

Original Research Article

Operative outcome of high energy pilon fractures: a retrospective comparison between internal fixation and Ilizarov external fixation

Satya Ranjan Patra*, Dasarath Kisan, Naresh Kumar Panigrahi, Dibya Singha Das, Medini Manoj, Saswat Samant, Anmol Shiv

Department of Orthopaedics, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha, India

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***Correspondence:**

Dr. Satya Ranjan Patra,

E-mail: drsatyarp@gmail.com

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ABSTRACT

Background: Pilon fractures are serious injuries with many devastating soft-tissue complications associated with them. Deciding a definite treatment plan has always proved a challenge. Comparative studies between the various surgical techniques used for pilon fractures are uncommon and consensus is yet to be reached regarding the best surgical option. Purpose of this study is to retrospectively compare the operative results (complications, functional and radiographic outcomes) of pilon fractures treated either with internal fixation or Ilizarov ring fixators.

Methods: Forty-six patients with pilon fractures were retrospectively studied; twenty-one of them had minimal invasive fixation by ankle spanning Ilizarov fixators and 25 patients had internal fixations by either minimal invasive plate osteosynthesis (MIPO) or by open reduction. The patients were followed-up for a mean of 34 months (range, 24-51 months).

Results: The internal fixation group had a higher incidence of soft-tissue complications and deep infections. In comparison the Ilizarov group had only superficial pin-tract infections but no other soft-tissue complications. Although the Ilizarov group had a higher incidence of malreduction and malunion in their series compared to the internal fixation group, there was no significant difference in the AOFAS ankle function score (p-value 0.2922) between the two groups after a follow-up of 2-4 years.

Conclusions: The moderately long term functional outcome appears to be similar in both internal fixation and Ilizarov groups. But the Ilizarov technique is less likely to cause any serious peri-operative soft-tissue complications or deep infection. Familiarity of the surgeon with a particular technique should also be considered during surgical decision making.

Keywords: Pilon fractures, Plafond fractures, Ankle, Ilizarov, Minimally invasive surgery, Ligamentotaxis

INTRODUCTION

Fracture of distal tibia involving the horizontal articular surface is known as pilon or plafond fractures. Vertical or axial compression injuries are most commonly implicated in causing these fractures; apart from that rotational trauma to the distal tibia can also lead to fractures in the tibial pilon.¹ Historically the results of these injuries are plagued with devastating complication like skin and soft tissue dehiscence, bone loss, infection, osteomyelitis and

post traumatic arthritis.²⁻⁴ With advancement of orthopaedic science and newer principles of fractures fixation, various treatment protocols have been adopted by different researchers over the ages such as skeletal traction, open reduction and internal fixation (ORIF), minimal internal fixation with casting, external fixation, hybrid external fixators, Ilizarov ring fixators, minimal invasive plate osteosynthesis (MIPO) etc. But a comprehensive and universally acceptable treatment protocol is yet to be laid out for managing these injuries,

largely because of insufficient evidence. Randomized comparison between different techniques has proved a difficult task owing to the uncommon nature of these fractures and also due to surgeons' personal inclination towards a particular operative method giving rise to bias.

The purpose of this study was to retrospectively compare the functional outcomes, radiographic outcomes and complications of all the high energy pilon fractures treated either with internal fixation technique or with external fixation by Ilizarov ring fixators.

METHODS

The present study was conducted retrospectively up on all the patients of high energy Pilon fractures operatively treated at a tertiary care hospital in between October 2011 to September 2014. A total number of 46 cases of Pilon fractures treated operatively by one of the two methods (Ilizarov external fixators or internal fixation method) during this period were studied retrospectively. There were two group of surgeons who preferred different methods of fixation to manage these fractures.

All the pilon fractures presenting within 'two weeks' after the injury which were treated operatively during this period with a minimum follow up of two years were included in the study. Previously operated cases, patients presenting beyond two weeks from injury (as ligamentotaxis technique may not be useful in these delayed cases), mal-united cases requiring corrective osteotomies and cases with less than two years follow up were excluded from the final evaluation. All the radiological assessments were done by a radiologist. Functional scoring of patients was done by two Orthopaedic registrars in the department.

