

ASSESSMENT OF OUTCOMES FOLLOWING TWO DIFFERENT FIXATION TECHNIQUES FOR MEDIAL MALLEOLUS FRACTURES: CANNULATED CANCELLOUS SCREWS VERSUS TENSION BAND WIRING

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ABSTRACT

Medial malleolus fractures are mutual ankle wounds that frequently need operative fixation to restore ankle stability, achieve fracture union, and facilitate early functional recovery. Cannulated Cancellous (CC) Screw fixation and Tension Band Wiring (TBW) are established surgical techniques; however, the optimal fixation method remains controversial because of differences in biomechanical properties, functional outcomes, and implant-related complications. A prospective comparative study was conducted at Sree Balaji Medical College and Hospital, Chennai, involving 30 patients with medial malleolus fractures. Patients underwent operative fixation using either CC Screw fixation (n = 15) or TBW (n = 15). Radiological fracture union, postoperative pain restrained via the Visual Analogue Scale (VAS), functional outcome restrained by the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, postoperative complications, and secondary implant removal were evaluated over a minimum follow-up period of six months. Both groups achieved satisfactory fracture union, progressive pain reduction, and substantial functional development throughout follow-up. The CC Screw group demonstrated slightly shorter union time, lower VAS scores, higher AOFAS scores, and fewer implant-related complications than the TBW group. However, none of these alterations were statistically significant ($p > 0.05$). Hardware irritation and secondary implant removal occurred more frequently following TBW fixation. Both CC Screw fixation and TBW provided effective treatment for medial malleolus fractures, with comparable radiological, functional, and clinical outcomes. Implant selection should be individualised according to fracture morphology, bone quality, and intraoperative assessment.

KEYWORDS: Medial malleolus fracture; Cannulated cancellous screw; Tension band wiring; AOFAS score; Fracture union.

INTRODUCTION

Fractures of the ankle are the commonest prevalent type of injury in orthopaedics and often need surgical treatment. Medial malleolus fractures are typically caused by falls or traffic accidents. They can be independent fractures or a component of bimalleolar and trimalleolar fractures. Since the medial malleolus plays a vital part in the constancy of the ankle joint, insufficient decrease can cause incongruity of the joint, which results in pain, instability, reduced movement, delayed healing, and post-traumatic arthritis. Thus, adequate treatment is necessary to restore normal function and have positive long-term outcomes for the ankle joint (Agarawal, 2020). Modern researches have also highlighted the need to choose techniques of fixation that guarantee stability of fixation while reducing complications associated with the implants and allowing early rehabilitation (Batar et al., 2024). Advancements in the technology of compression screws have increased the choice of treatment options while providing acceptable biomechanical performance (Choi et al., 2025).

The tibia's distal projection is known as the medial malleolus, and the insertion point of the deltoid ligament complex, which is essential for resisting valgus and rotational stresses, helping stabilize the ankle. The importance of anatomical reconstruction in fractures is that any amount of displacement will lead to altered joint stress distribution and faster degeneration. Thus, fixation devices must provide proper interfragmentary compression and stability during fracture healing. New implant design developments have provided better fixation capabilities while decreasing the prominence of

the implants, though the choice of the implant remains highly dependent on fracture shape and size (Kim et al., 2023; Bulut et al., 2021). New fixation concepts have also increased the treatment options for certain fracture types (Patir, 2024). Classification of fractures plays a crucial role in planning treatment as fracture morphology determines the choice of implants and the approach used. Herscovici classification classifies medial malleolus fractures into four types, A-D, and is still widely used in clinical practice. Different fractures need different fixation techniques that will ensure reliable osteosynthesis and mobilization. Modern research shows the constant improvement of fixation techniques depending on the fracture morphology, and biomechanical studies confirm the significance of tension banding and cannulated screw fixation (Ahmed, 2025; Calisal & Uğur, 2023; Abouelwafa et al., 2022).

Operative fixation is recommended in cases of displaced medial malleolus fractures and unstable ankle fractures, as it helps achieve anatomical reduction, stable fixation, fracture healing, and early movement. Various methods of fixation have been reported, such as Cannulated Cancellous (CC) screws, Tension Band Wiring (TBW), headless compression screws, or plate fasciation. Even with the improvements in implants, none of the fixation techniques has gained universal acceptance due to the variability of treatment results, which depend on the type of fracture, bone quality, and patient-related factors (Das et al., 2025; Park et al., 2022). The CC screw technique allows interfragmentary compression based on lag screw principle and shows positive clinical and radiographic results, but the decreased screw purchase might be observed in patients with osteoporosis or small bone fragments (Chang et al., 2025; Choo et al., 2025).

