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External fixation versus mini open reduction and internal fixation in management of intra-articular calcaneal fractures, a comparative study

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Abstract

The incidence of calcaneal fractures in adults ranges from 1% to 4%. Intraarticular calcaneal fractures account for 60% to 80% of all cases. Smaller incisions and less invasive surgical methods lower the risk of soft tissue problems. A stable calcaneal fracture repair has been shown with the use of external fixation. Purpose It is the goal of this research to examine the functional and radiological results of intra-articular calcaneal fractures treated with external fixation and micro open reduction with internal fixing Methods and patients Orthopedic surgery at Benha University Hospital and Benha Health Insurance Hospital treated a total of twenty patients with intra-articular calcaneal fractures; ten had external fixation and ten underwent small open reduction with internal fixation as part of the research. The EF group's average age was 36 years, with a range of 22 to 55 years old. There were seven men and three women. The ORIF group's age varied from 24 to 52 years, with a mean of 36.4 years. There were five men and five women in all. Results When compared to the ORIF group, the EF group had a substantially longer time from injury to surgery, a much shorter operating time, and a significantly smaller amount of blood loss. A substantial drop in VAS was seen in both the EF and ORIF groups throughout the course of time. It was shown that both the EF and ORIF groups had a large rise in their VAS scores over time, although the EF group had an immediate decrease in VAS scores, while the ORIF group had a considerable increase in VAS scores over time. There was a huge increase in the EF group's Comparing AOFAS to the ORIF group after 1 month and 3 months. Postoperatively, in both the EF and ORIF groups, Böhler's angle rose considerably compared to preoperative measurements. In both the EF and ORIF groups, it was shown that Gissan's angle rose considerably postoperatively in comparison to preoperative measurements. 20% of EF patients and 30% of ORIF patients had a superficial infection as a result of the procedure. ORIF patients developed deep infection in 10% of instances, but no EF patients had deep infection. One-tenth of the patients undergoing ORIF were complicated by wound edge necrosis, although none of the ones undergoing EF were. There were no sural nerve injuries in any of the instances evaluated. Conclusion It has been shown that external fixation is a safe and effective method for reconstructing calcaneal fractures. Because it's less intrusive, the time it takes for surgery and hospitalisation to be completed, and the danger of complications is smaller, it is a better option for patients. Intra-articular calcaneal fractures may be treated with minimally invasive surgery, which has low complication rates, decreased morbidity, and greater quality of life for patients. The results of this investigation show that external fixation is statistically better than minimally invasive fixing.

Keywords: Calcaneal fractures, Intra-articular, External fixation, Iinternal fixation.

1. Introduction

It is estimated that between one percent and four percent of all adult bone fractures are calcaneal fractures, the most frequent. The vast majority of calcaneal fractures (60 to 80%) occur inside the joint [1].

Several biomechanically significant abnormalities may result from calcaneus fractures. It is crucial to estimate the height of the calcaneus on the lateral x-ray from the posterior facet to the heel bone's inferior border in order to prevent anterior tibiotalar impingement. [2]

There are up to 75% of all foot breaks and 1%–2% of all breaks that occur in men. They are also more prevalent in those who work in the industrial sector. Because of this, workers who suffer bilateral intra-articular fractures and are supported financially suffer worse outcomes. [3]

Falling from a high altitude or crashing a car at high speeds are common causes of calcaneal fractures. Fracture patterns, both primary and secondary, may be reproduced and help to identify an injury and any related complications [4].

