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A Comparison of the Functional Outcome of Closed and Extra-Articular Distal 1/3rd Tibial Fractures: Interlock Nailing vs. Plating

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ABSTRACT

Tibia fractures are among the most common long bone fractures, with distal tibial fractures representing 10-13% of all tibial fractures. This study aimed to compare the outcomes of different treatment modalities for closed distal tibial fractures, specifically focusing on Open Reduction and Internal Fixation (ORIF) with plating and Closed Reduction and Internal Fixation (CRIF) with interlocking nails. This descriptive study was conducted over two years at MGM Medical College and Hospital, Aurangabad and included 100 patients aged 18-90 years (mean age: 45.53 years; standard deviation: 17.902). The fractures primarily resulted from road traffic accidents (73%) and falls (27%). The study compared the duration of weight-bearing, hospital stays, time to return to work, range of motion, callus formation, bone union and functional outcomes between the CRIF with interlocking nail group and the ORIF with plating group. The CRIF with interlocking nail group had significantly shorter durations for nil weight-bearing (mean: 5.52 weeks), partial weight-bearing (mean: 10.4 weeks) and full weight-bearing (mean: 16.02 weeks) compared to the ORIF with plating group (nil weight-bearing mean: 8.55 weeks., partial weight-bearing mean: 14.86 weeks., full weight-bearing mean: 21.14 weeks., $p<0.001$). The CRIF group also had shorter hospital stays (mean: 5.64 days) compared to the ORIF group (mean: 14.227 days., $p<0.001$). Additionally, the time to return to work was significantly shorter in the CRIF group (mean: 5.12 weeks) compared to the ORIF group (mean: 6.00 weeks; $p<0.001$). Significant improvements in range of motion ($p=0.015$), callus formation ($p<0.001$) and bone union ($p<0.001$) were observed over 12 months for both treatment groups. Functional outcomes were also better in the CRIF group, with a higher number of "Excellent" and "Good" outcomes compared to ORIF ($p=0.001$). ORIF and CRIF both treatment methods were effective, but CRIF offered advantages in quicker rehabilitation and return to normal activities. The study highlights the importance of selecting the appropriate treatment modality based on individual case characteristics to optimize patient outcomes.

INTRODUCTION

Tibia fractures are among the most frequent long bone fractures, accounting for approximately 2% of all adult fractures[1,2]. Distal tibial fractures, in particular, have an incidence rate of 0.6% and represent around 10-13% of all tibial fractures[3]. In 1962, Ruedi and Allowed published a pivotal study in which they reported that 74% of patients achieved a good functional outcome after four years of follow-up, which significantly influenced the treatment protocols for distal tibia fractures[4]. During the 1970s and 1980s, Open Reduction and Internal Fixation (ORIF) became widely adopted for managing fractures of the lower third of the tibia. However, this approach was linked to a high rate of complications, including superficial infections, arthrodesis, osteomyelitis, non-union and malunion[5,6]. Distal tibial fractures can result from either low-energy or high-energy injuries. Low-energy fractures are more common in the older population and are typically caused by rotational forces following minor falls or slips[7]. This mechanism often results in spiral fractures, with or without intra-articular extension. In contrast, high-energy fractures, which generally affect younger individuals, usually occur due to road traffic accidents or falls from height[8]. These injuries involve axial loading, compression and torsional forces, leading to comminuted fractures that may extend into the ankle joint[9-11]. Currently, both minimally invasive plate osteosynthesis (MIPO) and intramedullary nailing (IMN) are well-established techniques for treating distal tibial fractures, each with its own advantages and disadvantages. Nailing is commonly associated with knee pain and malalignment[12,13], whereas plating can lead to wound complications and implant prominence[14]. The purpose of this study is to compare, analyze and determine the most appropriate treatment modality for managing distal tibial fractures, based on individual case characteristics.

