MINIMIZING HARDWARE IN INTRA-ARTICULAR FRACTURE CALCANEUS

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ABSTRACT

BACKGROUND

Calcaneus fractures are the most common tarsal bone fractures accounting to 2% of all tarsal bone fractures. These fractures are mostly associated with high energy trauma. The aspects of soft tissue healing, ease of operation, anatomic reduction, use of low cost implants and functional outcome by open reduction with minimal hardware is presented here.

MATERIALS AND METHODS

26 displaced intra-articular fractures in 23 patients were treated by open reduction and minimal hardware (2mm subchondral K-wire and recon plate) from January 2013 to January 2015. The group consisted of 21 male patients and 2 female patients; almost all of them sustained injury following fall from height or axial loading. Average age was 34.2 years. A follow up of minimum 2 years is done for assessment of functional outcome.

RESULTS

The results are assessed by Maryland foot score. Radiological evaluation for changes in Bohler's and Gissane angles before and after injury is assessed. Follow up of minimum 2 year is done. Soft tissue at operative site is assessed at day 14 of surgery.

CONCLUSION

We conclude that osteosynthesis with open reduction and minimal hardware provides excellent soft tissue outcome as well as functional results with greater return to work. The technique used is easy to perform, requires less soft tissue dissection, shorter operative time and lesser burden of cost of implant on the patients.

KEYWORDS

Minimising hardware, intra-articular, calcaneal fractures, soft tissue, implant cost.

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BACKGROUND

Calcaneus fractures are uncommon fractures accounting to only 2% of all fractures. However, this is the most common tarsal bone fracture. 10% of these fractures are bilateral and 75% are of intra-articular type.[1,2]

Calcaneus fractures most commonly occur due to high energy trauma; fall from height being the most common cause followed by road traffic accidents. These fractures have a significant impact on the socio-economic perspective of the patients. 20% of the patients fail to return to work as seen in a 3 to 5 years follow up.[3,4,5]

Axial loading is the prime cause of fracture which occurs when the processus lateralis tali impacts or hammers the area of gissane's angle (G angle), thus breaking the posterior articular facet.[1]

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Restoration of the anatomy of the calcaneum and the articular surface is the prime objective of any surgery. This prevents later complications such as malposition, flattening of the longitudinal arch, anterior ankle impingement syndrome and lateral impingement syndrome, axial malalignment of hindfoot, heel widening and subtalar joint arthrosis.[6,7]

Calcaneus fractures were described as early as in 1839 by Norris. Malgaigne proposed a classification way back in 1843.[8,9,10,11] Leriche published on open reduction with metal plates and screws initially. The management principles for the treatment of the calcaneus fractures have evolved over time from conservative to operative methods. However, treatment still remains controversial for the same.[12]

In 1882, Bell applied the first open reduction for an open calcaneal fracture.[13] In 1902, Morstein performed the first ORIF.[14] Kocher proposed the lateral approach for calcaneal fractures in 1846.[15]

Calcaneus has an irregular bony anatomy, complicated joint mechanics, fragile soft tissue cover and a complex 3D anatomy.[16] Maintenance of the articular surface remains the primary goal of treatment. A CT scan with 3D reconstruction view becomes mandatory for appropriate assessment and planning for the treatment of intra-articular calcaneal fractures.

Open reduction and internal fixation with an L-shaped approach is the most commonly used and followed exposure for the calcaneal fractures because it gives excellent exposure to the articular surface.[17,18] Calcaneal fractures are commonly associated with soft tissue complications due to the thin and vulnerable skin. Wound edge necrosis is about 2-11% and soft tissue infection ranges from 1.3% to 7%. The cumulative rate of wound complications is approximately 25% and 21% requires further surgery.[19,20,21]

MATERIALS AND METHODS

The study was conducted as a hospital based prospective study from January 2013 to January 2015, a duration of two years. There were 32 patients in the study. We lost 9 patients to follow up and hence excluded them from the study. Twenty-three patients with intra-articular calcaneal fractures were included in the study. Twenty-one patients were male and the rest were female. Three male patients had bilateral calcaneal fractures and hence a total of 26 cases of calcaneal fractures were included in the study. Thirteen patients had isolated right sided calcaneal fractures and seven patients had isolated left calcaneal fractures. The mechanism of injury was fall from height in all cases except in one female patient which occurred due to road traffic accident.

