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A prospective study on results of bacterial culture from wound in type III compound fractures

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ABSTRACT

Background: Open fractures still represent a major challenge for the treating surgeon. Sound knowledge of the bacteriological epidemiology and antimicrobial susceptibility helps to prevent complications. Our aim is to study about the common bacteria causing open fracture infection and their antibiotic sensitivity in patients who are admitted in the department of Orthopedics, Government medical college, Kottayam.
Methods: A prospective study on 130 patients with type III open long bone fractures were studied for infection during study period of June 2016 to July 2017. After initial debridement and at third day during follow up wound inspection, swabs were taken from wound site. Swabs were send for microscopic examination, culture and antimicrobial susceptibility testing.
Results: Out of 130 type III open long bone fractures, 7.7% were having day 0 infection and 25.4% were having day 3 infection. 19.2% of patients developed infection from day 3 onwards. *Staphylococcus aureus* (37.1%) was the most commonly isolated bacteria from wound. Other organisms isolated were *Acinetobacter*, *Pseudomonas*, *Klebsiella*, *E coli*, *Enterococcus*, *Streptococcus* and *Enterobacter*. 100% of diabetic patients developed infection on day 3. Gentamicin, amikacin doxycycline, ciprofloxacin, vancomycin, piperacillin + tazobactum and cefoperazone + sulbactum were found to be effective against isolated organisms.
Conclusions: Gram positive *Staphylococcus aureus* was found to be the most common cause of wound infection in type III open fractures. An early adequate wound debridement, proper antibiotic therapy and aseptic post-operative wound care are essential for wound healing and fracture union in an open fracture.

Keywords: Open fracture, Infection, Antimicrobial susceptibility

INTRODUCTION

An open fracture is defined as an injury where the fracture and the fracture hematoma communicate with the external environment through a traumatic defect in the surrounding soft tissues and overlying skin. Apart from severe bone and soft tissue involvement, these injuries have other risk factors such as skin degloving, soft tissue crushing, contamination with dirt and debris and injury to neurovascular structures. Hence they are associated with a high risk of complications, including infection, non-union and amputation. 60–70% of compound fractures are believed to be contaminated with bacteria at the time of injury from both skin and environment. Infection of open fractures depends on the microbial and host factors.[1]

Open fractures have significant importance as poor outcome of treatment is associated with poor health status. Majority of open fractures are due to high velocity trauma like road traffic accidents especially in males of productive age group. These fractures frequently results in long term disability with potentially severe economic

impact on the patient. According to Lee et al, wound infecting pathogens differ from country to country and from one hospital to another within the same country due to the difference in bacterial prevalence in different environments.[2] Here is an effort to study the most prevalent pathogenic bacteria and there antibiotic sensitivity in type III compound fractures in our hospital and compare with other studies.

METHODS

This is a prospective observational study on 130 patients with type III open long bone fractures admitted in department of Orthopaedics, Government Medical College, Kottayam during the study period of June 2016 to July 2017. All patients were informed about the study in all respects and informed written consent was obtained.

Inclusion criteria

All patients with type III open long bone fractures.

Exclusion criteria

All patients who are immune compromised and with any other focus of infection.

Procedure

The study was approved by the Ethical and Research committee of Government medical college, Kottayam, Kerala. After finding the suitability as per inclusion and exclusion criteria, patients were selected for the study, briefed about the nature of study and written informed consent were obtained.

