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RADIOLOGICAL AND FUNCTIONAL OUTCOME OF UNSTABLE BIMALLEOLAR FRACTURES THROUGH SURGICAL TREATMENT USING BAIRD- JACKSON SCORING SYSTEM.

Orthopaedics

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ABSTRACT

BACKGROUND : Ankle fractures are one of the commonest injuries treated by orthopaedic surgeons today. The incidence of malleolar fractures is estimated to be 125/100,000/year.[5] They are common in younger men and older women. The goals of surgical treatment must include anatomic reduction of articular surfaces, restoring metaphyseal stability , preserving blood supply and allowing early motion.

MATERIALS AND METHODS : A prospective study was conducted in the Department of Orthopaedic Surgery, Grant Medical Foundation-Ruby Hall Clinic,India on 26 cases of unstable bimalleolar fractures of ankle joint in patients between the age of 18-60 years who underwent surgical treatment with Open Reduction and Internal Fixation with one third tubular locking plate for lateral malleolar fracture and CC/Malleolar screw(s) for medial malleolar fracture between December 2017- March 2019 . These patients were followed for 12 months (minimum for 6 months) and evaluated based on union rate through xray radiograph, any complications (infections, mal/nonunion, stiffness) and functionally by Baird and Jackson ankle scoring system.

RESULTS: In our study, majority of the patients were male (65.3%), most of the patients were in the age group of 21- 48 years with mean age of 34.5 years. Majority of the patients sustained these injuries following RTA(69.2%). According to Lauge-Hansen classification system, 15 (57.69%) cases had supination external rotation type of injury, 6 (23.07%) cases had pronation external rotation type of injury, 4 (15.38%) cases had supination adduction type of injury and 1 (3.84%) cases had pronation abduction mechanism of injury pattern.3 patients had associated syndesmotic injury. Radiological union was seen at 8 weeks in 4 (15.38%) cases, 10 weeks in 13 (50%) cases, 12 weeks in 5 (19.23%) cases, 14 weeks in 3 (11.53%) cases and 16 weeks in 1 (3.84%) cases. Out of 26 cases, two (7.69%) cases had superficial infection which resolved completely with oral antibiotics and one (3.84%) case had ankle joint stiffness.There were no cases of nonunion or malunion in the present study.As per the Baird Jackson scoring system, 15 (57.7%) cases had excellent results, 7 (26.9%) had good, 2 (7.69%) had fair and 2 (7.69%) of the cases had poor results respectively.

CONCLUSION: Open reduction and internal fixation should be the treatment of choice for the unstable bimalleolar fractures, as these surgical methods restores the anatomy, biomechanics and contact loading characteristics of the ankle joint.

KEYWORDS

Bimalleolar Fracture, Ankle Joint Orif , Lauge-hansen, Weber, Baird Jackson.

INTRODUCTION

Ankle fractures are one of the commonest injuries treated by orthopaedic surgeons today. The incidence of malleolar fractures is estimated to be 125/100,000/year.They are common in younger men and older women.They are increasingly becoming a common osteoporotic fracture in the elderly.[5]The ankle joint is stabilized by the tibiofibular, deltoid and collateral ligaments which primarily function to regulate the coupled motion occurring among the mortise talus, hindfoot and midfoot. The medial margin has 2 different radii of curvature and the lateral side is constant and longer than the medial side. Treatment of bimalleolar fractures are complicated and challenging as the outcome determines the locomotive power [6-7]. Improper and inadequate surgical fixation can cause long term disability as body weight is transmitted through it. As per Paul L Ramsey, [8] 1-mm talar shift reduces the ankle surface contact area by 42%, leading to increased joint contact forces and, early degenerative changes. Hence perfect anatomical reduction is achieved by open reduction and internal fixation.[8] It aims at restoration of anatomic reduction of articular surfaces, restoring metaphyseal stability , preserving blood supply and allowing early motion. In this study, we aim to evaluate the functional and radiological outcome of patients who underwent open reduction and internal fixation surgery for bimalleolar ankle joint fractures at our centre and to assess the factors associated with the functional outcome.

