A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults

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Abstract: To evaluate clinically and radiologically the closed displaced bimalleolar ankle fracture in adults above 18 yrs of age treated with one third tubular plate along with partially threaded screw and one third tubular plate along with tension bend wiring. This prospective study was done in Regional Institute of Medical Science, Imphal in the year 2016-18. In this study the total number of patients were 30 divided in two groups i.e. closed bimalleolar ankle fracture treated with one third tubular plate with partial threaded screw and closed displaced bimalleolar ankle fracture treated with tension bend wiring. Each group had 15 patients. Cephalosporin antibiotics was administered prior to operation and then 12 hourly for another 5 days. Suture removal was done at 10 days. After discharged regular opd check up was done at monthly interval for one year. Post operative evaluations of functional and radiological outcome was done using Olerud C and Molander H functional score system on the basis of poor, fair, good and excellent. And the two groups were compared using Independent t-test and Chi-square test. Difference was considered significant when the value was < 0.05. In partially threaded screw with one third tubular plate there was excellent functional outcome in 11 cases (73.3%), good in 3 cases (20%), fair in one case (6.7%) in tension bend wiring with one third tubular plate also there was excellent functional outcome in 6 cases (40%), good (5%), fair in 4 cases (26.7%). Both the groups was comparable as the p value was > 0.05. Radiologically, the mean time to union in threaded screw with one third tubular plate was 11.80 weeks while in tension bend wiring with one third tubular plate was 12.93 weeks but the difference between two groups were insignificant as the p value was >0.05...Both the operative techniques used in the study provides excellent results in terms of union rate as well as functional outcome. The limitation of this study was small sample size in both groups and absence of long term follow-up.

Keywords: Bimalleolar ankle fracture, Functional outcome, Olerud C and Molander H functional score system, One third tubular plate, Partially threaded screw, Tension bend wiring.

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I. Introduction

Ankle fractures are one of the most common lower limb fractures¹; they account for 9% of all fractures², representing significant portion of the trauma workload.³ The annual incidence of ankle fracture is between 107 and 184 per 100,000 persons⁴,⁶ and round 2% of ankle fractures are open fractures⁵. Ankle fractures usually affect young men and older women⁷, however, below the age of 50; ankle fractures are the commonest in men. After this age, females become predominant. Alcohol and slippery surfaces are each involved in nearly third of the cases⁸. The most common causes of ankle fractures are twisting injuries and falls, followed by sports injuries⁴,⁵. Diabetes mellitus and obesity are associated with fractures in middle aged and older adults⁸. Most fractures are associated with ligament injuries, and the magnitude and direction of the deforming force applied to the ankle joints directly correlate to the fracture pattern⁹. The ankle joint is hinge joint, the lower end of the tibia and its medial malleolus, together with the lateral malleolus of the fibula and the inferior transverse tibiofibular ligament form deep recess (mortise) to articulate with the body of the talus, the ankle joint has strong medial collateral (deltoid) ligament. The lateral ligament The inferior tibio fibular ligament is usually considered syndesmosis,. The ankle joint receives its blood supplied from the anterior and posterior tibial and fibular arteries. The joint is innervated by branches from deep fibular, saphenous, sural and tibia nerves⁵.
Passive stability is mainly achieved by the medial and lateral ligament complexes, tibiobular ligaments, tendons crossing the joint, bony contours and capsular attachments. Dynamic stability is usually conferred by gravity, muscle action and ground reaction forces. Stability requires the continuous action of soleus assisted by gastrocnemius, it increases on leaning forward and decreases on leaning backwards. The posterior malleolus acts as restraint against posterior translation of the talus.

The first classification system for ankle fractures were developed by Sir Percival Pott who described fractures in terms of the number of malleoli involved, thus dividing injuries into unimalleolar (70%), bimalleolar (23%) and trimalleolar (7%)\textsuperscript{4}. There are two other commonly used classification systems i.e., Danis-Weber Classification which was introduced by Danis in 1949, modified by Weber in 1966 then adopted by the AO group, and Lauge-Hansen Classification which was described in 1950 by Lauge-Hansen as a result of both cadaveric dissections of experimentally produced fractures, and clinical and radiological examinations\textsuperscript{9}. The basis of this classification is on the position of the foot and the deforming force at the time of injury.

The ankle injuries gained importance because body weight is transmitted through it and the locomotion depends upon the stability of this joint. It must be realized that ankle injuries are mixed ones, ligamentous and body failures due to deforming forces, thus the primary goal of treatment should be full restoration of anatomy. Though malleolar fractures are discussed extensively, the opinions in the treatment of these fractures varies widely because of differences in classification, reduction techniques and subjective symptoms at follow up studies. Many of these fractures were managed by manipulative reduction and conservative treatment and have yielded satisfactory results. Injuries like unstable syndesmotic distasis, tri or bimalleolar fractures required open reduction and fixation.