MATERIALS AND METHODS

The study was a descriptive study conducted following approval from the ethical committee of the hospital. It included approximately 100 cases and was carried out over a period of 2 years, from 1st October 2022 to 10th June 2024, at MGM Medical College and Hospital, Aurangabad, specifically in the Department of Orthopedics. The study focused on patients admitted to the orthopedic ward and operated on for closed distal tibial fractures. The inclusion criteria comprised adults aged 18-90 years with distal tibial fractures, specifically closed, extra-articular, displaced, or un displaced fractures. Patients were excluded if they had compound fractures, partial articular fractures, or were unfit for surgery due to severe cardiac morbidity or other absolute contraindications for anesthesia. All patients presenting with distal tibial fractures (closed, extra-articular) to the Orthopedics outpatient and emergency department and meeting the study's inclusion and exclusion criteria, were selected. Written informed consent was obtained from the chosen patients before conducting any regular investigations. Each patient underwent a thorough clinical and radiological examination and pre-anesthetic fitness was obtained. The fixation modality was determined based on the type of fracture, whether extra-articular, intra-articular, or comminuted. Patients were assessed for major injuries to the head, chest and abdomen and their affected limb was immobilized using an above -knee slab, elevated on a B.B. splint. Analgesics were administered as needed and tetanus toxoid was given. A complete medical history was obtained, including details of the injury, comorbidities such as hypertension, diabetes and pulmonary disorders, along with medication history. Personal history, including smoking, tobacco use, and previous injuries, was also recorded. A local examination assessed the skin condition, swelling, tenderness, range of motion and neurovascular status, while an X-ray ruled out other fractures and bony pathologies. The pre-operative work up included hematological tests, serology, chest X-ray and ECG to ensure anaesthetic fitness. Radiological findings were reviewed with an Orthopaedic Trauma surgeon to plan the appropriate procedure. The treatment, procedure, risks, complications and prognosis were explained to the patient and their relatives and the recommended procedure was advised based on the fracture type. Pre-operative planning included advising the patient to be nil by mouth (NBM), starting intravenous fluids as needed, reserving cross-matched blood and administering intravenous antibiotics (Injection Cefuroxime Axetil 1.5grams) 30 minutes before surgery. The treatment of distal tibial fractures involved various approaches depending on the severity and type of fracture. In cases of non-displaced or minimally displaced fractures, conservative management through splinting and casting was employed. Initially, the fracture was stabilized using a splint to allow for swelling reduction, followed by the application of a circumferential cast to maintain immobilization for a period of 6-12 weeks, with regular follow-up to monitor healing. For more stable fractures, C.C. screws, both partial and fully threaded, were used. These were inserted per cutaneously under fluoro scopic guidance, with partial-threaded screws providing compression at the fracture site and fully threaded screws maintaining position without compression. In cases of comminuted, unstable, or intra-articular fractures, open reduction and internal fixation with plating were performed, involving a surgical incision to anatomically reduce the fracture and secure it with a pre-contoured plate and screws. External fixation was utilized for open fractures or those with severe soft tissue damage, where pins or wires were inserted into the bone and connected to an external frame, serving as either a definitive treatment or a temporary stabilization method. Lastly, for long oblique, spiral, or comminuted fractures, especially in younger, active patients, an interlock nail was used. This involved the insertion of a guide wire and intramedullary nail into the medullary cavity, secured with locking screws to provide stable fixation while allowing for early mobilization. Data were analyzed using SPSS software version 20. An Analysis of Variance (ANOVA) test was employed to compare the outcomes across different treatment modalities. Additionally, Cochran's Q test was used to assess the differences in categorical variables.