Further, demographic profile of patient, history of diabetes mellitus, mode of injury, clinical and radiological examination were recorded on predesigned proforma. First sample (D0) was collected from emergency room and second sample (D3) was taken on 3rd day during follow up wound inspection. Wound beds were prepared before specimen collection by using Levine's technique, where the wound surface is cleansed of surface exudates and contaminants with a moistened sterile gauze and sterile normal saline solution.[3] Dressed wounds were cleansed with non-bacteriostatic sterile normal saline after removing the dressing. The end of a sterile cotton-tipped applicator was rotated over a 1 cm^2 area for 5 seconds with sufficient pressure to express fluid and bacteria to surface from within the wound tissue. The applicators were applied deep into the wounds in order to avoid contaminants that are usually found on the surface of the wounds. Two wound swabs were taken from each compound fracture wound at a time. Specimens were placed in a sterile container, properly labeled and transported to microbiology laboratory, Government medical college, Kottayam without any delay for further analysis. After taking D0 sample patients were started on empirical therapy with Cefotaxime, Gentamicin and Metronidazole. Microscopic examination for Gram staining, culturing of organisms and antimicrobial susceptibility were done from microbiology laboratory. Results were collected by hand from department of Microbiology, Government medical college Kottayam.

Statistical analysis

Data is entered in Microsoft Excel software, and analysis done using SPSS version 20.0 software. The level of significance will be $p<0.05$ and high significance $p<0.01$. The results are analyzed at the end of the study and observations made.

RESULTS

Patients were divided into four groups according to the age (Table 1). Most of the patients were between 21 and 40 years (66.2%) of age. Mean age of the study population was 35.02 years. Among the study population 88.5% were men, with a male: female ratio of 7.67: 1. Mechanism of injury (Table 2) in majority of study population was road traffic accident (81%), fall from height (13.1%) and assault (5.4%). Only 6.2% of the study population was diabetic patients. Majority of the fractures (Table 3) were of type III-B (75.4%) followed by type III-A (23.1%) and type III-C (1.5%).

Table 1: Distribution of study population according to age.

Age group (in years)	Number of patients	Percentage (%)
<20	11	8.5
21–40	86	66.2
41–60	28	21.5
61–80	5	3.8

Table 2: Distribution of study population according to mechanism of injury.

Mechanism of injury	Number of patients	Percentage (%)
Road traffic accident	106	81.5
Fall from height	17	13.1
Assault	7	5.4

Table 3: Distribution of study population based on type of fracture.

Type of fracture	Number of patients	Percentage (%)
Type III-A	30	23.1
Type III-B	92	75.4
Type III-C	2	1.5

Table 4: Distribution of study subjects based on infection status.

Infection	Number of patients	Percentage (%)
On day 0:-		
Yes	10	7.7
No	120	92.3
On day 3:-		
Yes	33	25.4
No	97	74.6
On day 0 or day 3:-		
Yes	35	26.9
No	95	73.1

Table 5: Distribution of organisms isolated from infected samples.

Organism isolated	Day 0 n (%)	Day 3 n (%)	Either day n (%)
Staphylococcus	5 (50)	11 (33.3)	13 (37.1)
Acinetobacter	3 (30)	10 (30.3)	10 (28.6)
Pseudomonas	2 (20)	9 (27.3)	9 (25.7)
Klebsiella	2 (20)	6 (18.2)	6 (17.1)
E-coli	1 (10)	5 (15.2)	5 (14.3)
Enterococcus	0 (0)	3 (9.1)	3 (8.6)
Streptococcus	0 (0)	2 (6.1)	2 (5.7)
Enterobacter	0 (0)	1 (3)	1 (2.9)

100% of diabetic patients had infection and it was found to be statistically significant with a Chi-Square value of 23.138 at p<0.001. Out of 130 patients 26.9% showed a positive culture for organism either on day 0 or day 3. Only 7.7% showed a positive wound culture on day 0. 24.5% of patient had positive culture on day 3. Among the cases who had infection on day 0, 20% got cured by day 3. In addition to this 19.2% developed infection by day 3, thus making the total number of cases with infection to be 24.5% of the study population (Table 4).

Figure 1: Type III-B open bimalleolar fracture with ankle dislocation.