UNDERSTANDING THE SURGICAL ANATOMY AND BIOMECHANICS OF THE ANKLE JOINT.

The word "ankle" is derived from the root word "ank" which means to bend and is a hinge type synovial joint.The movements of ankle are not only pure plantarflexion and pure dorsiflexion. In the extreme end of both plantar and dorsiflexion there is a variable amount of varus and valgus respectively. The ankle joint has a large load bearing surface area (11–30 cm2). A 1-mm talar shift reduces the ankle surface contact area by 42%, leading to increased joint contact forces and, early degenerative changes.[8] When an individual stands on tip-toe, the joint reaction force is 2.1 × the body weight and the Achilles tendon force reaches about 1.0 × the body weight.(3) Normal Dorsiflexion in Adults : 10°–20° (past perpendicular) Normal Plantarflexion in Adults : 20°–40° For normal ambulation, 10° dorsiflexion and 20° plantarflexion are required. Less than 10° of dorsiflexion is an equinus deformity. The ankle joint is most stable in the maximally dorsiflexed position.(2)

The ankle mortise comprises of both bony and soft tissue components as mentioned here :

BONY COMPONENTS

- Lower articular end of tibia with its flares and projections on medial, posterior and anterior aspects.
- Medial articular surface of the lateral malleolus.
- The talus: This consists of a body, neck and head. The superior surface (trochlea of talus) is grabbed by the malleoli to transmit weight of the body. The talus is the only tarsal bone with no muscular or tendon attachments, it is largely covered with articular cartilage.

SOFT TISSUE COMPONENTS

The ankle joint is surrounded by a fibrous capsule, which is attached to the articular margin except: Posterosuperiorly where it is attached to the inferior transverse tibiofibular ligament, and Anteroinferiorly where it is attached to the dorsum of the neck of talus. The anterior and posterior parts of the capsule are loose and the sides are reinforced by strong collateral ligaments. The stability of the ankle joint is mainly ensured by the stout ligaments on the medial and lateral sides. On the medial side there is the strong deltoid ligament. It is a triangular ligament with superficial and deep parts. The superficial part consists of: (1) anterior fibers (Tibionavicular) are attached to the tuberosity of navicular and medial margin of spring ligament, (2) middle fibers

(Tibiocalcaneal) attached to the whole length of sustentaculum tali, and (3) posterior fibers (Tibiotalar) attached to the medial tubercle and adjoining part of the medial surface of talus.The deep part (anterior tibiotalar) is attached to the anterior partof medial surface of talus.(3) On the lateral side, the lateral collateral ligament consists of three components: (1) Anterior Talofibular (a flat band) which is attached above to the anterior margin of the lateral malleolus and below to the neck of the talus; (2) Posterior Talofibular (strong horizontal band) which extends from lower part of malleolar fossa to the posterior tubercle of the talus; (3) Calcaneofibular ligament (a long rounded cord) extends from the lower border of lateral malleolus to the tubercle on the lateral surface of calcaneum. The axis of this hinge joint is not horizontal; rather it is sloping down and laterally, passing through the malleoli just above the apices. The two main superficial veins of the lower limb are the great saphenous and the small saphenous vein. The great saphenous vein is formed by both the dorsal venous arch and the dorsal vein of the great toe, it ascends anterior to the medial malleolus, posterior to medial femoral condyle and through the saphenous opening within the fascia lata. The small saphenous vein is formed by the dorsal vein of the little toe and the dorsal venous arch. It passes posterior to the lateral malleolus (as the lateral marginal vein). The dorsal venous arch mainly supplies the superficial veins however perforating veins supply the anterior tibial vein (deep vein). The posterior tibial and fibular veins are continuations from the medial and lateral plantar veins. The ankle is supplied by three cutaneous nerves, medially the saphenous nerve (via femoral nerve L3-L4), anteriorly the superficial fibular nerve (from common fibular nerve L4-S1) and laterally the sural nerve (S1-S2).