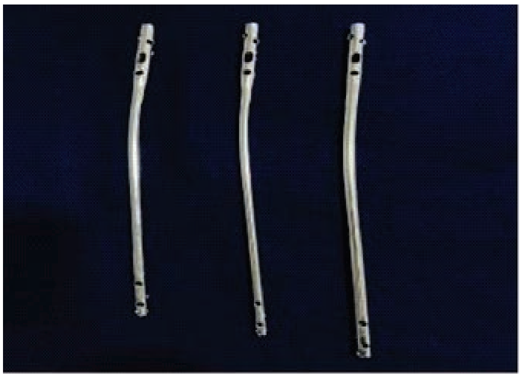

Fig. 1 : Expert Tibia Nail

Fig. 2: Expert Tibia Nail Assembled with Proximal Locking Jig

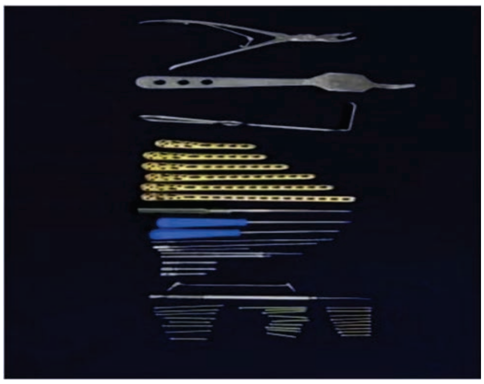

Fig. 3: Plate Set Instrumentation

Fig. 4: Various Sizes of Distal Tibia Plate

Fig. 5: MIPO Plating Technique

Fig. 6: Small Skin Incisions

RESULTS AND DISCUSSIONS

Mean age of 100 study sample was 45.53 years (standard deviation-17.902 years), with the highest 89 years and lowest 18 years. There were 75% male and 25% female in the study while 23% samples were from 41-50 years age group followed by 21% from 31-40 years age group. A study on closed distal tibial fractures revealed that 73% of the injuries were caused by road traffic accidents, while falls accounted for 27%. The fractures predominantly affected the right side in 54% of cases, with the left side involved in 46%. Various associated injuries were noted, including distal 1/3rd fibula fractures in 39% of patients, proximal

1/3rd fibula fractures in 10%, mid-shaft fibula fractures and segmental fibula fractures each in 3%, talus fractures and distal end radius fractures each in 2% and distal end femur fractures, medial malleolus fractures and proximal 1/3rd tibia fractures each in 1% of cases. The AO classification types for closed distal tibial fractures showed the following distribution in percentages: Type 42-C1 fractures accounted for 11% of the cases, while Type 43-A1 fractures were the most common, comprising 59%. Type 43-A2 fractures were observed in 12% of the cases and Type 43-A3 fractures made up 18%.

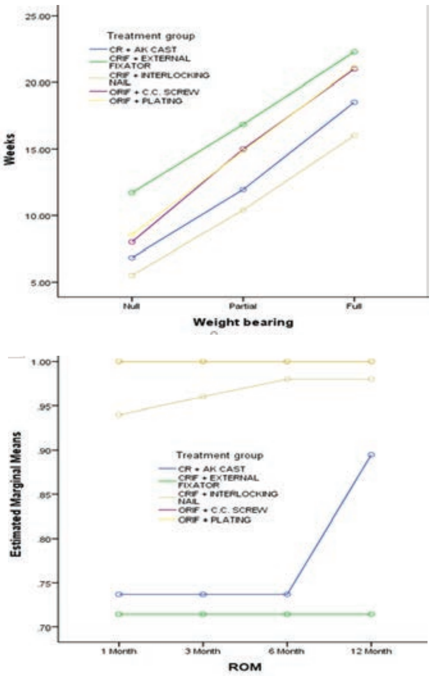

Fig. 7: Line Diagram Showing Weight Bearing and ROM in Different Treatment Modalities

In the study examining the impact of different treatment modalities on weight-bearing time lines for closed distal tibial fractures, it was found that the CRIF with interlocking nail group had a mean duration of 5.52 weeks for nil weight bearing, 10.4 weeks for partial weight bearing and 16.02 weeks for full weight bearing. In comparison, the ORIF with plating group had mean durations of 8.55 weeks for nil weight bearing, 14.86 weeks for partial weight bearing and 21.14 weeks for full weight bearing. The between -subjects effects test indicated a significant difference among the treatment groups, with a Type III Sum of squares of 1322.588 and a mean square of 330.647 (F=14.134, p<0.001), accounting for 37.3% of the variance in weight-bearing time lines. This suggests that patients treated with CRIF and interlocking nails generally had shorter durations for nil and partial weight bearing compared to those treated with ORIF and plating (Fig. 7). The study on post-surgery restriction of movement (ROM) showed significant improvement over 12 months. Mean ROM scores increased from 0.90 at 1 month to 0.95 at 12 months, indicating better movement over time. Initially, 10 patients had restricted ROM, which reduced to 5 patients by 12 months. The Cochran's Q test confirmed this improvement was statistically significant (Q=10.500, p=0.015). Thus, most patients experienced better ROM as time progressed (Fig. 7).

