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Comparative Evaluation of Locking Compression Plate versus Intramedullary Nailing in the Management of Diaphyseal Tibial Fractures.

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Abstract
Background: Diaphyseal tibial fractures are among the most common long-bone injuries requiring surgical stabilization. Locking compression plate (LCP) fixation and intramedullary interlocking nailing (IMILN) are widely used treatment modalities, each having specific advantages and limitations. Comparative evaluation of these techniques is essential to optimize patient outcomes. ***Objectives:*** To compare the clinical, radiological, functional, operative, and postoperative outcomes of locking compression plate fixation and intramedullary interlocking nailing in the management of diaphyseal tibial fractures. ***Materials and Methods***: A hospital-based comparative observational study was conducted in the Department of Orthopaedics at a tertiary care teaching hospital. A total of 100 adult patients with diaphyseal tibial fractures were included, with 50 patients undergoing locking compression plate fixation and 50 undergoing intramedullary interlocking nailing. Clinical assessment, radiological evaluation, operative parameters, postoperative recovery, complications, and functional outcomes were recorded during follow-up. Fracture union was assessed radiographically using the Radiographic Union Score for Tibial (RUST) fractures, while functional outcome was evaluated using Johner and Wruhs' criteria. Data were analyzed using SPSS version 26.0. Continuous variables were compared using the independent Student's t-test, whereas categorical variables were analyzed using the Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant. ***Results:*** Intramedullary nailing demonstrated significantly lower postoperative pain scores (3.5±1.2 vs. 4.1±1.3; p=0.018), superior knee and ankle range of motion (p=0.025 and p=0.035, respectively), shorter mean radiological union time (16.1±3.1 vs. 18.6±3.8 weeks; p<0.001), and significantly higher final functional scores (87.6±7.8 vs. 82.4±9.1; p=0.003) compared with locking compression plate fixation. Operative duration, intraoperative blood loss, hospital stay, and time to partial and full weight-bearing were also significantly lower in the intramedullary nailing group (all p<0.01). Although radiological union by 24 weeks (94.0% vs. 82.0%), overall complications (16.0% vs. 28.0%), delayed union, non-union, malunion, and reoperation rates favored intramedullary nailing, these differences were not statistically significant. Fluoroscopy exposure was significantly lower following locking compression plating, whereas anterior knee pain occurred significantly more frequently after intramedullary nailing (16.0% vs. 2.0%; p=0.031). ***Conclusion:*** Both locking compression plate fixation and intramedullary interlocking nailing provided satisfactory outcomes in the management of diaphyseal tibial fractures. However, intramedullary nailing offered superior clinical and functional recovery, earlier fracture union, shorter operative time, faster rehabilitation, and improved overall postoperative outcomes. Locking compression plating remained a valuable alternative in selected fracture patterns where anatomical reduction or specific fracture characteristics favored plate fixation. Surgical technique should therefore be selected according to fracture morphology, soft-tissue condition, patient requirements, and surgeon experience.

Keywords: Diaphyseal tibial fracture. Intramedullary interlocking nailing. Locking compression plate.

INTRODUCTION
Diaphyseal fractures of the tibia are among the most common long-bone fractures encountered in orthopedic practice because of the subcutaneous location of the tibia and its exposure to both high-energy and low-energy trauma. These fractures frequently result from road traffic accidents, falls from height, sports injuries, and industrial accidents. The management of tibial shaft fractures presents unique challenges owing to limited soft tissue coverage, compromised blood supply, and the risk of delayed union, non-union, malunion, infection, and functional impairment. The primary goals of

treatment include achieving stable fracture fixation, restoring limb alignment and length, promoting early union, minimizing complications, and facilitating early mobilization and return to normal activities.[1]

Surgical fixation has become the preferred treatment for most displaced diaphyseal tibial fractures. Among the available fixation methods, intramedullary interlocking nailing (IMILN) and locking compression plating (LCP) are the two most commonly employed techniques. Intramedullary nailing is considered the gold standard for many closed and selected open tibial shaft fractures because it provides load-sharing fixation, preserves fracture biology through minimally invasive insertion, allows early weight-bearing, and demonstrates high union rates. However, complications such as anterior knee pain, malalignment, hardware failure, rotational deformity, and difficulty in proximal or distal third fractures remain concerns.[2]

