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Management of Distal Tibial Intra-Articular Fractures by Using Ring External Fixators Assisted Arthroscopically

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ABSTRACT

Background: Tibial pilon fractures are relatively uncommon injuries, representing only 1% of all fractures of the lower limb and 5% to 10% of those of the tibia. Frequent comminution and the thin soft-tissue envelope in the area make the treatment of these fractures challenging. The tibial pilon is characterised by a total absence of muscle coverage and marginal vascularity. Therefore, even moderate trauma often results in extensive soft-tissue damage.

Objective: The aim of this present study was to evaluate the arthroscopic assisted (Ilizarov) ring external fixation of distal tibial intra articular (pilon) fractures.

Patients and methods: This was a prospective study conducted between February 2012, April 2015 on thirty patients with closed, and Gustilo Types I & II open fractures of pilon fractures of the distal tibia who were admitted to Zagazig University Hospitals. During a period of two years, all cases were treated by Ilizarov fixators with or without limited internal fixation and assessment of intra-articular reduction tibial plafond by arthroscopy.

Results: Nineteen patients had right-sided injury, eleven patients had left sided injury and one patient had bilateral injury. At the time of injury, the youngest patient was 19 years old and the oldest was 6o years. The results in relation to pain as distributed according to the fracture. It is noted that the excellent results were with type I & II fracture, while the fair and poor results were with type II and III fracture.

Conclusion: The present study provided information on the use and the role of ankle arthroscopy in assisting and evaluation (the value, advantages, techniques of ankle arthroscopy and ring external fixators) of distal tibial intra-articular reduction after pilon fracture. The study showed that this technique might be a good method to manage the pilon fractures.

Keywords: Distal tibial intra-articular fractures, Pilon fractures, Arthroscopy.

INTRODUCTION

Two distinct mechanisms are believed to be responsible for most tibial pilon fractures: low-stress trauma (sports injuries), which is less common and secondary to rotational forces. The second is high-stress trauma (motor vehicle accidents, falls from height and workplace accidents), which is more common and produces axial transmission of the load with the talus pushed onto the distal tibia, resulting in a multifragmentary implosion of bones and cartilage structures. The pattern of the fracture with the mechanism of injury depends on the position of the foot at the time of trauma. With the foot dorsiflexed, compressive forces are placed on the anterior part of the plafond, whereas with the foot plantar flexed the forces are directed posteriorly. If the foot is in a neutral position, the axial force can also compromise the integrity of the articular surface [(1)]. Several classification systems have been proposed for tibial pilon fractures. Rüedi and Allgöwer introduced a classification that divides fractures into three groups according to the degree of displacement and comminution of the articular and metaphyseal fragments [(2)], to which Ovadia and Beals added two fracture variants [(3)].

Currently, the most widely used classification is the AO/OTA classification, which divides fractures into three groups: type A, extra-articular; type B, partially intra-articular; and type C, completely intra-articular. Each group is further divided into subgroups that indicate the severity of the comminution and the fracture pattern [(4)].

The treatment of tibial pilon fractures, particularly high-stress fractures, is complex and often difficult. The historically disappointing results of conservative treatment and the first attempts at limited internal fixation led the AO to develop guidelines for open reduction and internal fixation. This method has produced and still produces good results, particularly in less severe, low stress fractures, but results are not as good in high-stress injuries. In fractures with severe soft-tissue damage and metaphyseal comminution, the introduction of plates and screws through an extensive exposure is associated with a high rate of failure and severe complications, such as surgical wound infections, osteomyelitis, and non-union [(5)].

Hybrid external fixation represent a possible alternative method to provide stable fixation and reduce complications. These devices have gained increasing popularity among orthopaedic surgeons because they provide a stable fracture synthesis that can drastically reduce soft-tissue damage. However, in some cases, a relatively simple and standardized method of assembly of the external fixation is balanced by the need for minimal additional internal fixation to restore proper joint congruity.

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Despite the growing interest in this type of technique, most of the studies in the literature are based on relatively small numbers of cases [6].

The aim of the present study was to evaluate the arthroscopic assisted (Ilizarov) ring external fixation of distal tibial intra articular (pilon) fractures. Using the following approach: reduction of the fracture, visualization of the plafond articular fracture by standard ankle arthroscopic techniques, and application of ring external fixators.

PATIENTS AND METHODS

This was a prospective study conducted between February 2012 and April 2015 on thirty patients with closed and Gustilo Types I & II open fractures of pilon fractures of the distal tibia who were admitted to Zagazig University Hospitals. During a period of two years, all cases were treated by Ilizarov fixators with or without limited internal fixation and assessment of intra-articular reduction tibial plafond by arthroscopy. The cases were followed up for one year with an average 6 months.