Tension Band Wiring is an accepted technique of fixation, especially in the case of small fracture fragments which do not warrant screw fixation. Through its skill to change tensile forces into compressive forces at the breakage site, TBW ensures effective and stable fixation for early functional rehabilitation. Implant prominence, irritation, and second-time implant removal have been documented as potential complications of the procedure. Modifications of traditional TBW methods have been proposed to enhance fixation stability and minimize implant-related problems (Gumaste et al., 2023; Shimura et al., 2021). Systematic reviews conducted recently on the use of CC Screw fixation and TBW have shown acceptable functional and radiographic results, although there are differences in their complication profiles and implant-related results with no universal recommendation possible based on available evidence (Tai et al., 2025). Additionally, discrepancies in study design, fracture classification, and outcome measures have hindered direct comparison among previous publications (Aydın & Çınaroğlu, 2022; Choi et al., 2021).

In light of the persisting ambiguity concerning the best technique for fixing medial malleolar fractures, this prospective comparative investigation was done at Sree Balaji Medical College & Hospital to compare the functional and radiographic results of Cannulated Cancellous Screw Fixation and Tension Band Wiring. The study compared pain after surgery, fracture healing, functional recovery, and complications using standardized clinical, radiographic, and functional assessment techniques.

Aim

To compare the functional and radiological outcomes in operative treatment of medial malleolus fractures with Cannulated Cancellous (CC) Screw fixation and Tension Band Wiring (TBW).

Objectives of the study

- To compare the postoperative pain outcomes between patients treated with Cannulated Cancellous (CC) Screw fixation and Tension Band Wiring (TBW) using the Visual Analogue Scale (VAS).
- To compare the radiological outcomes by evaluating the time to fracture union between the CC Screw and TBW groups.
- To assess and compare the functional outcomes of both fixation techniques using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score during postoperative follow-up.
- To compare the postoperative complication profile between the CC Screw and TBW groups, including superficial infection, hardware irritation, delayed union, implant failure, wound dehiscence, and secondary implant removal.
- To determine the comparative effectiveness of Cannulated Cancellous (CC) Screw fixation and Tension Band Wiring (TBW) in terms of fracture union, postoperative pain, functional recovery, and complication profile for the operative management of medial malleolus fractures.

2. METHODOLOGY

2.1 Study Design and Setting

A prospective comparative investigation was undertaken in the Department of Orthopedics at Sree Balaji Medical College and Hospital (SBMCH), Chennai, Tamil Nadu, comparing the functional and radiological results of Cannulated Cancellous (CC) Screw Fixation or Tension Band Wiring (TBW) for the surgical treatment of medial malleolus fractures. The individuals were selected from the Orthopedic Outpatient Department and Emergency Room. Patient selection was done between March 2024 and September 2025, with a least follow-up period of six months and overall duration of the study being two years.

2.2 Study Population and Sample Size

Thirty individuals with breakages of the medial malleolus, which included bimalleolar or trimalleolar fractures, that satisfied the pre-established inclusion criteria were recruited for this investigation. The individuals were separated into two groups – 15 with Cannulated Cancellous Screw Fixation and 15 with Tension Band Wiring Fixation. Assignment of patients to the treatment group was done through purposive sampling based on the intraoperative findings of the operating

surgeon. The sample size was permitted by the Institutional Ethics Committee of Sree Balaji Medical College and Hospital, Chennai.

2.3 Inclusion and Exclusion Criteria

The requirements for participation's inclusion in the investigation involved male or female patients, aged 18-75 years, with a presentation of new-onset symptomatic medial malleolus fracture, bimalleolar fracture, or trimalleolar fracture that required surgical fixation. The participants were those with Herscovici Types A, B, and C fractures who gave their informed consent and promised to adhere to the follow-up schedule. Those with pathological fractures, active infections, Gustillo-Anderson Type II or III open fractures, neglected fractures, ipsilateral long bone fractures, Herscovici Type D fractures requiring plate fixation, chronic local infection, or inability to walk due to systemic illness were excluded from the study.