Locking compression plates, particularly when inserted using minimally invasive plate osteosynthesis (MIPO) techniques, have gained popularity because they provide angular stability while preserving periosteal blood supply and fracture hematoma. Locking plates are especially advantageous in fractures extending towards the metaphysis, fractures with complex configurations, and situations where intramedullary nailing may not provide optimal fixation. Nevertheless, plating may be associated with increased surgical exposure, soft tissue irritation, implant prominence, infection, and delayed weight-bearing in some patients.[3]

Several randomized controlled trials and meta-analyses have compared these two fixation modalities with respect to fracture union, operative duration, blood loss, infection rates, malalignment, implant-related complications, and functional outcomes. Although intramedullary nailing generally demonstrates shorter rehabilitation periods and earlier weight-bearing, plating has shown comparable union rates and may offer better alignment in selected fracture patterns. The superiority of one technique over the other remains controversial because treatment outcomes are influenced by fracture morphology, soft tissue injury, patient characteristics, surgeon expertise, and rehabilitation protocols.[4]

In recent years, improvements in implant design, locking technology, and minimally invasive surgical techniques have significantly enhanced clinical outcomes for both methods. Consequently, choosing the most appropriate fixation strategy requires careful consideration of fracture characteristics and patient-specific factors. Comparative evaluation of locking compression plating and intramedullary nailing in patients with diaphyseal tibial fractures is therefore essential to determine differences in radiological union, functional recovery, complication rates, operative parameters, and overall treatment effectiveness. The findings of the present study are expected to provide evidence regarding the relative advantages and limitations of these two commonly practiced surgical techniques, thereby assisting orthopedic surgeons in selecting the most appropriate management strategy for diaphyseal tibial fractures.[5]

AIM

To compare the clinical, radiological, and functional outcomes of locking compression plate fixation and intramedullary nailing in the management of diaphyseal tibial fractures.

OBJECTIVES

1. To compare the time to radiological fracture union between locking compression plate fixation and intramedullary nailing.
2. To evaluate and compare the functional outcomes and postoperative complications associated with both surgical techniques.
3. To compare operative parameters including duration of surgery, hospital stay, and time to full weight-bearing between the two treatment groups.

MATERIALS AND METHODS

Source of Data

The data were collected from patients diagnosed with diaphyseal tibial fractures who underwent operative management in the Department of Orthopaedics at the tertiary care teaching hospital. Information was obtained from patient interviews, clinical examinations, operative records, radiological investigations, inpatient case records, and scheduled postoperative follow-up assessments.

Study Design

The study was conducted as a hospital-based comparative observational study.

Study Location

The study was carried out in the Department of Orthopaedics of a tertiary care teaching hospital.

Study Duration
The study was conducted over a period of 24 months, including patient recruitment, surgical intervention, postoperative follow-up, data collection, and statistical analysis.

Sample Size
A total of 100 patients diagnosed with diaphyseal tibial fractures were included in the study.
- Group A: Locking Compression Plate fixation (n = 50)
- Group B: Intramedullary Interlocking Nailing (n = 50)

Inclusion Criteria
- Patients aged 18–65 years.
- Patients with fresh diaphyseal tibial fractures.
- Closed fractures and Gustilo-Anderson Grade I or II open fractures.
- Patients treated with either locking compression plate fixation or intramedullary interlocking nailing.
- Patients willing to provide written informed consent.
- Patients available for regular postoperative follow-up.

Exclusion Criteria
- . Patients younger than 18 years or older than 65 years.
- Gustilo-Anderson Grade III open fractures.
- Pathological fractures.
- Periprosthetic fractures.
- Polytrauma patients requiring damage-control orthopaedic procedures.
- Patients with neurovascular injuries requiring vascular reconstruction.
- Patients with previous surgery on the affected tibia.
- Patients lost to follow-up or unwilling to participate.

Procedure and Methodology
After obtaining approval from the Institutional Ethics Committee, eligible patients fulfilling the inclusion criteria were enrolled after obtaining written informed consent. Detailed demographic information, mode of injury, associated comorbidities, fracture characteristics according to the AO/OTA classification, side involved, and soft tissue status were recorded. Routine preoperative investigations including complete blood count, renal function tests, blood sugar, coagulation profile, chest radiograph, electrocardiography, and radiographs of the affected leg in anteroposterior and lateral views were performed. Appropriate preoperative antibiotic prophylaxis was administered according to institutional protocol.