Out of 46 patients, 41 were males and five were females. The mean age of the patients in the Ilizarov group (n =21) was 39.9 years (range, 21-70 years), and mean age in the internal fixation group (n =25) was 40.2 years (range, 21-62 years). Nine out of 46 patients (19.6%) presented with open fractures (classified by Gustillo-Anderson classification). Among them three open fractures were in IF group and six were in the Ilizarov group. Thirty six patients suffered their injuries due to road accidents, eight patients following fall from height and two had domestic falls. Twenty nine were right sided injury and 17 were left sided, bilateral fracture was not seen in any of the patients.

External fixation with Ilizarov method

One group of surgeons (group A) treated all the pilon fractures under their care (n =21) using the principle of ligamentotaxis and indirect reduction across the ankle joint with the help of an ankle-spanning Ilizarov ring fixator. They used the same technique in all their cases irrespective of fracture type or classification, type of wound or soft-tissue conditions. A four ring construct

spanning the ankle was used in all the cases. Two-rings were placed over the proximal tibial fragment keeping the limb in the center. Ilizarov wires (1.8 mm diameter) passed under image intensifier guidance were used for fixation of the rings and around 2-3 wires were used in each ring. The most proximal ring was placed at the level of fibular head parallel to the knee joint. The third ring was positioned just above the ankle joint without any wire fixation in the beginning. The fourth (distal- most) ring which was placed at the level of the calcaneal tuberosity was a 5/8th ring to accommodate the foot anteriorly. After the application of the calcaneum ring, distraction is applied across the ankle joint between the second and fourth rings. This distraction force resulted in 'ligamentotaxis' effect which helps in reduction of the fractured fragments and brings them back to alignment. After acceptable reduction is seen under image intensifier, the final fixation was done by passing multiple wires through the dummy ring that was left free near the ankle joint. Whenever necessary, inter-fragmentary compression between the major articular fragments was achieved using olive wires or occasionally using minimal internal fixation by means of 4.0 mm cannulated cancellous screws as shown in Figure 1.

In the Ilizarov group the mean duration of calcaneal ring removal was 3.9 weeks (range, 3-6 weeks) to allow early mobilization of the ankle. Partial weight bearing with the help of a walker was started at a mean of 4.7 weeks (range, 3-7 weeks). Full weight bearing was allowed with the Ilizarov frame at a mean of 13.1 weeks post-op (range, 12-15 weeks). Complete removal of the Ilizarov fixator was done at a mean of 15.5 (Range 14-16 weeks).

Internal fixation

The second group of surgeons (group B) treated all the pilon fractures admitted under their care (n =25) by either using the principle of minimal invasive biological plate fixation (MIPO) or by open reduction and definitive internal fixation. In all the cases in this group, the primary objective was to do closed or minimally invasive reduction under image intensifier until acceptable articular reduction was achieved and definitive internal fixation was subsequently to be done by biological bridge plating technique using low profile, anatomically contoured locking compression plates (LCP) specifically designed for distal tibial. But in few cases satisfactory reduction could not be achieved during surgery by MIPO technique and therefore those fractures were reduced by open reduction method in the same sitting followed by internal fixation by plates and screws. Wherever felt necessary fibular fixation was done, in most cases before tibial plating. Interfragmentary lag screws were applied for major articular fragments where ever required as shown in Figure 2.

In the ORIF cases below knee posterior plaster of paris (POP) slab was given for support with a plantigrade foot. Intermittent supervised physiotherapy was started out of

the splint on as early as the 3rd post-operative day. Partial weight bearing with help of walker was started at a mean of 5.8 weeks (range, 4-8 weeks); full weight bearing was allowed at a mean of 14.2 weeks (range, 14-17 weeks) after radiological evidence of union was seen.

Articular reductions after surgeries were studied radiographically; less than 2mm step or gap in the articular margins was taken as 'good' reduction, 2-4 mm gap as 'fair' and 5mm or more step/gap was considered 'poor' reduction.

The duration for clinical and radiological union in both groups was compared using the 'mean'. The 'mean' of

range of motion (ROM) in ankle joints in both the study groups were also compared.

The functional outcome of all the patients was analysed by using American Orthopaedic Foot and Ankle Society (AOFAS) scoring system after a minimum follow-up of one year. The mean score in Ilizarov group was 76.3 (range, 56-88), the mean score in Internal Fixation group was 78.9 (range, 51-97). No significant difference in AOFAS ankle function scores between the Ilizarov and internal fixation group could be seen (p-value 0.2922) at a mean follow up of 34 months (range, 24-51 months) as given in Table 1.



