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# Comparative Study of Intramedullary Nail Fixation versus Plate Fixation for Distal Fibula Fractures with Associated Ankle Instability: A Prospective Randomized Study.

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## Abstract

***Background:*** Distal fibula fractures associated with ankle instability commonly require operative fixation to restore ankle alignment and stability. Plate fixation remains a widely used method; however, it may be associated with soft-tissue complications and hardware-related symptoms. Intramedullary nail fixation provides an alternative, minimally invasive method that may reduce soft-tissue morbidity while achieving comparable stability and fracture healing. Aim: To compare the functional and radiological outcomes and complications of intramedullary nail fixation versus plate fixation in patients with distal fibula fractures associated with ankle instability. ***Materials and methods***: This prospective randomised study was conducted in the Department of Orthopaedics, tertiary care hospital in Rajasthan from October 2023 to October 2026. A total of 30 patients with closed distal fibula fractures associated with ankle instability were included and randomly allocated into two groups of 15 patients each. One group underwent intramedullary nail fixation, while the other underwent plate fixation. Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score and pain using the Visual Analog Scale (VAS). Radiological parameters, fracture healing and postoperative complications were assessed during follow-up. Statistical analysis was performed to compare outcomes between the two groups. ***Results***: The mean age was comparable between the intramedullary nail and plate groups (48.26±7.91 vs 47.15±8.25 years; p>0.05). Danis-Weber type B fractures were the most common fracture pattern in both groups. The mean fracture healing duration was 9.63±2.38 weeks in the intramedullary nail group and 9.21±1.70 weeks in the plate group (p=0.47). At six months, the mean AOFAS score was 91.75±10.62 and 92.41±11.35 in the nail and plate groups, respectively (p=0.83). However, the mean VAS score at six months was significantly lower in the nail group compared with the plate group (5.12±4.42 vs 8.75±4.92; p=0.04). Radiological parameters, including medial clear space, tibio-malleolar angle, fibular length, talar angle and tibio-fibular clear space, showed no significant differences between the groups. Overall complications occurred in 13.33% of patients in the nail group compared with 46.67% in the plate group; however, this difference was not statistically significant. Superficial wound infection and hardware-related complications were more frequently observed in the plate group. ***Conclusion***: Intramedullary nail and plate fixation provided comparable functional and radiological outcomes for distal fibula fractures with associated ankle instability. Intramedullary nail fixation was associated with significantly lower pain at six months and a lower numerical incidence of complications, particularly wound and hardware-related problems. However, the difference in overall complication rates did not reach statistical significance. Larger studies with longer follow-up are required to establish the comparative advantages of either fixation method.

**Keywords:** Distal fibula fracture; Ankle instability; Intramedullary nail fixation; Plate fixation; Ankle fracture; Functional outcome; AOFAS score; Complications.



## INTRODUCTION

Ankle fractures are among the most common lower-limb fractures, with a reported incidence of approximately 107–187 cases per 100,000 population. Their management is particularly important because restoration of ankle mortise congruency and stability is essential for satisfactory long-term function [1-3]. Distal fibula fractures may occur in isolation or as part of more complex ankle injuries, and associated disruption of the syndesmosis, medial malleolus or talar position may result in ankle instability.

The fibula plays an important role in maintaining ankle mortise stability. In unstable distal fibula fractures, surgical treatment aims to restore fibular length, alignment and rotation and to achieve anatomical reduction of the ankle mortise. Accurate restoration is important to minimise the risk of malunion, chronic instability and post-traumatic degenerative changes [4]. Danis-Weber classification is commonly used to describe fibular fractures according to their relationship with the syndesmosis and provides useful guidance regarding the stability of the ankle injury.

Open reduction and internal fixation using a plate and screws has traditionally been the standard method for operative treatment of unstable distal fibula fractures. Plate fixation provides reliable fracture reduction and fixation across different fracture patterns. However, the lateral aspect of the distal fibula has limited soft-tissue coverage, and plate fixation may therefore be associated with wound problems, infection, implant prominence, irritation and subsequent implant removal, particularly in patients with increased soft-tissue risk [5,6].