NORMALANKLE SYNDESMOTIC RELATIONSHIPS (Fig.1)**:**

(A) The tibiofibular overlap should be greater than 6 mm in anteroposterior (AP) view or greater than 1 mm on mortise view;

(B) The tibiofibular clear space, 1 cm above the tibial plafond, should be less than 6 mm (in both AP views and mortise views);

© Medial clear space should be less than or equal to the clear space between talar dome and tibial plafond. (5)

Fig.1 - Normal Ankle Syndesmotic Relationships.

Talocrural Angle (Fig.2)

A line drawn parallel to the tibial plafond and a second line drawn connecting the tips of the medial and lateral malleoli. This measurement is useful in assessing syndesmotic injuries and ankle fractures. Normal value is 83° ± 4. (5)

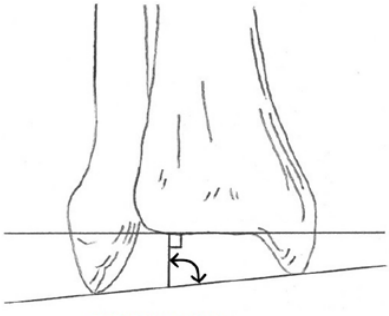


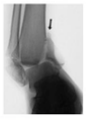
Fig.2 - Talocrural Angle

Lauge-Hansen Classification

- Describes position of foot and mechanism of injury. Fx progresses from Stage 1 to involve more areas.
- 4 general areas of injury:
  - * ATFL ligament tear
  - * LM fx
  - * PM fx (or PTFL tear)
  - * MM fx (or deltoid ligament tear)

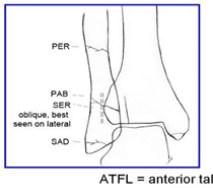
Supination-External Rotation (SER) – 40-75% of all ankle fx
Stage 1: ATFL tear
Stage 2: Spiral oblique distal fibula fx at ankle mortise level
Stage 3: PM fx or PTFL tear
Stage 4: Transverse MM fx or deltoid lig tear

Supination-Adduction (SAD) – 10-20% of all ankle fx
Stage 1: Low avulsion LM fx or lateral ligament injury
Stage 2: Vertical shear fx of MM



Pronation-Abduction (PAB) – 5-20% of all ankle fx
* Assoc with syndesmosis instability
Stage 1: Transverse MM fx (or deltoid ligament tear)
Stage 2: ATFL or PTFL tear
Stage 3: Transverse fibula fx at or above ankle mortise
- Typically fibula fx has butterfly segment (comminuted)

Pronation-External Rotation (PER) – 7-19% of all ankle fx
* Maisonneuve fx is a type of PER injury
* Assoc with syndesmosis instability
Stage 1: Transverse MM fx (or deltoid ligament tear)
Stage 2: ATFL tear
Stage 3: Spiral oblique fibula fx above ankle mortise
Stage 4: PM fx or PTFL tear



Often fibula fx pattern hints at classification

ATFL = anterior talofibular ligament, PFTL = posterior talofibular ligament
MM = medial malleolus, PM = posterior malleolus

DANIS-WEBER CLASSIFICATION

Danis (1949) and Weber (1972) classified ankle fractures based on the relationship of the fibular fracture to the syndesmosis. (Fig. 3)

Type A: Fracture below the syndesmosis
Type B: Fibular fracture at the level of syndesmosis
Type C: Fibular fracture above the level of the syndesmosis.

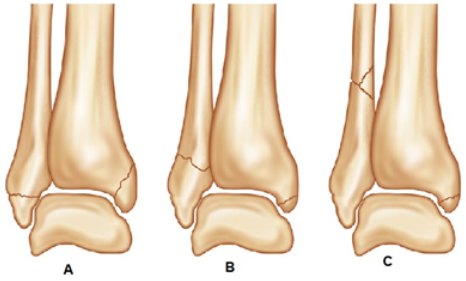


Fig.3 DANIS-WEBER CLASSICATION

Herscovici classification of medial malleolar fractures.