The majority were occurring in males. The average age was 35 ± 11 years (range from 19 years to 60 years). The data of each patient were collected as regard the name, age, sex, occupation, address, special habits, mechanism of injury, associated injury, history of receiving treatment of diabetes, hypertension and peripheral vascular disease. In addition, complete history and physical examination was taken. The specific details of the mechanism of injury are important, as they will suggest the type of force exerted upon both the soft and skeletal tissues, which will vary considerably depending upon the mechanism of injury.

History:

a) Age of the patient
b) Mechanism of injury

- The history of jumping injury or an accident or a simple falls at home. i.
- Information that is relevant to the mechanism of injuries included distance of the fall, surface ontoii. which the patient fall and the position in which the patient landed. iii.

Sever compression injuries were elicited in patients falling from height (four cases), or motor vehicle-related accidents (six cases). Minimal comminution and large articular fragments were seen in with rotational injuries like falling from height of low distance (14 cases), fall down stairs (three cases) and falling forward with entrapped foot (three cases).

Some systemic disease, which may be associated with vascular complications such as diabetes mellitus or systemic vascular disease. We had two diabetic patients one of them had hypertension and three patients had hypertension.

Clinical examination:

- Patients had been examined for any associated injuries.
- Clinical examination first assess the condition of the skin (closed or open)

Swelling:

Swelling may be produced by direct acting external force and by internal fragment pressure or fracture haematoma. In pilon swelling, there is collar like imbibition of the distal lower leg contrary to malleolar fracture where the swelling presented as a haemoarthrosis around the ankle joint. Swelling and ecchymosis under the planter aspect of the foot was found in a case with fracture calcaneus, ten cases with skin contusion and abrasion and nine cases with skin blisters.

Vascular assessment:

Our examinations also included evaluation of the peripheral arterial tree as the swelling might be precluding palpation of the foot pulse our based on the microcirculation (toes). There are no cases with impairment or injury of major blood vessels. Motor function tested by active movement of the toes particularly the ankle, metatarsus and calcaneus, which are too close to the pain radiating from fracture site so difficult to test.

Neurological status:

Included both planter and dorsal aspect of the foot sensorimotor status due to fracture that was not found in our cases. However, we had two cases with bilateral hypothesia due to diabetes.

Roentgenogram examination:

Plain x-ray film of the affected leg included the entire tibia and fibula for all patients. Antero-posterior, lateral and multiple oblique views for all the patients. Plain x-ray film for unaffected leg was taken.
Roentgenogram had been examined to identify:
Fracture line, the major fracture fragment and the number of fragments.
Pieces of subchondral bone, which may have been driven into the assessment of bone quality.

Ethical approval:

The study was approved by the Ethics Board of Zagazig University and an informed written consent was taken from each participant in the study.

Statistical analysis

All data were collected, tabulated and statistically analyzed using SPSS 18.0 for windows (SPSS Inc., Chicago, IL, USA). Continuous data were expressed as the mean ± SD & median (range). The categorical data were expressed as number (percentage). Continuous variables were checked for normality by using Shapiro-Wilk test. Independent

samples Student's t-test was used to compare two groups of normally distributed data. Mann Whitney U test was used to compare two groups of non-normally distributed data. One-way ANOVA test was used to compare more than two groups of normally distributed data. Kraskall Wallis H test was used to compare more than two groups of non-normally distributed data. Categorical data were compared using the Chi-square ($\chi 2$) test or Fisher's exact test when appropriate. All tests were two tailed. $p \leq 0.05$ was considered statistically significant (S), $p < 0.01$ was considered highly statistically significant (HS), and $p > 0.05$ was considered non statistically significant (NS).

RESULTS

At the time of injury, the youngest patient was 19 years old and the oldest was 6o years. Table (1) showed classification of patients according to their ages.

Table (1): Age of the patients

Age in year	Number of patient	Percentage
18-19 y	2	7%
20-29 y	9	3o%
30-39 y	10	33%
40- 49 y	6	20%
> 50 y	3	10%

Table (2): Sex and side distribution

Sex	No.	Right	Left
Male	24	15	9
Female	6	4	2
Total	30	19	11

Table (2) showed gender of the patients and side of fractures. Nineteen patients had right-sided injury, eleven patients had left sided injury and one patient had bilateral injury.

Table (3): Mechanism of injury

Cause of trauma	No.	Percentage
Road traffic accidents	4	13%
Fall from height	20	70%
Fall on stairs	3	10%
Fall with entrapped foot	3	7%

Table (3) showed the causes of injuries. Fall of height varied approximately from 2 meters to 6 meters.

