IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 2 Ser. 1 (February. 2019), PP 55-66
www.iosrjournals.org

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

Dr. Trinajit Debbarma[1], Dr. Khoda Tada[1], Prof. S. N Chishti[2], Dr. Debasish Parija[1], Dr. Dilip Soring[3], Dr. Monish Mohan[1], Dr. Tanuj Kanti Chaudhuri[1], Dr. Herojeet Takhellambam[1]

[1]*(Post Graduate Trainee, Department of Orthopaedic, Regional Insititute of Medical Sciences, Imphal, Manipur, India)*
[2] *(Professor, Department of Orthopaedic, Regional Insititute of Medical Sciences, Imphal, Manipur, India)*
[3] *(Senior Resident, Department of Orthopaedic, Regional Insititute of Medical Sciences, Imphal, Manipur, India)*
Corresponding Author: Dr. Trinajit Debbarma

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 ie 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 functionl 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 out come, Olerud C and Molander H functional score system, One third tubular plate, Partially threaded screw, Tension bend wiring.*

Date of Submission: 20-01-2019 Date of acceptance: 04-02-2019

I. Introduction

Ankle fractures are one of the most common lower limb frctures[1]; they account for 9% of all fractures[2], representing significant portion of the trauma workload.[3] The annual incidence of ankle fracture is between 107 and 184 per 100,000 persons[4,6,] and round 2% of ankle fractures are open frctures[4]. Ankle fractures usually affect young men and older women[7], 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 cases[6]. The most common causes of ankle fractures are twisting injuries and falls, followed by sports injuries[4,5]. Diabetes mellitus and obesity are associated with fractures in middle aged and older adults[5]. 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 pattern[8]. 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 tibila nerves[8].

Passive stability is mainly achieved by the medial and lateral ligament complexes, tibiofibular 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 decreses on leaning backwrds[8].The posterior malleolus acts as restraint against posterior translation of the talus[9].

The first classification system for ankle fractures were developed by the 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%)[4], There are two other commonly used classifictions systems i.e.., Danis-Weber Classifiction 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 examintions[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[15]

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 anterio 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 10^{th} day and then patients were discharged or the patients were discharged and called for suture removal on the 10^{th} 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.[43]

3.6 Functional assessment

The results were evaluated using Olerud C and Molander H functional score system.[44] C. Olerud and H. Molander: A scoring scale for symptoms evaluation after ankle fracture as given below:

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

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.[44]

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[45] and 1.6:1 in Shams N et al.[47]

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.[45]

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.[45]

The mean age of fracture in threaded screw with one third tubular plate group was 5.13 (±1.959) 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.[47] 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.[15,41]

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 to12 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[43,44,42] 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.[45]

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

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 al[46], 80 % in Shams N et al[32], 90 % in Maruthi CV et al[33] and 79 % in Ebraheim NA et al.[49] There was no major intraoperative or post operative complications in both the grpups.

V. Tables

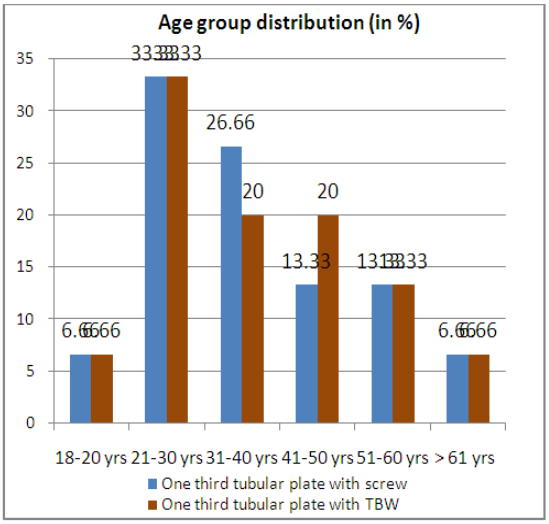

Table 1: showing age group distribution (in %).

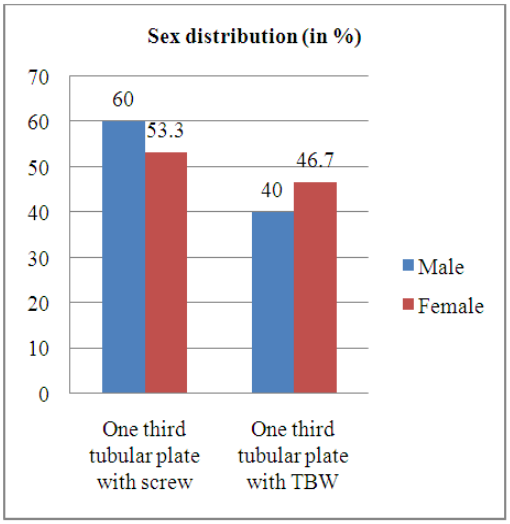

Table 2: showing sex distribution (in %).