50% of the positive culture on day 0 showed *Staphylococcus aureus*. Remaining were 30% *Acinetobacter*, 20% *Pseudomonas aeruginosa* and *Klebsiella*, 10% were *E. coli*. In day 3 culture 33% were of *Staphylococcus aureus*, 30.3% were *Acinetobacter*, 27.3% were *Pseudomonas*, 18.2% were *Klebsiella*, 15.2% were *E-coli*, 9.1% were *Enterococcus*, 6.1% *Streptococcus*, 3% were *Enterobacter* respectively (Table 5). The antibiotic sensitivity pattern of various organisms isolated are shown in Table 6. 69.2% of *Staphylococcus* were sensitive to cloxacillin. 40% of *Acinetobacter* were sensitive to gentamicin and cefoperazone + sulbactum. 55.6% of Pseudomonas were sensitive to amikacin and ciprofloxacin. 83.3% of *Klebsiella* were sensitive to gentamicin. 80% of *E-coli* were sensitive to amikacin. 66.7% of *Enterococcus* were sensitive to ampicillin, amoxicillin + clavulanic acid and gentamicin. 50% of *Streptococcus* showed sensitivity to ceftriaxone, cefotaxime and gentamicin. 100% of *Enterobacter* showed sensitivity to ceftazidime and amikacin.

Table 6: Sensitivity pattern of various organisms isolated.

Antibiotic	Organisms isolated							
	Staphylococcus	***Streptococcus***	***Pseudomonas***	***Klebsiella***	***E. coli***	***Enterococcus***	***Acinetobacter***	***Enterobacter***
Amoxicillin	2 (15.4)	0 (0)	0 (0)	0 (0)	0 (0)	1 (33.3)	0 (0)	0 (0)
Ampicillin	0 (0)	0 (0)	0 (0)	0 (0)	1 (20)	2 (66.7)	0 (0)	0 (0)
Amoxyclav	2 (15.4)	0 (0)	0 (0)	0 (0)	1 (20)	2 (66.7)	0 (0)	0 (0)
Cloxacillin	9 (69.2)	0 (0)	0 (0)	0 (0)	2 (40)	0 (0)	3 (30)	0 (0)
Cefazolin	3 (23.1)	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)	0 (0)
Ceftriaxone	2 (15.4)	1 (50)	1 (11.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cefotaxime	2 (15.4)	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ceftazidime	0 (0)	0 (0)	4 (44.4)	0 (0)	1 (20)	0 (0)	0 (0)	1 (100)
Gentamicin	6 (46.2)	1 (50)	4 (44.4)	5 (83.3)	2 (40)	2 (66.7)	4 (40)	0 (0)
Amikacin	4 (30.8)	0 (0)	5 (55.6)	1 (16.7)	4 (80)	0 (0)	2 (20)	1 (100)
Doxycycline	5 (38.5)	0 (0)	1 (11.1)	1 (16.7)	2 (40)	1 (33.3)	3 (30)	0 (0)
Ciprofloxacin	1 (7.7)	0 (0)	5 (55.6)	1 (16.7)	1 (20)	0 (0)	1 (10)	0 (0)
Vancomycin	4 (30.8)	0 (0)	1 (11.1)	0 (0)	1 (20)	1 (33.3)	1 (10)	0 (0)
Piperacillin+ Tazobactam	5 (38.5)	0 (0)	4 (44.4)	4 (66.7)	0 (0)	0 (0)	2 (20)	0 (0)
Cefoperazone +Sulbactum	2 (15.4)	0 (0)	2 (22.2)	1 (16.7)	0 (0)	0 (0)	4 (40)	0 (0)
Cotrimoxazole	1 (7.7)	0 (0)	1 (11.1)	1 (16.7)	1 (20)	0 (0)	1 (10)	0 (0)

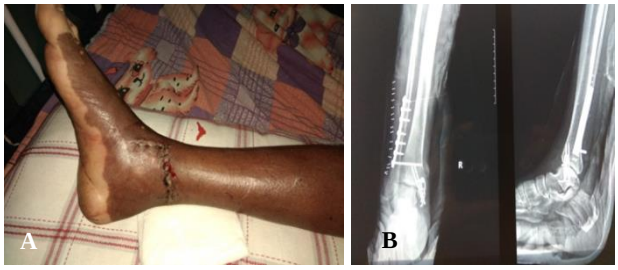

Figure 2 (A and B): Postoperative day 3 wound with postoperative X-ray.

