e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(2); 286-291

Original Research Article

Analysis of Clinical and Radiological Outcomes in Locked Versus Non-Locked Plating of Distal Fibular Fractures: A Retrospective Study

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Received: 10-01-2026 / Revised: 23-01-2026 / Accepted: 24-02-2026
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Conflict of interest: Nil

Abstract:

Background: Distal fibula fractures are common injuries, with their configuration largely determined by the mechanism of trauma. Surgical fixation remains the treatment of choice for displaced fractures, with plating techniques such as semi-tubular plate (STP), limited-contact dynamic compression plate (LC-DCP), and locking compression distal fibula plate (LCDFP) being frequently used.

Aim: This study aimed to compare clinical and radiological outcomes of distal fibula fractures treated with STP, LC-DCP, and LCDFP.

Methodology: A retrospective comparative study was conducted over 12 months at the Department of Orthopedics, Srinivash (G) Educational and Research Institute of Medical Sciences, Chapra, India. STP treatment was performed on 90 individuals with closed malleolar fractures (n=54), LC-DCP (n=14), or LCDFP (n=22). Outcomes assessed included union time, weight-bearing, complications, and reoperation rates.

Results: Patients treated with LCDFP were older (mean 58 years) and had more complex fracture patterns compared to STP and LC-DCP groups. Radiographic union was slightly faster with LCDFP (14.5 weeks) versus STP (15.2 weeks) and LC-DCP (15.6 weeks), though the median time was 12 weeks for all. Full weight-bearing was achieved earliest with STP (6.8 weeks). Complications were infrequent across groups, with superficial infections most common. STP had more reoperations, primarily for symptomatic hardware removal.

Conclusion: All three plating techniques demonstrated comparable union and complication rates. Individuals with complicated fractures who are old or osteoporotic may benefit from locking plates while semi-tubular plates remain effective for simpler fractures.

Keywords: Distal Fibula Fracture, Ankle Fracture, Semi-Tubular Plate, Locking Compression Plate, Fracture Fixation, Orthopedic Surgery.

DOI: 10.25258/ijpqa.17.2.44

Introduction

The pattern of distal fibula fractures is determined in large part by the type and amount of force applied to the fibula during injury, with clearly defined fracture patterns associated with different mechanisms of injury. For instance, spiral fractures are commonly associated with forced external rotation of the ankle with the foot supinated [1]. Because the fibula is long, the rotational force transmits stress along the fibula and produces a spiral fracture. In the opposite positioning with the foot pronated due often to an outward twisting mechanism or valgus force, the fibula is under tensile and bending stresses causing a transverse fracture line, usually above the syndesmosis. In addition to rotational injuries, consideration of direct trauma to the lateral leg and ankle needs to occur, with transverse or comminuted fractures resulting depending on the energy of the impact.

Fractures of the distal fibula are undoubtedly one of the most common ankle fractures seen in everyday orthopedic practice, often due to low-energy trauma such as twisting injuries or high-energy injuries in the case of highway collisions. Due to its crucial role in ankle joint stability, the proper management of distal fibular fractures is important for functional outcomes and for preventing complications, such as malunion, nonunion and post-traumatic arthritis. Surgical fixation is common with displaced or unstable fractures, with plate osteosynthesis being one of the most recognized treatment methods [2]. There have been a wide variety of plating methods described over time, from non-locking plates and locking plates that provide greater strength and stability.

The advancement in plating techniques has now introduced locking plate technology as a potential advance for the use of osteoporotic bone or

comminuted fractures. Locking plates provide biomechanical advantages, acting as internal fixators and allowing for a lessened incidence of screw loosening with less plate-to-bone compression dependence. Locking plates also include increased costs of the implant and possible soft tissue irritation due to the bulkiness involved with a locking plate system [3]. Non-locking plates, as an alternative, remain an option due to the lower cost and availability as well as what may have been perceived to have reasonably favorable clinical outcomes. Ultimately, the choice between locking and non-locking plating systems continues to be debated amongst orthopedic surgeons, and the effectiveness information does not directly correlate with comparative complication rates.

