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A comparative study of radiological and functional outcome of multidirectional locking nail with locking plate for management of distal Tibial Metaphyseal fractures

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Abstract

***Background & Aims*:** Road traffic accidents and high-energy injuries are the leading cause of distal tibial metaphyseal fractures. The management of tibial fractures remains controversial despite advances in non-operative and operative care. Plates and intramedullary nails are well-accepted and effective methods, but each has been historically related to complications. The present study compared the results of displaced extra-articular distal metaphyseal tibia fractures.

***Materials & Methods*:** This descriptive cross-sectional study was conducted in the department of orthopedics at R. G. Kar medical college and hospital, Kolkata, West Bengal, India on 27 Locking Plate the 27 Multidirectional Plate patients attending orthopedics and emergency room with a tibia fracture from January 2019 to August 2020. All patients with extra-articular distal tibial fracture without distal neurovascular deficit, closed injury, or Gustillo Anderson type 1 were included. Post-operatively, X-rays were taken of the surgical site, and a series of X-rays were taken at 4, 16, 24, and 36 weeks' intervals. SPSS v.27 and GraphPad Prism v.5 along with statistical tests were used. P values below 0.05 were considered significant.

***Results*:** In Locking Plate, 8(29.6%) patients were 21-30 years old, 10(37.0%) patients were 31-40 years old, and 9(33.3%) patients were 41-50 years old. In Multidirectional Nail, 6(22.2%) patients were 21-30 years old, 11(40.7%) patients were 31-40 years old, and 10(37.0%) patients were 41-50 years old. The Association of age with group was not statistically significant (p=0.8245). In Locking Plate, 11(40.7%) patients were female, and 16(59.3%) were male. In Multidirectional Nail, 10(37.0%) patients were female, and 17(63.0%) patients were male. The Association of sex with group was also not statistically significant (p=0.7801).

***Conclusion*:** We found that Fair outcome was more in Multidirectional Nails compared to Locking Plate for the AAOS Lower limb questionnaire at four weeks, which was not statistically significant. It was found that the excellent outcome was more in Multidirectional Nails compared to Locking Plate for the AAOS Lower limb questionnaire at five weeks, which was not statistically significant.

***Keywords*:** Distal Tibial Metaphyseal Fractures, Locking Plate, Multidirectional Locking Nail

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Introduction

Road traffic accidents and high-energy injuries are the leading cause of distal tibial metaphyseal fractures. The tibia is a weight-bearing bone of the leg, and takes part in the formation of the knee joint above and the medial malleolus below. The management of tibial fractures remains controversial despite advances in non-operative and operative care. Plates and intramedullary nails are well-accepted and effective methods, but each has been historically related to complications. The shaft of the tibia is triangular in cross-section. It has five surfaces including: medial, lateral, anterior, posterior, and inferior faces (1).

The lower part of the anterior surface of the shaft and the anterior aspect of the lower end is crossed (from medial to the lateral side) by the tibialis anterior, the extensor hallucis longus, the anterior tibial artery, the deep peroneal nerve, the extensor digitorum longus, and the peroneus tertius (2).

The lowermost part of the shaft's posterior surface and the lower end's posterior aspect are related (from medial to the lateral side) to the tibialis posterior, the flexor digitorum longus, the posterior tibial artery, the tibial nerve, and the flexor hallucis longus. The groove for the tibialis posterior tendon continues downwards on the posterior surface of the medial malleolus (3). The great saphenous vein crosses the lower one third of the medial surface of the shaft. The nutrient artery originates from the posterior tibial artery, which enters the bone through nutrient foramina on its posterior surface. It is the largest nutrient artery in the body (4). Distal tibia has very little soft tissue coverage and lies in the subcutaneous plane, thus having very little skin mobility, also being supplied by end arteries. These two factors largely contribute to the fact of high post-op infection of the tibia (5). Distal tibial fractures are 3 to 10% of all tibial fractures. In 70 to 85% of the cases, a fibular fracture is also seen. Up to 50% have additional lower extremity injuries. About 6% have multiple system injuries (6).

Conservative or surgical methods can treat distal tibial fractures. Surgical techniques range from external to internal fixation with nails and plates (7).

As tibial fractures are commonly associated with soft tissue injury, if these are not adequately treated, they can cause substantial disability to the patient. High-energy motor vehicle trauma constitutes the commonest cause (3), followed by falls, direct blows, and sports injury. The incidence of distal tibia fractures in most series is 0.6%, constituting about 10%–13% of all tibial fractures (8). The distal tibial metaphysis is constructing a square with sides of length defined by the broadest portion of the tibial plafond (5). Because of its subcutaneous location, poor blood supply and decreased muscular cover anteriorly, complications such as delayed union, nonunion, wound infection, and wound dehiscence are often seen as a great challenge to the surgeon.

Minimally Invasive Plate Osteosynthesis (MIPO) and Intramedullary Interlocking Nail (IMLN) are well-accepted and effective methods, but each has been historically related to various complications. Malalignment and knee pain are frequently reported after IMLN (6,7), whereas wound complications and implant prominence have been associated with tibial plating in some series (9).