Patients underwent surgical fixation using either locking compression plate fixation or intramedullary interlocking nailing depending on fracture characteristics and surgeon preference. Operative details including duration of surgery, blood loss, fluoroscopy time, and intraoperative complications were documented. Postoperative management consisted of analgesics, intravenous antibiotics, limb elevation, wound care, thromboprophylaxis where indicated, and standardized physiotherapy. Early knee and ankle mobilization exercises were initiated. Progressive weight-bearing was allowed based on fracture stability and radiological evidence of healing. Patients were followed at 6 weeks, 3 months, 6 months, and 12 months. At each visit, clinical examination and radiographic assessment were performed. Fracture union, malalignment, infection, implant failure, delayed union, non-union, and other complications were recorded. Functional outcome was evaluated using the Johner and Wruhs' Criteria at the final follow-up.

Sample Processing
The collected data were checked for completeness and accuracy immediately after collection. Clinical findings, operative details, radiographic observations, and follow-up outcomes were entered into a structured case record form. The data were coded, verified, and entered into Microsoft Excel before being imported into the statistical software for analysis. Radiographs were independently reviewed by experienced orthopedic surgeons to determine fracture union and alignment.

Statistical Methods
The collected data were analyzed 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:
- Independent Student's t-test for continuous variables.
- Chi-square test or Fisher's exact test for categorical variables.

- Mann-Whitney U test for non-normally distributed continuous data.
- A p-value of <0.05 was considered statistically significant.

Data Collection

Data were collected using a predesigned structured case record form that included:

- Demographic profile (age, sex)
- Mechanism of injury
- Side involved
- Associated injuries
- Fracture classification (AO/OTA)
- Open or closed fracture status
- Time from injury to surgery
- Surgical procedure performed
- Duration of surgery
- Blood loss
- Hospital stay
- Time to partial and full weight-bearing
- Radiological union time
- Functional outcome (Johner and Wruhs' Criteria)
- Postoperative complications including infection, delayed union, non-union, malunion, implant failure, anterior knee pain, hardware irritation, and reoperation
- Final clinical and radiological outcome at the last follow-up.

RESULTS

Table 1: Comparison of clinical, radiological and functional outcomes between locking compression plate and intramedullary nailing groups (N=100)

Outcome variable	LCP group, n=50 n (%) or Mean ± SD	IM nailing group, n=50 n (%) or Mean ± SD	Test of significance	Effect estimate and 95% CI	P value
Postoperative pain score at 6 weeks	4.1 ± 1.3	3.5 ± 1.2	t=2.40	MD=0.60 (0.10–1.10)	0.018*
Knee range of motion at final follow-up, degrees	127.6 ± 9.8	131.8 ± 8.7	t=−2.27	MD=−4.20 (−7.88 to −0.52)	0.025*
Ankle range of motion at final follow-up, degrees	42.7 ± 5.9	45.1 ± 5.3	t=−2.14	MD=−2.40 (−4.63 to −0.17)	0.035*
Mean radiological union time, weeks	18.6 ± 3.8	16.1 ± 3.1	t=3.60	MD=2.50 (1.12–3.88)	<0.001 *
Radiological union achieved by 24 weeks	41 (82.0)	47 (94.0)	χ^2=3.41	OR=0.29 (0.07–1.15)	0.065
Final functional score	82.4 ± 9.1	87.6 ± 7.8	t=−3.07	MD=−5.20 (−8.56 to −1.84)	0.003*
Excellent or good functional outcome	38 (76.0)	45 (90.0)	χ^2=3.47	OR=0.35 (0.11–1.09)	0.062
Returned to previous occupation	39 (78.0)	46 (92.0)	χ^2=3.84	OR=0.31 (0.09–1.05)	0.050
Overall postoperative complications	14 (28.0)	8 (16.0)	χ^2=2.10	OR=2.04 (0.77–5.42)	0.148
Reoperation required	4 (8.0)	2 (4.0)	Fisher's exact test	OR=2.09 (0.36–11.95)	0.678

Table 1 compares the overall clinical, radiological and functional outcomes between patients treated with locking compression plate fixation and those treated with intramedullary nailing. The mean postoperative pain score at 6 weeks was significantly higher in the LCP group than in the intramedullary nailing group (4.1 ± 1.3 versus 3.5 ± 1.2; mean difference=0.60, 95% CI: 0.10–1.10; p=0.018). At final follow-up, patients treated with intramedullary nailing had significantly greater knee range of motion (131.8 ± 8.7° versus 127.6 ± 9.8°; p=0.025) and ankle range of motion (45.1 ±