(A) Tip avulsions (anterior colliculus);
(B) Intermediate;
(C) Level of plafond;
(D) Above plafond (adduction fractures) (Fig.4)

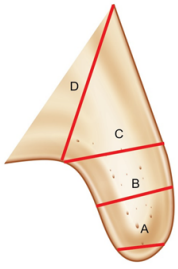


Fig.4 Herscovici Classification of medial malleolar fractures.

MATERIALS AND METHODS :

A prospective study was conducted in the Department of Orthopaedic Surgery, Grant Medical Foundation-Ruby Hall Clinic, Pune, India on 22 cases of unstable bimalleolar fractures of ankle joint in adult patients between the age of 18-65 years who underwent surgical treatment with Open Reduction and Internal Fixation with one third tubular locking plate for lateral malleolar fracture and CC/Malleolar screw(s) for medial malleolar fracture between December 2017-March 2019 . These patients were followed for 12 months (minimum for 6 months) and evaluated based on union rate through xray radiograph, any complications (infections, nonunion, ankle stiffness) and functionally by Baird and Jackson ankle scoring system.

Inclusion Criteria -

1. Age between 18-65 years.
2. Patients of either sex.
3. Skeletally matured patients having closed displaced/unstable bimalleolar fracture of either ankle joint.
4. Fractures less than 1 week old.
5. Patients who are fit for surgery.
6. Patients who comply with regular follow up for a period of at least 6 months.

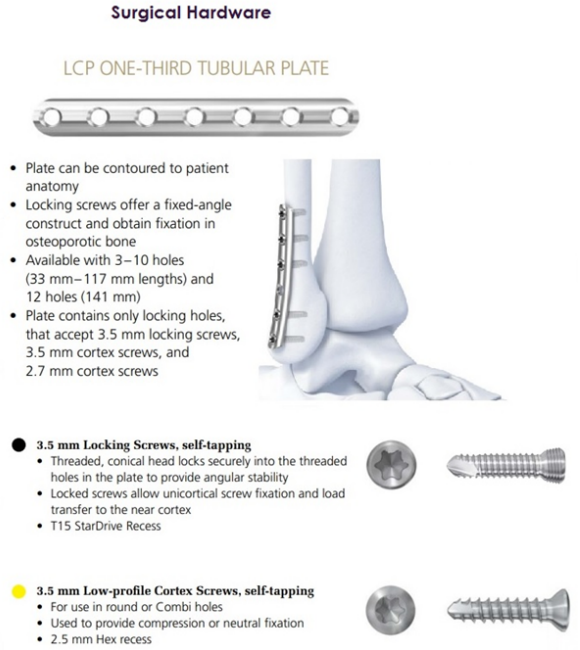
Exclusion Criteria –

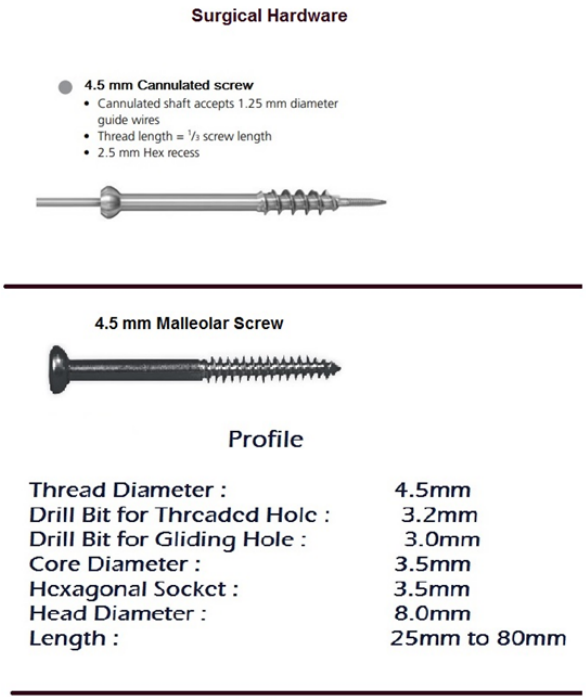
1. Age below 18 years and above 65 years.
2. Unwillingness to participate in the study.
3. Patients unfit for surgery and/or anaesthesia.
4. with history of previous bimalleolar fracture of either ankle.
5. Patients with minimally displaced mono-malleolar fractures, avulsion fractures.
6. Open/Compund bimalleolar fracture associated with or without pilon fracture.
7. Multiple Trauma / Neurovascular injuries.
8. Pathological Fractures.
9. Fractures more than 1 week old.