Intramedullary nail fixation has emerged as a less invasive alternative for distal fibula fractures. Fibular nailing requires a smaller surgical exposure and less soft-tissue dissection, potentially reducing wound-related complications and implant prominence. Modern locked fibular nails are also designed to provide axial and rotational stability comparable with plate constructs [7]. However, concerns remain regarding fixation of very distal or comminuted fractures and the appropriate indications for nail fixation.

Comparative studies have reported broadly similar fracture union and functional outcomes between intramedullary nailing and plating, while several studies have suggested fewer wound and hardware-related complications with intramedullary fixation [7,8]. A recent systematic review and meta-analysis of randomised controlled trials also found no significant difference in functional outcomes or union rates between the two techniques, although intramedullary nailing showed advantages in some complication-related outcomes [9].

Despite increasing use of fibular nails, evidence specifically addressing distal fibula fractures associated with ankle instability remains limited, with differences in fracture patterns, definitions of instability and outcome assessment among published studies. Therefore, prospective comparative evaluation is required to determine whether intramedullary nail fixation provides outcomes comparable to conventional plate fixation while reducing postoperative morbidity.

The present study was undertaken to compare intramedullary nail fixation with plate fixation for distal fibula fractures with associated ankle instability, with particular emphasis on functional outcome, radiological parameters, fracture healing and postoperative complications.

## MATERIALS AND METHODS

### Study Design and Participants

This prospective randomised comparative study was conducted in the Department of Orthopaedics, in a tertiary care hospital in Rajasthan from October 2023 to October 2026. A total of 30 patients with distal fibula fractures fulfilling the eligibility criteria were included in the study and divided into two groups of 15 patients each. Patients in one group underwent intramedullary nail fixation, while those in the other group underwent plate fixation.

Prior approval was obtained from the Institutional Ethics Committee. Written informed consent was obtained from all participants after explaining the nature, purpose, procedure, potential risks and benefits of the study.

Patients aged 18–50 years with recent closed distal fibula fractures, either isolated or associated with medial or posterior malleolar fractures, who were skeletally mature and willing to undergo operative management were included. Patients aged below 18 years, those with neglected or old fractures, previous ankle surgery, open or pathological fractures, associated talar fractures, pre-existing ankle deformity, disability or infection, and those unwilling to undergo surgical management were excluded.

### Clinical, Radiological and Outcome Assessment

A detailed history and clinical examination were performed for all patients. The affected ankle was examined for deformity, tenderness, abnormal mobility and range of motion. Fractures were classified according to the Danis-Weber classification, while the Lauge-Hansen classification was used to describe the mechanism of injury. Radiographic evaluation was performed using anteroposterior, lateral and mortise views of the ankle.

Patients were managed surgically with either intramedullary nail fixation or plate fixation. Following surgery, patients were evaluated clinically and radiologically at discharge and subsequently at one, three and six months. Ankle exercises were advised during follow-up to facilitate functional recovery.

Radiological assessment included fracture healing and restoration of ankle alignment. The parameters evaluated included medial clear space, tibio-malleolar angle, fibular length, talar angle and tibio-fibular clear space. Fracture union was assessed clinically and radiologically and was defined as the presence of bridging callus across at least three cortices on radiographs, together with absence of pain and abnormal mobility at the fracture site.

Pain was assessed using the Visual Analog Scale (VAS), while functional outcome was evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) score at follow-up visits. Postoperative ankle range of motion was also assessed. Complications, including superficial wound infection, hardware irritation or pain, delayed union and implant-related complications, were recorded during the follow-up period.

**Statistical Analysis**

The collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS), version 26.0. Continuous variables were expressed as mean±standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons between the two groups were performed using the Chi-square test for categorical variables and Student's t-test or Analysis of Variance (ANOVA) for continuous variables, as appropriate. A p-value <0.05 was considered statistically significant.

## RESULTS

A total of 30 patients with distal fibula fractures were included in the study, with 15 patients each in the intramedullary nail fixation and plate fixation groups. The baseline demographic and fracture characteristics of both groups were comparable. The mean age was 48.26±7.91 years in the nail fixation group and 47.15±8.25 years in the plate fixation group. There was no statistically significant difference in age or gender distribution between the groups. The mean Body Mass Index (BMI) was also comparable. According to the Danis-Weber classification, Type B fractures were more common in both groups, comprising 66.67% of the nail fixation group and 60.00% of the plate fixation group. According to the AO classification, 44-B2 fractures were most common in the nail group, whereas 44-C1 fractures predominated in the plate group. None of these baseline differences were statistically significant (Table 1).