Figure 3: Infected open fracture both bone leg.

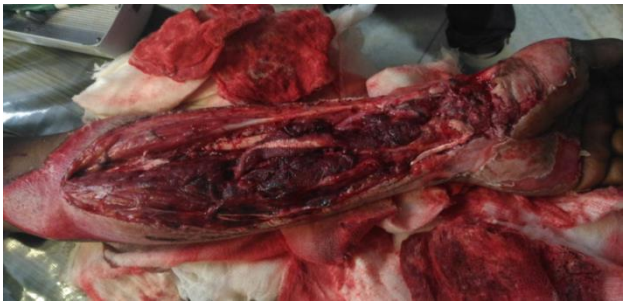

Figure 4: Type III-B open fracture both bone forearm with soft tissue loss.

DISCUSSION

Infection still represents one of the major complications in the treatment of open fractures. Break down of the tissue barrier between the fracture zone and the environment leaves the underlying bone prone to direct contact with contaminating agents. Subsequent chronic osteitis and/or non-union still represent today a major source of disability and decreased quality of life for the individual patient as well as a socio-economic problem for public health systems.

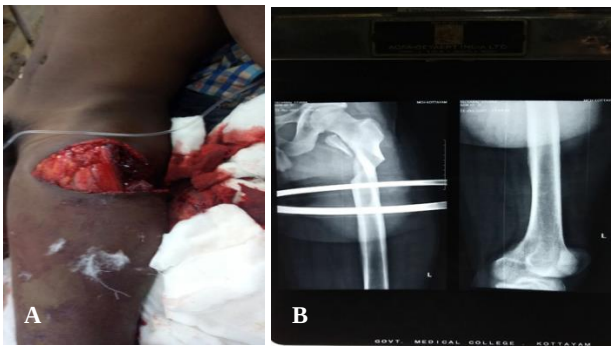

Figure 5 (A and B): Type III-B open fracture femur.

In our study most of the patients were between 21 and 40 years of age with a mean age of 35.02±12.85 years. Age of the study population ranged from 11 years to 79 years. Ikem et al, reported similar finding in a study conducted in Ile-Ife, Nigeria.[4] Among the study population 88.5% were men, with a male: female ratio of 7.6: 1. The male predominance in our study may be due to various social and demographic factors. The leading cause of open fracture was found to be road traffic accidents. Similar findings have been reported by Azam et al.[5] Majority of the fractures were of type III-B followed by type III-A and type III-C. Among the diabetic patients 100% developed day 3 wound infection, which means diabetes is a strong precursor for infection.

The total bacterial isolation rate from the compound fracture wounds in this study was 26.9% which included both day 0 and day 3 cultures. This is lower than that (45%) reported from Chandigarh, by Sen et al, 45.8% reported from Ile-ife, Nigeria by Ikem et al and 30% reported by ketterl et al.[4,6,7] Different factors related to wound bed preparation, sample collection, sample transportation and culturing technique might have an effect in the bacterial isolation rate. New culture positivity on day 3 observed in the study may also be due to inadequate debridement, improper wound care from the ward, insufficient antibiotic coverage.