We used Sander's classification for decision making. Sander's type II, III and IV were included in our study (Table 1). Open fractures were not included in our study.

Sander's Type	Total Number of Patients
Type I	Not included in the study
Type II	13
Type III	9
Type IV	4

Table 1. Sander's Classification of Fracture

In all the cases antero-posterior, lateral and axial radiographs were obtained. G-angle and Bohler's angle were measured and recorded preoperatively as well as postoperatively. CT scan imaging with 3D reconstruction was done mandatorily as a part of preoperative planning.

Amongst the cases, four patients had associated other bone fractures (thoracic vertebrae compression fracture, distal radius fracture, pubic rami fracture and tibial plateau fracture). One of the patients was admitted in the neurosurgery ward for EDH. Two patients also showed undisplaced extra-articular calcaneus fracture of the opposite side which was managed conservatively by plaster of Paris cast (Table 2).

Characteristics	Male (%)	Female (%)	Over all (%)
Age (mean)	34.7	38.2	35.3
Sex	21 (91.30%)	2 (8.70%)	23 (100%)
Mode of Injury			
• Fall from height	21	1	22
• RTA	0	1	1
• Others	0	0	0
Side Involved			
• Unilateral right	12	1	13
• Unilateral left	6	1	7
• Bilateral	3	0	3
Associated Injuries			
• Spine	1	0	1
• Pelvis	1	0	1
• Contralateral limb	1	0	1
• Upper limb	1	0	1
• Head injury	1	0	1
Interval between injury and surgery (days)			8.76
Follow-up (months)			24.36
Time to union (in weeks)			9.10

Table 2. Demography of the Study Participants (n=23)

All the patients were initially managed in the OPD and emergency with a below knee POP slab with adequate cotton padding. Strict limb elevation and anti-inflammatory medications were started as soon as possible.

All the patients were operated between day 5 to day 14 of the injury. A patient with head injury was operated on day 26 after being treated by neurosurgery side.

Surgical Technique

The patients were placed on a radiolucent table in a lateral decubitus position with the fractured foot facing towards the ceiling and a bolster below the ankle. The same sided iliac crest area was also draped if the need for bone grafting arises. Tourniquet was used to reduce the bleeding. In all the patients, a standard lateral L shaped exposure was used. Skin and subcutaneous tissue is raised as a single flap up to the periosteum (Figure 1). No touch technique was used for handling the soft tissues. Reduction was achieved by creating a window and lifting the fractured lateral wall (Figure 2). Subsequently the sustenteculum, anterior process, tuberosity and the posterior facet is reduced. The reduction of the articular fragments was done under c-arm fluoroscopy guidance. Maintenance of calcaneal height, width, length and restoration to no varus-valgus angulations was trued as much as possible. The patients with bilateral fractures were treated in the same setting. A single or double 2mm K-wires were passed in the subchondral bone in the posterior to anterior direction to maintain the reduction of the articular fragments. The k wire is passed along the side of the tendo Achillis, first a lateral k wire and then a medial one if found necessary to hold the reduction. The K-wire could be inserted into the cuboid for increasing the holding strength of the fragments (Figure 3, 4). A non-

locking recon plate is contoured according to the lateral surface of the calcaneus (Figure 5). The K-wires were kept in situ and a non-locking recon plate was applied on the lateral surface of the bone. Four to five screws in the recon plate was found to be sufficient enough in our cases (Figure 6). After ascertaining the fixation, the wound was closed in layers over a drain of 12 French size. Skin was closed in a standard fashion with interrupted polyamide sutures. Bone grafting from the ipsilateral iliac crest was done in 20 cases to fill up the void.