II. Aim Of The Study

To evaluate clinically and radiologically the closed displaced bimalleolar ankle fractures in adult above 18 years of age treated with open reduction and internal fixation.

III. Materials And Methods

This is prospective interventions randomised study conducted in Department of Orthopaedics, Regional Institute of Medical Science, Imphal between 2016-18 to evaluate clinically and radiologically the displaced bimalleolar ankle fracture in adults above 18 yrs of age treated with one third tubular plate long with partial threaded screw and one third tubular plate long with tension bend wiring. The duration of study was 2 years with minimum follow up of 6 months and maximum follow up of 1 years (Avg-15 months). Total number of patients assessed and evaluated in this study-30

3.1 Inclusion Criteria:
   i. All displaced bi-malleolar ankle fractures in adults were included.
   ii. Age above 18 years and less than 70 years

3.2 Exclusion criteria for case:
   i. Undisplaced fractures and fractures treated by closed reduction.
   ii. Childhood and epiphyseal injuries around ankle were excluded from the study.
   iii. Ankle fractures with late presentation, with nonunion or mal-union were not included in the study.
   iv. Patient medically unfit or unwilling for surgery

3.3 Management in Casualty/OPD

On arriving in the Casualty/OPD, the patients were thoroughly assessed clinically. The cause of injury was inquired; vitals parameters were checked; associated head, neck, chest, abdominal injuries, etc were looked for. On local examination skin condition including fracture blisters, haemarthrosis, open or closed, distal neurovascular compromise and any sign of compartment syndrome were noted. Any other associated limb injury or bony injury was noted and the patient was sent for x-ray anteroposterior view and lateral view of the involved extremity. According to the general condition and vital parameters intravenous access was sought for and intravenous fluids given accordingly. Other bony injuries were immobilized and appropriately treated. A below knee posterior slab was applied for temporary immobilization of the ankle fracture.

On admission the patients were again thoroughly assessed clinically. All the routine investigations were sent and the patients were prepared for operation.
3.4 Operative procedures

Patients were subjected to operative procedures by open reduction and internal fixation and fixed with either partial threaded screw and one third tubular plate or tension band wiring with one third tubular plate. Operation was under anaesthesia (spinal or general).

3.4.1 Positioning

Patient was kept in supine position and the affected limb was kept in extended and externally rotated on the operating table. A tourniquet was applied to the thigh as per requirement.

3.4.2 Draping

The skin over the ankle region with leg and foot was prepared by soap scrub and application of the povidine iodine (10%) solutions. The operative field was draped with sterile sheets and placing the towel clips so that they were not superimposed on the fracture on subsequent imaging.

3.4.3 Fixation of the fibula with one third tubular plate

Skin incision was given as j shaped incision behind the malleolus for exposure of lateral malleolus as all the bimalleolar case the fibula is fixed first. Incision started about 5 cm above the tip of malleolus and will extend downward and forwards 2.5 cm to 3.5 cm below it. The incision was subjected to extended proximally when required. After exposing the fracture site the haematoma and interposed soft tissue if any was removed and fracture surface was cleaned with a curette. The fracture was reduced and held in alignment with the help of bone holding forceps. A one third tubular plate either 5 or 6 holes, depending upon the type of fracture was applied. The bone was drilled with a 2.8mm drill bit using a drill guide and will tap with a 3.5 mm cortical bone tap.3.5 mm cortical screws was then be used to fix the fracture.

3.4.4 Fixation of medial malleolus with partially threaded screws

An anteromedial incision was made over the medial malleolus that begins approximately 2 cm proximal to the fracture line, extends distally and slightly posteriorly, and ends approximately 2 cm distal to the tip of the medial malleolus. The skin with its underlying subcutaneous tissue was retracted anterior and posteriorly. The great saphenous vein and its accompanying nerve were retracted anteriorly.

The fracture site was exposed and the fracture fragments were curetted to remove any loosed osseous or chondral fragments. With a bone-holding clamp or towel clip, the detached fragments were brought into normal position and internally fixed with two 1.5mm smooth Kirschner wires drilled across the fracture site as temporary fixation devices. If the reduction was satisfactory, a 2.8mm drill bit was drilled across the fracture fragments and a 4mm partially threaded screw was inserted using a 4mm screw driver and one of the Kirschner wires was removed. A second screw was then placed in a similar fashion and the second K-wire was removed. After fixation had been confirmed, the wound was irrigated and closed atraumatically, usually with interrupted non absorbable skin sutures. A posterior below knee plaster slab was applied after skin closure.