Before the surgical intervention , all the patients were temporarily immobilized with a POP or Scotch fiberglass below knee posterior slab, underwent routine investigations, obtained anesthetic and medical clearance, analgesics and antibiotics.

URGICAL TECHNIQUE

Main objective of our surgical treatment is to maintain proper alignment, stable fixation and to address the associated syndesmotic injury. Under spinal anaesthesia, patients were taken in supine position. Under tourniquet control and guidance of c-arm image intensifier, all lateral malleoli fractures were fixed initially with 1/3rd tubular neutralization plate. Hook test was done intraoperatively to determine the syndesmotic injury. Syndesmotic injury was addressed with syndesmotic screw.





Open Reduction And Internal Fixation Of The Lateral Malleolus

A vertical incision over the distal fibula of about 8-10 cm was taken. The fibula was exposed subperiosteally by deepening the incision through subcutaneous tissue and deep fascia. The foot was externally rotated to separate fracture fragments, blood clots and intervening soft tissue was removed with a small curette from the fracture site.Fracture reduction done with reduction forceps/bone holding forceps under the guidance of c-arm image intensifier. A 3.5mm 1/3rd tubular plate applied post fracture reduction with atleast 4-6 cortices purchased on either side with proximal and distal screws insertion.

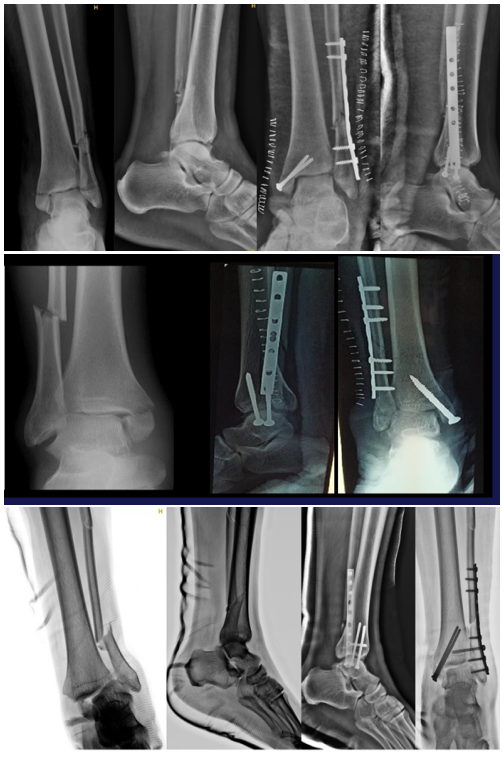
Intra operative image - Lateral malleolus fixation

Intra operative image - Lateral malleolus fixation

Open Reduction and Internal Fixation of the Medial Malleolus

A medial longitudinal incision of 6-8cm was made over the medial malleolus between its anterior and posterior borders with the distal end curving anteriorly at the tip of medial malleolus. The incision was deepened to the bone considering the protection of the long saphenous vein over the anterior part of the incision. The fracture site was exposed and cleared of blood clots and intervening periosteum with a curette exposing small serrations of the fracture. The distal fragment was held with a towel clip and pulled proximally, reducing the small serrations of the fracture. The fracture was fixed by passing one or two 4.5 mm cannulated cancellous / malleolar screws.