5.3° versus 42.7 ± 5.9°; p=0.035). The mean radiological union time was significantly shorter in the intramedullary nailing group than in the LCP group (16.1 ± 3.1 versus 18.6 ± 3.8 weeks; mean difference=2.50 weeks, 95% CI: 1.12–3.88; p<0.001). Radiological union by 24 weeks was achieved in 94.0% of the intramedullary nailing group and 82.0% of the LCP group; however, this difference was not statistically significant (p=0.065). The mean final functional score was significantly higher following intramedullary nailing (87.6 ± 7.8) compared with LCP fixation (82.4 ± 9.1; p=0.003). Excellent or good functional outcomes were observed in 90.0% and 76.0% of patients, respectively, although the difference was not significant (p=0.062). Return to previous occupation was more frequent in the intramedullary nailing group than in the LCP group (92.0% versus 78.0%), with a borderline p-value of 0.050. Overall postoperative complications occurred in 28.0% of the LCP group and 16.0% of the intramedullary nailing group (p=0.148), while reoperation was required in 8.0% and 4.0%, respectively (p=0.678).

Table 2: Comparison of time to radiological fracture union between locking compression plate and intramedullary nailing groups (N=100)

Radiological outcome	LCP group, n=50 n (%) or Mean ± SD	IM nailing group, n=50 n (%) or Mean ± SD	Test of significance	Effect estimate and 95% CI	P value
Appearance of bridging callus, weeks	9.7 ± 2.3	8.2 ± 1.9	t=3.56	MD=1.50 (0.66–2.34)	<0.001*
Partial radiological union, weeks	13.8 ± 2.9	11.9 ± 2.6	t=3.45	MD=1.90 (0.81–2.99)	0.001*
Complete radiological union, weeks	18.6 ± 3.8	16.1 ± 3.1	t=3.60	MD=2.50 (1.12–3.88)	<0.001*
Union achieved within 16 weeks	18 (36.0)	31 (62.0)	χ^2=6.76	OR=0.35 (0.16–0.79)	0.009*
Union achieved within 20 weeks	36 (72.0)	44 (88.0)	χ^2=4.00	OR=0.35 (0.12–1.01)	0.046*
Union achieved by 24 weeks	41 (82.0)	47 (94.0)	χ^2=3.41	OR=0.29 (0.07–1.15)	0.065
Delayed union	7 (14.0)	2 (4.0)	Fisher's exact test	OR=3.91 (0.77–19.83)	0.160
Non-union	3 (6.0)	1 (2.0)	Fisher's exact test	OR=3.13 (0.31–31.14)	0.617
Malunion	4 (8.0)	2 (4.0)	Fisher's exact test	OR=2.09 (0.36–11.95)	0.678
Mean RUST score at 12 weeks	8.1 ± 1.6	9.2 ± 1.4	t=−3.66	MD=−1.10 (−1.70 to −0.50)	<0.001*
Mean RUST score at 24 weeks	10.7 ± 1.3	11.3 ± 1.0	t=−2.59	MD=−0.60 (−1.06 to −0.14)	0.011*

RUST: Radiographic Union Score for Tibial fractures.

Table 2 presents the comparison of radiological fracture healing between the two treatment groups. The appearance of bridging callus occurred significantly earlier in the intramedullary nailing group than in the LCP group (8.2 ± 1.9 versus 9.7 ± 2.3 weeks; mean difference=1.50 weeks, 95% CI: 0.66–2.34; p<0.001). Similarly, partial radiological union was achieved earlier following intramedullary nailing (11.9 ± 2.6 weeks) than after LCP fixation (13.8 ± 2.9 weeks; p=0.001). Complete radiological union also occurred significantly earlier in the intramedullary nailing group (16.1 ± 3.1 weeks) compared with the LCP group (18.6 ± 3.8 weeks; p<0.001).

Union within 16 weeks was achieved in 62.0% of patients treated with intramedullary nailing compared with 36.0% treated with LCP fixation (OR=0.35, 95% CI: 0.16–0.79; p=0.009). Likewise, union within 20 weeks occurred in 88.0% and 72.0% of patients, respectively (p=0.046). Although union by 24 weeks was higher in the intramedullary nailing group than in the LCP group (94.0% versus 82.0%), the difference did not reach statistical significance (p=0.065).

Delayed union, non-union and malunion were more frequently observed in the LCP group, but none of these differences were statistically significant. The mean RUST score was significantly higher in the intramedullary nailing group at both 12 weeks (9.2 ± 1.4 versus 8.1 ± 1.6; p<0.001) and 24 weeks (11.3 ± 1.0 versus 10.7 ± 1.3; p=0.011).

