ORIGINAL RESEARCH PAPER
Volume - 12 | Issue - 02 | February - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

FUNCTIONAL AND RADIOLOGICAL ANALYSIS OF SURGICALLY MANAGED DISPLACED INTRA-ARTICULAR CALCANEUM FRACTURE

Orthopedics

Dr Selvin Prabhakar Vijayan Assistant Professor, Department Of Orthopaedics, Chettinad Hospital And Research Institute

Dr Pradeep Elangovan Associate Professor, Department of Orthopaedics, Chettinad Hospital and Research Institute

Dr Arun Kumar Kannan Associate Professor, Department of Orthopaedics, Chettinad Hospital and Research Institute

Dr Dinesh Kumar Suganathan* Junior Resident, Department of Orthopaedics, Chettinad Hospital and Research Institute
*Corresponding Author

ABSTRACT

Introduction: One of the most common foot fractures is fracture of calcaneum. It is usually caused by high energy trauma, with 75% being intra-articular. Advances in imaging, implants, AO principles of internal fixation and the routine use of intraoperative imaging have made internal fixation a recommended procedure in recent past. **Material and methods:** The study included 38 patients of intra-articular calcaneal fractures treated operatively with ORIF with PO using the modified Kocher's approach. The patients were assessed radiologically and for functional outcome as per AOFAS (American Orthopedic Foot and Ankle Score) score. **Results:** 43 fractures in 38 patients were included in our study with mean age of 38.58 years. 56% had good and 44% had excellent results with final AOFAS score. All radiological parameters like Böhlers angle, Gissane's angle and calcaneal width and height showed improvement following surgery, with later three having statistical significance. There was no influence of complications following surgery over final AOFAS score. **Conclusion:** Surgical management of calcaneal fracture require thorough understanding of anatomy and various radiological parameters. Careful patient selection, preoperative planning, appropriate timing for surgery, proper approach and accurate anatomic reduction gives a good functional outcome. Sander's classification helps in surgical planning as well as prognostication.

KEYWORDS

Calcaneus fractures, intra articular, open reduction, internal fixation, locking plate

INTRODUCTION

Fractures of calcaneum are the most common foot fractures. Most of these fractures are caused by high energy trauma, 75% are intra-articular fractures.[1] The bone consists of four facets, three superior and one anterior. The largest facet, posterior is oval and runs distal and lateral in the sagittal plane. It is separated from the other two facets by the calcaneal sulcus. The sinus tarsi houses the interosseous ligament complex between the talus and calcaneus. The middle facet and anterior facets are fused together in approximately 20% of cases [2]. Medially, the sustentaculum tali emerges from the medial wall and is the most stable portion of the calcaneus. The posterior half is called tuber-calcaneus or calcaneal tuberosity. The inferior 2/3rd of the calcaneal tuberosity provides the Achilles tendon and plantaris an insertion point. The internal structure is characterized by longitudinal and transverse trabeculae that form a strong support and is termed as the thalamic portion. Underneath this portion lies an area which is devoid of bone (40%) or consists of sparse trabeculae (60%) called the neutral triangle due to the mutual cancellation of compression and tension forces. It is into this chamber that the primary fracture line occurs [2,3]. Intra-articular fractures of the calcaneus occur secondary to axial load, as the talus undergoes compression, the subtalar joint goes into eversion and acts as a wedge at the angle of Gissane. This produces the primary fracture line across the posterior facet and produces postero-lateral tuberosity fragment and antero-superior medial sustentacular fragment. [4] The most commonly used classification currently is Essex-Lopresti and Sander's classification. Essex-Lopresti classification system describes the tongue type and joint depression type of fragment. The classification determines the treatment, but not the prognosis [5,6,7,8]. Sander's classification is CT based and classifies the fractures based on the number of fracture fragments that are identified on CT imaging. Sander described the talus as being divided into 3 equal columns by two lines A and B. These lines divided the posterior articular facet into 3 potential pieces: a medial, a central, and a lateral column. A third fracture line C, corresponding to the medial edge of the posterior facet of the talus, separates the posterior facet from the sustentaculum and results in a total 4 potential pieces. The lines are named A, B, C from lateral to medial.

Type 1: All non-displaced articular fractures, regardless of the number of fracture lines.

Type 2: 2-part fracture which is further sub divided into type II A, II B and II C based on the primary fracture line.