3.4.5 Fixation of medial malleolus by tension band wiring

A similar incision was made on the medial malleolus to expose the medial malleolus, and after reducing the fragment a towel clip was used to hold it in position and two k-wires was passed parallel to each other through the fragments. Then a through and through antero posterior drill hole was made on the tibia above 3 cm proximal to fracture and a length 20 or 22 gauge stain less steel was passed through the hole. The end was crossed over, with one end passing under the 2 k-wires and ends was tightened and twisted in a figure of eight fashion. After through irrigation the wound was closed in layers and below knee plaster of paris was applied.

3.5 Post-operative management

Postoperatively, the ankle was immobilized in a posterior plaster splint with the ankle in neutral position and elevated. A cephalosporin antibiotic was administered prior to the operation and then 12 hourly for 24 to 48 hours after surgery and continued with oral antibiotics for another 5 days. Suture removal was done on the 10th day and then patients were discharged or the patients were discharged and called for suture removal on the 10th day after surgery in the OPD. Regular OPD check up was done at monthly intervals thereafter for 1 year and AP and lateral radiographs were obtained. Range-of-motion exercises were begun once the wound was healed. Weight bearing was restricted for 6 weeks, after which partial weight bearing was started when the fracture was healing well. Full weight bearing was allowed depending on radiographic evidence of fracture consolidation.
3.6 Functional assessment

The results were evaluated using Olerud C and Molander H functional score system. C. Olerud and H. Molander: A scoring scale for symptoms evaluation after ankle fracture as given below:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Degree</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. pain</td>
<td>None</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>While walking on uneven surface</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>While walking on even surface</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>While walking indoors</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Constant and severe</td>
<td>0</td>
</tr>
<tr>
<td>2. Stiffness</td>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Stiffness</td>
<td>0</td>
</tr>
<tr>
<td>3. Swelling</td>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Only evening</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>0</td>
</tr>
<tr>
<td>4. Stair Climbing</td>
<td>No problem</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Impaired</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>5. Running</td>
<td>Possible</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>6. Jumping</td>
<td>Possible</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>7. Squatting</td>
<td>Possible</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Impossible</td>
<td>0</td>
</tr>
<tr>
<td>8. Supports</td>
<td>None</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Taping, Wrapping</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Stick or Crutch</td>
<td>0</td>
</tr>
<tr>
<td>9. Work, Activities of daily life</td>
<td>Same as before injury</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Loss of tempo</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Change to a simple job/ part-time job</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Severely impaired work capacity</td>
<td>0</td>
</tr>
</tbody>
</table>

Total Score = 180
Poor : 0% - 30%.
Fair : 31% - 60%.
Good : 61% - 90%.
Excellent : 91% - 100%.

3.7 Statistical analysis

Data was checked for completeness and consistency. Data as age, sex, fracture side, mode of injury, age of fracture, operating time, weight bearing, time of union and functional outcomes were entered and analysed by using SPSS V.21 for windows (IBM Inc). The data were compared between the two groups under study by using Independent t-test and Chi-Square test. Difference was considered significant when the p value was < 0.05.

IV. Results

The following variables of each patient record were analyzed: age, sex, distribution of fracture side, mode of injury, age of fracture, operating time, weight bearing, time of union, complications and functional outcomes.

During the subsequent follow up the following variables were recorded: range of motion of knee, any complains by the patient in their daily activities and sign and symptoms of union. Functional outcome were evaluated using Olerud C and Molander H functional score system.

In our present study, the average age of patients in threaded screw with one third tubular plate group was 37.13 years (S.D ±13.303) with range being 18–65 years and in tension band wiring with one third tubular plate group, average age of the patient was 37.40 years (S.D ±12.822) with the range being 18–65 years. There were 9 males (60%), 6 females (40%) in threaded screw group and male to female ratio was 1.5:1 while in tension band wiring with one third tubular plate group there were 8 males (53.3%), 7 females (46.7%) and male to female ratio was 1.14:1. Males were predominantly involved in both the groups which were comparable to male to female ratio of 1.44:1 in Kulloli SS et al and 1.6:1 in Shams N et al.
A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults

There were 9 fractures (60.0%) on the left side and 6 fractures (40.0%) on the right side in threaded screw with one third tubular plate group while in tension band wiring with one third tubular plate group there were 8 fractures (53.3%) on the left side and 7 fractures on the right side (46.7%). Fractures on the left side were predominantly involved in both the groups which was comparable to 55% fractures on left side and 45% fractures on right side in Kulloli SS et al.