Figure 1: A- AP and lateral view radiographs of Type C3 pilon fracture with comminuted fracture of the distal fibula; B- CT scan reconstruction of the same fracture; C- radiograph showing ankle spanning Ilizarov external fixation of the same fracture; D- Final follow-up radiograph after union and fixator removal.



Figure 2: A- AP view radiograph of type C3 pilon fracture; B- Lateral view of the same fracture; C & D- Post-operative radiographs of the same fracture following open reduction and internal fixation.

RESULTS

The retrospective analysis of patients belonging to both the groups revealed that the mean duration of delay in definitive intervention from the time of injury in Ilizarov group was 3.7 days (range, 1-13 days) and in internal fixation group, was 7.3 days (range, 1-14 days). The most common cause of delay was late presentation of the referred patients coming from long distances. Out of 46 patients, 37 presented with closed injuries and nine were compound. All patients had swelling around the ankle joint of varying severity. And out of 37 closed injury, 7 patients had severe soft-tissue contusion with swollen

ankle and discoloration. All the patients presenting with open injuries were classified by Gustilo-Anderson classification (seven were Grade-I compound and two each were Grade-II and Grade-III B).

Thirteen patients in the internal fixation group had 'good' reduction and twelve had 'fair' reduction. The articular reduction in the Ilizarov group was observed to be 'good' in seven patients and 'fair' in 14 patients as shown in Figure 3.

Clinical union was achieved in the Ilizarov group at a mean of 11.9 weeks in comparison to 13.6 weeks in

internal fixation group. The mean duration to radiological union in Ilizarov group was 13.1 weeks and in internal fixation group was 14.8 weeks as presented in Table 1.

The most common early complications encountered in the internal fixation group was varied degree of ankle stiffness seen in all the cases, followed by superficial incision site infection seen in six cases (24%). One patient with Grade III-B wound went on to have deep

infection, exposed implant and chronic discharging sinus. Two sessions of wound debridement and secondary suture was done to deal with wound dehiscence and gaping. Commonest complication of Ilizarov group was pin-tract infection; 1-3 wires in almost 19 patients showed signs of superficial entry-point infection, but none had deep tissue infection or osteomyelitis as shown in Figure 4.