Type 3: 3-part fracture which is further sub divided into type III AB, III AC and III BC.

Type 4: 4-part or highly comminuted

Often there are more than 4 articular fracture fragments. This system has been useful in terms of determining treatment, and was shown to correlate well with prognosis and level of operative difficulty [9,10,11,12].

The treatment of intra-articular fractures of calcaneus varies between operative or conservative treatment [13]. Advances in 3D CT scan imaging [14,15], improvements in implants, AO principles of internal fixation and the routine use of intraoperative imaging has aided in operative fixation. Internal fixation is routinely recommended for displaced intra-articular calcaneal fractures. [16,17].

MATERIALS AND METHODS

The study included 43 prospective and retrospective cases of intra-articular calcaneal fractures treated operatively at Department Of Orthopaedics, Chettinad Hospital And Research Institute, Kelambakkam, Chennai, Tamil Nadu. The patients were called for follow up, assessed radiologically and for functional outcome as per AOFAS (American Orthopedic Foot and Ankle Score). Displaced intra-articular calcaneal fractures in patients with age between 16-65 years, excluding Open fractures or severe soft tissue compromise and fixation with implants other than calcaneal locking plate were included in the study. X-rays of ankle: anteroposterior, lateral, oblique and axial view was done. CT scan with 3D reconstruction was done in all patients with intraarticular calcaneal fractures. Before surgery, crepe bandage was applied, affected limb was elevated. The patient was taken up for surgery once skin wrinkling was seen and no pitting oedema was present.

The calcaneus was approached through a modified Kocher's incision. In most cases, a lazy L shaped incision was used, with the vertical limb situated almost half way between fibula and Tendo Achilles, starting 4 cm above lateral malleolus (figure 1). The skin was incised vertically up to bone avoiding undermining of the edges and a full thickness flap was raised by detaching retinaculum, calcaneofibular ligament,

talocalcaneal ligament. The subtalar joint capsule was opened. Hematoma was removed and the flap was retracted by the 'no touch technique', using three 2-mm Kirschner wires drilled into the lateral malleolus, lateral process of talus and cuboid thus allowing adequate visualization of calcaneum. Planning of reduction was done depending on fracture anatomy. In joint depression type, window in lateral wall was made. The lateral wall fragment was dis-impacted, removed and kept in a blood-soaked gauge (figure 2).

Figure 1

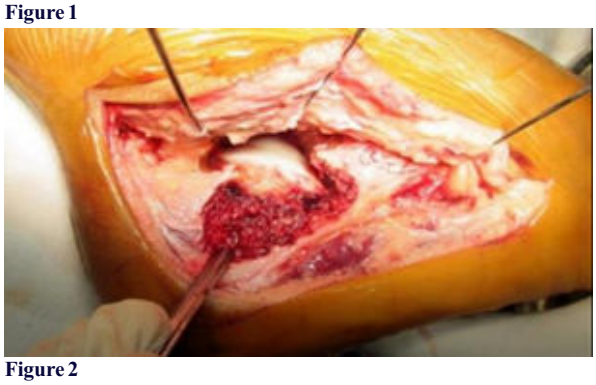

Figure 2

The reduction of five standard fragments in joint depression type of fracture was done by identifying the sustentacular fragment which remains attached to the talus and does not displace using k-wires (figure 3). Disimpaction and reduction of the articular fragments resulted in varying degrees of void. After saline wash, the void was filled with bone substitute materials or autogenous graft if needed (figure 4). The lateral wall was replaced, calcaneal locking plate was contoured for the specific individual, placed over the lateral wall (figure 5), position was checked under fluoroscopy and fixed with locking screws of appropriate size. It was made sure hindfoot remained in neutral or slight valgus.