2.4 Surgical Intervention

All the recruited subjects were managed by surgical fixation through Cannulated Cancellous Screw Fixation or Tension Band Wiring based on the pre-defined treatment assignment. The mode of fixation was determined based on the surgeon's intra-operative assessment of the nature of the fracture and the requirements of fixation. All patients received standard peri-operative management and post-operative care according to the institutional protocol for rehabilitation. Follow up was done in accordance with the study protocol.

2.5 Data Collection

The baseline demographics and clinical details such as age, sex, injured limb, type of injury, presence of any other diseases, and nutrition status of all patients were recorded. The surgical factors involved were fracture pattern as per the Herscovici classification, surgical time, type of anesthesia, and the fixation technique used. Radiographs of the foot were taken after six weeks, three months, and six months after surgery, as well as on the first postoperative day. The functional results, ankle joint mobility, and postoperative complications were recorded at each follow-up appointment.

2.6 Outcome Measures

The main functional outcome was the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale. The 100-point scale was separated into three sections: alignment (10 points), function (50 points), and discomfort (40 points). The function section consisted of limitations in activities, maximum walking distance, walking surface, anomalies in gait, ankle sagittal movement, hindfoot motion, ankle-hindfoot stability, and foot alignment. The function outcome was categorised as bad (<50), fair (50-74), good (75-89), and outstanding (90-100).

2.7 Radiological Assessment

Radiological outcome was measured based on the time taken for the fractures to unite from the day of surgery. Fractures were said to be united when there was linking callus in at least three cortices in two projections. Clinical union was demonstrated by the lack of pain at the fracture site through palpation and stress testing. The x-rays were analyzed at the scheduled follow-up appointments to measure the healing of the fractures and measure the time taken for union in both groups.

2.8 Statistical Analysis

The statistical evaluates were done using SPSS software version 22.0. The categorical information were accessible in the form of frequency and percentage, while the continuous information were labelled in terms of mean $\pm$ SD. Comparison of continuous data among the Cannulated Cancellous Screw and Tension Band Wiring groups was done using independent samples t-test, while assessment of categorical information was done using Chi-square test. A value of $p < 0.05$ was taken to be statistically substantial for all statistical analyses.

2.9 Ethical Considerations

The investigation was preceded by the ethical clearance from the Institutional Ethics Committee of Sree Balaji Medical College and Hospital, Chennai. Informed written agreement was taken from all subjects prior to enrolment either in English or Tamil language. Patient confidentiality was ensured by providing identification numbers of the study while collecting data and doing statistical analysis. It is also to be noted that participation in the study was totally voluntary and subjects had full right to quit the study at any point of time.