Table 3: Comparison of functional outcomes and postoperative complications between the two surgical techniques (N=100)

Functional outcome/complication	LCP group, n=50 n (%) or Mean ± SD	IM nailing group, n=50 n (%) or Mean ± SD	Test of significance	Effect estimate and 95% CI	P value
Final functional score	82.4 ± 9.1	87.6 ± 7.8	t=−3.07	MD=−5.20 (−8.56 to −1.84)	0.003*
Excellent outcome	17 (34.0)	26 (52.0)	χ^2=3.31	OR=0.48 (0.22–1.07)	0.069
Good outcome	21 (42.0)	19 (38.0)	χ^2=0.17	OR=1.18 (0.53–2.63)	0.684
Fair outcome	8 (16.0)	4 (8.0)	Fisher's exact test	OR=2.19 (0.61–7.81)	0.357
Poor outcome	4 (8.0)	1 (2.0)	Fisher's exact test	OR=4.26 (0.46–39.56)	0.362
Excellent or good outcome	38 (76.0)	45 (90.0)	χ^2=3.47	OR=0.35 (0.11–1.09)	0.062
Superficial surgical-site infection	6 (12.0)	2 (4.0)	Fisher's exact test	OR=3.27 (0.63–17.07)	0.269
Deep infection	2 (4.0)	1 (2.0)	Fisher's exact test	OR=2.04 (0.18–23.27)	1.000
Delayed union	7 (14.0)	2 (4.0)	Fisher's exact test	OR=3.91 (0.77–19.83)	0.160
Malalignment >5°	4 (8.0)	2 (4.0)	Fisher's exact test	OR=2.09 (0.36–11.95)	0.678
Implant prominence or irritation	7 (14.0)	2 (4.0)	Fisher's exact test	OR=3.91 (0.77–19.83)	0.160
Anterior knee pain	1 (2.0)	8 (16.0)	Fisher's exact test	OR=0.11 (0.01–0.89)	0.031*
Knee stiffness	3 (6.0)	2 (4.0)	Fisher's exact test	OR=1.53 (0.25–9.59)	1.000
Ankle stiffness	6 (12.0)	3 (6.0)	Fisher's exact test	OR=2.14 (0.50–9.07)	0.487
Implant failure	2 (4.0)	1 (2.0)	Fisher's exact test	OR=2.04 (0.18–23.27)	1.000
Any postoperative complication	14 (28.0)	8 (16.0)	χ^2=2.10	OR=2.04 (0.77–5.42)	0.148

Table 3 compares functional outcomes and postoperative complications between LCP fixation and intramedullary nailing. The mean final functional score was significantly higher in the intramedullary nailing group than in the LCP group (87.6 ± 7.8 versus 82.4 ± 9.1; mean difference=−5.20, 95% CI: −8.56 to −1.84; p=0.003). Excellent outcomes were achieved in 52.0% of patients treated with intramedullary nailing and 34.0% treated with LCP fixation, although this difference was not statistically significant (p=0.069).

Good outcomes were observed in 38.0% and 42.0%, respectively, while fair and poor outcomes were relatively more frequent in the LCP group. Overall, excellent or good outcomes were recorded in 90.0% of the intramedullary nailing group and 76.0% of the LCP group, but the difference did not reach statistical significance (p=0.062). Superficial surgical-site infection, deep infection, delayed union, malalignment, implant prominence, knee stiffness, ankle stiffness and implant failure were numerically more common following LCP fixation, although none of these differences were statistically significant.

In contrast, anterior knee pain was significantly more frequent in the intramedullary nailing group than in the LCP group (16.0% versus 2.0%; OR=0.11, 95% CI: 0.01–0.89; p=0.031). Any postoperative complication occurred in 28.0% of patients in the LCP group compared with 16.0% in the intramedullary nailing group (p=0.148).

Table 4. Comparison of operative and postoperative recovery parameters between the two treatment groups (N=100)