Intra operative image - Medial malleolus fixation



Intra-operatively, all the patients were given prophylactic IV antibiotic 30 minutes before the surgical procedure. Post operatively, patients were immobilized with a below knee posterior slab(POP/Scotch Fiberglass)and limb elevation.

Post-operative protocol:

IV antibiotics for 3-4 days. Sterile dressing was done on second post op day. Touch down weight bearing was started after 21 days. Suture removal was done after 13-15 days depending upon healing. The BK slab continued till 3 weeks following which the patients were advised dorsi and plantar flexion ROM exercises. Full weight bearing was withheld until complete radiological fracture union occurred. In patients with syndesmotic screw fixation, weight bearing was delayed till screw removal. All the patients were assessed serially for 12 months(minimum period of six months) radiologically with xray of the ankle joint in anteroposterior, lateral and mortise views and functionally with Baird and Jackson ankle scoring system.

FUNCTIONAL ASSESSMENT :

Baird and Jackson scoring system was used to evaluate the patients at the 6th month post op.

Baird and Jackson Scoring System

Pain	Score
No Pain	15
Mild Pain with strenuous activity	12
Mild Pain with activities of daily living	8
Pain with weight bearing	4
Pain at rest	0
Stability of Ankle	
No Clinical instability	15
Instability with sports activities	5
Instability with activities of daily living ability to walk	0
Able to Walk	
Able to walk desired distances without limp or pain	15
Able to walk desired distances with limp or pain	12
Moderately restricted inability to walk	8
Able to walk short distance only	4
Unable to walk	0
Able to Run	
Able to run desired distances without Pain	10
Able to run desired distances with slight Pain	8
Moderate restriction in ability to run with mild pain	6
Able to run short distances only	3
Unable to run	0
Motion of the Ankle	
Within 10 degrees of uninjured ankle	10
Within 15 degrees of uninjured ankle	7
Within 20 degrees of uninjured ankle	4
<50 degree of uninjured ankle, or dorsiflexion <5 degree	0

RADIOGRAPHIC EVALUATION

A - Anatomical with intact mortise (normal medial clear space, Normal 2mm superior joint space, no talar tilt) : 25 Points

B - Same as above with mild reactive changes at the joint margins : 15 Points

C - Measurable narrowing of the superior joint space, superior joint space 2mm, or talar tilt >2mm : 10 Points

D - Moderate narrowing of the superior joint space, with superior space between 2 and 1mm. : 5 Points

E - Severe narrowing of the superior joint space, with superior joint space <1mm widening of the medial clear space, severe reactive changes. : 0 Point

OBSERVATION AND RESULTS :

In our study, majority of the patients were male (65.3%), most of the patients were in the age group of 21- 48 years with mean age of 34.5 years. Majority of the patients sustained these injuries following RTA(69.2%). According to Lauge-Hansen classification system, 15 (57.69%) cases had supination external rotation type of injury, 6 (23.07%) cases had pronation external rotation type of injury, 4 (15.38%) cases had supination adduction type of injury and 1 (3.84%) cases had pronation abduction mechanism of injury pattern.3 patients had associated syndesmotic injury. Radiological union was seen at 8 weeks in 4 (15.38%) cases, 10 weeks in 13 (50%) cases, 12 weeks in 5 (19.23%) cases, 14 weeks in 3 (11.53%) cases and 16 weeks in 1 (3.84%) cases. Out of 26 cases, two (7.69%) cases had superficial infection which resolved completely with oral antibiotics and one (3.84%) case had ankle joint stiffness.There were no cases of nonunion or malunion in the present study.As per the Baird Jackson scoring system, 15 (57.7%) cases had excellent results, 7 (26.9%) had good, 2 (7.69%) had fair and 2 (7.69%) of the cases had poor results respectively.