Associated injuries:

- Associated injuries were presented in 12 patients (40%), some of them suffered from two or three sites of associated skeletal injuries (3 cases). Patient no. 6 was associated with fracture of distal femur and wedge fracture of 1st lumbar vertebra. Patient no. 11 was associated with fracture of ipsilateral forearm and fracture of contra lateral tibia after car accident. Case no. 20 was associated with contra-lateral fracture of tibial shaft and distal radius after falling from height (Table 4).

Table (4): Associated injuries

Associated injuries	No. Of the patients
Tibial plateau fracture	1
Vertebral fracture	2
Forearm fracture	1
Olecranon fracture	1
tibial shaft fracture	2
Bimalleolar fracture	1
Os calcis fracture	2
Colles' fracture	1
Fracture femur	2
Fracture neck-femur	1
Brain concussion	2

Classification:

The plain x-ray was studied and the fracture was classified according to **Rüedi and Allgöwer** [(2)] classification, which based on the degree of displacement of articular fragments:

- Two patients (6.67%) had type I fracture both of them were males.
- Nineteen patients (63-33%) had type II fracture, five of them were females and fourteen were males. Nine patients (30%) with type III, two patients were female and seven patients were males (Table 5 & 6).

Table (5): Classification of types of fracture

Classification of fracture	Number of patients	Percentage
Type I	2	6.6%
Type II	19	63.4%
Type III	9	30%

Table (6): Number of male and female patients

Classification of fracture	Number of patients	Male	Female
Type I	2	2	-
Type II	19	14	5
Type III	9	7	2
Total	30	23	7

Closed or open fractures:

With type II pilon fracture, one with Gustilo type one open fracture and other with Gustilo type three A open fracture. Third patient had type one open fracture and fourth patient had open fibula type two open fracture (type three-pilon fracture) (Table 7).

Table (7): Number of open and closed fractures

Classification of fracture	Number of patients	Male	Female
Type I	2	-	2
Type II	19	2	17
Type III	9	2	7
Total	30	4	26

Types I fractures were torsion injuries whereas type II and III were associated with vertical compression (fall from height or road traffic accident).
The results in relation to pain as distributed according to the fracture, it was noted that the excellent results were with type I and II fractures while the fair and poor results were with type II and III fracture (Table 8).

Table (8): Results in relation to pain

	Number of the patients No. Percent	Type of fracture		
		I	II	III
Excellent	5 16.7%	2	3	
Good	17 56.7%	--	14	3
Fair	6 20.0%		2	4
Poor	2 6.6%			2

Discussion

Although open reduction and anatomical reconstruction of the articular surface was ideal in any intraarticular fracture. it is particularly difficult in high-energy tibial pilon fractures. Pre-existing severe soft tissue injury will preclude open reduction in view of the potential wound problems due to ischaemia or infection of the soft tissues. Precarious blood supply in this region of the tibia can add to the problems of nonunion along with infection [(7)]. We believe that treatment with Ilizarov external fixator provides multiple advantages concerning fragment manipulation, stabilization, and maintenance of capsular and ligamentous traction required to enhance and promote normal cartilage metabolism [(8)].

In a recent study of 23 patients with high-energy tibial pilon fractures treated with early external ring fixation and arthroscopic assisted reduction, **EL-Mowafi *et al.*** [(9)] found encouraging results with good functional outcome, (as well as reduced rates of ankle stiffness). There were no long-term problems with fracture union, and no patient required an ankle fusion at the end of 1 year of follow-up. Compared with their patients our series had less severely injured patients and hence better outcomes. The Ilizarov percutaneous fixator preserves endosteal and periosteal blood supply, helps capture the small metaphyseal and subchondral bony fragments, and helps compression of fracture fragments using the olive wires. The rigidity of fixation can be adjusted to suit the stage of fracture healing. It also allows correction of deformity during the process of fracture healing.

Arthroscopic-assisted fracture reduction can provide a less invasive operative reduction of the fracture and respects the soft tissue envelope. **Lonjon *et al.*** [(10)] in a techniques similar to ours, describe ankle arthroscopy as useful tool and seemed more appropriate to us to use this minimal surgery, we used a standard 4-mm arthroscope through the classic portal of anterior arthroscopy.