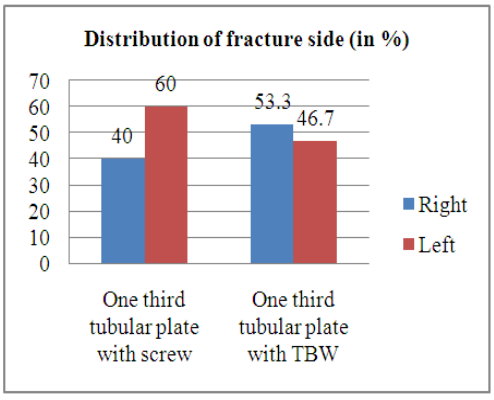

Table 3: showing distribution of fracture side (in %).

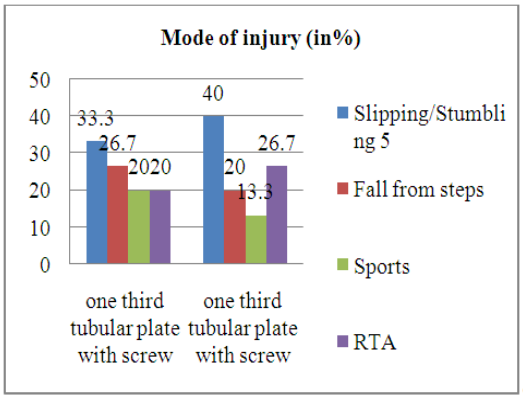

Table 4: showing mode of injury (in %).

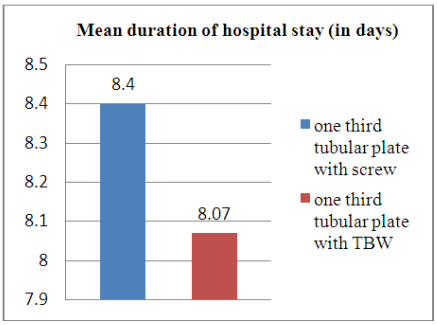

Table 7: showing mean duration of hospital stay (in days).

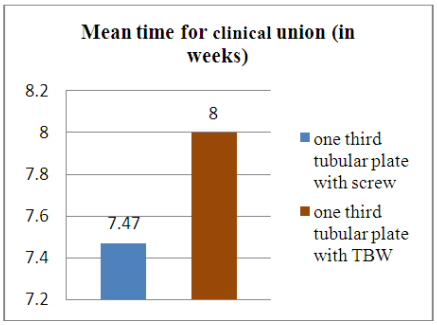

Table 8: showing mean time for clinical union (in weeks)

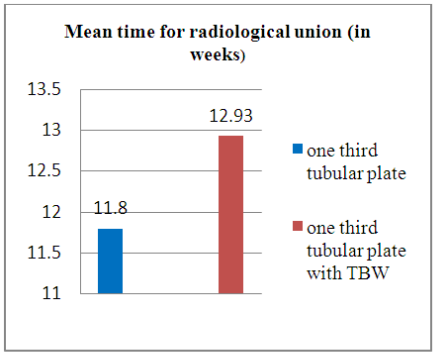

Table 9: showing mean radiological union (in weeks).

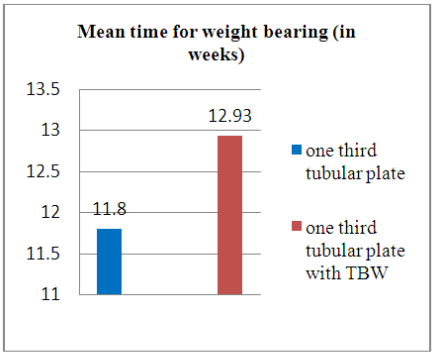

Table 10: showing mean time for weight bearing (in weeks).