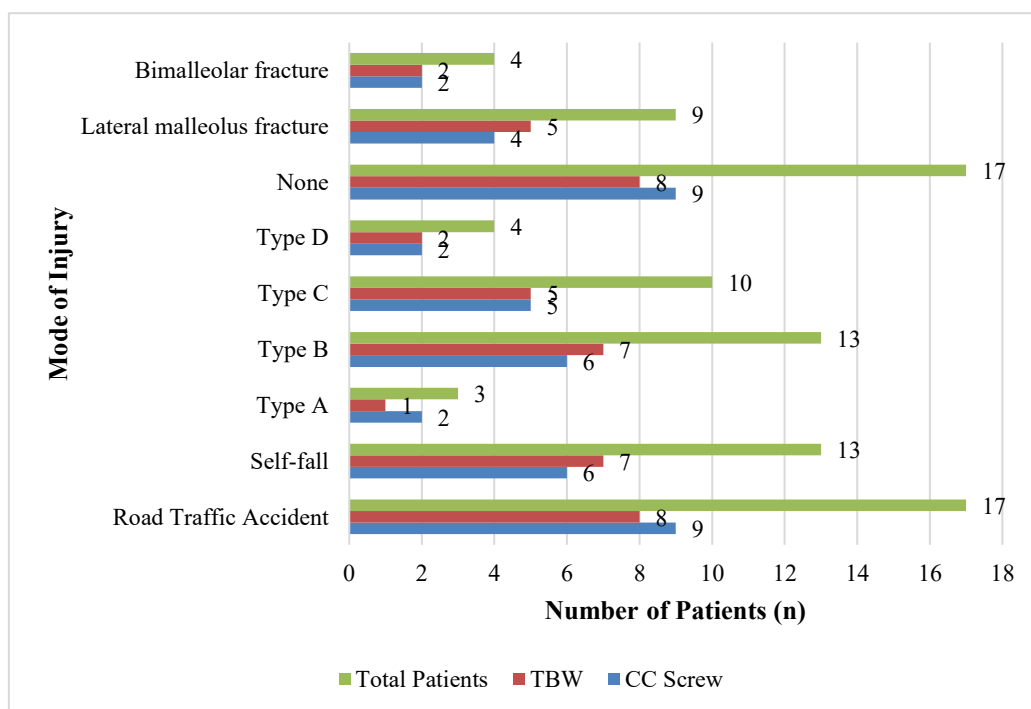
3. RESULTS

3.1 Baseline Features

Demographic and baseline clinical data of the subjects are presented in Table 1. The mean age was 41.6 ± 10.2 years in the CC Screw group and 43.1 ± 9.8 years in the TBW group. The amount of male patients was 60.0% of the total number of subjects in the study. Road traffic accidents reported for 56.7% of the mechanism of damage, and Herscovici Type B fractures made up 43.3% of the fracture pattern. Associated injuries and time from injury to surgery were similar in both groups. There were no statistically substantial alterations in any baseline variables (all $p > 0.05$) (Table 1).

Table 1. Baseline Features of the Study Population

Variable	CC Screw (n=15)	TBW (n=15)	Total	p-value
Age (years), Mean $\pm$ SD	41.6 $\pm$ 10.2	43.1 $\pm$ 9.8	-	0.91
Age Group, n (%)				
20–30	3	2	5 (16.7%)	
31–40	4	5	9 (30.0%)	
41–50	5	4	9 (30.0%)	
51–60	3	4	7 (23.3%)	
Sex, n (%)				1.00
Male	9	9	18 (60%)	
Female	6	6	12 (40%)	
Time from Injury to Surgery (days), Mean $\pm$ SD	3.8 $\pm$ 1.2	4.1 $\pm$ 1.4	—	0.57

**Figure 1. Baseline Clinical Features of the Study Population**

The distributions of the baseline clinical features among the patients who had Cannulated Cancellous (CC) Screw and Tension Band Wiring (TBW) have been presented in Figure 1. These variables consist of the mode of injury, Herscovici fracture classification, and associated injuries. Similar distributions were seen among the two groups, with no substantial alteration in any baseline feature ($p > 0.05$).

3.2 Radiological Outcomes

Radiological fracture union was accomplished in all patients of both treatment groups during the study period. Majority of patients (50.0%) showed radiological fracture union within 10–12 weeks while 36.7% of patients showed fracture union within 8–10 weeks and 13.3% of patients had fracture union beyond 12 weeks. Radiological fracture union time was 10.4 ± 1.8 weeks in the CC Screw group and 10.9 ± 2.1 weeks in the TBW group. There was no statistically substantial alteration in fracture union time among both treatment groups ($p=0.42$) (Table 2).

Table 2. Comparison of Radiological Union

Union Time (weeks)	CC Screw (n=15)	TBW (n=15)	Total (%)
8–10 weeks	6	5	11 (36.7%)
10–12 weeks	7	8	15 (50.0%)
>12 weeks	2	2	4 (13.3%)
Mean Union Time (weeks)	10.4 $\pm$ 1.8	10.9 $\pm$ 2.1	-
p-value			0.42

3.3 Clinical Outcomes

Pain after surgery was assessed using Visual Analogue Scale (VAS) at Three weeks, six weeks, eight weeks, and six months postoperatively. Decreasing trends in pain scores were noted in both groups throughout the entire follow-up period. The mean pain score declined from 5.8 ± 1.0 to 1.4 ± 0.8 in CC Screw group and from 6.0 ± 1.1 to 1.6 ± 0.9 in TBW group. No statistically substantial alterations were found among the two groups during all follow-ups ($p > 0.05$ for all).