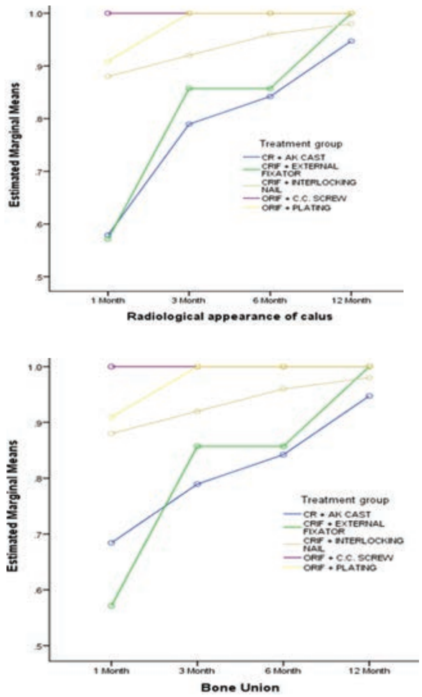

Fig. 8: Line Diagram Showing Radiological Appearance of Calus and Bone Union in Different Treatment Modalities

The study on the radiological appearance of callus formation after surgery showed significant improvement over 12 months. The mean scores increased from 0.81 at 1 month to 0.98 at 12 months, indicating more callus formation over time. At 1 month, callus was seen in 81 patients and not seen in 19. By 12 months, callus was seen in 98 patients and not seen in only 2. The Cochran's Q test confirmed this improvement was statistically significant (Q=35.111, p<0.001). Therefore, the radiological appearance of callus significantly improved over the year following surgery (Fig. 8). The study on bone union after surgery showed significant improvement over 12 months. Mean scores for bone union increased from 0.83 at 1 month to 0.98 at 12 months. Initially, 83 patients achieved bone union, while 17 did not. By 12 months, 98 patients had bone union and only 2 did not. The Cochran's Q test confirmed this improvement was statistically significant (Q=30.250, p<0.001). Therefore, the occurrence of bone union significantly improved over the year following surgery (Fig. 8).

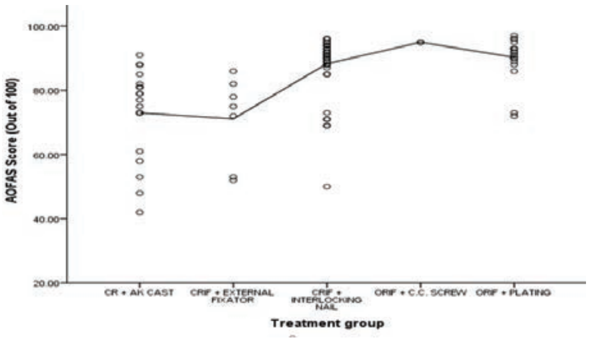

Fig. 9: AOFAS Score in Different Treatment Modalities

In the analysis of AOFAS scores for different treatment groups, the CRIF+Interlocking Nail and ORIF+Plating groups demonstrated notably high outcomes. The CRIF +Interlocking Nail group had a mean score of 88.3 with a standard deviation of 8.728, ranging from 50-96. Similarly, the ORIF+Plating group had a mean score of 90.273 with a standard deviation of 6.333, ranging from 72-97. These scores indicated superior performance compared to other groups and the ANOVA results confirmed that the differences between treatment groups were statistically significant (F=13.950, p=.000). (Fig. 9).