The mode of damage determines the appearance of a calcaneal fracture, which may be further split into two categories: intra-articular and extra-articular. For 70–75 percent of all calcaneal fractures, axial force results in shear or compression fracture lines. Hannover and Sanders are the two primary classification systems for intra-articular fractures, and Sanders is the one most generally used since it helps with treatment planning and prognosis. Soft tissue problems that may develop when using the usual extensile lateral technique are also a cause for concern when treating calcaneus fractures surgically [5]. Flap necrosis, wound dehiscence, and infection are all possible outcomes in 1.7% to 20% of patients, according to research. Osteomyelitis has been found to have a prevalence of roughly 2.5 percent. [6]

In order to prevent soft tissue issues, less invasive surgical methods using tiny incisions have been developed. Percutaneous and arthroscopy-assisted reductions are included. In a perfect world, intraoperative 3-D imaging would allow surgeons to preserve joint congruency, anatomic alignment and calcaneal height and breadth restoration as they

operated. It has been shown that external fixation is a safe and effective method for reconstructing calcaneal fractures. In comparison to open surgery, external fixation is less intrusive, takes less time to perform, enables patients to bear weight on the injured limb sooner, and has a reduced risk of complications. Intra-articular calcaneal fractures that are treated with external fixation or small open reduction and internal fixation are the focus of this research.

2. Material and Methods

This study carried out on twenty patients with intra-articular calcaneal fractures at Benha University Hospital and Benha health insurance hospital.

Inclusion criteria:

Skeletally mature patients with intra-articular calcaneal fractures.

Exclusion criteria:

Any cases with the following criteria will be excluded

- Skeletally immature patients with calcaneal fractures.
- Extra articular calcaneal fractures.
- Neurovascular injury.
- Open Fractures.

Patient evaluation:

Patient's history:

- Clinical history was taken from the patient in the sort of name, sex, age, job, address and smoking habits.
- Associated illness like diabetes, hypertension and cardiac condition.
- Patients were asked about the mechanism of injury and if there are any associated injuries.

Clinical examination:

Standard hand examination was performed in the form of:

- Side affected.
- Presence of pain and swelling.
- Skin condition overlying the fracture.
- Presence or absence of associated vascular or neurological injuries.

Radiological evaluation:

An antero-posterior, lateral, oblique & optional view radiograph and CT calcaneus done for all patients.

Surgical Technique:

Patients divided into 2 groups (every group contain 10 patient).

- Group (1) Patients treated using external fixation.
- Group (2) Patients treated using mini open reduction and internal fixation.

Fitness to surgery:

The patients were assessed for fitness for surgery by clinical history, examination and routine pre-operative laboratory investigations.

Surgical procedure:

External Fixator technique:

The operation was performed under image intensifier control. The new Orthofix Mini-Calcaneal 6 pins Fixator comprises two arms connected by a central clamp.

The major horizontal arm lay almost parallel to the longitudinal axis of the foot, while the second arm could be moved along the central clamp to find the best and appropriate position according to the foot size and the posterior facet position. Both arms were supported by a small slide system to enable the frame to be lengthened or shortened. The pins were self-drilling and self-tapping, with a diameter of 4 mm and are available in two lengths, 70 mm and 90 mm.

The patient was placed in the lateral decubitus position, exposing the lateral surface of the heel. The first step was to control and adjust the Varus–valgus deformity through an additional screw or Steiman wire. Therefore, an additional optional 1 cm lateral incision over the sinus tarsi might be helpful for a percutaneous reduction of the thalamic articular fragments using a small lever inserted below the fragments from the floor of the sinus.

Finally, the external fixator was placed inserting the six pins as follow: the first two was placed in the thalamic fragments; two pins in the posterior apophysis; the last two in the anterior tuberosity. When severe comminution of the anterior tuberosity was described, one or both pins may be positioned in the cuboid.

The body of the mini-fixator could be used as a template to find the right position for other pins. After locking clamps, the inclination of the posterior facet joint could be adjusted before locking the central screw. After the fixator has been applied, further reduction and elevation of the thalamic fragment may be carried out by elongating the clamps on the slide using the appropriate key in the distraction mechanism.