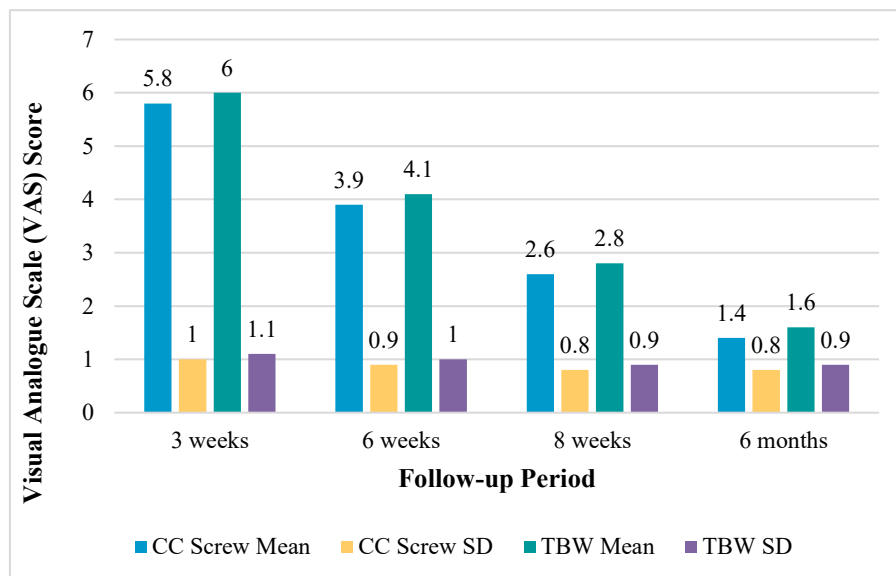


Figure 2. Comparison of Postoperative Pain (VAS Score) During Follow-up

The postoperative pain pattern among the subjects receiving CC screw fixation therapy and those undergoing TBW is illustrated in Figure 2. The pain level was restrained using the VAS. The results show that both the subjects exhibited decreasing pain levels during the course of their recovery period.

3.4 Functional Outcomes

The assessment of functional recovery was done with the help of AOFAS Ankle-Hindfoot Score. Both treatment groups showed gradual improvement in functional activity during the postoperative period. The mean AOFAS scores improved from 52.3 ± 6.5 at 3 weeks to 88.6 ± 6.2 at 6 months in the CC Screw group and 50.8 ± 7.1 to 86.9 ± 7.1 in the TBW group. Although the mean AOFAS score was higher in the CC Screw group during follow-up, there was no statistical alteration among the two groups ($p > 0.05$) (Table 3).

Table 3. Comparison of Functional Outcomes (AOFAS Score) During Follow-up

Follow-up	CC Screw (Mean $\pm$ SD)	TBW (Mean $\pm$ SD)	p-value
3 weeks	52.3 ± 6.5	50.8 ± 7.1	0.49
6 weeks	68.7 ± 7.2	66.9 ± 7.8	0.52
8 weeks	78.9 ± 6.8	77.1 ± 7.4	0.55
6 months	88.6 ± 6.2	86.9 ± 7.1	0.56

The functional assessment at six months using the AOFAS grading system showed that 19 patients (63.3%) obtained excellent results, 9 patients (30.0%) obtained good results, and 2 patients (6.7%) got fair results. None of the patients had a poor result in terms of functionality. The distribution of functional scores was comparable in the CC screw and TBW groups.