Operative/recovery parameter	LCP group, n=50 Mean ± SD or n (%)	IM nailing group, n=50 Mean ± SD or n (%)	Test of significance	Mean difference/OR and 95% CI	P value
Injury-to-surgery interval, days	4.8 ± 2.1	4.3 ± 1.8	t=1.28	MD=0.50 (−0.28 to 1.28)	0.204
Duration of surgery, minutes	94.7 ± 15.6	78.9 ± 13.8	t=5.36	MD=15.80 (9.95–21.65)	<0.001*
Intraoperative blood loss, mL	176.4 ± 48.7	121.8 ± 39.6	t=6.15	MD=54.60 (36.98–72.22)	<0.001*
Fluoroscopy exposure, seconds	46.3 ± 13.5	58.7 ± 15.2	t=−4.31	MD=−12.40 (−18.11 to −6.69)	<0.001*
Length of hospital stay, days	7.8 ± 2.4	6.3 ± 2.0	t=3.40	MD=1.50 (0.62–2.38)	0.001*
Initiation of knee and ankle mobilization, days	3.7 ± 1.3	2.8 ± 1.1	t=3.74	MD=0.90 (0.42–1.38)	<0.001*
Time to partial weight-bearing, weeks	8.4 ± 2.1	6.7 ± 1.8	t=4.34	MD=1.70 (0.92–2.48)	<0.001*
Time to full weight-bearing, weeks	17.9 ± 3.6	15.2 ± 3.0	t=4.07	MD=2.70 (1.38–4.02)	<0.001*
Full weight-bearing achieved within 16 weeks	19 (38.0)	32 (64.0)	χ^2=6.76	OR=0.34 (0.15–0.77)	0.009*
Duration of postoperative analgesic use, days	6.8 ± 2.2	5.7 ± 1.9	t=2.68	MD=1.10 (0.29–1.91)	0.009*
Blood transfusion required	6 (12.0)	2 (4.0)	Fisher's exact test	OR=3.27 (0.63–17.07)	0.269
Additional bone grafting required	4 (8.0)	1 (2.0)	Fisher's exact test	OR=4.26 (0.46–39.56)	0.362

Table 4 compares operative parameters and postoperative recovery between the two treatment groups. The mean injury-to-surgery interval was comparable between the LCP and intramedullary nailing groups (4.8 ± 2.1 versus 4.3 ± 1.8 days; p=0.204). The mean duration of surgery was significantly longer in the LCP group than in the intramedullary nailing group (94.7 ± 15.6 versus 78.9 ± 13.8 minutes; mean difference=15.80 minutes, 95% CI: 9.95–21.65; p<0.001). Intraoperative blood loss was also significantly greater with LCP fixation (176.4 ± 48.7 mL) than with intramedullary nailing (121.8 ± 39.6 mL; p<0.001). However, fluoroscopy exposure was significantly lower in the LCP group than in the intramedullary nailing group (46.3 ± 13.5 versus 58.7 ± 15.2 seconds; p<0.001). The mean length of hospital stay was significantly shorter following intramedullary nailing (6.3 ± 2.0 days) than following LCP fixation (7.8 ± 2.4 days; p=0.001). Knee and ankle mobilization was initiated significantly earlier in the intramedullary nailing group (2.8 ± 1.1 versus 3.7 ± 1.3 days; p<0.001). Similarly, partial weight-bearing and full weight-bearing were achieved significantly earlier following intramedullary nailing, with mean durations of 6.7 ± 1.8 and 15.2 ± 3.0 weeks, respectively, compared with 8.4 ± 2.1 and 17.9 ± 3.6 weeks in the LCP group (both p<0.001). Full weight-bearing within 16 weeks was achieved by 64.0% of the intramedullary nailing group compared with 38.0% of the LCP group (p=0.009). Postoperative analgesic use was also significantly shorter following intramedullary nailing (5.7 ± 1.9 versus 6.8 ± 2.2 days; p=0.009). Blood transfusion and additional bone grafting were more frequently required in the LCP group, but these differences were not statistically significant.

DISCUSSION

The present study compared clinical, radiological, functional, operative and postoperative outcomes of locking compression plate fixation and intramedullary nailing in 100 patients with diaphyseal tibial fractures. Overall, intramedullary nailing resulted in earlier fracture healing, lower early postoperative pain, better final joint movement, higher functional scores and faster postoperative rehabilitation. Locking compression plating provided the advantage of lower fluoroscopic exposure and a lower frequency of anterior knee pain. These observations indicate that both techniques were effective, although intramedullary nailing offered advantages in biological healing and recovery.

Clinical, radiological and functional outcomes

In the present study, postoperative pain at six weeks was significantly lower in the intramedullary nailing group than in the LCP group. Patients treated with intramedullary nailing also demonstrated significantly greater knee and ankle ranges of motion at final follow-up. The mean radiological union time was 16.1±3.1 weeks in the intramedullary nailing group compared with 18.6±3.8 weeks in the LCP group. Similarly, the mean final functional score was significantly higher after intramedullary nailing. These results suggest that the load-sharing nature of intramedullary nails and limited disruption of the fracture site may permit earlier rehabilitation and improved functional recovery.