GENDER DISTRIBUTION

There was a male predominance in the ratio of 3: 2 in our study, accounting for 65.3% of the patients.

Table 1.Gender Distribution

Gender	Frequency	Percent %
Male	17	65.3
Female	9	34.6
Total	26	100

SIDE DISTRIBUTION

There was a predominance of right side in our study, accounting for 61.5 % of the patients.

Table 2. Side Distribution

Side	Frequency	Percent %
Right	16	61.5
Left	10	38.4
Total	26	100

MODE OF INJURY

There was a predominance of RTA as a mode of injury in our study, accounting for 69.2 % of the patients.(Table 3)

Table-3

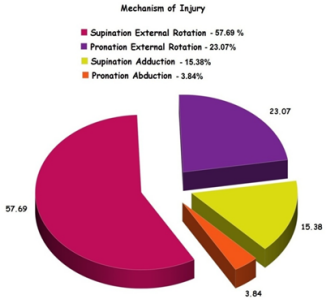
Mode of injury	Frequency	Percent %
RTA	18	69.2
Sports Injuries	5	19.2
Domestic fall	3	11.5
Total	26	100

MECHANISM OF INJURY

There was a predominance of Supination External Rotation injury mechanism in our study, accounting for 57.69 % of the patients.(Table 3 and Pie Chart)

Table-4 and Pie chart

Mechanism of injury	Frequency	Percent %
Supination External Rotation	15	57.69
Pronation External Rotation	6	23.07
Supination Adduction	4	15.38
Pronation Abduction	1	3.84
Total	26	100



RADIOLOGICAL UNION IN WEEKS

Radiological union was seen at 8 weeks in 3 (11.53%) cases, 10 weeks in 13 (50%) cases, 12 weeks in 6 (23.07%) cases, 14 weeks in 3 (11.53%) cases and 16 weeks in 1 (3.84%) cases.(Table 5.)

Table- 5

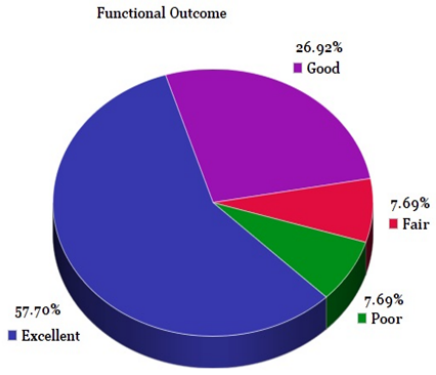
Union In Weeks	Number of Cases	Percentage %
8 Weeks	3	11.53
10 Weeks	13	50
12 Weeks	6	23.07
14 Weeks	3	11.53
16 Weeks	1	3.84
Total	26	100

FUNCTIONAL OUTCOME :

As per the Baird and Jackson scoring system, 57.7% cases had excellent results, 26.92% cases had good, 7.69% cases had fair and 7.69% of the cases had poor results respectively.(Table 6 and Pie Chart)

Table -6

Functional Outcome	Cases	Percent %
Excellent	15	57.6
Good	7	26.9
Fair	2	7.6
Poor	2	7.6
Total	26	100



COMPLICATIONS :

Out of 26 cases , two (7.69%) cases had superficial infection which resolved completely with oral antibiotics and one (3.84%) case had ankle joint stiffness. There were no cases of nonunion or malunion in the present study.