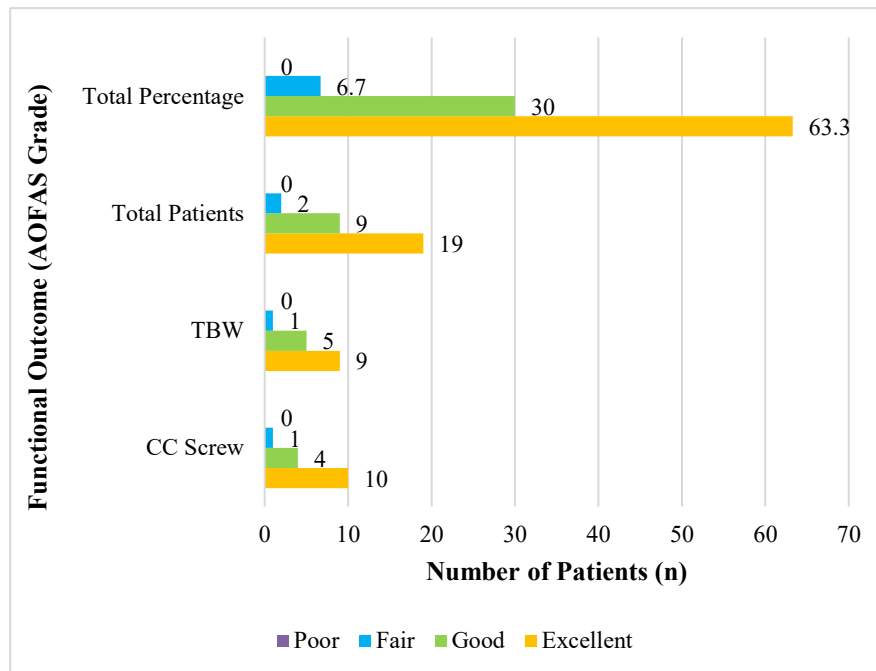


Figure 3. Comparison of Functional Outcomes According to AOFAS Grading at Six Months

The comparison of distribution of functional outcome among the subjects at the sixth month post-surgery who were operated with CC screws and TBW is shown in Figure 3. The valuation of the functional result was done with the help of the AOFAS scale.

3.5 Safety Outcomes

Complications post surgery were rare in both groups. The most common complications were hardware irritation, which was found in one case from the CC Screw group and three cases from the TBW group. Superficial infection was seen in one case of CC Screw group and two cases of TBW group. Delayed union was found in one case in both groups. Implant failure and wound dehiscence were found in one case from TBW group only. There was no substantial alteration in the pattern of complications in both groups ($p=0.48$) (Table 4).

Table 4. Comparison of Postoperative Complications

Complication	CC Screw (n=15)	TBW (n=15)	Total (%)	p-value
Superficial infection	1	2	3 (10.0%)	0.48
Hardware irritation	1	3	4 (13.3%)	
Delayed union	1	1	2 (6.7%)	
Implant failure	0	1	1 (3.3%)	
Wound dehiscence	0	1	1 (3.3%)	

Implant removal secondary to the operation was done on seven patients (23.3%) during the follow-up. Removal of implants was done on two patients (13.3%) who were subjected to CC Screw fixation while it was done on five patients (33.3%) who underwent TBW fixation. Although removal of implants was more common in the TBW group, the alteration among the two was not statistically substantial ($p = 0.18$).

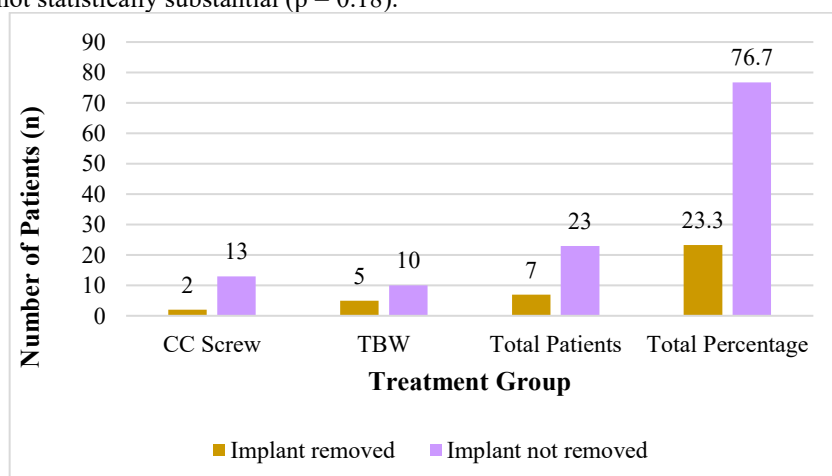


Figure 4. Comparison of Secondary Implant Removal Between CC Screw and TBW Groups

Figure 4 shows the distribution of secondary removal of implants in the patients who have undergone CC screw and TBW fixation. Majority of the patients had their implants retained, while some had implants removed. The distribution of the removal of implants was compared between the two groups, and the result was similar to each other.

4. DISCUSSION

The current prospective comparative investigation was done to measure the functional and radiological results of CC Screw fixation and TBW in medial malleolus fractures. The baseline features of individuals and injuries in both groups were similar, which suggested that the results obtained after surgery were mainly due to the mode of fixation and not the differences between patients. Road traffic accidents were the main cause of injuries, and the majority of fractures were of Herscovici Type B. Satisfactory bone union, progressive functional improvement, and low complication rate were achieved in both groups.