**Table 1: Baseline demographic and fracture characteristics of the study groups**

| Parameter | Nail fixation (n=15) | Plate fixation (n=15) | p-value |
|---|---|---|---|
| Age (years), Mean±SD | 48.26±7.91 | 47.15±8.25 | 0.71 |
| Male, n (%) | 8 (53.33) | 6 (40.00) | 0.78 |
| Female, n (%) | 7 (46.67) | 9 (60.00) | |
| BMI (kg/m²), Mean±SD | 25.98±4.30 | 26.53±5.00 | 0.67 |
| Preoperative VAS (0–100 mm), Mean±SD | 76.48±8.35 | 78.93±7.81 | 0.60 |
| Danis-Weber Type B, n (%) | 10 (66.67) | 9 (60.00) | 0.71 |
| Danis-Weber Type C, n (%) | 5 (33.33) | 6 (40.00) | |
| AO 44-B1, n (%) | 4 (26.67) | 5 (33.33) | 0.74 |
| AO 44-B2, n (%) | 6 (40.00) | 4 (26.67) | |
| AO 44-C1, n (%) | 5 (33.33) | 6 (40.00) | |

Radiological outcomes were comparable between the two fixation techniques. Mean fracture healing duration was 9.63±2.38 weeks in the nail group and 9.21±1.70 weeks in the plate group (p=0.47). Similarly, medial clear space, tibio-malleolar angle, fibular length, talar angle and tibio-fibular clear space did not differ significantly between the groups (Table 2).

**Table 2: Comparison of radiological outcome parameters between the study groups**

| Parameter | Nail Fixation | Plate Fixation | P Value |
|---|---|---|---|
| Healing duration (weeks), mean ± SD | 9.63 ± 2.38 | 9.21 ± 1.70 | 0.47 |
| Medial Clear Space (mm) | 2.57 ± 0.41 | 2.45 ± 0.52 | 0.36 |
| Tibio-Malleolar Angle (°) | 109.12 ± 6.05 | 110.42 ± 5.61 | 0.43 |
| Fibular Length (mm) | 27.18 ± 2.95 | 27.05 ± 3.11 | 0.88 |
| Talar Angle (°) | 79.35 ± 3.95 | 78.76 ± 3.42 | 0.57 |
| Tibio-Fibular Clear Space (mm) | 3.77 ± 1.21 | 3.84 ± 1.29 | 0.84 |

*Data expressed as Mean±SD.*

Pain progressively decreased in both groups during follow-up. At one month, the mean VAS score was 31.42±9.64 in the nail fixation group and 34.17±8.92 in the plate group (p=0.42). At three months, the respective values were 14.26±7.58 and 16.13±6.81 (p=0.48). At six months, however, the nail fixation group showed a significantly lower VAS score compared with the plate fixation group (5.12±4.42 vs 8.75±4.92; p=0.04).

AOFAS scores progressively improved in both groups. At six months, the mean AOFAS score was 91.75±10.62 in the nail group and 92.41±11.35 in the plate group, with no significant difference (p=0.83). Postoperative ankle extension and flexion were slightly greater in the nail fixation group, although the differences were not statistically significant (Table 3).

**Table 3: Comparison of pain, functional outcome and ankle range of motion**

| Outcome | Nail fixation (n=15) | Plate fixation (n=15) | p-value |
|---|---|---|---|
| **VAS score (0–100 mm)** | | | |
| 1 month | 31.42±9.64 | 34.17±8.92 | 0.42 |
| 3 months | 14.26±7.58 | 16.13±6.81 | 0.48 |
| 6 months | **5.12±4.42** | **8.75±4.92** | **0.04** |
| **AOFAS score** | | | |
| 1 month | 79.12±9.02 | 80.55±9.87 | 0.59 |
| 3 months | 87.48±8.65 | 88.93±9.42 | 0.57 |
| 6 months | 91.75±10.62 | 92.41±11.35 | 0.83 |
| Postoperative ankle extension (°) | 18.67±6.21 | 16.84±5.63 | 0.40 |
| Postoperative ankle flexion (°) | 45.41±7.31 | 43.81±6.79 | 0.54 |