Postoperative complications, especially concerning surgical wound sites, are a major potential complication associated with operative fixation of distal fibular fractures. The ankle joins the body under the skin with scant coverage of soft tissue, leading to the complications of wound healing, superficial and deep infections, and wound dehiscence [4]. Other complications such as irritative hardware, delayed union, nonunion, and hardware has been associated with complications that can adversely affect recovery and functional outcomes. Reducing complications is one of the most important considerations when choosing the appropriate implant and operative technique.

Pott's fractures are not only clinically significant but also marks the third most common type of fracture in the elderly. Rates of Pott's fractures from epidemiological studies suggest an incidence rates of ~184 per 1,0000 persons each year reflecting its prevalence and significance in orthopedic clinics and research. This is describable, at least in part, by the presence of low bone density in elderly populations, an increased likelihood of imbalance due to aging, and an increased risk of falls. To obtain an understanding of the biomechanical forces that are at play when these fractures occur is key to consider for accurate diagnosis, appropriate surgical planning, and the ultimate rehabilitation of the ankle to restore stability and function [5].

"The decreased compression of the periosteum is an added benefit of locking plates. A non-locking conventional plate attains secure fixation by the frictional force between the plate and the bone. This compression may obstruct blood flow to the bone, resulting in a detrimental state for bone union. Thus, less periosteal compression may enhance the likelihood of bone union. Numerous plate designs have been created that do not impede cerebral blood flow; nevertheless, no definitive clinical efficacy has been established for these plates [6].

A locking plate has various purposes, including serving as a compression plate, bridge plate, neutralisation plate or tension band plate. The application of the locking plate as a neutralisation device for lag screw fracture fixation is among the most effective approaches for locking plates [7]. Lateral malleolus displaced fractures of the ankle typically require anatomical reduction with absolute stability, often employing a lag screw and neutralisation plate for fixation."

Recent reports indicate that the majority of comminuted fractures of the distal fibula result from high-energy pronation-abduction impacts. The elevated non-union rate of comminuted distal fibular fractures necessitates internal fixation to achieve full reduction [8]. To achieve total reduction in comminuted fibula fractures, the length and rotational angle of the fibula must be precisely regulated. Clinically, conventional bone screws are inadequate for stabilising comminuted fractures of the distal fibula, necessitating the identification of an appropriate treatment to address improper reduction.

In recent decades, ankle fractures have increased in prevalence, currently representing around 10% of all fractures. Ankle fractures impose considerable strain, with 33% need surgical treatment. The majority of these patients are young and fit; nonetheless, research indicates that miticosis-related fragility fractures are rising among the older population [9]. The surgical fixation of ankle fractures often employs an interfragmentary lag screw in conjunction with a non-locking neutralisation plate. Achieving this form of fixation in elderly patients with compromised bone quality is challenging.

Trauma frequently results in ankle fractures. They affect 122 to 184 people per 100,000 annually, with older adults (over 65) accounting for 25% of cases. This positions them as the third most prevalent fracture following hip and distal radius fractures in elderly people. The standard treatment for displaced distal fibula fractures is currently open reduction and internal fixation [10]. The primary surgical method in current practice is plating. Locking plates have fundamentally revolutionized the treatment of lengthy bone fractures. "This innovative method utilizes fixed-angle screws that improve angular and axial stability, especially in metaphysis and epiphysis, irrespective of bone mineral density. These locking mechanisms have regularly impacted our surgical procedures, particularly for patients with osteoporosis or comminuted fractures, as well as those facing instability and/or necessitating cortical fixation [11]".

This study aims to analyze the complication rates associated with locking plates versus non-locking plates in distal fibular fractures. Investigating both methods of fixation should provide evidence to help with implant selection, surgical outcomes, and recovery post-operatively. Due to its clinical significance and high frequency with ankle fracture

fixation, the state of the surgical wound site following surgery serves as the study's primary end measure. The secondary outcome is to identify and investigate any other complications that may arise following distal fibular plating. In investigating these areas, this study intends to add to the ongoing research in the literature regarding the efficacy, safety, and complications associated with fixation of distal fibular fractures using locking and non-locking plates.

Methodology

Study Design: This study was designed as a retrospective comparative analysis evaluating clinical and radiological results of individuals who received surgical treatment for distal fibula fractures using either locked plating systems or non-locked plating systems.