In our study, slipping/stumbling was the most common mode of injury seen in 5 cases (33.3%), followed by fall from steps in 4 cases (26.7%) and sports injuries in 3 cases (20%) and 3 cases (20%) RTA in threaded screw with one third tubular plate group. In tension band wiring with one third tubular plate group, slipping/stumbling was the cause of fracture in 6 cases (40%) followed by RTA in 4 cases (26.7%), fall from steps in 3 cases (20%) and sport injuries in 2 cases (13.3%). Slipping/Stumbling (fall from same level) was the most common mode of injury in both groups which was comparable to 40% in Kulloli SS et al.

The mean age of fracture in threaded screw with one third tubular plate group was 5.12 (±1.773) days ranging from 3-10 days while it was 5 (±1.773) days ranging from 3-9 days in tension band wiring with one third tubular plate group. None of the fractures were operated upon as emergency. The mean age of fracture in our study was comparable with 4.8 days in Shams N et al. We feel that operating upon first week after the injury is technically a bit easier.

The operating time ranged from 35-50 minutes in threaded screw with one third tubular plate group with the mean operating time being 43.00 minutes and standard deviation of 4.551 while in threaded screw with one third tubular plate group, the operating time ranged from 30-45 minutes with mean operating time was 37.00 minutes and standard deviation of 4.140. It took less time to operate with tension band wiring with one third tubular plate fixation than threaded screw with one third tubular plate and the difference in the duration of operating time was found to be statistically significant (p<0.05). This was because in threaded screw with one third tubular plate fixation we have to drill twice, first the near cortex with 3.5 mm drill bit for the gliding hole and second for the far cortex with 2.5 mm drill bit while in tension band wiring with one third tubular plate fixation we drilled only once with 2.5 mm drill bit.

In the fully threaded screw group the average hospital stay was 8.40 (± 2.501) days, ranging from 5 to 12 days and in partially threaded screw group the average stay was 8.07 (± 2.187) days ranging from 6 to 12 days. The comparison was statistically insignificant (p>0.05). This could not be compared with other studies, as in our present study, some patients were discharged two or three days after operation and called for stitch removal in the OPD and some patients were discharged after stitch removal.

Clinically, the mean time for union in threaded screw with with one third tubular plate group was 7.47 weeks (range 5-10 weeks) with standard deviation of 1.302 while in tension band wiring with one third tubular plate group was 8.00 weeks (range 6-12 weeks) with standard deviation of 1.558. The difference between the two groups was insignificant (p>0.05). Radiologically, the mean time for union in threaded screw with one third tubular plate group was 11.80 weeks (range 8-15 weeks) with standard deviation of 2.210 while in tension band wiring with one third tubular plate group was 12.93 weeks (range 9-18 weeks) with standard deviation of 2.251. The difference between the two groups was insignificant (p>0.05).

It took more time for bony union in tension band wiring with one third tubular plate fixation both clinically and radiologically comparing to threaded screw with one third tubular plate fixation. This because in threaded screw with one third tubular plate fixation there is bicortical purchase, stiffer construct in tension as well as the increased thread engagement length that gives excellent and firm fixation comparing to tension band wiring with one third tubular plate fixation but the difference between the two groups was statistically insignificant (p>0.05) in this study.

Weight bearing was restricted depending on the fracture union detected clinically and partial weight bearing was allowed after that. The mean time for restricted weight bearing in threaded screw with one third tubular plate group was 7.47 weeks (range 5-10 weeks) with standard deviation of 1.302 while in tension band wiring with one third tubular plate group was 8.00 weeks (range 6-12 weeks) with standard deviation of 1.558. Unrestricted weight bearing was allowed after the fracture had united radiologically. The mean time for unrestricted weight bearing in threaded screw with one third tubular plate group was 11.80 weeks (range 8-15 weeks) with standard deviation of 2.210 while in tension band wiring with one third tubular plate group it was 12.93 weeks (range 9-18 weeks) with standard deviation of 2.251. It took less time to allow the patient for unrestricted weight bearing after the operation in threaded screw with one third tubular plate group comparing to tension band wiring with one third tubular plate group but the differences between the two groups was statistically insignificant (p>0.05). This was comparable with mean unrestricted weight bearing of 13 weeks in Kulloli SS et al.