Mini open reduction and internal fixation technique:

Mini-incision and fixation with threads and screws: lateral 3- to 5-cm incision directly above the tarsal sinus. Divulsion of the soft tissues, paying careful attention to the fibularis tendons. The joint fracture is reduced using delicate fine-tip chisels. A temporary fixation is performed using 1.6-mm Kirschner wires in the fragments, for maintenance of the reduction, and definite fixation is achieved with cannulated 3.5- or 4.5-mm screws

Postoperative evaluation &Care:

The patients receive intravenous antibiotics for at least 48 hours, pain medication as required discharging after 24 hours. Early mobilization of the ankle and subtalar joints is stimulated in the first post-operative week. The sutures are removed two weeks after the surgery. For patients operated with the external fixation technique, partial load is initiated after four weeks; total load starts at eight weeks, together with the removal of the fixator. In Mini-incision and fixation technique, partial load is initiated in the eighth post-operative week.

Follow-up care:

Post-operative follow up will be done at:

- Immediate post-operative X-ray and CT.
- Then at two weeks' interval for 2 months.

- Then monthly for six months.

3.Case 1:

Male patient, 35-year-old, fall from height present, sustained right intraarticular calceaneal fracture, there was swelling and pain in the heel and leg (Figure 34), there was no other spinal or pelvic injury or history of loss of consciousness, His CT scan revealed calceaneal fracture type III According to sanders classification (Figure 36), postoperatively patient developed mild infection of the surgical wound, which was settled in two weeks. He returned to his work in four months. According to AOFAS patient had an Excellent result with 85 score.

Fig. (1) Preoperative skin condition.

Fig. (2) Pre – operative X- Ray AP, lateral view

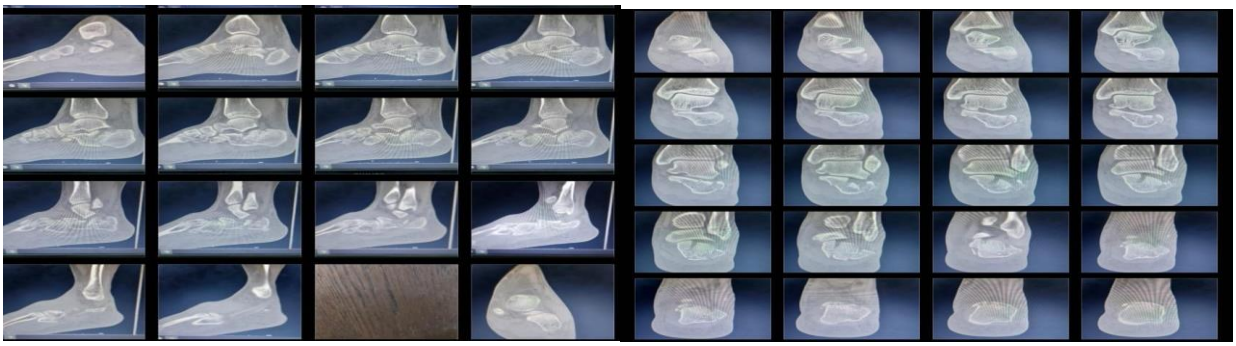

Fig. (3) Pre operative CT Scan

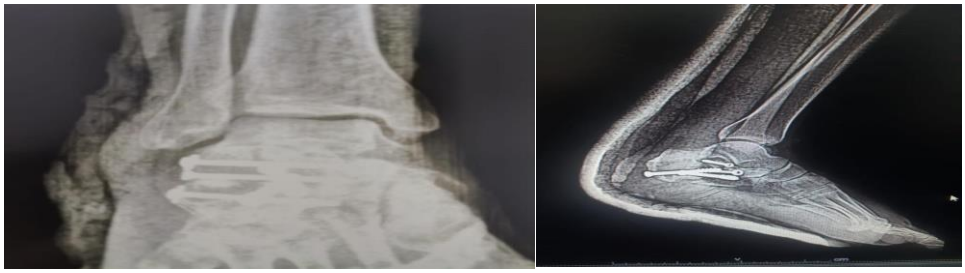

Fig. (4) Post-operative X – Ray

Fig. (5) Functional outcome.