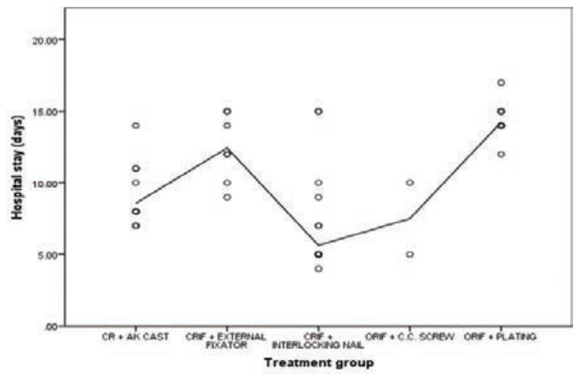

Fig. 10: Line Diagram Showing Hospital Stay in Different Treatment Modalities

In the analysis of hospital stay duration for different treatment groups, the CRIF+Interlocking Nail and ORIF +Plating groups showed distinct differences. The CRIF +Interlocking Nail group had a mean hospital stay of 5.64 days with a standard deviation of 2.164, ranging from 4-15 days. In contrast, the ORIF+Plating group had a significantly longer mean hospital stay of 14.227 days with a standard deviation of 0.869, ranging from 12-17 days. The ANOVA results confirmed that these differences between treatment groups were statistically significant (F=85.043, p=.000). (Fig. 10).

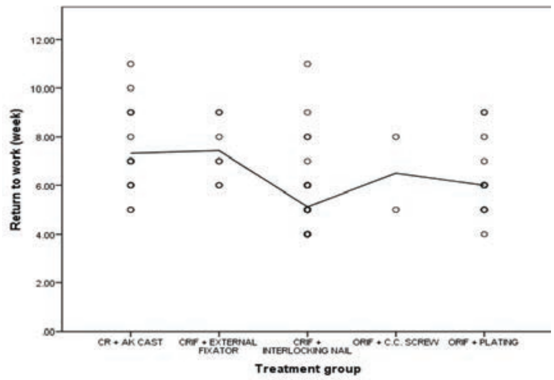

Fig. 11: Line Diagram Showing Time Return to Work in Different Treatment Modalities

In the analysis of the time taken to return to work for different treatment groups, the CRIF+Interlocking Nail and ORIF+Plating groups showed notable differences. The CRIF+Interlocking Nail group had a mean return to work time of 5.12 weeks with a standard deviation of 1.423, ranging from 4-11 weeks. The ORIF+Plating group had a mean return to work time of 6.00 weeks with a standard deviation of 1.272, ranging from 4-9 weeks. The ANOVA results indicated that these differences between treatment groups were statistically significant (F=10.413, p=.000). (Fig. 11). In the analysis of functional outcomes by treatment group, the CRIF+Interlocking Nail and ORIF+Plating groups demonstrated significant variations. The CRIF+ Interlocking Nail group had the highest number of "Excellent" outcomes (6) and a predominant number of "Good" outcomes (38), with only one "Poor" outcome. Conversely, the ORIF+Plating group had 4 "Excellent" outcomes, 2 "Fair" and 16 "Good" outcomes, with no "Poor" outcomes. The Pearson Chi-Square test confirmed that the differences in functional outcomes across treatment groups were statistically significant (χ^2=31.812, p=.001). In the analysis of the type of bone union by treatment group, the CRIF+Interlocking Nail and ORIF+Plating groups showed distinct patterns. The CRIF+Interlocking Nail group had 14 cases of primary union, 35 cases of secondary union and only 1 case of atrophic non-union. In contrast, the ORIF+Plating group had 20 cases of primary union and 2 cases of secondary union, with no atrophic non-union cases. The Pearson Chi-Square test indicated that these differences in the type of union among treatment groups were statistically significant (χ^2=49.185, p=.000).