The radiological evaluation confirmed complete fracture union in all patients, most of which occurred within 10-12 weeks after surgery. However, despite the CC Screw group showing a slight superiority in the mean time to fracture union compared to the TBW group, there was no statistically substantial alteration among the two groups. This information designates that the use of either fixation technique provides an adequate level of stability for reliable fracture healing if the anatomical reduction is achieved. Similar results were found by Ethiraj et al. (2022) who found satisfactory fracture healing after the surgical treatment of medial malleolus fractures. Moreover, Giordano et al. (2024) have found that stable screw fixation provides enough interfragmentary compression for successful fracture union. Pain levels of patients decreased progressively in both groups throughout the follow-up period. In particular, the CC Screw group had consistently lower Visual Analogue Scale (VAS) scores; however, the difference was not statistically significant. This data suggests that both fixation techniques provide effective pain control and help in recovering from surgery. Similar outcomes were reported by Afifi et al. (2024) who found favorable outcomes after screw fixation of medial malleolar fractures. Yurul et al. (2021) found that different fixation techniques provide similar biomechanical stability and thus effective pain control and rehabilitation.

There was steady improvement in functional recovery, measured by the AOFAS Ankle-Hindfoot Score. Excellent and good functional recovery was achieved by most of the patients within six months after surgery, with no substantial alteration detected among the two groups. While the CC Screw group showed slightly higher average scores compared to the AO Internal Fixation group, both techniques resulted in successful restoration of ankle functionality. This is supported by the findings of Islam et al. (2025) in their study on functional recovery in cases of operative fixation of ankle fractures involving the medial malleolus. Similarly, Li et al. (2025) highlight that stable cannulated screw fixation facilitates early ambulation and good functional recovery after fixation.

Postoperative complications were rare in both groups. The most common postoperative complication was hardware irritation, which was seen more frequently in TBW cases, while other complications such as superficial infection, delayed union, implant failure, and wound dehiscence were rare. Secondary implant removal was also more common in TBW cases; however, there was no statistical significance. This implies that both surgical procedures are safe, but TBW is more prone to implant-related irritation owing to hardware prominence. Kong et al. (2024) also made similar observations about the role of fixation constructs in implant-related complications.

On a clinical basis, the results suggest that the use of both the methods can be considered in orthopaedics. CC Screw Fixation can be used for the cases where there is sufficient size of the fracture for the provision of interfragmentary compression and decrease of implant-related symptoms. In turn, the TBW can be considered in the case where there is a problem in using screws due to the size of the fragment. However, proper preoperative planning and surgical technique are necessary for obtaining the best possible results no matter what the chosen method of fixation is. There are numerous boundaries of the present investigation. First of all, the number of patients in the sample (30) and its monocentric character and six-month follow-up period can restrict the generalisability of the findings and prevent from evaluating the functional outcomes and complications in the long run. Second, the allocation of treatment was performed based on the decision of the surgeon during the surgery and not randomly, so the risk of selection bias cannot be excluded.

Further multicentric prospective studies with large samples, random allocation of the treatment and long follow-up period are necessary for the validation of the findings. Additional research should include patient-reported outcomes, cost-effectiveness analysis and long-term evaluation of ankle function and implant-related complications.

5. CONCLUSION

This current prospective comparative investigation showed that both CC Screw fixation and TBW are secure and efficient surgical procedures for the surgical management of medial malleolus fractures. Both treatment approaches yielded satisfactory radiographic fracture healing, gradual pain reduction, improved functional results, and low complication rates inside the six-month follow-up period. Despite the fact that the CC Screw group had significantly shorter fracture union time, reduced pain levels, increased AOFAS scores, and fewer implant-related complications compared to the TBW group, there were no statistically substantial alterations among the two groups. Radiographic healing was achieved in all patients, while most of the individuals had either an excellent or good functional consequence in the final follow-up, suggesting that both methods are reliable fracture stabilizers. Irritation from hardware and secondary implant removal was more common in the TBW group, but the overall pattern of complications was similar in both groups. It can be said that there is no superior method of fixation for these fractures in terms of healing, function, or complication rate. Thus, the selection of fixation technique should be individualised based on the nature of the fracture, the size of fragments, the quality of bone, and intraoperative assessment. Further studies including large multicentre randomised trials with extended follow-up are required to establish the best fixation technique for various types of medial malleolar fractures.

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