4. Results

This study was carried out on 20 patients with intra-articular calcaneal fractures, 10 were treated by external fixation and 10 were treated by mini open reduction and internal fixation. Mean age of EF group was 36 years, ranged from 22 to 55 years. They were 7 males and 3 females. While mean age of ORIF group was 36.4 years, ranged from 24 to 52 years. They were 5 males and 5 females. No significant differences were found between both studied groups regarding age and gender. (table 1)

Table (1) Comparison of demographic data among studied groups.

			External fixation N=10	ORIF N=10	p
Age (years)		mean±SD	36±11.9	36.4±9.4	0.934
		Min-max	22-55	24-52	
Gender	Male	N (%)	7(70%)	5(50%)	0.650
	Female	N (%)	3(30%)	5(50%)	

EF group had 60% fractures on the right side and 40% on the left side. Injuries were caused by fall from height in 80% and RTA in 20%. The same was found regarding ORIF group which had 60% fractures on the right side and 40% on the left side. Injuries were caused by fall from height in 80% and RTA in 20%. (table 2)

Regarding Sanders classification, EF group had 30% type II, 40% type III and 30% type IV. ORIF group had 10% type II, 60% type III and 30% type IV, with no noticed significant difference between studied groups regarding Sanders classification (p>0.05). (table 2)

Table (2) Comparison of general characteristics among studied groups

			External fixation N=10	ORIF N=10	p
Fracture side	Right	N (%)	6(60%)	6(60%)	1
	Left	N (%)	4(40%)	4(40%)	
Mechanism of injury	Fall From Height	N (%)	8(80%)	8(80%)	1
	RTA	N (%)	2(20%)	2(20%)	
Sander's classification	II	N (%)	3(30%)	1(10%)	
	III	N (%)	4(40%)	6(60%)	0.485
	IV	N (%)	3(30%)	3(30%)	

EF group showed significantly longer time from injury to operation (mean =8.5 versus 4.8 days respectively, p<0.001); significantly shorter operative time (mean=46.7 versus 71.3 minutes respectively, p<0.001); significantly lower blood loss volume (mean=36.5 versus 80.5 mL respectively, p<0.001); significantly shorter length of hospital stay (mean=2.8 versus 6.5 minutes respectively, p<0.001), when compared to ORIF group. (table 3)

Table (3) Comparison of operative characteristics between studied groups

.		External fixation N=10	ORIF N=10	p
Time from injury to operation (days)	mean±SD	8.5±1.6	4.8±1.3	<0.001
	Min-max	6-11	3-6	
Operative time (minutes)	mean±SD	46.7±5	71.3±7.7	<0.001
	Min-max	40-55	60-85	
Blood loss (mL)	mean±SD	36.5±7.5	80.5±10.7	<0.001
	Min-max	25-50	60-100	
Hospital stay (days)	mean±SD	2.8±0.8	6.5±1	<0.001
	Min-max	2-4	5-8	

EF group showed significant decrease in VAS across time (mean= 3.4, 2.3, 1.8 at immediate, 1, 3 months respectively, p2<0.001), as well as ORIF group which also showed significant decrease in VAS across time (mean= 4.4, 2.9, 2.1 at immediate, 1, 3 months respectively, p2<0.001).EF group showed significantly lower immediate VAS (mean =3.4 versus 4.4 respectively, p1=0.005); after 1 month (mean =2.3 versus 2.9 respectively, p1=0.032); after 3 months (mean =1.8 versus 2.1 respectively, p1=0.032), when compared to ORIF group. (table 4)

Table (4) Comparison of VAS between studied groups

		External fixation N=10	**ORIF N=10**	**p1**
Immediate	mean±SD	3.4±0.5	4.4±0.7	0.005
	Min-max	2.5-4	3-5	
1 month	mean±SD	2.3±0.6	2.9±0.6	0.032
	Min-max	1.5-3.3	1.9-4	
3 month	mean±SD	1.8±0.5	2.1±0.3	0.046
	Min-max	1.9-4	1.6-2.4	
	p2	<0.001	<0.001	