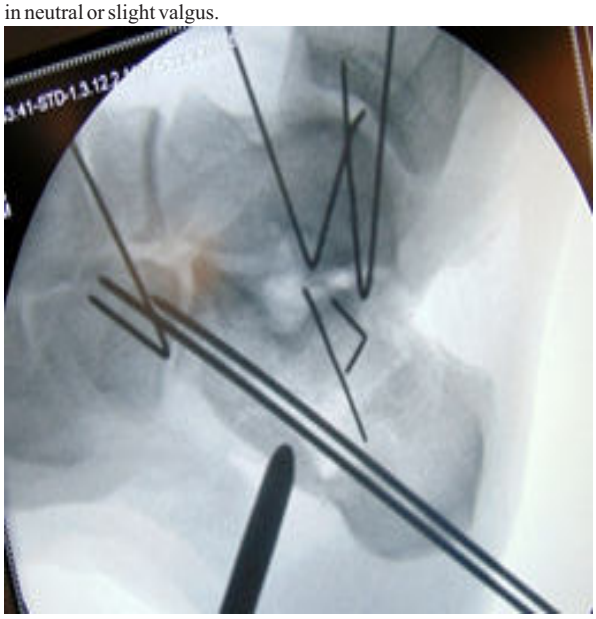

Figure 3

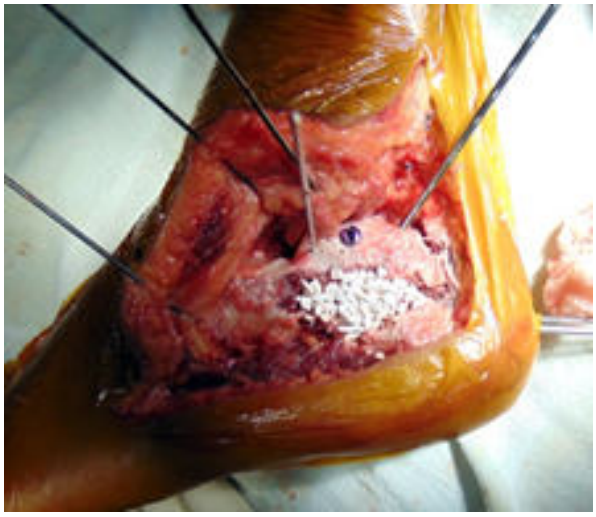

Figure 4

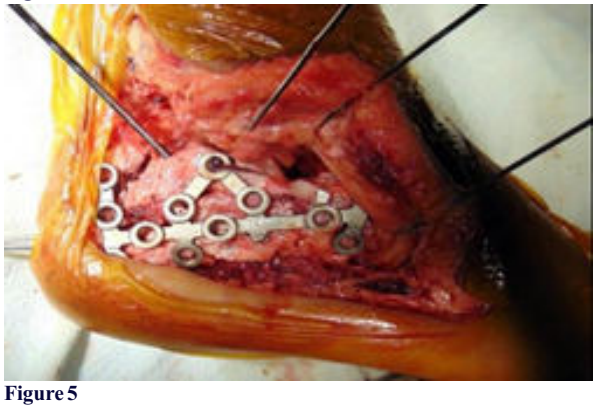

Figure 5

Postoperative X ray was done on day 1. Sutures was removed on 15th post op day. Active and passive range of motion exercises was started. Non-weight bearing crutch walking was allowed for 2 months followed by partial weight bearing and gradually progressed to full weight bearing by end of 3 months. Ankle, subtalar joint mobilization, strength endurance training and gait training were done. On last follow up, Xray was done and the results were assessed using American Orthopaedic Foot Ankle Society (AOFAS) Score system. The patients were classified into excellent, good, fair and poor outcome group depending on the score.

OBSERVATIONS AND RESULTS

A total of 43 fractures in 38 patients were included in our study. Age was between19 to 62 years, with mean age between 38.53±11.17 years. 79% patients were males and 21% were females. 47% patients had fractures on left side, 40% on right side and 15% had bilateral fractures. In our study maximum number of patients, that is 63% was operated between 8 to 14 days. The mean duration between injury and surgery was 12.46 days. About 25% of patients had associated spine fractures. Maximum fractures were Sander's type 2 (56%) and type 3 (42%). Only 2% (1 fracture) was Sander's type 4. 67% of fractures were joint depression type and 33 % had tongue type with joint depression fracture or comminuted fracture. Pure tongue type of fractures was excluded from our study.

All patients had good to excellent results. 56% had good final results with AOFAS score between 80 to 89 and 44% had excellent results with AOFAS score ≥ 90. The mean total score was 88 and no patients had fair or poor results (table 1). On sub group analysis the mean AOFAS score of patients in Sander's type 2 was 87.83, Sander's type 3 was 88.22 and Sander's type 4 was 95 with a significant p value of 0.058.