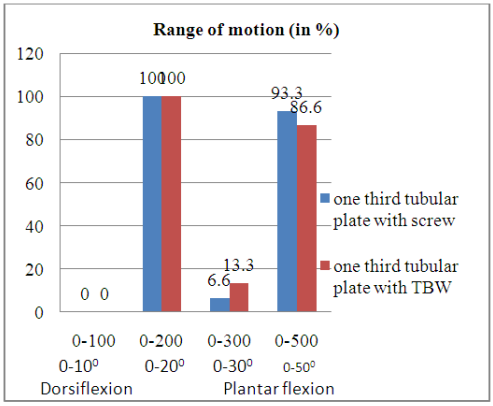

Table 11: showing Range of motion (dorsiflexion and planter flexion) in the two groups

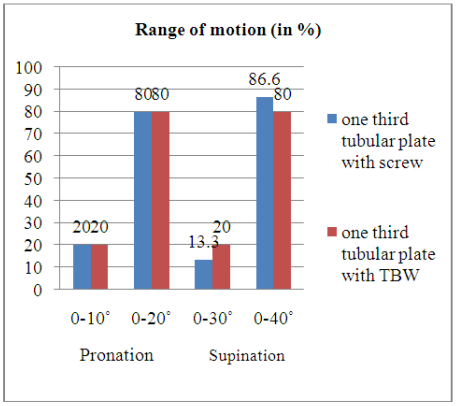

Table 12: showing Range of Motion (pronation and supination) in the two groups.

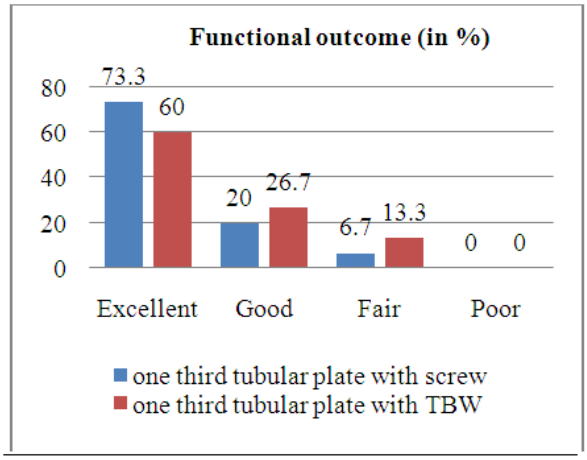

Table 13: showing functional outcome of the two groups (in %).

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

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- Planterflexion

C- Pronation

D- Supination

Fig 14: Tension band wiring with one third tubular plate :- Range of motion (A B C D)

A- Dorsiflexion

B- Planterflexion

C- Pronation

D- Supination

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 al[46], 80 % in Shams N et al[47], 90 % in Maruthi CV et al[48] and 79 % in Ebraheim NA et al.[49]

Acknowledgements

To all my teachers and resident doctors who contributed in this study as well as to all the patients who participated in the study

References

[1]. Lash N, Horne G, Fielden J and Devane P. Ankle Fractures: Functional and Lifestyle Outcomes at 2 Years. ANZ J of Surg 2002;72:724- 30.
[2]. Court-Brown CM and Caesar B. Epidemiology of Adult Fractures: A Review. Injury 2006;37:691-7.
[3]. Bugler KE, White TO ,Thordarson DB. Focus on Ankle Fractures. J of Bone and Joint Surg 2012;94:1107-12.