*Data expressed as Mean±SD. A p-value <0.05 was considered statistically significant.*

Postoperative complications were numerically less frequent in the intramedullary nail group. Overall, complications were reported in 2 (13.33%) patients in the nail fixation group compared with 7 (46.67%) in the plate fixation group. Superficial wound infection was observed in two patients (13.33%) in the plate group and in none of the patients in the nail group. Hardware irritation or pain occurred in one patient (6.67%) in the nail group and three patients (20.00%) in the plate group. Delayed union was observed in one patient in each group, while implant failure occurred in one patient in the plate group and none in the nail group. Despite the numerical difference, the overall difference in complications was not statistically significant (p>0.05) (Table 4).

**Table 4: Comparison of postoperative complications between the study groups**

| Complication | Nail fixation n (%) | Plate fixation n (%) |
|---|---|---|
| Superficial wound infection | 0 (0.00) | 2 (13.33) |
| Hardware irritation/pain | 1 (6.67) | 3 (20.00) |
| Delayed union | 1 (6.67) | 1 (6.67) |
| Implant failure | 0 (0.00) | 1 (6.67) |
| **Total complications** | **2 (13.33)** | **7 (46.67)** |

The comparison of postoperative complications did not reach statistical significance (p>0.05).

## DISCUSSION

Distal fibula fractures associated with ankle instability require adequate reduction and stable fixation to restore the anatomy of the ankle mortise and achieve satisfactory functional recovery. Plate fixation has traditionally been widely used for unstable fractures; however, concerns regarding wound complications and implant-related symptoms have encouraged the use of minimally invasive intramedullary fixation. The present prospective randomised study compared intramedullary nail fixation and plate fixation in 30 patients with distal fibula fractures and evaluated radiological healing, pain, functional recovery, ankle range of motion and postoperative complications.

The demographic characteristics were comparable between the two groups. The mean age was 48.26±7.91 years in the nail fixation group and 47.15±8.25 years in the plate fixation group. Gender distribution, BMI and preoperative pain scores also showed no significant differences, indicating reasonable baseline comparability between the treatment groups. According to the Danis-Weber classification, Type B fractures predominated in both groups, accounting for 66.67% of the nail group and 60.00% of the plate group.

### Radiological and Fracture Healing Outcomes

The mean fracture healing duration was 9.63±2.38 weeks following nail fixation and 9.21±1.70 weeks following plate fixation, with no statistically significant difference (p=0.47). Furthermore, medial clear space, tibio-malleolar angle, fibular length, talar angle and tibio-fibular clear space were comparable between the two groups. These observations suggest that both fixation techniques were capable of achieving satisfactory fracture union and restoration of ankle alignment.

Comparable union between intramedullary and plate fixation has also been reported in the existing literature. Bäcker and Vosseller [7] observed that both techniques provided satisfactory fracture healing, with the minimally invasive nature of fibular nailing being a potential advantage in selected patients. Asloum et al. [8], in a prospective randomised study comparing fibular nailing and plating, similarly demonstrated satisfactory fracture healing with both techniques. More

recently, Zhang et al. [9] found no significant difference in union rates between intramedullary nail and plate fixation in their meta-analysis of randomised controlled trials. Similarly, Samuel et al. [10], in a systematic review involving 29 studies, reported union rates of approximately 99% following intramedullary fixation and 97% following plate fixation, with no significant difference in comparative studies. These findings support the present observation that the choice of implant did not materially affect fracture healing.

**Pain and Functional Outcome**

Pain progressively decreased in both groups during follow-up. At one and three months, VAS scores did not differ significantly between the groups. However, at six months, the mean VAS score was significantly lower in the nail fixation group than in the plate fixation group (5.12±4.42 versus 8.75±4.92; p=0.04). This may reflect reduced soft-tissue disruption and less implant prominence with intramedullary fixation. Nevertheless, as the absolute pain levels were low in both groups by final follow-up, this finding should be interpreted together with the overall functional outcome.