EF group showed significant increase in AOFAS across time (mean= 77.5, 82.6, 89 at immediate, 1, 3 months respectively, p2<0.001), as well as ORIF group which also showed significant increase in AOFAS across time (mean= 72.9, 77.5, 84.2 at immediate, 1, 3 months respectively, p2<0.001).EF group showed significantly higher immediate AOFAS (mean =77.5 versus 72.9 respectively, p=0.026); after 1 month (mean =82.6 versus 77.5 respectively, p=0.044); after 3 months (mean =89 versus 84.2 respectively, p=0.045), when compared to ORIF group. (table 5)

Table (5) Comparison of AOFAS

		External fixation N=10	**ORIF N=10**	**p**
Immediate	mean±SD	77.5±5.4	72.9±7.3	0.026
	Min-max	71-86	60-82	
1 month	mean±SD	82.6±5.3	77.5±7.4	0.044
	Min-max	75-91	65-87	
3 month	mean±SD	89±4.2	84.2±6.5	0.045
	Min-max	83-96	74-92	
	p2	<0.001	<0.001	

Böhler's angle increased significantly postoperative when compared to preoperative measures in EF group (mean =10.8° versus 26.2° respectively, p2<0.001), as well as in ORIF group (mean =10.1° versus 25.7° respectively, p2<0.001). No significant differences were found between studied groups regarding Böhler's angle preoperatively as well as postoperatively (p1>0.05 for each). (table 6)

Table (6) Comparison of Böhler's angle between studied groups

		External fixation N=10	**ORIF N=10**	**p1**
Preoperative	mean±SD	10.8±2.3	10.1±2.3	0.508
	Min-max	7-14	7-14	
Postoperative	mean±SD	26.2±3.1	25.7±3.8	0.749
	Min-max	22-31	21-32	
	p2	<0.001	<0.001	

Gissan's angle increased significantly postoperative when compared to preoperative measures in EF group (mean = 127.7° versus 103.4° respectively, p2<0.001), as well as in ORIF group (mean =130.5° versus 110.4° respectively, p2<0.001). No significant differences were found between studied groups regarding Gissan's angle preoperatively as well as postoperatively (p1>0.05 for each). (table 7)

Table (7) Comparison of Gissan's angle

		External fixation N=10	**ORIF N=10**	**p**
Preoperative	mean±SD	103.4±14.1	110.4±11.8	0.244
	Min-max	85-129	94-128	
Postoperative	mean±SD	127.7±9.1	130.5±6.7	0.442
	Min-max	115-142	120-138	
	p2	<0.001	<0.001	

Superficial infection complicated 20% of cases subjected to EF and 30% of cases subjected to ORIF. Deep infection complicated 10% of cases subjected to ORIF, while none of EF cases had deep infection. Wound edge necrosis complicated 10% of cases subjected to ORIF, while none of EF cases had wound edge necrosis. None of all studied cases had sural nerve injury. No significant differences between studied groups regarding complications with superficial, deep infections Wound edge necrosis and Sural nerve injury ($p>0.05$ for each). (table 8)

Table (8) Comparison of complications among studied groups

			External fixation N=10	ORIF N=10	p
Superficial infection	Absent	N (%)	8(80%)	7(70%)	0.606
	Present	N (%)	2(20%)	3(30%)	
Deep infection	Absent	N (%)	10(100%)	9(90%)	0.305
	Present	N (%)	0(0%)	1(10%)	
Wound edge necrosis	Absent	N (%)	10(100%)	9(90%)	0.305
	Present	N (%)	0(0%)	1(10%)	
Sural nerve injury	Absent	N (%)	10(100%)	10(100%)	-
	Present	N (%)	0(0%)	0(0%)	

5. Discussion

The American Orthopedic Foot and Ankle Society (AOFAS) defines the purpose of calcaneal fracture therapy as restoring the natural alignment and shape of the calcaneus. Restoring heel height and length, realigning the posterior facet of subtalar joint, and restoring the mechanical axis of the foot are all steps in this process. [9]