Most of our cases are males 83 %, with main age 36 years. This is explained by that lesion is work related. Regarding to the fracture type more than half of the patients had type II Ruedi fracture. The incidence of open fractures was 83%. **Zhao *et al.*** [(11)] in a retrospective study on Twenty-five type C pilon fractures, including 4 open fractures, using the same technique. An excellent or good AOFAS outcome was obtained in 81% of the patients. Most of the studies that dealt with this type of fractures and used the arthroscopic-assisted ring fixation lacked the high percentage of open fractures in comparison to our study. Multiple strategies have been employed for dealing with the challenges of open pilon fractures. **Sirkin *et al.*** [(12)] reported on a series of pilon fractures using plate or Ilizarov-type constructs however, they used the Ilizarov system exclusively in their open fractures, which the authors attributed to their low wound complication rate.

The main time passed before the operation, in our series is 3-5 days, with median range of 3 due to the preparations and management of other associated lesions, with consideration of changing the operative procedure as some cases were planned to open reduction and internal fixation but edema and skin bullae were challenging. Recently, some articles have recommend early interference before edema occurs. In the study of **Kapoor *et al.*** [(13)] on 17 patients with type II and III pilon fracture, the main interval between injury and operation was 3.4 (6 hours to 23 days), they emphazised that time of surgical interference with ilizarov fixation is not so important as open reduction and fixation by plate. While **Sirkin *et al.*** [(12)] considered that thin wire ring external fixator (with or without internal fixator) is preffered to be used within the first 72 hours after injury. In a recent study of 23 patients with high-energy tibial pilon fractures treated with early external ring fixation and arthroscopic assisted reduction, **EL-Mowafi *et al.*** [(9)] found encouraging results with good functional outcome (as well as reduced rates of ankle stiffness)

Arthroscopic-assisted fracture reduction can provide a less invasive operative reduction of the fracture and respects the soft tissue envelope.
by Kirschner wires and olive wires adjusted properly to the ring external fixator, as **Vidyadhara and Rao** [(7)] recommended this technique, as olive wires squeeze the fracture pattern in a very methodical way. They treated 21 consecutive patients with complex tibial pilon fractures, using percutaneous reduction and fixation with Ilizarov apparatus.

In the present study, we depends on both ankle arthroscopy and fluoroscopy to help and evaluate the reduction, by direct vision and radiologically. Many studies were released considering the reduction of pilon fracture by ring external fixators, but very few studies were conducted to evaluate and to describe the combined arthroscopic technique with external fixators in the treatment of distal tibial intra-articular fractures,

EL-Mowafi *et al.* [9], enrolled 23 patients in their study, using the same technique.

Lonjon *et al.* [10] in their case presentation showed that minimally invasive surgical reduction under arthroscopic guidance appears to be a promising alternative in this type of fracture.

In our study, the ankle syndesmosis, talar dome cartilage and deltoid ligament integrity were examined in 21 patients (70%). These pathological entities were absent, while talar dome cartilage lesions (osteochondral flaps, ulcers) were found in 5 patients (16,7%). Ankle syndesmosis was examined radiologically and arthroscopically to exclude occult diastasis, torn inter syndesmotic ligaments and anteroinferior tibiofibular ligaments. Syndesmotic disruption was confined if the interval between tibia and fibula, according to **Chiang *et al.* [15]**, is increased by more than 2 mm when viewed from the anterolateral ankle portal. **Chiang *et al.* [15]** described an algorithm for arthroscopic-assisted reduction and evaluation of the distal intra-articular tibial fractures, ankle syndesmosis and ankle ligaments especially the deltoid ligament. In their retrospective study on 105 patients with distal intra-articular tibial fractures divided into two groups, ankle arthroscopy was used as diagnostic tool for ankle structures evaluation in the first group only. They found in the first group that 52 patients (80%) had ankle syndesmotic diastasis that need fixation, while the same lesion was discovered in only 23 (57.5%) patients in the second group.

Associated fibular fracture with ipsilateral pilon fracture, in our study, was present in 27 patients (90%),which is slightly higher compared to previous studies, as they reported that the incidence was about 80% **[16 & 17]**.

Tibial pilon fractures are frequently accompanied by a rotational component in addition to axial load, which should be resisted with a chosen fixation method. Rotational forces not only affect the distal tibia but often result in a fibular fracture as well, allowing for a marker during radiographic evaluation. Comminuted fibular fractures are seen because of valgus stresses, whereas transverse fractures of the fibula result from varus angulation **[17]**. We did not attempt to recommend for or against fibular fixation, as this was not our aims, controversy remains regarding when and how to perform the fibular fixation that is associated with pilon fractures in 80% of cases **[16]**.

CONCLUSION

The present study provided information on the use and the role of ankle arthroscopy in assisting and evaluation of distal tibial intra-articular reduction after pilon fracture (the value, advantages, techniques of ankle arthroscopy and ring external fixators). The study showed that this technique might be a good method to manage the pilon fractures. The results reported in this study could contribute towards the importance of this combined technique and the encouraging outcome.

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