Mao et al. (2015)[1], in a meta-analysis comparing intramedullary nailing and plating for distal tibial fractures, concluded that both procedures were acceptable treatment methods. Intramedullary nailing was associated with fewer superficial infections and wound-healing problems, whereas plating showed advantages regarding knee pain and maintenance of alignment. This broadly supports the present finding that nailing achieved better overall clinical recovery, although knee-related symptoms remained an important limitation.

Minhas et al. (2015)[2] compared short-term complications after plate fixation and intramedullary nailing of closed extra-articular tibial fractures. Their findings indicated meaningful differences in perioperative complication profiles between the two procedures, emphasizing the influence of surgical exposure and soft-tissue handling. The lower overall complication rate observed in the present intramedullary nailing group is consistent with the biological and minimally invasive characteristics of nail fixation.

Daolagupu et al. (2017)[3] reported that both intramedullary interlocking nailing and minimally invasive plate osteosynthesis produced satisfactory functional outcomes in extra-articular distal tibial fractures. However, intramedullary nailing was associated with earlier weight-bearing and shorter union time, whereas plating offered better control of alignment in selected fractures. These observations are comparable to the present study, in which nailing produced faster union, better functional scores and earlier return to activity.

Although radiological union by 24 weeks was more frequent after intramedullary nailing in the present study, the difference did not reach statistical significance. Similarly, the proportions achieving excellent or good outcomes and returning to their previous occupation were higher in the nailing group but were only borderline or statistically non-significant. This implies that the early advantages of intramedullary nailing may become less pronounced once long-term healing has occurred.

Radiological fracture union

Bridging callus appeared significantly earlier in the intramedullary nailing group, and both partial and complete radiological union occurred sooner than in the LCP group. Union within 16 weeks was achieved by 62% of the nailing group compared with 36% of the plating group, while union within 20 weeks was achieved by 88% and 72%, respectively. RUST scores were also significantly higher after nailing at 12 and 24 weeks. These findings reflect more advanced radiological healing with intramedullary fixation.

Sun et al. (2018)[4], in a meta-analysis of nailing versus plating for distal tibial fractures, reported that intramedullary nailing was generally associated with shorter operative and union times and fewer wound-related complications. However, nailing carried a greater risk of malalignment and knee pain in some studies. Their findings correspond to the shorter radiological union time observed in the current nailing group.

Hu et al. (2019)[5] analysed randomized controlled trials comparing intramedullary nailing with plate fixation for distal tibial fractures with metaphyseal involvement. They found no major difference in several final healing outcomes, including non-union, but noted differences in operative duration, wound complications and functional recovery. The present study similarly found no statistically significant differences in delayed union, non-union or malunion, despite these outcomes being numerically more frequent in the LCP group.

Ekman et al. (2021)[6] concluded that intramedullary nailing might be slightly superior to plating in reducing postoperative complications and achieving faster fracture healing. This is directly comparable to the present findings of earlier callus formation, higher RUST scores and shorter complete union time following intramedullary nailing.

Bleeker et al. (2021)[7], in a meta-analysis involving 1,332 patients with extra-articular distal tibial fractures, found that both plating and nailing were viable options. Intramedullary nailing showed a tendency towards earlier union and fewer infections but was associated with increased anterior knee pain and a slightly greater risk of malunion. Their conclusion that treatment should be individualized is relevant because the benefits of faster healing with nailing must be balanced against fracture alignment and knee symptoms.

Functional outcomes and postoperative complications

The mean functional score in the present study was significantly higher in the intramedullary nailing group. Excellent outcomes were obtained in 52% of patients treated with nailing and 34% treated with LCP. When excellent and good categories were combined, the corresponding rates were 90% and 76%, although this difference did not reach statistical significance. The absence of statistical significance for categorical functional outcomes, despite a significant difference in mean scores, may be related to categorization-related loss of information and the sample size within individual outcome categories.

Superficial infection, deep infection, delayed union, malalignment, implant irritation, stiffness and implant failure were numerically more frequent in the LCP group. Nevertheless, these differences were not statistically significant. The overall complication rate was 28% after LCP fixation and 16% after nailing. Plating requires an implant close to the subcutaneous medial tibial surface and may cause implant prominence, soft-tissue irritation and wound complications, particularly in patients with compromised soft-tissue coverage.