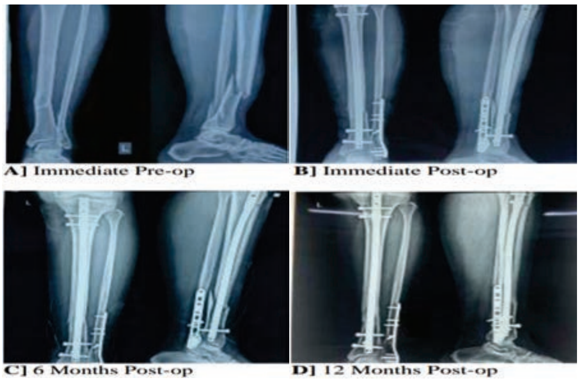

Fig. 12: Radiological Outcome of Pre and Post Operative for CRIF+Expert Tibia Nailing

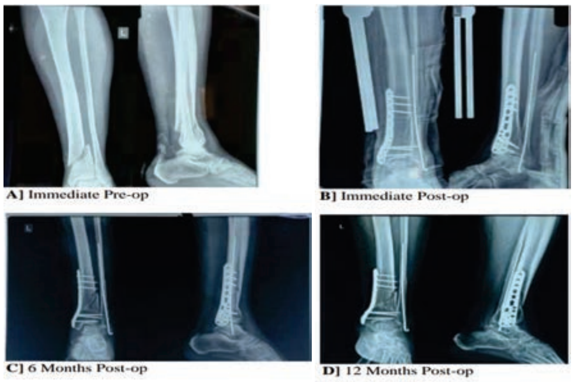

Fig. 13: Radiological Outcome of Pre and Post Operative for ORIF+Distal Tibia Automatic Plaiting