The foot was kept in a below knee slab with adequate cotton padding. The slab was removed at 2 weeks and stitch removal was done. A boot cast was applied after that and the patient was made ambulatory with crutches. The K-wire was removed at 4 weeks with a window made in the cast and a small incision under local anaesthesia. It was subsequently closed with Vicryl Rapide sutures. Cast was removed at two and half months to three months duration. Ambulation and weight bearing was done after that.

RESULTS

The average duration of follow-up in the study was 26.7 months with a range of 24 months to 29 months. A total of 26 cases of calcaneal fractures were operated and followed up. Follow up was done at 2 weeks, 1 month, then at 2 to 3 months and then 6 monthly. Thirteen fractures were sander's type II (50%), nine were sander's type III (34.61%) and four of them were sander's type IV (15.38%). According to Maryland Foot Score (Table 3) Excellent results were obtained in 16 patients, good results seen in 8 patients and fair result in 2 patients. Sander's type II had the maximum number of patients with excellent results. Fair result was only seen in the sander's type IV category (Table 4).

The mean Bohler's angle preoperatively was 9.36° and the mean Gissane angle preoperatively was 151.42°. Postoperatively the angles improved to a mean of 28.7° in case of Bohler's angle and 129.2° in case of Gissane angle. The improvement in the Bohler's angle was 19.34° and an improvement of 22.22° was noted in the Gissane angle (Figure 7).

Soft tissue related problems such as infections, wound gaping and skin necrosis were not encountered in any of our cases. All the cases healed up uneventfully.

According to Maryland Foot Score (Table 3). Excellent results were obtained in 16 patients, good results seen in 8 patients and fair result in 2 patients.

Parameter		Marks
Pain	None, including sports	45
	Slight; no change in activities of daily living (ADL) or work ability	40
	Mild; minimal change in ADLS or work	35
	Moderate; significant decrease in ADLS	30
	Marked; during minimal ADLS	10
	Disabled; unable to work or shop	5
Distance walked	Unlimited	10
	Slight limitation	8
	Moderate limitation (2 or 3 blocks)	5
	Severe limitation (1 block)	2
	Indoors only	0
Stability	Normal	4
	Weak feeling; no true giving way	3
	Occasional giving way (1-2 months)	2
	Frequent giving way	1
	Orthotic device used	0
Support (walking aid)	None	4
	Cane	3
	Crutches	1
	Wheelchair	0
Limp	None	4
	Slight	3
	Moderate	2
	Severe	1
	Unable to walk	0
Shoes	Any type	10
	Minor concessions	9
	Flat, laced	7

	With orthotics	5
	Space shoes	2
	Unable to wear shoes	0
Stairs	Normally	4
	With bannister	3
	Any method	2
	Unable	0
Terrain	No problem with any surface	4
	Problems on stones or hills	2
	Problems on flat surfaces	0
Cosmesis	Normal	10
	Mild deformity	8
	Moderate deformity	6
	Severe deformity	0
	Multiple deformities	0
Motion (ankle, subtalar, metatarsophalangeal, midfoot)	Normal	5
	Slightly decreased	4
	Markedly decreased	2
	Ankylosed	0

Table 3. Maryland Foot Score

Functional Outcome	Overall Number (%)	Sander's Type II (%)	Sander's Type III (%)	Sander's Type IV (%)
Maryland foot score (mean)	86	89	86	82
Excellent (90-100)	16	9	6	1
Good (75-89)	8	4	3	1
Fair (50-74)	2	0	0	2
Poor (<50)	0	0	0	0
Over all	26(100)	13(100)	9(100)	4(100)

Table 4. Functional Outcome of Subject in terms of Maryland Foot Score

The changes in the Bohler's and Gissane angles are summarised in table 5.