External fixation and small open reduction and internal fixation of intra-articular calcaneal fractures were compared in terms of functional and radiological results in this research. In a retrospective study, Takasaka, M. et al. looked at 54 patients who had calcaneus fractures and had surgery between 2002 and 2012 using the following methods: (1) open reduction with an extended L-shaped lateral incision and fixation with a Double-H plate of 3.5 mm; (2) open reduction with a minimal incision lateral approach and percutaneous fixation with wires and screws; and (3) open reduction with a minimal incision lateral approach and fixation with wire There were 60% fractures on the right side, and 40% on the left, in the EF group, according to [10]. An RTA (road traffic accident) was responsible for 20% of the injuries. The ORIF group had 60% right-side fractures and 40% left-side fractures, as did the other groups. Most injuries were caused by falling from a height, with just 20% coming from RTA.

The EF group contained 30% type II, 40% type III, and 30% type IV according to Sanders categorization. For Sanders' categorization, the ORIF group contained 10% type II, 60% type III, and 30% type IV, with no discernible variation across the study groups.

When compared to the ORIF group, the EF group had a substantially longer time from injury to surgery, a much shorter operating time, and a significantly smaller amount of blood loss.

A substantial drop in VAS was seen in both the EF and ORIF groups throughout the course of time. When compared to the ORIF group, the VAS in the EF group was considerably lower immediately, after a month, and after three months.

When it came to the AOFAS questionnaire, the EF and ORIF groups both exhibited substantial increases in AOFAS throughout the course of the experiment. When compared to the ORIF group, the AOFAS in the EF group was considerably greater immediately, after one month, and after three months.

Takasaka, M. et al. found that the minimally invasive approach with percutaneous fixation produced outstanding outcomes in 7.4% of patients, good results in 51.8%, fair results in 29.6%, and bad results in 11.1% of patients. The questionnaire findings assigned 20% excellent outcomes, 60% fair, and 20% unsatisfactory to the least invasive procedure with external fixation (monoplanar adjustable fixator). With typical open reduction and fixation utilising a plate and screws, satisfactory and outstanding outcomes may range from 42% to 62% in the literature. This shows that the mini-open reduction with percutaneous fixation has an advantage over the other procedures. [10]

A study by Magnan et al. found that a small external fixator was effective in treating 54 consecutively closed, dislocated, intraarticular calcaneal fractures. Over 90% of patients had excellent or good clinical outcomes (as determined by the Maryland Foot Score). Localized transitory osteoporosis affected 18.5% of patients, as were superficial pin tract infections, which affected 5.6% of patients. Without the dangers of hardware failure or infection, the outcomes of minimally invasive external fixing were equivalent to those of open fixation. [11]

Patients with Sanders III fractures who were not excellent surgical candidates due to extensive soft tissue damage were treated with the Ilizarov approach by Emara and Alam. As a comparison to a control group treated with internal fixation, they found equivalent AOFAS scores. [12]

An increase in Böhler's angle after surgery in both the EF and ORIF groups was seen when the radiography findings of the angle measurements were compared to those taken preoperatively. Preoperatively

and postoperatively, there were no significant variations in Böhler's angle between the groups investigated.

EF and ORIF groups in the radiographic study of Gissane angle measurements showed a substantial postoperative increase in Gissan's angle compared to preoperative readings. The angle of Gissan preoperatively and postoperatively was not significantly different in any of the groups studied.