Study Area: The study was conducted in the Department of Orthopedics at Srinivash (G) Educational and Research Institute of Medical Sciences in Chapra, Bihar, India.

Study Duration: The present study was planned to be conducted over a period of 12 months.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Patients who were admitted within a year in order to treat locked ankle ligament fractures.

Exclusion Criteria

- Patients with injuries managed using an external fixator.
- Pilon fractures, open ankle fractures, fractures managed exclusively isolated medial malleolar and syndesmotic screws fractures.

Sample Size: A distal fibular plate was surgically fixed in 90 individuals who had ankle fractures.

Procedure: All patients, with the exception of those who were allergic to penicillin, got antibiotic prophylaxis with a single dose of a second-generation cephalosporin; in that event, the hospital policy called for teicoplanin. The operative surgeon had discretion over the implant selection and lag screw application. Three types of implants were available during the study period: a 2.7-mm/3.5-mm locking compression distal fibula plate (LCP-F), a 3.5-mm limited-contact dynamic compression plate (LC-DCP), and a one-third semi tubular plate (STP). All three plates were produced by DePuy Synthes (West Chester, PA). Drains were not employed consistently. All patients received low-molecular-weight heparin for thromboprophylaxis during the six hours post-surgery and throughout the plaster cast immobilisation phase. Radiographs were obtained six weeks post-surgery and during subsequent conduct additional investigations as required until clinical and radiographic union is attained.

Statistical Analysis: Statistical analysis was conducted utilizing SPSS, version 27 (IBM, Armonk, NY). The normality of the data was assessed using a Kolmogorov-Smirnov test. The outcomes were considered statistically significant at $p < .05$."

Result

Table 1 summarizes the demographic and clinical characteristics of 90 patients treated with three different plating techniques for ankle fractures: STP (Semi Tubular Plate), LC-DCP (Limited-Contact Dynamic Compression Plate) and LCDFP (Locking Compression Distal Fibula Plate). The mean age of patients was similar in the STP (40 ± 15.5 years) and LC-DCP (39 ± 16.4 years) groups, while the LCDFP group had an older mean age (58 ± 15.5 years). Gender distribution was relatively balanced across groups, though LCDFP had slightly more female patients (13) compared to males (10). Diabetes mellitus was more prevalent in the LCDFP group (3 patients) than in the others. In terms of fracture types, bimalleolar and trimalleolar fractures were more common in the LCDFP group (11 and 9, respectively), whereas STP had a higher proportion of lateral malleolus fractures (22). According to Weber classification, Weber B fractures predominated across all groups, particularly in STP (45 patients), while Weber C fractures were more frequent in the LC-DCP group (8). Lag screw fixation was most frequently used with STP (49 cases), followed by LCDFP (11) and LC-DCP (6). Overall, the LCDFP group included older patients and more complex fractures, whereas STP was used more commonly in younger patients with less severe fractures.

Table 2 compares healing and recovery times across three fixation methods for ankle fractures in 90 patients. The mean time to radiographic union was shortest with the Locking Compression Distal Fibula Plate (14.5 weeks), followed by the Semi Tubular Plate (15.2 weeks) and the Limited-Contact Dynamic Compression Plate (15.6 weeks), although the median union time was consistently 12 weeks across all groups. Confidence intervals indicate some variability, with the LC-DCP group showing the widest range (12.0–21.5 weeks). For full weight-bearing, patients with the Semi Tubular Plate achieved this earliest (mean 6.8 weeks), while the LC-DCP and LCP groups required slightly longer durations (7.3 and 7.5 weeks, respectively). Overall, the Locking Compression Plate showed slightly faster radiographic healing, whereas the Semi Tubular Plate enabled earlier weight-bearing.