Table 1- Distribution of patients on comparison of Sander's type with AOFAS score

SANDER'S TYPE	AOFAS SCORE (80-89)	AOFAS SCORE (>90)	TOTAL
TYPE 2	15	9	24

TYPE 3	9	9	18
TYPE 4	0	1	1
TOTAL	24	19	43

Four radiological parameters were calculated in Xrays which include pre and post-operative Böhlers angle, Gissane's angle and calcaneal width and height. Mean pre operative Böhler's angle was 7.05 degrees, with majority (89%) having an angle less than 20 degree. The mean postoperative Böhler's angle was 21.33 degrees, with 68% of patients between 20 and 30 degrees (table 2). Mean preoperative Gissane's angle was 119.16 degrees, with 37% had a preoperative angle between 121and 130 degrees and 26% between 110 and 120 degrees. Post operatively maximum (72%) of patents had Gissane's angle between 110 and 120 degrees and mean angle was118 degrees. There was statistically significant improvement of Gissane's angle (table 3). Pre operatively 35% of patients had calcaneal width between 5 to 5.5 cm, 28% between 5.6 and 6 cm, 23% less than 5 cm and 14% more than 6 cm with mean preoperative calcaneal width of 5.36 cm. Post operatively 46% of patients had calcaneal width less than 5cm, 40% between 5 and 5.5cm with mean postoperative calcaneal width of 4.99 cm. There was statistically significant reduction in calcaneal width (table 4). Pre operatively, 49% of patients in our study had calcaneal height between 4 to 4.5 cm, 47% had height less than 4 cm with mean of 3.87 cm. Post operatively, maximum (65%) patients had calcaneal height between 4 to 4.5 cm, with a mean height of 4.34 cm. There is a statistically significant increase in calcaneal height (table 5).

Table 2 - Comparison of pre and postoperative Böhler's angle

	Pre Op- Bhöler's Angle			Post Op- Bhöler's Angle		
Category	Sample Size	Mean ± Stdev	Min-max	Sample Size	Mean ± Stdev	Min-max
<20 Degrees	38	4.89 ± 12.87	-30-19	38	21.03 ± 4.39	12-36
20 To 30 Degrees	4	20.25 ± 0.5	20-21	4	23.25 ± 4.57	18-29
31 To 40 Degrees	1	36 ± 0	36-36	1	25 ± 0	25-25

Table 3 - Comparison of variables of pre and postoperative Gissane's angle

	Pre Op- Gissane's Angle			Post Op- Gissane's Angle			P Value
Category	Sample Size	Mean ± Stdev	Min-max	Sample Size	Mean ± Stdev	Min-max	
<110 Degrees	8	94.25 ± 11.21	75-108	8	114.38 ± 4.47	110-120	0.002
110 To 120 Degrees	11	114.82 ± 3.82	110-120	11	122.09 ± 8.57	110-137	0.023
121 To 130 Degrees	16	125.5 ± 2.99	122-133	16	116.31 ± 4.9	108-126	<.0005
>130 Degrees	8	137.38 ± 5.97	132-150	8	119.38 ± 5.88	112-130	0.001

Table 4 - Comparison of pre and postoperative calcaneal width

	Pre Op- Width			Post Op- Width			P Value
Category (cm)	Sample Size	Mean ± Stdev	Min-max	Sample Size	Mean ± Stdev	Min-max	
< 5	10	4.55 ± 0.26	4.2-4.8	10	4.35 ± 0.28	4-4.8	0.044
5 to 5.5	15	5.2 ± 0.2	5-5.5	15	4.89 ± 0.24	4.3-5.2	<.0005
5.6 to 6	12	5.8 ± 0.17	5.6-6	12	5.27 ± 0.48	4-5.8	0.002
>6	6	6.27 ± 0.19	6.1-6.6	6	5.75 ± 0.39	5-6	0.027

Table 5 - Comparison of pre and postoperative calcaneal height

	Pre Op- Height			Post Op- Height			P Value
Category (cm)	Sample Size	Mean ± Stdev	Min-max	Sample Size	Mean ± Stdev	Min-max	
<4	20	3.48 ± 0.3	3-3.9	20	4.14 ± 0.36	3.5-4.8	<.0005
4 to 4.5	21	4.14 ± 0.2	4-4.5	21	4.44 ± 0.28	3.9-5	<.0005
4.6 to 5	2	4.95 ± 0.35	4.7-5.2	2	5.25 ± 0.35	5-5.5	0.157
>5				1	5.5±0		

Table 6 - Distribution of patients according to complications of surgery

Complications	Frequency	Percentage
Nil	35	81.40
Deep Infection	4	9.30
Pain	3	6.98
Implant Related	1	2.33
Total	43	100

There was no statistical significance on comparison of functional outcome (AOFAS score) with associated injury (p value 0.614), and with duration between injury and surgery (p value 0.688). There was no correlation between AOFAS scores and various radiological parameters measured except calcaneal width.