[4]. Court-Brown CM, McBirnie J and Wilson G. Adult Ankle Fractures—An Increasing Problem? Acta Orthopaedica Scandinavic 1998;69:43-7.
[5]. Daly PJ, Fitzgerald JRH, Melton LJ, and Ilstrup DM. Epidemiology of Ankle Fractures in Rochester Minnesota. Acta Orthopaedica Scandinavica 1987;58: 539-44.
[6]. Jensen SL, Andresen BK, Mencke S ,Nielsen PT. Epidemiology of Ankle Fractures: A Prospective Population-Based Study of 212 Cases in Aalborg, Denmark. Acta Orthopaedica Scandinavica 1998;69:48-50.
[7]. Donken CCMA, Al-Khateeb H, Verhofstad MHJ, van Laarhoven CJ. Surgical versus Conservative Interventions for Treating Ankle Fractures in .Adults. Cochrane Database Syst Rev 2012 Aug 15;8(1):1-8.
[8]. Michael P, Clare MD. A Rational Approach to Ankle Fractures. Foot and Ankle Clinics 2008;13(4):593-610.
[9]. Arimoto HK, Forrester DM . Classification of Ankle Fractures: An Algorithm. American Journal of Roentgenology 1980;135:1057-63.
[10]. Harper MC. Ankle Fracture Classification Systems: A Case for Integration of the Lauge-Hansen and AO Danis-Weber schemes. Foot Ankle 1992;13(7):404-7.
[11]. Gougoulias N, Khanna A, Sakellariou A, Maffulli N. Supination-External Rotation Ankle Fractures: Stability a Key Issue. Clinical Orthopaedics and Related Research 2009;468(1):243-51.
[12]. Taweel NR, Raikin SM, Karanjia HN, Ahmad J. The Proximal Fibula Should Be Examined in All Patients with Ankle Injury: A Case Series of Missed Maisonneuve Fractures. Journal of Emergency Medicine 2013;44(2):251-5.
[13]. Van Rensberg CJ. Approach to and Management of Acute Ankle Ligamentous Injuries 2004;22:112-5.
[14]. Polzer H, Kanz K ,Pranz W. Diagnosis and Treatment of Acute Ankle Injuries: Development of an Evidence-Based Algorithm. Orthopaedic Review 2012 4e 5.
[15]. Van Dijk CN, Lim LS, Bossuyt PM, Marti RK. Physical Examination Is Sufficient for the Diagnosis of Sprained Ankles. J of Bone and Joint Surg 1996;78:958-962.
[16]. Stiell, I. Ottawa Ankle Rules. Canadian Family Physician 1996;42:478-480.
[17]. Bachmann LM, Kolb E, Koller MT, Steurer J, Riet G. Accuracy of Ottawa Ankle Rules to Exclude Fractures of the Ankle and Mid-Foot: Systematic Review. BMJ, 2003;326-417.
[18]. Dowling S, Spooner CH, Liang Y. Accuracy of Ottawa Ankle Rules to Exclude Fractures of the Ankle and Midfoot in Children: A Meta-Analysis. Academic Emergency Medicine 2009;1:277-287.
[19]. Stiell IG, Greenberg GH, McKnight RD, Nair RC, McDowel I, Worthington JR. A Study to Develop Clinical Decision Rules for the Use of Radiography in Acute Ankle Injuries. Academic Emergency Medicine 1992;21:384-90.
[20]. Brandser EA, Berbaum KS, Dorfman DD. Contribution of Individual Projections Alone and in Combination for Radiographic Detection of Ankle Fractures. American J of Roentgenology 2000;174:1691-7.
[21]. Egol KA, Amirtharajah M, Tejwani NC, Capla EL, Koval KJ .Ankle Stress Test for Predicting the Need for Surgical Fixation of Isolated Fibular Fractures. Journal of Bone and Joint Surgery 2004;86-A: 2393-8.
[22]. Coughlin MJ, Saltzman CL.Chapter 3—Imaging of the Foot and Ankle. In: Coughlin, M.J., Mann, R.A. and Saltzman, C.L., Eds., Surgery of the Foot and Ankle, 8th Edition, Elsevier Mosby,2006 68-96.
[23]. Hoshino CM, Nomoto EK, Norheim EP, Harris TG. Correlation of Weightbearing Radiographs and Stability of Stress Positive Ankle Fractures. Foot & Ankle Internationa 2012; 33:92-8.
[24]. Gardner MJ, Demetrakopoulos D, Briggs SM, Helfe D ,Lorich DG.The Ability of the Lauge-Hansen Classification to Predict Ligament Injury and Mechanism in Ankle Fractures: An MRI Study. J Orthop Trauma 2006;20:267-272.
[25]. Nielson JH, Gardner MJ, Peterson MG, Sallis JG, Potter HG, Helfet DL et al.Radiographic Measurements Do Not Predict Syndesmotic Injury in Ankle Fractures: An MRI Study. Clinical Orthopaedics and Related Research & NA 2005;216-21.
[26]. Hsu CC, Tsai WC, Chen CP, Chen MJ, Tang SF ,Shih L et al. Ankle Sprains Associated with Ultrasonographic Examination for Inversion Osseous Injuries. American Journal of Physical Medicine & Rehabilitation 2006;85:785-92.
[27]. Salai M, Dudkiewicz I, Novikov I. The Epidemic of Ankle Fractures in the Elderly—Is Surgical Treatment Warranted? Archives of Orthopaedic and Trauma Surgery 2000;120:511-3.
[28]. Lin CW, Donkers NA, Refshauge KM, Beckenkamp PR, Kher K ,Moseley AM. Rehabilitation for Ankle Fractures in Adults. Cochrane Database of Systematic Reviews 2012 11, Article ID: CD005595.
[29]. Dalal BY, ChaudhriKj, Patel PJ, Bhesaniya RR. A Study of Bimalleolar fractures treated with open and closed method by TBW, k wire, CC screw and semitubular plate. IJSR Oct 2014;3(10):322-3
[30]. Ramana SSV, Vittal MPR. A study on internal fixation of bimalleolar ankle fractures. IOSR-JDMS Oct 2015;14(10):01-4.
[31]. Maruthi CV, Venugopal N, Nanjundappa HC, Swamy MKS. Bimalleolar fracture of ankle joint managed by tension band wiring technique: A Prospective Study. Sch J App Med Sci 2014;2(1D):428-32.
[32]. Alamgir MHM, Islam M, Islam N, Kader A. Open reduction and internal fixation of displaced fractures of lateral malleolus by tension and wiring and plating in bimalleolar fractures in adults. JSSMC Dec 2013;5:2
[33]. Federici A, Sanguineti F, Santolini F. the closed treatment of severe malleolar fractures. Acta Orthop Belg. 1993;59(2):189-96.
[34]. Singh S, Tsai CH, Kim A, Dailey T. Open dislocated bimalleolar ankle fracture in a diabetic treated with the illizorov apparatus: A case report in early ambulation and stabilization. The Foot and Ankle online J. Feb 2010;3(2):2.
[35]. TorbjörnAhl, Nils Dalén, Arne Lundberg & Carin Bylund (1993) Early mobilization of operated on ankle fractures: Prospective, controlled study of 40 bimalleolar cases, Acta Orthopaedica Scandinavica, 64:1, 95-99, DOI: 10.3109/17453679308994541.
[36]. Shah ZA, Arif U. Surgical management of bimalleolar fractures of ankle. P J M H S Jun 2013;7(2):470-473
[37]. Motwani GN, Shah HD, Chavli VH, Daveshwar RN, Parmar H, Suthar PP. Results of open reduction and internal fixation in closed bimalleolarpott's fracture of ankle in adults. Int J Med Sci Public Health 2015;4(7):893-900
[38]. Kulloli SS, Magdum PB, Naik NP. Management of malleolar fractures of ankle joint. IOSR JDMS Nov-Dec 2012;3(3):27-31
[39]. Rangdal S, Singh D, Joshi N, Soni A, sament R. Functional outcome of ankle fractures treated with biodegradable Implants. Foot and ankle J 2012;18(3):153-6.
[40]. Wilson FC, Skilberd A. Long term results in the treatment of displaced bimalleolar fractures. J Bone Joint SurgAm 1966;48(6):1065-78.
[41]. Parada SA, Krieg JC, Benirschke SK, Nork SE. Bicortical fixation of medial malleolar fractures. Am J Orthop 2013;42(2):90-2.
[42]. Parker L, Garlick N, McCarthy I, Grechenig S, Grechenig W, Smitham P. Screw fixation of medial malleolar fractures: a cadaveric biomechanical study challenging the current AO philosophy. Bone Joint J 2013;95-B(12):1662-6.
[43]. Fowler TT, Pugh KJ, Litsky AS, Taylor BC, French BG. Medial malleolar fractures: a biomechanical study of fixation techniques. J Orthop 2011;34(8):349-55.
[44]. Smitham P, Parker L, McCarthy I, Garlick N. Is a short screw better? trends in medial malleolus fracture fixation and superior efficacy of shorter fully-threaded cancellous screws. J Bone Joint Surg Br 2012;94-B(58):134-6.