The main bacterial isolate in open fracture wounds in this study was *Staphylococcus aureus* in both day 0 and day 3 cultures. The predominating prevalence of *Staphylococcus aureus* in wounds in general and compound fracture wounds have been also reported in other developing and developed countries like USA by Gustilo and Anderson, France by Carsenti-Etesse et al, England by Bowler et al, India by Dhawan et al, Brazil by Fonteset al, Romania by Purghel et al and in Iran by Khosravi et al.[8-14] In the present study, *Acinetobacter* was the second most frequently isolated bacteria. Similar findings have been reported by Johnson et al.[15] Other cultured organisms were *Pseudomonas*, *Klebsiella*, *E-coli*, *Enterococcus*, *Streptococcus* and *Enterobacter*. The comparison of results of our study with similar studies

given in Table 7. The antibiotic susceptibility of bacteria were assed. It was found that Gentamicin, amikacin, doxycycline, ciprofloxacin, vancomycin, piperacillin + tazobactum and cefoperazone + sulbactum were sensitive against majority of the organisms.

CONCLUSION

With the development of new operative and aseptic techniques as well as a deeper understanding of the pathophysiology of fractures with soft tissue compromise the results can be improved. Gram positive *Staphylococcus aureus* were found to be the most common cause of wound infection in type III open compound fractures followed by Gram negative *Acinetobacter*, as the emerging cause of infection The careful handling of soft tissues with radical debridement of all necrotic tissues, proper antibiotic therapy and aseptic wound care from ward contributes to the avoidance of infection and non-union.

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Functional outcome of calcaneal locking compression plate

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ABSTRACT

Background: The calcaneus is the frequently injured tarsal bone.75% of calcaneal fractures are intraarticular. Treating calcaneal fractures is a challenge for orthopaedic surgeon due to complex fracture pathology. Our aim is to evaluate the functional outcome of calcaneum Locking compression plate in patients with intraarticular calcaneal fractures with Bohler's angle <20 degree who are admitted in the department of Orthopaedics, Government Medical College, Kottayam.

Methods: In this study, 41 patients with 42 intraarticular calcaneal fractures were operated on with locking compression plate through lateral approach during the period of July 2015 to December 2016. Radiological evaluation done with X-rays. Bohler's angle was measured from lateral view and those patients with angle $<20^0$ were selected for study. Patients were followed up clinically and radiologically for 24 weeks. Radiological assessment was done by Bohlers angle. Functional outcome was assessed using American Orthopaedic Foot and Ankle Society (AOFAS) scale.

Results: At 24 weeks follow up, 90.5% of the study population had excellent to good functional outcome and 9.5% had fair and none had poor result. All patients had stable hind foot with all having good dorsiflexion and plantar flexion. But some patients had limited inversion and eversion. The mean postoperative Bohler's angle was 30.02±3.97.

Conclusions: Open reduction and internal fixation with locking compression plate gives sound functional outcome, if the surgery is well timed. Anatomical articular reduction especially of the posterior facet to be achieved and restoration of Bohler's angle to normal range to be attempted.

Keywords: Intraarticular calcaneal fractures, Bohlers angle, Internal fixation

INTRODUCTION

The calcaneum is the most commonly fractured tarsal bone. Calcaneal fractures comprise 1-2% in adults.[1,2] Most of the calcaneal fractures are intraarticular and almost all occur due to an axial load such as a fall from height. Intraarticular calcaneal fractures have significant importance as poor outcomes of treatment are associated with poor health status. Calcaneal fractures are mostly work related, as they result from a fall from height especially in males aged 35-45 years. These fractures frequently result in long term disability with potentially severe economic impact on the patient.

Fractures of the calcaneus are typically the result of high-energy trauma, such as a fall from a height or a motor vehicle accident. The pattern of fracture lines and extent of comminution are determined by the position of the foot, the amount of force, and the porosity of the bone at the time of impact.

Treating calcaneal fractures is a challenge for orthopaedic surgeon. A wide range of treatment options varying from non-operative to operative methods are available. Studies conducted by Batra, Makki et al, Wu et al all had results favouring open reduction and internal fixation with plate and screws.[3-5] The purpose of this study is to assess the functional outcome of calcaneal locking compression plate in patients with intraarticular calcaneal fractures with Bohler's angle <20 degree.