Maximum number of patients (82%) did not have any associated complications. 18% of patients had associated complications, out of which 9% patients had deep infection, 7% patients had persisting pain and 2% patient had implant related complication (table 6). There was direct correlation on comparing duration between injury to surgery and complications following surgery (p value 0.021).Greater Sander's type of fracture pattern caused increased risk of complications following surgery.There was no influence of complications following surgery over final AOFAS score.

DISCUSSION

Intra-articular calcaneal fractures are one of the most difficult and complicated fractures to treat. There is still a lack of consensus on classification, treatment, operative technique and postoperative management in calcaneal fractures. Many attempts have been made to develop a classification and treatment protocol but none received universal acceptance because of complexity in using, understanding, inability to accurately represent the fracture pattern and prognostic outcome. In the literature, the management of calcaneal fracture varies from doing nothing, conservative treatment, open fixation, primary subtalar arthrodesis, delayed primary arthrodesis to calcanectomy. Nonoperative treatment is effective for fractures that are nondisplaced or minimally displaced (≤ 2 mm). ORIF is the standard therapy for fractures that are displaced greater than 2 mm with 65% to 80% good to excellent results [13].

Side

In various studies the incidence of calcaneal fractures on right side ranges from 27% to 46% and left sided fractures range from 40% to 73% [18,19]. In our study majority of the patients 47% had fracture on left side, 40% on right side and 13% had bilateral fractures which were closest to A.Siebe et al, who reported 46% had fracture in right side, 14 % bilateral and 40 % left side [20]. High percentage of bilateral fractures in our study was probably due to the higher incidence of high velocity road traffic accidents.

Injury association

Calcaneal fractures occur mostly in young individuals who undergo high energy trauma like fall from height or road side, thus having associated injuries. A.Siebe et al reported a total of 24% cases had associated injury and Saurabh Jain et al reported 13% patients had associated spine injury in his study1,20. In our study around 56% patients had associated injury which is higher than that described in various studies. Out of all the associated injuries maximum (25%) patients had associated spine injury without any neurologic deficit in our study.

Duration between injury and surgery

While planning a patient with calcaneal fracture for surgery there are number of factors to be taken regarding the timing of surgery. Some of the factors include skin conditions, condition of soft tissue envelope and associated injury. The patient is taken up for surgery only after wrinkle sign is positive which helps to determine if the swelling and oedema have subsided. On comparison of various studies, the mean duration between the date of injury to the date of surgery varies between 4.83 days to 16.2 days with range between 2 days to 25 days [1,18,21,20,22]. In our study maximum number of patients 63% were operated between 8 to 14 days. The mean duration between injury and surgery was 12.46 days. The wrinkle sign appeared in most of the patients during this time. Patients who had been operated later were because of time taken for management of associated injuries or poor soft tissue conditions. Surender Kumar et al reported average duration between injury and surgery was 11 days which was closest to our observation [23]. On comparison between duration between injury and

surgery with postoperative complications, it was evident that greater the duration, higher is the risk for complication (p value 0.021).

Sander's classification

Sander's classification is a CT based classification which divided calcaneal fractures into 4 types depending on the number of fracture lines on semi coronal and axial section of CT scan. The treatment of choice for Sander's type 1 fractures is conservative management and hence excluded from study. In various studies the percentage of patients in Sander's type 2 range from 45.4% to 78%, in type 3 from 20% to 40% and type 4 from 2% to 27.2%[18,19,20]. In our study maximum (56%) of patients were classified as Sander's type 2 fractures, 42% belonged to Sander's type 3 and 2% belonged to type 4 which closely resembles observations of Per-Henrik Agren, in his study of 42 cases, reported type 2 in 48%, type 3 in 40% and type 4 in 12% [24]. Sander's classification is prognostic classification, which was also proved in our study, on comparing Sander's classification with AOFAS Score, had a statistically significant p value of 0.05, thus inferring Sander's classification helps in prognostication. There was also a positive correlation between Sander's type and complication with a p value of <0.0005.