[45]. Kulloli SS, Magdum PB, Naik NP. Evaluation of management of malleolar fractures of ankle joint. Journal of Dental and Medical Sciences 2012;3(3):27-31.
[46]. Al-Lamy WA, Al-Obaidy MH. Comparative study of internal fixation of displaced closed fracture of medial malleolus using malleolar screw versus tension-band wiring. Karbala J Med 2008;2(4):308-18.
[47]. Shams N, Ahmed I, Hegde A. A study on surgical treatment of ankle fractures- A clinical study of 21 cases. International Journal of Biomedical and Advance Research 2014;5(4):190-2.
[48]. Maruthi CV, Venugopal N, Nanjundappa HC, Siddalingaswamy MK. Bimalleolar fracture of ankle joint managed by tension band wiring technique: a prospective study. Sch J App Med Sci 2014;2(1D):428-32.
[49]. Ebraheim NA, Ludwig T, Weston JT, Carroll T, Liu J. Comparison of surgical techniques of 111 medial malleolar fractures classified by fracture geometry. Foot Ankle Int 2014;35(5):471-7.
[50]. Du H, Tian XX, Li TS, Chu JJ, Xiong MY. Treatment of medial malleolus fractures with closed reduction and percutaneous internal fixation. Zhongguo Gu Shang 2011;24(9):788-90.

Dr. Trinajit Debbarma. "A Study on Different Surgical Treatment Modalities of Bimalleolar Fracture in Adults." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 2, 2019, pp 55-66.