The radiographic results of the Bohler and Gissane angle measurements showed that in the open reduction with plate and fixation with plate and screws and in the open reduction (minimal incision) with percutaneous fixation groups, it was possible to restore the angles in 100% of the cases, whereas in the open reduction (minimal incision) with adjustable monoplanar external fixator group, it was only possible to restore the Bohler angle in 100% of the cases. Meanwhile, all readings for the Gissane angle were within a few degrees of each other. The goniometer used to measure these angles may have a tiny error margin, which may be influenced by slight rotations during the radiography scan. However, these measures were standardised and carried out by a trained and knowledgeable expert. [10]

We discovered that 20% of patients who had EF and 30% of patients who underwent ORIF developed a superficial infection as a result of their procedures. ORIF patients developed deep infection in 10% of instances, but no EF patients had deep infection. One-tenth of the patients undergoing ORIF were complicated by wound edge necrosis, although none of the ones undergoing EF were. There were no sural nerve injuries in any of the instances evaluated. Study groups did not vary significantly when it came to infections, either superficial or deep, developing problems. Wound necrosis and damage to the sural nerve.

There were no soft tissue consequences such as necrosis, dehiscence, tendinitis, or nerve damage in the group treated with mini-open reduction and percutaneous fixation, as shown by Takasaka, M et al. via study of the complications. One patient (14.2%) in the external fixation with adjustable monoplanar fixator group had soft tissue infection. Patients who had open reduction and fixation with a plate and screws had the following complications: infection (25%), necrosis (50%), and sural nerve neuroma (25%). Zwipp et al. found profound infection in three instances with open reduction: none of them recovered despite severe debridement and latissimus dorsi free flap, and two needed a calcaneal resection. [10]. [13]

65.2% of type II fractures and 81% of type III and IV fractures were found to have arthritic alterations in the subtalar joint, according to Thermann et al. The subtalar joint was found to be arthritic in 44% of patients who had an Ayman radiological follow-up examination. For example, arthritic alterations were seen in 75% of type IV fractures, 70% of type III fractures, and only 9% of type II fractures. One patient required a subtalar arthrodesis due to symptomatic posttraumatic arthritis, but the follow-up period is insufficient to determine the true frequency of this subsequent problem. [14] Kumar et al. discovered that the minimally invasive group had a lower incidence of wound healing issues and better functional results than the ORIF group. A three-year follow-up study by Schepers et al. showed promising outcomes for minimally invasive procedures. The functional outcomes after minimally invasive procedures were less impressive than those following ORIF. They had comparable rates of infection and wound complications as ORIF. [16]

In spite of the lack of conclusive evidence, many authors advocate surgical treatment over conservative treatment for intraarticular calcaneal fractures due to their poor outcome and high incidence of complications, including malunion with widened heel and arches of the foot, horizontal talus, peroneal tendon impingement, subtalar joint stiffness and arthritic symptoms. Plantar heel discomfort may result from prolonged non-weight-bearing, which may cause the plantar heel pad to become more sensitive. [17], Surgery may successfully restore the calcaneus' anatomical features and lead to a better functional recovery in displaced intraarticular calcaneal fractures, although the risk of complications is significant. The relevance of anatomical repair of the articular surfaces has long been recognised. Biomechanical investigations have shown that as low as 1–2 mm of posterior facet articular incongruity may produce problems with load distribution and gait mechanics. [19]

For all displaced intra-articular calcaneal fractures, there is no one therapy or surgical method. The kind of fracture and the patient's features must be taken into consideration while deciding on a treatment plan. There are several factors to consider while evaluating a patient's health, including the kind of fracture and the degree of displacement, as well as their physical and mental status, and the existence of comorbidities, such as smoking and diabetes mellitus. Open reduction and fixation for displaced intra-articular calcaneus fractures has a learning curve of 35–50 procedures, according to the literature. Because of this, the expertise of the surgeon must also be taken into account when determining the optimal surgical method.

6. Conclusion

It has been shown that external fixation is a reliable approach for attaining stable calcaneal fracture repair. To put it another way: It's less intrusive; it takes less time; it allows for early weight-bearing on the injured leg; and it has a reduced risk of problems than traditional surgery. There are several advantages to the minimally invasive therapy for intra-articular calcaneal fractures, including reduced complications, decreased morbidity and improved quality of life for patients.

External fixation is statistically superior to minimally invasive fixing in the current investigation.

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