The primary objectives in managing distal tibial fractures include achieving anatomical reduction, maintaining joint stability, restoring axial alignment, ensuring fracture union and facilitating pain-free weight-bearing and motion without wound complications[15]. In our study, the mean age was 45.53 years (SD: 17.902), ranging from 18- 89 years, with 75% male participants. The most represented age groups were 41-50 years (23%) and 31-40 years (21%). Bajaj S *et al.* reported a mean age of 48.7 years (range: 19-68 years) with 55% male participants[16]. Katsenis *et al.* found a mean age of 35.5 years (range: 20-71 years) with 64% male participants[17]. In our study, 27% of closed distal tibial fractures were due to falls, while 73% were caused by road traffic accidents (RTA). The fractures affected the left side in 46% of cases and the right side in 54%. Distal 1/3rd fibula fractures were the most common associated injury (39%), and 94% of cases were initially treated with an AK slab. According to the AO classification, 59% of fractures were Type 43-A1 and 18% were Type 43-A3. Saini R *et al.* reported that 63.33% of injuries were due to RTA[18]. Cory Collinge *et al.* observed 100% high-energy fractures in their study[19], while Shrestha D *et al.* reported that 50% of their patients were injured due to RTA and 40% due to falls[20]. Similarly, Ch. Banikanta Sharma *et al.* reported that 81% of injuries were due to RTA[21]. In our study, weight-bearing timelines for patients treated with CRIF and interlocking nails were 5.52 weeks for nil, 10.4 weeks for partial and 16.02 weeks for full weight-bearing. For ORIF and plating, the time lines were 8.55 weeks, 14.86 weeks and 21.14 weeks, respectively, with a significant difference between the groups (F=14.134, p<0.001). Tukade MB *et al.* reported 13.86 weeks for plating, 11.09 weeks for nailing and 12 weeks for the Ilizarovmethod[22]. Kumar A *et al.* found 11.48 weeks for the IMIL group and 12.96 weeks for the MIPPO group, with a significant difference (p=0.001)[23]. Bone union significantly improved over 12 months, with mean scores rising from 0.83 at 1 month to 0.98 at 12 months. Initially, 83 patients achieved bone union and by 12 months, 98 patients had bone union, with only 2 not achieving it. Cochran's Q test confirmed this improvement (Q=30.250, p<0.001). In contrast, Rathod SR *et al.* found a higher rate of delayed union in group 2 (20%) compared to group 1 (10%)[24]. In our study, AOFAS scores significantly differed between treatment modalities, with CRIF+ Interlocking Nail scoring 88.3 (SD 8.728) and ORIF+ Plating scoring 90.273 (SD 6.333) (F=13.950, p=.000). Prakash V *et al.* reported mean scores of 77.2 for IM Nail, 70.5 for Ext. Fix and 88.1 for MIPO[25]. Nath R *et al.* found mean scores of 91.2±6.81 for MIPO and 92.6±5.41 for IMN, with mean union times of 21.07± 2.05 weeks and 18.29±2.13 weeks, respectively (p>0.05)[26]. Solanki R *et al.* reported scores of 75.2 (SD 8.3) for IM Nail, 71.5 (SD 5.9) for Ext. Fix and 87.1 (SD 7.4) for MIPO (p<0.001)[27]. After six months, 20% of our patients achieved an excellent outcome, 60% had a good outcome, and 20% had a fair outcome[28]. Saini R *et al.* reported 70% excellent, 26.66% good and 3.33% fair outcomes based on AOFAS scores[18]. Abdulla S *et al.* found 80% excellent results with their operative method[29], while Shikhar D Singh et al. reported 46% excellent, 30% good, 13.3% fair and 10% poor results using the Olerud-MolanderAnkle Score[30]. Ozkaya U *et al.* Noted that 81% of patients treated with titanium locking compression plates using the MIPO technique achieved good to excellent outcomes based on AOFAS scores[31]. In our study, functional outcomes showed that the CRIF+Interlocking Nail group predominantly achieved "Excellent" (6) and "Good" (38) results, while the ORIF + Plating group had "Excellent" (4) and "Good" (16) outcomes, with statistically significant differences (χ^2=31.812, p=.001). Tukade MB *et al.* reported mean OMAS scores for plating, nailing and Ilizarov techniques as 85 (SD 5.97), 87.27 (SD 5.17) and 85 (SD 7.07), respectively, with no significant differences (p=0.59)[22]. Kumar A *et al.* also found no significant difference in functional outcomes between IMIL and MIPPO groups, with mean scores of 84.84±9.66 and 84.26±11.79, respectively (p=0.75656)[23]. In our study, bone union varied significantly: CRIF+Interlocking Nail had 14 primary unions, 35 secondary unions and 1 atrophic non-union, while ORIF+Plating had 20 primary unions and 2 secondary unions (χ^2=49.185, p=.000). Tukade MB *et al.* found the mean fracture union duration was significantly different, with plating taking 21 weeks (SD 1.92), nailing 19.36 weeks (SD 2.42) and the Ilizarov technique 24 weeks (SD 1.63) (p=0.002)[22]. A meta-analysis by Guo, J. J., *et al.* of 354 patients managed with intramedullary nailing versus plating found no significant difference in postoperative union time between the groups (SMD=-0.20, 95% CI -0.58-0.18, p=0.3)[32].

CONCLUSION

The study concluded that CRIF with interlocking nails generally led to shorter hospital stays, faster recovery, and better early functional outcomes than compared to ORIF with plating for patients with closed Distal Tibial fractures. Patients treated with CRIF experienced shorter durations for nil and partial weight-bearing and returned to work sooner than those treated with ORIF. Significant improvements in range of motion, callus formation and bone union were observed over 12 months for both treatment groups. Overall, both treatment methods were effective, but CRIF offered advantages in quicker rehabilitation and return to normal activities. ORIF+Plating had the advantage of a marginally better bone union rate.

Ethics Approval and Consent to Participate: Ethical approval for conducting the study was obtained from MGM Medical College and Hospital, Aurangabad, Maharashtra. Written informed consent was obtained from the patient for their participation in the study.

Consent for Publication: The patient's informed consent has been acquired for the publication of the case details, clinical images and relevant medical information. All effort shave been made to ensure patient confidentiality and any identifying information has been appropriately anonymized.

Competing Interests: The authors declare no competing interests, financial or otherwise, that could have in flounced the content or interpretation of this case study.

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