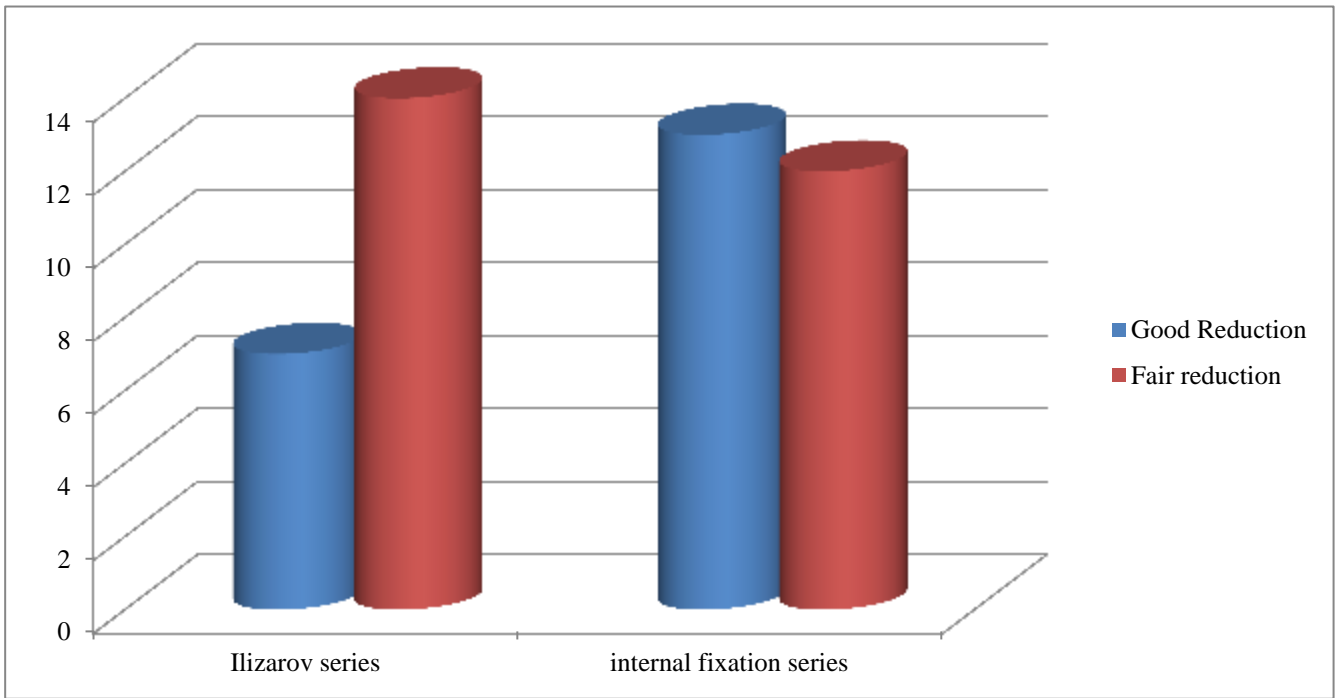


Figure 3: Bar Chart showing the quality of intra-articular reduction of fractures in both series.

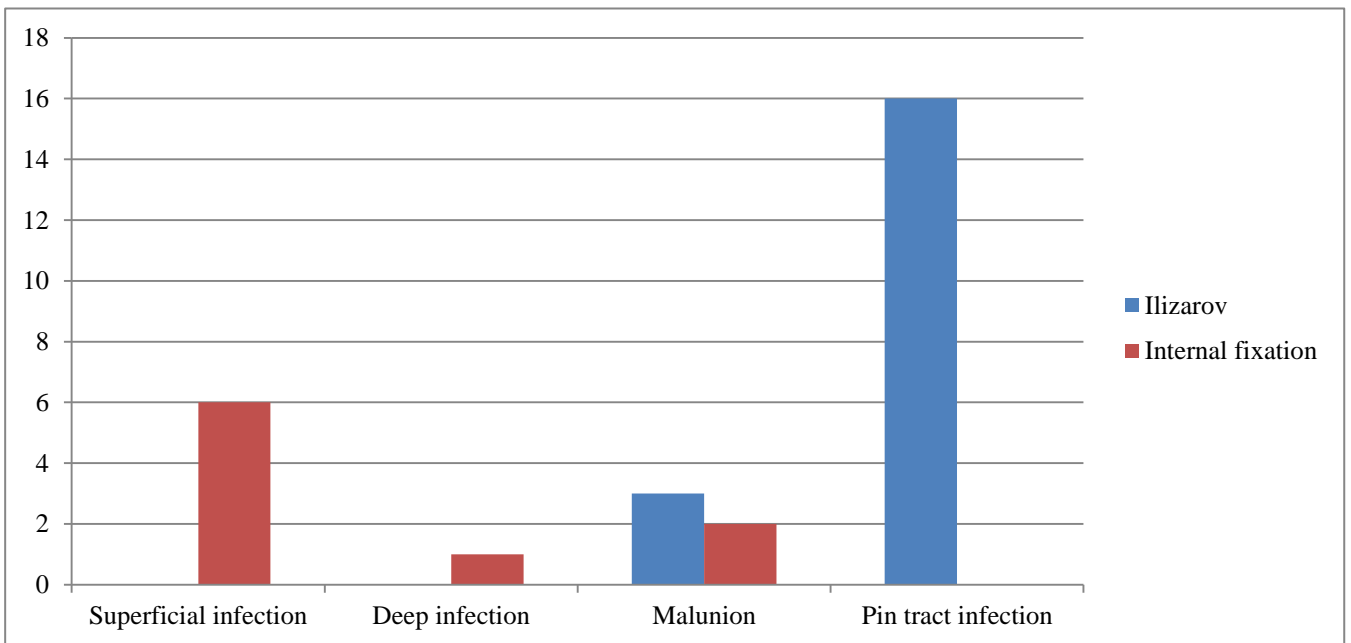


Figure 4: Bar Chart showing the prevalence of different complications in both groups.

Table 1: Comparison between the fracture types as well as clinical, radiological and functional outcome between the Ilizarov and internal fixation groups displayed by calculating the "mean".