Pre-operative Bohler's Angle (mean)	Postoperative Bohler's Angle (mean)	Mean Improvement in the Angles
9.36°	28.7°	19.34°
Pre-operative Gissane Angle (mean)	**Postoperative Gissane Angle (mean)**	
151.42°	129.2°	22.22°

Table 5. Assessment of the Radiological Angles

Figure 1. Skin and Subcutaneous Tissues Raised in a Single Flap

Figure 2. Reduction of the Lateral Wall by Lifting the Fragment

Figure 3. Passing the Subchondral K-Wire to Maintain the Reduction

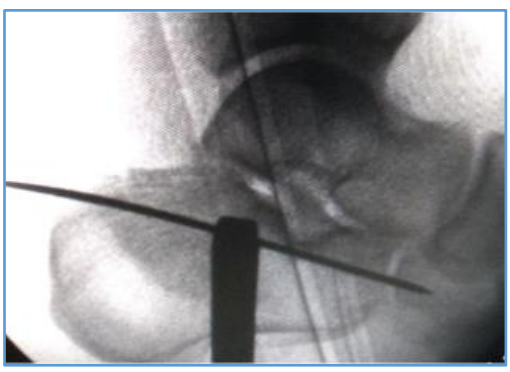

Figure 4. X-ray of the Subchondral K-Wire Passed to the Cuboid to Maintain the Articular Reduction

Figure 5. Contouring of the Recon Plate

Figure 6. Plate and Screws Applied to the Lateral Surface of the Calcaneum

Figure 7. Pre-Operative and Post-Operative X-Rays

DISCUSSION

Calcaneus fractures are a difficult category of fractures for treatment to provide a good functional outcome. They comprise approximately 2% of all fractures, and most of them are intraarticular (60-75%).[1,2] Accompanying injuries such as spinal injury, long bone fractures, head injury and chest injury may produce difficult circumstances for treatment and rehabilitation.

91.30% of the study population were males within an age range of 23 years to 42 years. This signifies the impact on the economy of the country as most of the patients are the earning members of the family. These fractures are almost always associated with high energy trauma such as fall from height or road traffic accidents. All the patients had a history of fall from height except one patient whose fracture occurred as a result of run over by a car over the foot.

CT scan with 3D reconstruction was done mandatorily in all our cases for planning of the surgery. Calcaneus is an irregular bone and assessment of the fractures associated with the same may become difficult with plain radiographs. Here CT scan plays an important role for assessment and planning and should be considered in all cases planned for operative treatment.[17,22]

The average time for operative intervention was 8.76 days. This was determined by the appearance of the wrinkle sign over the fractured area. Presence of wrinkles over the dorsum of the foot did not qualify to undergo operative fixation.

There implant used for the procedure was of low cost. As compared to the international and the national brands for the locked calcaneal plate implant, the cost of implant i.e., recon plate and k wire was less than half to them (Table 6). In a developing country like India, good functional outcome at low cost of treatment carries maximum benefit to the patient and the economy.

Implant	Average Price
International Brand calcaneum lock plate	10000 INR – 20000 INR
National Brand calcaneum lock plate	8000 INR – 12000 INR
Recon Plate and K-wire	2000 INR – 4500 INR

Table 6

The role of the subchondral K-wire is immense in this operative technique. The K-wire is necessary for preventing both intra-operative and postoperative loss of reduction, and the recon plate acts like a neutralization plate in this case.

This is a simple and reproducible method. Postoperative and even intraoperative loss of reduction can be encountered during the fixation of these fractures which is effectively controlled by the K-wire. The key to success in the surgical treatment of intraarticular calcaneus fractures is ensuring reduction and the maintenance of the same.[23] Sanders et al. reported[17] 132 displaced intra- articular calcaneal fractures (types II through IV) where by a lateral approach with lag screw fixation of the posterior facet, plate fixation of calcaneal body was done. No bone grafting was done. In the type II fractures, 86% had anatomic reduction and 73% showed good or excellent results. Type III fractures had 60% anatomic reduction with 70% good or excellent results. Whereas, type IV fractures had no anatomic reduction and only one patient showed good results. Compared to Sanders et al., excellent and good results were found in 100% cases in Sander's type II and III, and 50% cases in type III fractures in our study. Also, after a two year follow up, the loss of post-operative reduction was only 2.75° for Bohler's angle and 2.06° for Gissane angle.