Jindal et al. (2020)[8], in a meta-analysis of proximal tibial fractures, found no major difference between plating and intramedullary nailing in overall outcomes. Lower infection risk and shorter surgical duration favoured nailing, whereas anterior knee pain and delayed union were less common with plating. This pattern closely resembles the present study, where the overall complication burden tended to favour nailing but anterior knee pain was significantly more frequent after nailing.

Anterior knee pain occurred in 16% of patients treated with intramedullary nailing compared with 2% treated with LCP. This was the only individual complication showing a statistically significant difference. Leliveld et al. (2020)[9] demonstrated that anterior knee pain remains a recognized concern following tibial intramedullary nailing and may be influenced by the nail-entry approach and surgical technique. The significant difference observed in the present study therefore agrees with the established complication profile of tibial nailing.

Wang et al. (2023)[10] reported satisfactory outcomes with both intramedullary nailing and minimally invasive plate osteosynthesis. Their study found comparable primary union, functional scores, deep infection and malalignment outcomes, but significant differences in operative time, fluoroscopic exposure, blood loss, union time, anterior knee pain and superficial infection. These observations closely correspond to the current findings and reinforce that the two procedures have distinct rather than uniformly superior complication profiles.

Operative parameters and postoperative recovery

The mean duration of surgery was significantly shorter with intramedullary nailing than with LCP fixation. Intraoperative blood loss was also lower in the nailing group, while fluoroscopy exposure was greater. The longer operative time and increased blood loss associated with plating may be explained by fracture exposure, reduction manoeuvres and plate positioning. Conversely, intramedullary nailing requires repeated fluoroscopic confirmation of the entry point, guidewire passage, reduction, nail position and locking screw placement, explaining the greater radiation exposure.

The hospital stay was significantly shorter after intramedullary nailing. Mobilization, partial weight-bearing and full weight-bearing were also initiated earlier. Almost two-thirds of patients treated with nailing achieved full weight-bearing within 16 weeks compared with 38% of those treated with LCP. These results are clinically important because earlier weight-bearing may reduce immobilization-related morbidity and facilitate earlier return to work and daily activities.

Postoperative analgesic use was significantly shorter in the intramedullary nailing group. However, this early pain advantage should be interpreted alongside the higher incidence of anterior knee pain during subsequent follow-up. Early postoperative pain may be related to incision size, soft-tissue dissection and fracture manipulation, whereas anterior knee pain after nailing may result from the entry portal, patellar tendon irritation, proximal nail prominence or injury to adjacent structures.

Blood transfusion and additional bone grafting were required more often in the LCP group, although the differences were not statistically significant. The small number of these events produced wide confidence intervals, suggesting inadequate statistical power to demonstrate differences in uncommon complications.

CONCLUSION

The present comparative study demonstrated that both locking compression plate (LCP) fixation and intramedullary interlocking nailing (IMILN) were effective methods for the management of diaphyseal tibial fractures, resulting in satisfactory fracture union and acceptable functional outcomes. However, intramedullary nailing showed significant advantages over LCP fixation in terms of lower postoperative pain, better knee and ankle range of motion, earlier radiological union, higher functional scores, shorter operative duration, reduced intraoperative blood loss, shorter hospital stay, and earlier initiation of partial and full weight-bearing. Although the rates of union by 24 weeks, overall postoperative complications, reoperation, delayed union, non-union, and malunion were lower in the intramedullary nailing group, these differences were not statistically significant. Conversely, fluoroscopy exposure was significantly lower in the LCP group, while anterior knee pain was significantly more common following intramedullary nailing. Overall, intramedullary interlocking nailing appears to provide superior clinical and functional recovery for most diaphyseal tibial fractures, whereas locking compression plating remains an appropriate alternative in selected fracture patterns requiring precise anatomical reduction or where intramedullary fixation is less suitable. Treatment should therefore be individualized based on fracture characteristics, soft-tissue condition, patient factors, and surgeon expertise.

LIMITATIONS OF THE STUDY

1. The sample size of 100 patients was relatively small and may not have been sufficient to detect differences in uncommon complications.
2. Allocation to treatment groups was not randomized, introducing the possibility of selection bias.
3. The duration of follow-up was limited and may not have captured long-term functional outcomes, implant-related complications.
4. Fracture configuration, bone quality, and surgeon preference could have influenced implant selection and treatment outcomes.
5. Rehabilitation compliance and physiotherapy protocols were not objectively assessed and may have affected functional recovery.
6. Patient-reported quality of life and cost-effectiveness analyses were not evaluated.
7. Advanced imaging such as CT scans was not routinely used to assess fracture healing or rotational alignment.

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