	Ilizarov Series	Internal fixation series
Classification of fractures	B 3- 1	B 1- 1
	C 2- 16	B 2- 2
		C 1- 7
	C 3- 4	C 2- 12
		C 3- 3
Wound grading (Gustilo classification)	Closed - 15	Closed - 22
	Grade I - 4	Grade I - 1
	Grade II - 2	Grade III B - 2
Mean time for Clinical Union (in weeks)	11.9	13.1
Mean time for Radiological Union (in weeks)	13.6	14.8
Mean Ankle dorsiflexion/ plantar flexion (in degrees)	9.95/31.2	10/24.4
Mean time of Weight bearing partial/ full (in weeks)	4.7/13.1	4.7/14.2
Mean AOFAS ankle function score	76.33	78.88

DISCUSSION

Pilon fractures are among the most challenging and difficult injuries around the ankle faced by orthopaedic surgeons.^{4,7} These fractures are often due to serious high energy trauma resulting in gross comminution of the articular surface as well as the distal tibial metaphysis.^{4,6,8,9} The associated soft tissue injury around ankle makes the matters more serious due to high incidence of skin and surgical site complications.¹⁰ Various techniques of surgical and non-surgical treatment have been advocated by different researchers across the decades with more and more variable outcomes. Since the time of Bonin, it has been well recognized that involvement of the articular surface and the covering cartilage play important role in the outcome of these complicated injuries.¹¹ Surgical fixation of pilon fractures in the form of anatomical reduction of the fracture fragments by open methods followed by rigid internal fixation was popularised by Ruedi and Allgower in the sixties with good results. These authors also introduced a new classification system to classify pilon fractures depending on the fracture patterns seen in the epiphysio-metaphysial region of the distal tibia.¹²

But similar good outcomes were not reproduced by subsequent workers who followed the same principles of ORIF described by Ruedi et al. Bourne et al in 1989 opined that ORIF technique does not produce satisfactory results in Ruedi type-III pilon fractures, unlike those seen in low energy type-I and type-II injuries.¹³ In 1990 Teeny et al raised serious questions on the ORIF technique of Ruedi due to unacceptably high percentage of serious complications involving both bone and soft tissues seen in their series of 48 cases.¹⁴ The complications rates were higher in Ruedi type-II & type-III fractures and ranged from fracture blisters to skin breakdown, operative wound dehiscence, infections, loss of fixation, malunion and osteomyelitis etc. They favoured limited

percutaneous fixation techniques in association with external fixation devices for these fractures.^{9,14} In the same year Bone et al observed that the improved outcome of ORIF method seen in the study of Ruedi and Allgower was due to the low energy nature of most pilon fractures in that series, but similar encouraging results were not seen in high energy pilon fractures. They recommended the use of fibular plating with ankle spanning external fixator with or without minimal internal fixation.¹⁵ In our study, one group of surgeons managed their pilon fractures by internal fixation methods. Out of 25 pilon fractures treated with internal fixation, seven were AO type C1, twelve were type C2, three were type C3, two were type B2 and one belonged to B1 type. Among all fifteen were high-energy injuries (type C2 & C3). One patient with C2 fracture which was grade III B compound developed osteomyelitis and discharging sinus in spite of undergoing the "two-stage" surgery protocol.

The overwhelming incidences of serious limb threatening complications reported by a number of studies on ORIF methods prompted many researchers to shift their focus towards minimal invasive fixation techniques. Consensus started to develop that open surgical techniques inflict additional trauma to the soft tissues around the tibialpilon.¹⁶ MIPO technique avoids large surgical incisions and the fractured segment along with its periosteal and muscular attachments is left undisturbed. Small incisions are used for introducing and sliding of the plate submuscularly along the shaft of tibia. Reduction is done by means of closed manipulation under fluoroscopic guidance and small interrupted incisions are used for placement of the screws. This method became more evolved and refined by the invention of locking compression plates (LCP).³ These plates act as internal fixators and provide angularly stable fixations for the fractured fragments. The MIPO technique also advocates accurate anatomical reduction of the articular pilon but doesn't necessitate perfect reduction of the non-articular

fragments to avoid stripping of their soft tissue attachments. Although MIPO has significantly improved

the soft tissue healing by virtue of this "biological plating" concept compared to the classical ORIF methods, it has still not been able to completely eliminate the devastating complications associated with these internal fixation surgeries.⁸ In our study of internal fixation group, thirteen were managed with MIPO technique. Out of them three patient developed superficial wound infection in post-operative period; retrospectively two of them were found to have been operated on the 3rd day after trauma when the soft tissues are generally considered to be less favourable.

Although anatomic reduction and internal fixation by either MIPO or ORIF methods often produces satisfactory results in pilon fractures, these methods are not suitable options in the presence of severe soft tissue trauma and open wounds. Such procedures should ideally be undertaken within the first 12 hours from injury before the soft tissue oedema sets in. Many researchers advocate "two stage protocol" for pilon fractures complicated with severe soft tissue injuries. As per this protocol a temporary joint spanning external fixator is applied to provisionally stabilise these ankles without inflicting any further surgical trauma to the already traumatised soft tissue cover.^{15,17} Maintenance of length, alignment and stability leads to improvement in arterial blood flow, venous drainage and lymphatic drainage, thereby helping in healing of wounds and soft tissue injuries. Only after the appearance of "wrinkle sign" the second stage surgery is performed in the form of ORIF or MIPO. Although these two stage procedure improves soft tissue outcome, the patient has to undergo multiple surgeries contributing to increase morbidity.