The options for treating intraarticular calcaneus fractures may be evaluated in four groups[24,25,26] as: Conservative treatment, closed reduction percutaneous fixation, open reduction internal fixation and primary subtalar arthrodesis, and mini open approaches with percutaneous fixation.[27,28,29]

Kitoaka et al.[30] reviewed the results of the walking analyses in conservatively treated calcaneal fractures treated with plaster which showed conservative treatment of displaced calcaneus fractures results in permanent functional disorders, at least to some extent.

O'Farrel et al.[31] and Leung et al.[32] compared the surgical outcome with the conservative management and concluded that the results of the group treated surgically were significantly better.

The use of bone grafting is controversial for the treatment of calcaneus fractures. Some authors suggest that the calcaneus being a cancellous structure will recover without use bone grafting, but other authors consider bone grafting as a mandatory part for treating calcaneal fractures to protect joint reduction, add mechanical strength and stimulate fracture healing.[3,33-35] We used bone grafting where ever necessary to fill up the bone gaps. In our belief, gaps in the cancellous bone left behind are filled up with fibro-cartilaginous tissue as cancellous bone heal up only by direct contact. Later it gets calcified. Bone grafting is beneficial to preserve joint reduction for displaced intraarticular calcaneus fractures as bone defect develops following reduction.

The most common complication faced following calcaneus fracture is related to wound healing.[36,37,38] Risk factors for wound problems include smoking, diabetes, open fractures, high body mass index, and enclosing the skin in a single layer. Movement exercises are delayed if any wound problem arises in order to prevent any further disintegration.[17,27] No soft tissue related problems were noted in our study. This perhaps may be attributed to the lesser soft tissue handling, less instrumentation and the use of the subchondral k- wire which significantly reduces the effort to maintain the reduction during the surgical process and also decreases the operative time.

There is lack of consensus regarding surgical maintenance and rehabilitation of the intraarticular fractures.[39,40] One school of thought prefer fixation by plaster for two to three weeks following surgery, while others have the patient start on early active movements on second day. Rehabilitation along with anatomic stable fixation remains a key to the success to treatment of intra-articular calcaneus fractures. In our cases a boot cast was applied on stitch removal and toe touch weight bearing was allowed with the aid of crutches. The application of a fiberglass cast seemed to provide better stability to the fracture, prevented breakage and loosening during ambulation. Physiotherapy was initiated from the second postop day to prevent disuse atrophy of muscles. Partial weight bearing ambulation was initiated at one month after the removal of the k wires. Full weight bearing and return to activities of daily living was archived at two and half months to three months duration.

Sural nerve injury is the most common iatrogenic neurological injury that can be seen in the operative treatment of calcaneal fractures. This may be seen in up to 15% of the cases.[23] No neurological complications were present in our study.

Excellent results were obtained in 61.5% cases, good results in 30.7% and fair in 7% cases. There were no poor results as per Maryland Foot Score. Stable anatomic fixation, proper handling of soft tissues, maintenance of reduction and early rehabilitation are key to success in treatment of intra-articular calcaneal fractures. All the patients returned to their former jobs within an average of 5.93 months except on patient with Sanders type IV fracture who changed his job and returned to work at 8 months.

CONCLUSION

ORIF with recon plate and K-wire is good substitute for the operative treatment of displaced intra-articular calcaneal fractures with definite advantages over the conventional locking calcaneal plate system. It provides good soft tissue results, prevents loss of reduction post operatively and also is cost effective in a developing country like India. The operative procedure is reproducible and the learning curve for the surgeon and his team is less.

Limitations

1. A small sample size.
2. Limited duration of follow up.
   For the results to have a better clinical impact, a randomized controlled study with a larger sample size and a longer duration of follow is necessary.

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