Graft

In our study in most of patients' graft/ graft substitutes were used. In maximum number of patients (86%) synthetic bone graft substitute was used. 1 packet of synthetic bone graft contains hydroxyapatite (60%) and β tricalcium phosphate (40%) granules of diameter 2 to 3mm of 5cc was used, in 5% patients autograft from iliac crest used, in 3% patients both synthetic bone graft and autograft from iliac crest used. In 1 patient graft from preserved femoral head was used. A.K Singh et al reported the mean full weight-bearing time and loss of Bohler's angle with 2 years follow up was significantly lower with bone grafting [18]. The infection rate and mean AOFAS score was lower in grafted cases, but this difference was not significant. Saurabh Jain et al reported 13% cases required bone grafting [1].

Complications

Surgical treatment of calcaneal fractures with open methods still remains a challenge to many orthopaedic surgeons because of high rate of associated complications like wound infection, compartment syndrome, iatrogenic neurovascular injury, peroneal tendon impingement, heel pad pain, implant failure, maluninon and subtalar arthritis. Various studies describe complication rate between 10.5 % upto 23% [19,24]. Surender Kumar et al reported 20% patients had complications [25]. These were superficial wound healing problem, pain and implant prominence which was closest to our study in which 18% of patients had associated complications. Maximum (9%) patients had deep infection, which were treated with antibiotics and regular antiseptic dressing, 7% patients persisting pain and 2% patient implant related complication. None of the patients required removal of calcaneal plate. Vaclav Rak et al reported serious wound healing complications in 10.5% and Saurabh Jain et al reported most common complications reported are incision flap necrosis and superficial or deep infection ranging from 5% to 15% similar to our study [1,21]. In our study some of complications found with long term follow up like sub talar osteoarthritis, malunion, sural neuritis was not present because the mean follows up time was relatively short. There was a significant positive correlation between surgical complications and age of patient, duration between injury and surgery, Sander's type and graft used.

AOFAS score

It is a functional scoring system which includes pain, functional ability and alignment. The mean AOFAS Score was 88.16 with a range between 82 to 95 which was close to observations reported by Saurabh Jain et al, who reported more than 96% of the patients had no or only mild occasional pain with no limitation of daily activity, no gait abnormality and were able to walk at least more than 200 meters with only some difficulty on uneven surface [1]. In his study average AOFAS score at final follow-up was 86.3 (range 66 to 97), with 86% having excellent to good results and 2 (7.7%) and 1 (3.7%) had fair and poor results respectively [20,21,22,24]. In our study maximum (56%) patients had good functional score (80 to 89) and 44% have excellent functional score (≥ 90). On categorizing AOFAS score according to Sander's type, type 2 had 62.5% good score and 37.5% excellent score, type 3 had 50% good score and 50 % excellent score and type 4 had 100% (n=1) excellent score. There was significant correlation between AOFAS score and Sander's type of fracture in our study, with p value of 0.058.

CONCLUSION

At the end of our study, we concluded that calcaneal fractures with intra-articular displacement are difficult to treat and require thorough understanding of anatomic features of this area. Careful patient selection, preoperative planning, appropriate timing for surgery, proper approach for raising full thickness flaps and accurate anatomic reduction gives a good functional outcome. Various radiological parameters helps to understand the accuracy of fracture reduction. Sander's classification helps in better understanding of anatomy as well as prognostication. Open reduction and internal fixation with calcaneal locking plate by extended lateral approach is preferred treatment in Sander's type 2,3 and 4 fractures of calcaneum.. Good postoperative care and physiotherapy is must for obtaining good functional results with an acceptable incidence of complication.