Post -Op Complications	Number of Cases	Percentage %
Superficial Infection	2	7.69
Deep Infection	0	0
Ankle Joint Stiffness	1	3.84
Non Union/ Mal union	0	0

DISCUSSION

There has been an increase in the prevalence of bi malleolar fractures over the last two decades both in the young, active patients and in the elderly [10]. Burwell and Charnley presented that anatomical reduction and rigid fixation promotes early return to function [11].There has been gradual evolution in management of ankle fractures due to improved analysis of biomechanics, improvement in fixation techniques and evaluation of results in recent studies. The goal of treatment is to provide fracture union with painless full motion of ankle and with anatomical restoration of the injured ankle. Several studies indicicates internal fixation of displaced malleolar fractures of ankle provides better results [11, 12, 13] The treatment of malleolar fractures with accurate open reduction and stable internal fixation using AO method and principles was found to give a higher percentage of excellent and good results [14]. This study supports these conclusions. In the current study, we have 26 patients with unstable bimalleolar ankle fractures who underwent orif surgery. All patients were followed up with minimum period of 6 months. In our study, fractures were commoner in the 21-48 yrs age group, with mean age being 34.5 yrs. Our findings are comparable to the studies made by, Beris et al [14], Roberts RS [15], Baird and Jackson [16] and Lee et al [17]. The results in our study were compared with that of Burnwell & Charnley, Colton [18], De souza et al[12], Beris et al. In Colton series, 70% of the patients had a good to excellent results. Burnwell & Charnley in their study of 132 patients, 102 (77.3%) had good results, 16% had fair results and 6% were found to poor score. In De souza series, 150 cases of ankle fractures treated by Orif obtained 90% good results. In a study by Beris et al, of 144 patients with ankle fractures, 105 (74.3%) had good to excellent results.The functional results of the present study were comparable with that of the above cited studies, with 84.6% had good to excellent results, 7.6% had fair results and poor results in 7.6%.

Study	Good to Excellent	Fair	Poor
Burnwell & arnley	102 (77%)	22 (17%)	8 (6%)
Colton	18 (70%)	4 (15%)	4 (15%)
Beris et al	105 (74.3%)	21 (14.6%)	16 (11.1%)
De souza	135 (90%)	9 (6%)	16 (4%)
Our Study	22 (84.6%)	2 (7.6%)	2 (7.6%)

Most authors have stated that anatomical reduction of displaced medial malleolus ensures correction of talar displacement and is of paramount importance in treating unstable fractures [19]. However, Heller et al [20] depicts that talus is more accurately repositioned in mortise by anatomical reduction of lateral malleolus. Observation in this study support the contention of Yablon et al [20] that lateral malleolus is the key to the anatomical reduction of bimalleolar fractures, because the displacement of the talus faithfully followed that of the lateral malleolus. Yablon[20] stated that anatomical reduction of the fibula is

the key factor in achieving good outcome of the treatment of ankle fractures with syndesmotic disruption. In the current series, three patients underwent trans-syndesmotic screw fixation,excellent outcome was seen in one patient and good outcome was seen in two patients.The treatment of bimalleolar fractures with accurate open reduction and stable internal fixation through AO principles was found to give a high percentage of excellent and good results. This study supports these conclusions and was comparable with those in the above mentioned series.

CONCLUSION

In this study, the 26 cases of unstable bimalleolar fractures of ankle were treated surgically by open reduction and internal fixation.These fractures are common due to road traffic accidents and are more common in males.Age groups between 21-48 years were most commonly injured. The mean age in the present study was 34.5 years. Majority of them(57.6%), were caused by supination external rotation injury mechanism. As per the Baird and Jackson scoring system, post operative results were satisfactory in 84.5% cases, with good to excellent functional outcome. Understanding the mechanism of injury is essential for anatomical reduction and fixation. Fibular alignment in context to rotation and length has to be kept in the mind for maintaing lateral stability of the ankle. Chances of non-union of medial malleolus due to periosteal inter position and that of fibula due to soft tissue interposition are avoided with open reduction and appropriate anatomical alignment. The goals of surgical treatment must include anatomic reduction of articular surfaces, restoring metaphyseal stability , preserving blood supply and allowing early motion. Hence, as per our study, we conclude that open reduction and internal fixation should be the treatment of choice for the unstable bimalleolar fractures, as these surgical methods restores the anatomy, biomechanics and contact loading characteristics of the ankle joint.

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CONFLICT OF INTEREST None

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