours; the average healing period was 13.7 2 weeks (the range was 12–18 weeks), and 23 of 25 fractures healed within 4 months.

Numerous studies have shown that surgical treatment of tibial pilon fractures results in substantial rates of soft tissue problems. McFerran and Smith et al. observed that 54% of the local issues comprised wound breakdown, deep soft tissue infection/osteomyelitis, and superficial wound infections in their examination of complications associated with the treatment of tibial pilon fractures [19]. Similar findings were made by Ovadia and Beals et al. [20], who discovered that 16 out of 142 patients required soft tissue treatments for wound closure. There were no incidents of fixation loss, implant failure, or screw breakage in our study. In this study, one patient (4%) experienced soft tissue issues (superficial infection), and two patients experienced delayed union. Both of these patients had a lengthy history of diabetes and were heavy smokers.

The biggest drawback of this strategy is the danger of superficial peroneal nerve (SPN) injury from the anterolateral tibial approach, which requires careful protection of it during surgery. According to Herron et al. [21], the SPN is close to the inferior part of the incision and is in the surgical risk zone at the ankle joint line, 1 cm medial to the fibula and 1 cm medial to the tibia [3]. Dorsal foot numbness in one of the 25 patients was caused by an iatrogenic injury to the intermediate branch of the SPN, but it resolved on its own after two months. Because they share some cutaneous innervation, the sural nerve and medial branch of the SPN can often compensate for injury to the intermediate branch of the SPN [14].

A common obstacle in the anteromedial approach and one of the primary causes of the tendency to fixation using the anterolateral approach, according to the findings of Garg et al. [22], was symptomatic hardware. As 39% of patients who underwent medial plating wanted an additional procedure to remove the implants since the medial plate caused them discomfort. Our findings indicated there was no need for additional procedures to remove the implants following the application of the anterolateral plating. Neither of the participants in our study required implant removal after surgery or voiced concerns about complications related to the implant or implant prominence.

In a systematic review and meta-analysis comparing minimally invasive percutaneous plate osteosynthesis and intramedullary nail (IMN) fixation for distal tibial fractures, Ekman, et al. [16], found that IMN is a minimally invasive treatment due to the small skin incisions, little soft tissue stress, and preservation of extraosseous blood flow. Early mobilization is possible since the fixation is secure. Yet, anterior knee pain is likely and malunions have been seen as a complication of IMN. However, the MIPO procedures, which have a low rate of malunion, are linked with a longer wait until weight bearing and a higher risk of wound complications. MIPO, on the other hand, reduces the possibility of wound complications by protecting the distal tibia's blood supply from harm. They both reached the same result on the AOFAS score, with no differences. Our AOFAS score was excellent to good, with an average of 88.4 points, which is comparable to scores from several research [1,23,24].

Additionally, dorsiflexion (14.05 ± 2.8°) and plantar flexion (24.2 ± 6.7°) represented the average range of ankle motion in the present study, with remarkable results in both directions of as much as ninety percent. No patient experienced movement restriction and discomfort in their ankles; these findings are comparable to those of Ekman et al. [16].

CONCLUSION

In conclusion, anterolateral plating is a good one-step treatment for tibial pilon fractures. Using locking plates and minimally invasive procedures can reduce issues with soft tissue and bone healing. Anterolateral plating can help patients avoid the need for an additional procedure due to implant-related problems. The overall complication rates and functional outcomes of distal tibial anterolateral plating need to be compared and evaluated in longer-term research.

Despite the fact that all patients experienced positive short-term outcomes following minimally invasive anterolateral tibial plating, the study had notable limitations. The results of the study could be biased due to the relatively small number of patients we had, the short duration of the follow-up, the lack of a control group, and other factors. Large randomized controlled trials are required to confirm the findings in regard to these limitations and to corroborate the findings of the present investigation in order to increase the validity of the findings and the accuracy of the conclusions.

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