Table 1: Clinical and Patient Characteristics (n = 90)			
Characteristics	**Semi Tubular Plate (n = 54)**	**Limited- Compression Distal Fibula Plate (n = 23)**	**Locking Contact Dynamic Compression Plate (n = 13)**
Age (y) Mean ± SD	40 ± 15.5	58 ± 15.5	39 ± 16.4
Gender			
Male	29	10	8
Female	25	13	5
Diabetes mellitus	1	3	0
Fracture type			
Lateral malleolus	22	3	3
Bimalleolar	24	11	7
Tri malleolar	8	9	3
Weber Classification			
Weber A	0	0	0
Weber B	45	22	5
Weber C	9	1	8
Lag screw fixation	49	11	6

Table 2: Outcome Measures (n = 90)			
Outcomes	**Semi Tubular Plate (n = 54)**	**Limited- Compression Distal Fibula Plate (n = 22)**	**Locking Contact Dynamic Compression Plate (n = 14)**
Radiographic union (wk)			
Mean	15.2	14.5	15.6
Median	12	12	12
95% CI	11.8 to 16.4	11.5 to 17.2	12.0 to 21.5
Full weight bearing (wk)			
Mean	6.8	7.5	7.3
Median	6	7	6
95% CI	6.4 to 7.3	6.6 to 8.6	6.2 to 8.2

Table 3 summarizes complications and reoperations observed in 90 patients treated with three different fixation methods for distal fibular fractures. Among these, the Semi Tubular Plate group (n = 54) had the highest number of cases but showed a relatively low complication rate, with 50 patients having no complications, and only minor issues like superficial infections (2 cases), wound problems not requiring antibiotics (3 cases), and a single infection requiring washout. The Dynamic compression plate group with limited contact (n = 14) had minimal complications, with 13 patients complication-free and only one superficial infection, while the Compression Locking Group of Distal Fibula Plates (n = 22) reported slightly higher superficial infection rates (2 cases) and one washout-requiring infection. Reoperations were most frequent in the Semi Tubular Plate group, primarily for symptomatic metalwork removal (7 cases) and planned syndesmosis screw removal (3 cases), along with two revisions, whereas the other two groups had very few reoperations. Overall, complications were infrequent across all groups, though the Semi Tubular Plate group showed more reoperations, likely due to its higher usage and symptomatic hardware issues rather than severe complications.

Table 3: Complications and Reoperations (Sample size = 90)			
Variables	**Semi Tubular Plate (n = 54)**	**Limited- Compression Distal Fibula Plate (n = 22)**	**Locking Contact Dynamic Compression Plate (n = 14)**
Complications			
None identified	50	19	13
Infection requiring washout	1	1	0
Superficial infection requiring antibiotics	2	2	1
Wound issues not requiring antibiotics	3	0	0
Reoperation			
Washout with or without the extraction of metals	1	0	0
Planned removal of syndesmosis screw	3	0	1
Removal of symptomatic metalwork	7	0	1
Revision	2	1	0

Discussion

This study utilized three plating techniques: Semi Tubular Plate (STP), Limited-Contact Dynamic Compression Plate (LC-DCP), and Locking Compression Distal Fibula Plate (LCDFP) for ankle fracture fixation and reported demographic trends, clinical outcomes, and complications. Patients that underwent different protocols differed significantly with respect to distinctions in choosing patients, fracture complexity, time to union, and reoperation rate.

Patients who received LCDFP had a higher average age (mean age 58 years), had more comorbidities, like diabetes mellitus, and had more complex injury patterns (i.e. bimalleolar and Tri malleolar ankles). In contrast, we noted STP being used mostly in younger patients and simpler fracture patterns, especially isolated later malleolar fractures. The discrepancy in cohort is also reflected by the predominance of Weber B fractures across all groups where the Weber B class of fracture is the most represented of all ankle fractures in literature. The increase in lag screw fixation with STP relates directly to its usage in less comminuted fracture patterns whereas there is the possibility of LCDFP being used for additional stability to an osteoporotic or more complex fracture due to its locking type of construct. In contrast, a retrospective cohort study conducted by Huang et al., (2014) [12] investigated the radiological results of three distinct plate types in a cohort of 147 patients. "Research demonstrates that the healing duration was significantly shorter in patients receiving an LCP distal fibula plate (20.0 ± 3.8 weeks) compared to those treated with an LCP metaphyseal plate ($p < 0.0001$, 23.0 ± 3.4 weeks) and a conventional one-third tubular plate ($p < 0.0001$, 23.1 ± 3.6 weeks). No significant difference was detected between the final two plates ($p = 0.867$), albeit one being a locking plate. A notable deficiency of information pertains to the utilization of lag screws, which may clarify the extended healing period in the NLP group. Additionally, the MIPO technique, as articulated by Hess et al., (2011) [13] was utilized in the LP groups, which may potentially reduce the danger of periosteal damage and the depletion of the fracture hematoma."