METHODS

A descriptive study on 41 patients with 42 intraarticular fractures who were admitted in Government medical college, Kottayam during July 2015 to December 2016 were treated with open reduction and locking compression plating.

Inclusion criteria

All patients 18-60 yrs of age with intraarticular calcaneum fractures with Bohler's angle <20 degree, fractures less than 3 weeks old.

Exclusion criteria

Extraarticular calcaneal fractures, open fractures, undisplaced intraarticular fractures, ipsilateral limb fracture, polytrauma, patients with arthritis, abnormal gait, those with congenital defects of ankle, neurovascular injuries, tendon injury, ankle dislocation, fracture of other tarsal bones.

Surgeries are done after the appearance of wrinkle sign. Under proper aseptic precautions and preoperative antibiotic cover the surgeries are done. Our protocol in management of calcaneal fractures is immediate temporary plaster stabilization. Elevation of the fractured limb to reduce the swelling are utilised in the initial management. CT scan was used to assess the fracture pattern and the amount of comminution.

The patient is placed lateral on a radiolucent table. Antibiotic prophylaxis is administered, and standard intra-operative fluoroscopy was used throughout the procedure. Both the injured and the non-injured limb are prepared and draped above the knee, thus allowing intra-operative alignment to be checked against the uninjured limb. Benirschke and Sangeorzan technique (Figure 1A).[6] After exposure is complete lateral wall of calcaneum is removed. If there is a fracture line between anterior process and sustentacular process, that is reduced first. Tuberosity is reduced to sustentacular fragment by manipulating with a threaded Steinmann pin. It is then provisionally fixed with a Kirschner wire. Then depression of posterior facet is reduced and provisionally fixed. We used bone graft in most of the cases as there was void after the reduction of articular surface. Lateral wall is reduced and fixed by using calcaneal locking compression plate laterally (Figure 1B). Plate should extend from anterior process of calcaneus to the most posterior aspect of the tuberosity. Intraoperative radiographs are obtained using C-arm to confirm the reduction (Figure 1C). After completing fixation flap is closed and a below knee slab is applied. Post operatively regular wound inspection will be done, followed by suture removal on ninth postoperative day, and application of POP Cast. The casts will be removed after 6 weeks. No weight-bearing will be allowed till 12 weeks. Weight bearing will be started from 12 weeks along with range of movement exercises. Reviews will be done, and functional outcome will be recorded using AOFAS (American Orthopaedic foot and ankle society) scoring system at 6 weeks, 12 weeks and 24 weeks (Figure 1D) after the index procedure.

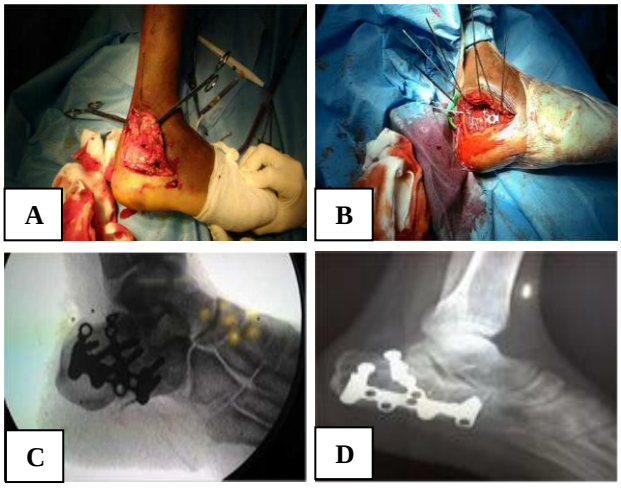

Figure 1 (A-D): A=Lateral approach to the calcaneum, B=Intraoperative picture showing plate fixation, C=Intraoperative fluoroscopic picture, D=Postoperative radiograph at 24 weeks follow-up.