AOFAS scores showed progressive improvement in both groups. At six months, the mean AOFAS score was 91.75±10.62 in the nail group and 92.41±11.35 in the plate group (p=0.83). Thus, despite the lower final pain score following intramedullary fixation, overall ankle function was comparable between the two methods. Zhang et al. [9] also reported no significant difference in functional outcomes between fibular nail and plate fixation. Samuel et al. [10] observed a trend towards better AOFAS and Olerud-Molander scores following intramedullary fixation, but these differences were not statistically significant.

Chen et al. [11], in a prospective randomised study of 81 patients with supination-external rotation Type IV ankle injuries, likewise found no significant differences between nail and plate fixation in AOFAS score, VAS score, bone healing time or functional evaluation. These findings reinforce the observation that intramedullary nailing can achieve functional outcomes comparable to conventional plating.

Postoperative ankle range of motion was also comparable. Mean extension was 18.67±6.21° after nail fixation and 16.84±5.63° after plate fixation, while mean flexion was 45.41±7.31° and 43.81±6.79°, respectively. Although both movements were numerically greater in the nail group, neither difference was statistically significant. Thus, the method of fibular fixation did not appear to have a major influence on final ankle mobility in the present study.

**Postoperative Complications**

An important observation was the difference in postoperative complication patterns. Overall complications occurred in 2/15 (13.33%) patients following intramedullary nail fixation compared with 7/15 (46.67%) following plate fixation. However, owing to the small sample size, this difference did not reach statistical significance and therefore should be interpreted as a numerical rather than confirmed statistical advantage.

No superficial wound infection occurred in the nail group, whereas two patients (13.33%) developed superficial wound infection following plate fixation. Hardware irritation or pain was observed in one patient (6.67%) in the nail group and three (20.00%) in the plate group. Implant failure was absent following nail fixation but occurred in one plate fixation patient. Delayed union occurred in one patient in each group.

This complication pattern is consistent with the proposed soft-tissue advantage of intramedullary fixation. Because fibular nailing requires smaller incisions and less periosteal and soft-tissue dissection, wound complications may potentially be reduced. Samuel et al. [10] reported complication rates of approximately 15% following intramedullary fixation compared with 30% following plate fixation, with a significantly lower overall risk of complications in comparative studies.

Chen et al. [11] also demonstrated a significantly lower postoperative complication rate with intramedullary nail fixation compared with plate fixation (9.52% versus 30.77%), despite comparable healing and functional outcomes. White et al. [12], in a randomised trial among elderly patients with ankle fractures, similarly demonstrated the usefulness of fibular nail fixation as a minimally invasive alternative to conventional open reduction and internal fixation, particularly in patients in whom soft-tissue complications are a concern.

A systematic review and meta-analysis comparing intramedullary and plate fixation also reported significantly fewer wound-related complications, implant removals and nonunions with intramedullary fixation [13]. These observations provide a possible explanation for the lower numerical frequency of wound and implant-related complications identified in the present study.

Overall, the findings indicate that intramedullary nail fixation and plate fixation provide broadly comparable radiological union and functional recovery in distal fibula fractures with associated ankle instability. The principal potential advantage observed with intramedullary fixation was a lower six-month pain score and fewer wound and hardware-related complications. However, the lack of a statistically significant difference in overall complications means that the present study does not establish the overall superiority of intramedullary nailing.

## CONCLUSION

Both intramedullary nail fixation and plate fixation provided satisfactory fracture healing, restoration of radiological parameters and functional recovery in patients with distal fibula fractures associated with ankle instability. No significant differences were observed in fracture healing duration, radiological alignment, AOFAS scores or ankle range of motion. Intramedullary nail fixation was associated with significantly lower pain at six months and a lower numerical incidence of wound and hardware-related complications; however, the overall difference in complications was not statistically significant. Thus, intramedullary nail fixation represents an effective minimally invasive alternative to plate fixation, particularly where minimising soft-tissue and implant-related morbidity is desirable. Larger studies with longer follow-up are needed to determine whether either technique offers a definitive long-term advantage.

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