The time to radiographic union was similar for all groups, although the LCDFP group appears to have slightly quicker mean union (14.5 weeks) compared to STP (15.2 weeks) and LC-DCP (15.6 weeks), the difference was clinically small, and all groups achieved a relatively similar median time to union of 12 weeks. It is noteworthy that patients with STP were again able to achieve full weight-bearing status sooner (mean 6.8 weeks) than those of similar fracture complexity operated with LCDFP or LC-DCP despite the LSDFP's greater mechanical constructs. Previously discussed migration of the STP implant and increased rates of non-union may explain this observation, but we are unsure if the inherent mechanical advantages of locking plates contribute to the lack of complication. The broader confidence intervals in LC-DCP may indicate variation in healing time, but LC-DCP had the lowest sample size and there was a predominance of Weber C fractures in this cohort. "Our analysis confirms Tsukada et al., (2013) [14] found no difference in complication rates or time to radiographic bone union between locking and nonlocking plates. The LCP-F implant is more expensive (about £500) than a standard fibula fixation device. Nonetheless, this must be considered alongside the costs of supplementary procedures for patients with unstable fractures or osteoporotic bones, which may increase the likelihood of displacement and require more surgical interventions [15]".

Complications were generally rare and minor, with superficial infections diagnosed in all fixation groups with no significant difference in terms of severity. Reporting two cases of deep infection that required washout demonstrates that all methods of fixation have a safe profile. The STP cohort had the most reported re-operations, most commonly for removal of symptomatic metalwork, which is in agreement with previous studies showing a greater incidence of hardware irritation when examined with non-locking plates, particularly in context of subcutaneous fixation at distal fibula. Interestingly, LCDFP and LC-DCP compared to STP had far fewer re-operations, potentially indicating a good profile of use perhaps from general less prominent design in the LCDFP plate and more selective use of more cumbersome LC-DCP fixation in difficult cases. Despite the reported lower overall complication profile with LC-DCP, we must acknowledge potential for bias from the smaller sample size. Schepers et al. (2011) [16] conducted a retrospective analysis of 165 individuals and discovered that locking compression plates were more likely to cause wound problems in distal fibular fractures than semi-tubular plates. They advised using these plates with caution. The groups did not differ in terms of hardware removal; however, the overall risk of wound complications was 17.5% for locking plates compared to 5.5% for semi-tubular plates.

Overall, the results indicate that all three plating strategies are satisfactory and safe for fixation of distal fibula fractures with low complication and infection risks. The choice of fixation modality seems to be driven by patient-related factors and complexity of the injury rather than potential differences in implant performance. Locking plates may be more beneficial in the elderly, osteoporotic and/or complex fractures, while semi-tubular plates are still valid alternatives for simpler injuries due to simplicity of application, lower costs, and acceptable healing. Future large-scale, randomized trials may be useful to confirm our findings and to differentiate

functional outcomes and cost-benefit comparisons among these implants.

Conclusion

This comparative study highlights that semi-tubular plates, limited-contact dynamic compression plates, and locking compression distal fibula plates are all effective options for the surgical fixation of distal fibula fractures, with low complication and infection rates across groups. While radiographic union times were similar, locking plates showed slightly faster healing, whereas semi-tubular plates enabled weight-bearing earlier, likely due to their use in less complex fracture patterns. Locking plates demonstrated advantages in elderly and osteoporotic patients, offering enhanced stability in comminuted or unstable fractures, though their higher cost must be balanced against the potential for reduced reoperations. Semi-tubular plates remained effective in younger patients with simpler fractures, though they were associated with a higher rate of hardware-related reoperations. Overall, the choice of implant should be individualized based on patient age, bone quality, and fracture complexity rather than relying on a single technique. Larger prospective studies are needed to further clarify long-term functional and economic outcomes.

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