The range of motion in threaded screw with one third tubular plate group was 100% in 0-20° dorsiflexion, 93.3% in 0-50° planter flexion, 80% in 0-20° pronation and 86.3% in 0-40° supination while in tension band wiring with one third tubular plate group was 100% in 0-20° dorsiflexion, 86.6% in 0-50° planter flexion, 80% in 0-20° pronation and 86.3% in 0-40° supination. Comparing the parameters of range of motion in

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both the groups it was found that patients have good range of motion in threaded screw with one third tubular plate group than in tension band wiring with one third tubular plate group but they were statistically insignificant (p>0.05). Moreover, 90% of patients had full range of motion in threaded screw with one third tubular plate group and 86% in tension band wiring with one third tubular plate group. This was comparable to 86% in Al-Lamy WA et al.46. Range of ankle movement was better in patients starting mobilization early post-operatively.

In threaded screw with one third tubular plate group there was excellent functional outcome in 11 cases (73.3%), good in 3 cases (20%) and fair in 1 case (6.7%). In tension band wiring with one third tubular plate group there was excellent functional outcome in 9 cases (60%), good in 4 cases (26.7%) and fair in 2 cases (13.3%). There were no poor results in both the groups. The functional outcome was better in threaded screw with one third tubular plate group comparing to patients in tension band wiring with one third tubular plate group but the difference between the two groups was statistically insignificant (p>0.05). In our study 93% patients achieved excellent to good results in threaded screw with one third tubular plate fixation and 86.7% patients achieved excellent to good results in tension band wiring with one third tubular plate fixation. This was comparable with other studies which achieved 80% in Al-Lamy WA et al46, 80% in Shams N et al32, 90% in Maruthi CV et al33 and 79% in Ebraheim NA et al.49. There was no major intraoperative or post operative complications in both the groups.

V. Tables

![Age group distribution](image1.png)

**Table 1:** showing age group distribution (in %).

![Sex distribution](image2.png)

**Table 2:** showing sex distribution (in %).

![Distribution of fracture side](image3.png)

**Table 3:** showing distribution of fracture side (in %).

![Mode of injury](image4.png)

**Table 4:** showing mode of injury (in %).
A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults

Table 7: showing mean duration of hospital stay (in days).

Table 8: showing mean time for clinical union (in weeks).

Table 9: showing mean radiological union (in weeks).

Table 10: showing mean time for weight bearing (in weeks).

Table 11: showing Range of motion (dorsiflexion and plantar flexion) in the two groups.

Table 12: showing Range of Motion (pronation and supination) in the two groups.

Table 13: showing functional outcome of the two groups (in %).
VI. Pre-operative, Intra-operative, Post operative and Follow up Figures

Fig 1: Pre-operative x-ray for threaded screw with one third tubular plate

Fig 2: Pre-operative x-ray for tension band wiring with one third tubular plate

Fig 3: Tourniquet application

Fig 4: Betadine solution application

Fig 5: Skin incision

Fig 6: Fracture site exposed

Fig 7: Fracture stabilization with K-wire

Fig 8: Fracture fixed with screw and plate
A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults

Fig 9: Wound closure

Fig 10: Below knee posterior slab

Fig 11: Threaded screw with one third tubular plate - Post operative x-rays

Fig 12: Tension band wiring with one third tubular plate - Post operative x-rays

Fig 13: Threaded screw with one third tubular plate: Range of motion (A B C D)

A: Dorsiflexion

B: Plantarflexion

C: Pronation

D: Supination
A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults

VI. Complications

There were no intra operative complications noted in our study in both groups. In threaded screw with one third tubular plate group, there was one superficial infection over the operative site which did not involve the bone.

In tension band wiring with one third tubular plate group, there was one case of superficial wound infection which did not involve the bone. Infection was controlled with local dressing and antibiotic therapy.

VII. Conclusion

In this interventional study, we studied the results of threaded screw with one third tubular plate fixation and tension band wiring with one third tubular plate fixation were insignificant in term fracture union, range of motion, weight bearing and functional outcome but there were definite advantages in threaded screw with one third tubular plate fixation comparing to tension band wiring with one third tubular plate group. Both groups had 100% union rate without any failure. There was significant difference in term of mean operating time which showed definite less time taken with tension band wiring with one third tubular plate fixation comparing to threaded screw with one third tubular plate fixation.

In our study the overall functional outcome was 93% excellent to good results in threaded screw with one third tubular plate fixation and 86.7% excellent to good results in tension band wiring with one third tubular plate fixation. This was comparable with other fixation methods for bimalleolar fracture in other studies which achieved 80% in Al-Lamy WA et al46, 80% in Shams N et al47, 90% in Maruthi CV et al48 and 79% in Ebraheim NA et al.49

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DOI: 10.9790/0853-1802015566 www.iosrjournals.org 64 | Page
A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults


A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults


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