REFERENCES

[1] Saurabh J, Anil Kumar J, Ish K. Outcome of open reduction and internal fixation of Intra-articular calcaneal fracture fixed with locking calcaneal plate. Chinese Journal of Traumatology 2013;16(6):355-360.
[2] Sarrafian SK. Anatomy of the foot and ankle. Philadelphia: Lippincott;1993
[3] Soeur R, Remy R. Fractures of the calcaneus with displacement of the thalamic portion. J Bone Joint Surg Br 1975; 57:413–21.
[4] Harty M. Anatomic consideration in injuries of the calcaneus. Orthop Clin North Am 1973; 4:179–83.
[5] Kearns R. Thomson, Carl M. Friesen. Treatment of comminuted fractures of the calcaneus by primary triple arthrodesis. The journal of bone and joint surgery 1959, Volume 41- A, No.8: 1423-1436.
[6] Allan J. H. The Open reduction of fractures of the os calcis. Ann. Surg1955;141 :890-900.
[7] Allison, Nathaniel. Timirtieth report of progress in orthopedic surgery. Arch. Surg, 1926;13:445-458.
[8] Bell, Charles. Statistics of operations in Mr.Bell's Wards: Compound fracture of os calcis. Edinburgh Med. J., 1882;27:1-100.
[9] Sander's R, Fortin P, DiPasquale A, et al. Operative treatment in 120 displaced intra-articular calcaneal fractures. Results using a prognostic computed tomographic scan classification. Clin Orthop,1993; 290:87–95.
[10] Thore. O. Os calcis fractures. Acta Orthop. Scand. 1964;70(Suppl.):1.
[11] Stephenson J.R. Treatment of displaced intraarticular fractures of calcanem using medial and lateral approaches, internal fixation and early motion. J. Bone Jont Surg, 1987;69A:115.
[12] 14. Sander's R. Current concepts review displaced intra-articular fractures of the calcaneus. The Journal of Bone and Joint Surgery February 2000;Volume. 82-A, No.2:225-250.
[13] Trevor Gaskill, Karl Schweitzer, and James Nunley. Comparison of surgical outcomes of intra-articular calcaneal fractures by age. The Journal of Bone and Joint Surgery, December 2010; Volume 92-A, No.18:2884-2889.
[14] Athavale SA, Joshi SD, Joshi SS. Internal architecture of calcaneus: correlations with mechanics and pathoanatomy of calcaneal fractures. Surg Radiol Anat. 2010; 32:115-22.
[15] Barla J, Buckley R, McCormack R, Pate G, Leighton R, Petrie D, Galpin R. Canadian Orthopaedic Trauma Society. Displaced intraarticular calcaneal fractures: longterm outcome in women. Foot Ankle Int. 2004; 25:853-6
[16] Clare MP, Lee WE, Sander's RW. Intermediate to long-term results of a treatment protocol for calcaneal fracture malunions. J Bone Joint Surg Am. 2005; 87:963-73.
[17] John D. Maskill, Donald R. Bohay, John G. Anderson. Calcaneus fractures: A review article. Foot Ankle Clinics 2005, (10): 463– 489.
[18] A. K. Singh, K. Vinay. Surgical treatment of displaced intra-articular calcaneal fractures: is bone grafting necessary. J orthopaed traumatol. 2013; 14:299-305.
[19] Cheng-Jung Ho, Hsuan-Ti Huang, Chung- Hwan Chen, Jian-Chih Chen. Open reduction and internal fixation of acute intra-articular displaced calcaneal fractures: A retrospective analysis of surgical timing and infection rates. Injury, Int. J. Care Injured.2013;44:1007-1010.
[20] A. Siebe De Boer, Esther M.M. Van Lieshout, Dennis Den Hartog. Functional outcome and patient satisfaction after displaced intra-articular calcaneal fractures: a comparison among open, percutaneous, and nonoperative treatment. The Journal of Foot & Ankle Surgery.2015;54: 298-305.
[21] Vaclav Rak, Daniel Ira, Michal Masek. Operative treatment of intra-articular calcaneal fractures with calcaneal plates and its complications. IJO. July - September 2009; Volume 43, Issue 3:271-280.
[22] Attilio Basile. Operative versus nonoperative treatment of displaced intra-articular calcaneal fractures in elderly patients. The Journal of Foot & Ankle Surgery.2010;49:25-32.
[23] Phinit Phisitkul, Jaron P. Sullivan, Jessica E. Goetz. Maximizing safety in screw placement for posterior facet fixation in calcaneus fractures. Foot & Ankle International.2013;34(9):1279- 1285.
[24] Per-Henrik Agren, Per Wretenberg, and Arkan S. Sayed-Noor. Operative versus nonoperative treatment of displaced intra-articular calcaneal fractures. J Bone Joint Surg Am.2013;95:1351-7.
[25] Surender Kumar, Loveneesh G. Krishna, Davinder Singh. Evaluation of functional outcome and complications of locking calcaneum plate for fracture calcaneum. Journal of clinical orthopaedics and trauma.2015;6:147-152