RESULTS

Most of the patients were between 21 and 40 years (47.6%) of age. Mean age of the study population was 38.05 years.

Table 1: Distribution of study population according to age.

Age group	Number of patients	Percentage (%)
<20	4	9.5
21-40	20	47.6
41-60	18	42.9
Total	42	100

Table 2: Distribution of study population according to gender.

Gender	Number of patients	Percentage (%)
Male	38	90.5
Female	4	9.5
Total	42	100

Mechanism of injury in majority of the study population was fall from height (90.5%) and road traffic accident constitutes 9.5%.

Among complications following surgery, skin necrosis was seen in 21.4% of the study population and all other complications like infection, wound dehiscence were less. None of the patient had malreduction, sural nerve injury or peroneal tendon injury. Mean preoperative Bohler's angle was 10.43 and that postoperatively was 30.02. This difference was found to be statistically significant with a t value of 22.313 at $p<0.001$.

Table 3: AOFAS score at 24 weeks postoperatively.

AOFAS score	Number of patients	Percentage (%)
Excellent	31	73.8
Good	7	16.7
Fair	4	9.5
Poor	0	0
Total	42	100

Excellent results were noted in 73.8% patients and majority of the patients (90.5%) had excellent-good functional outcome at 24 weeks postoperatively (Table 3), though only 52.4% of the study population had excellent-good functional outcome at 12 weeks follow up.

Among the study population, 76.3% of those who were treated after 1 week i.e., after wrinkle sign had appeared, had excellent result. On assessing the association between smoking and skin necrosis, smokers had more (25%) skin necrosis than non-smokers (20%). But there was no statistical significance with a Chi-Square value of 0.127 at $p<0.721$. On assessing the association of duration between injury and treatment and wound dehiscence, those who got treatment within 1 week had more (25%) wound dehiscence than those got after 1 week (5.3%).

DISCUSSION

Calcaneum intraarticular fractures are common as compared to extraarticular fractures, hence the importance of anatomical reduction to decrease the possibility of joint incongruity and subtalar arthritis. Open reduction and internal fixation is now more aggressively advocated for management of intraarticular fractures of calcaneum. 41 patients with intraarticular calcaneal fractures were admitted in Department of Orthopaedics, Medical College, Kottayam, for treatment between July 2015 to December 2016.

In our study most of the patients were between 21 and 40 years of age with a mean age of 38.05±11.98 years. Parmar noticed age range between 16-64 with mean age 50.9 years and Buckley noted that in his study the maximum age incidence was between 30-39 years.[7] 90.5% of the study population were males and majority were manual labourers.

We compared pre and postoperative Bohlers angle and it was found that mean preoperative Bohlers angle was 10.43±4.7 and postoperative was 30.02±3.97. Similar study was done by Makki et al in 2010.[4] They have done a retrospective review of 47 intraarticular fractures of calcaneum treated by open reduction and fixation. They concluded that restoration of Bohler's angle was associated with better outcome.

Surgical technique, soft tissue dissection and local conditions are most important in determining the success of surgery and rate of infections. Though CT scanning is better we found accurate radiological evaluation is adequate in planning operative management. Primary subtalar arthrodesis may be good option in severly comminuted intraarticular fractures.

AOFAS clinical rating system the ankle hindfoot scale for calcaneal area is a standard scoring system for foot function evaluation. Using this standard scoring system that takes into account subjective and objective assessments enables to achieve relevant results and comparisons of different patient's studies.

To conclude, well timed open reduction and internal fixation with locking compression plate in an indicated case, respecting soft tissue envelope and early rehabilitation lead to therapeutic success. Lateral approach with minimal soft tissue handling reduces skin complications. Anatomical articular reduction especially of the posterior facet to be achieved and restoration of Bohlers angle to normal range to be attempted. Long term study is needed to know about long term results.

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