The proponents of the external fixation technique have largely described about two types of external fixation methods. One that doesn't extend beyond the ankle joint and the other is an ankle-spanning fixator.^{15,18} A joint spanning fixator has the advantage of applying traction across the joint which results in indirect reduction of the fracture fragments by 'ligamentotaxis'. At the same time ankle spanning fixators have also been blamed for causing stiffness in ankle.

The Ilizarov ring fixators have been used since many years for pilon fractures by various researchers.^{4,8,18-20} The advantages of Ilizarov fixators are – minimal invasive fixation by thin wires, strong circumferential construct giving multiplanar stability, inter-fragmentary compression by use of olive wires and axial stability by threaded rods. Applications of Ilizarov fixators do not cause any significant additional trauma to the soft tissues because of its thin wire fixation. Spanning of the ankle joint by using the 5/8th ring on the calcaneum makes use of 'ligamentotaxis' principle for indirect reduction of the epiphyseal and metaphyseal fracture fragments.⁴ Problems commonly associated with pilon fractures such

as local oedema, soft tissue contusion, fracture blisters or contaminated open wounds do not prevent the use of the Ilizarov ring fixator.⁴ This instrument allows for axial micro-motion due to the use of flexible wires and also helps in early mobilization and weight bearing because of its three-dimensional stability. The unique feature of this instrument is that it can be used irrespective of any class of pilon fracture as a single stage definitive surgery. The ankle spanning calcaneal ring can be removed early and ankle mobilization can be started for prevention of stiffness.⁶ In our study, 21 patients belonging to the Ilizarov group were included in final evaluation. Fifteen out of 21 fractures were of AO type C2, five were type C3 and one was type B2; this implies that 20 patients in the study group had high-energy trauma.

Ilizarov method also has its share of complications. The wires may cause neuro-vascular injuries, tendon or muscle impingements, thermal damage during drilling and pin-tract infections. The other post-op complications are, obstruction to joint motion, axial deviations and malunion.¹⁹ The commonest complication in our Ilizarov series, was pin-tract infection; but there was no incidence of neuro-vascular injury, deep infection or osteomyelitis. Three patients had varus or valgus malunion of distal tibia and two patients had delayed bone healing. One case needed change of two wires for correction of mal-alignment. Patient compliance was a concern because of the prolonged use of the cumbersome Ilizarov frame.

No significant difference could be derived regarding the functional outcome scores measured by the AOFAS scoring system between the internal fixation (78.9) and the Ilizarov group (76.3) at the end of 24 to 51 months follow-up (p-value 0.2922). The Ilizarov technique appeared to be a safer method for treatment of pilon fractures with more severe soft-tissue trauma. MIPO or ORIF methods should be preferred only in cases of low-energy injuries with minimum soft tissue compromise.

This study has weaknesses like small number of patient population and relatively short duration of follow up. Ideally a randomized controlled trial involving a larger study population and longer post-operative follow up is desirable to reach at a definite conclusion.

High-energy Pilon fractures are notorious injuries associated with numerous devastating soft tissue complications. Although anatomic reduction of the articular surface achieved by open reduction methods is desirable and produces good long term results, at the time of presentation the local tissue condition may not be conducive for such open surgical internal fixation. On the other hand the ankle spanning Ilizarov technique which makes use of the principle of ligamentotaxis achieves a stable fixation with minimal invasive methods without inflicting any significant trauma to the soft tissues. The fracture reduction obtained by the Ilizarov technique may be marginally inferior to the internal fixation methods but there is no significant difference in the functional ankle

scores between these two methods at moderate follow-up. The world-wide orthopaedic opinion remains divided regarding the preferred technique for the management of high-energy pilon fractures, and the surgeon's familiarity with a particular technique may play a crucial role in surgical decision making. Among all these uncertainties the authors would be inclined to favor the Ilizarov method for pilon fracture treatment due to its minimally invasive nature and lower incidence of early peri-operative complications like skin breakdown, wound dehiscence and osteomyelitis.

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