Distal tibial metadiaphyseal fractures are a common consequence of road traffic accidents, while falling injuries and other high-energy trauma and usually involve a severe soft-tissue injury. These fractures require surgical managements such as reduction and internal or external fixation. Surgical treatment for distal tibial metadiaphyseal fractures is still challenging because extensive soft-tissue injuries often disrupt the vascular supply to the fracture site, increasing the risk of infection, and delayed union or nonunion (10). Various treatments may be used, including intramedullary (IM) nailing, plating, and external fixation (11). However, surgical treatment for distal tibial metadiaphyseal fractures remains controversial. Which internal fixation method should be chosen, and which is better: intramedullary (IM) nailing or plating? We hypothesized that superior results might be achieved when distal tibial metadiaphyseal fractures are treated with intramedullary (IM) nails. The present study compared the results of displaced extra-articular distal metaphyseal tibia fractures. This approach protects the soft tissue that envelops the fracture site.

Materials & Methods

The study was conducted in the department of orthopedics at R. G. Kar medical college and hospital, Kolkata, West Bengal, India. All the patients were attending orthopedics OPD and emergency room with a tibia fracture. The study period was 18 months, from January 2019 to August 2020.

Inclusion Criteria: All the patients with extra-articular distal tibial fracture without distal neurovascular deficit, closed injury, or Gustillo Anderson type 1.

Exclusion Criteria: All the patients with bone loss and extensive soft tissue injury (Gustillo Anderson type 2 or more). Also, All the patients with complicated comorbidities like diabetes or with polytrauma were excluded from the study.

Parameters Studied included: Time is taken for union (radiological), Lower extremity functional scale, American academy of orthopedic surgeon's lower limb questionnaire, Range of motion, and Complication rate.

Study tools included: Written and informed consent form X-rays, Pre-designed pro forma, CT scan, and Software SPSS VERSION 20/MICROSOFT EXCEL

Study techniques: The study was conducted after taking written informed consent from the patients and getting ethical clearance from the institute. Digital X-rays of the affected leg with knee and ankle were taken. Post-operatively, X-rays were taken of the surgical site, and a series of X-rays were taken at 4, 16, 24, and 36 weeks' intervals. Pre-op CT scans were done to rule out articular involvement.

Lower limb functional assessment scale:

The main objective of the lower limb functional assessment scale was to measure the patient's function and outcome. Therefore, the interpretation of scores was as follows lower the score, the greater the disability, the minimal detectable change is nine scale points, the minimal clinically significant difference is nine scale points, percentage of maximal function = (LEFS score)80*100, and American academy of orthopedic surgeon lower limb questionnaire was used.

Statistical Analysis:

For statistical analysis, data were entered into a Microsoft Excel spreadsheet and then analyzed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Two-sample t-tests for a difference in mean involved independent samples or unpaired samples. Paired t-tests were a form of blocking and had greater power than unpaired tests. Unpaired proportions were compared by Chi-square test or Fischer's exact test, as appropriate.

Results

In Locking Plate, 8(29.6%) patients were 21-30 years old, 10(37.0%) patients were 31-40 years old, and 9(33.3%) patients were 41-50 years old. In Multidirectional Nail, 6(22.2%) patients were 21-30 years old, 11(40.7%) patients were 31-40 years old and 10(37.0%) patients were 41-50 years old. The Association of Age in years with group was not statistically significant (p=0.8245) (Table 1).

Table 1. Association between Age in Years with groups

	GROUP		
Age in Years	**Locking Plate**	**Multidirectional Nail**	**TOTAL**
21-30	8	6	14
Row %	57.1	42.9	100.0
Col %	29.6	22.2	25.9
31-40	10	11	21
Row %	47.6	52.4	100.0
Col %	37.0	40.7	38.9

	GROUP		
Age in Years	**Locking Plate**	**Multidirectional Nail**	**TOTAL**
41-50	9	10	19
Row %	47.4	52.6	100.0
Col %	33.3	37.0	35.2
TOTAL	27	27	54
Row %	50.0	50.0	100.0
Col %	100.0	100.0	100.0

In Locking Plate, 11(40.7%) patients were female and 16(59.3%) patients were male.

In Multidirectional Nail, 10(37.0%) patients were female and 17(63.0%) patients were male. The Association of Sex with group was not statistically significant (p=0.7801) (Table 2).

Table 2. Association between Sex with groups

	GROUP		
Sex	**Locking Plate**	**Multidirectional Nail**	**TOTAL**
Female	11	10	21
Row %	52.4	47.6	100.0
Col %	40.7	37.0	38.9
Male	16	17	33
Row %	48.5	51.5	100.0
Col %	59.3	63.0	61.1
TOTAL	27	27	54
Row %	50.0	50.0	100.0
Col %	100.0	100.0	100.0

In Locking Plate, 11(40.7%) patients were female and 16(59.3%) patients were male.

In Multidirectional Nail, 10(37.0%) patients were female and 17(63.0%) patients were male. The Association of Sex with group was not statistically significant (p=0.7801) (Table 3).

Table 3. Association between Table: Association between AAOS Lower limb questionnaire at the 4 weeks

	GROUP		
AAOS Lower limb questionnaire at 4 weeks	**Locking Plate**	**Multidirectional Nail**	**TOTAL**
Fair	9	13	22
Row %	40.9	59.1	100.0
Col %	33.3	48.1	40.7
Poor	18	14	32
Row %	56.3	43.8	100.0
Col %	66.7	51.9	59.3
TOTAL	27	27	54
Row %	50.0	50.0	100.0
Col %	100.0	100.0	100.0

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In Locking Plate, 5(18.5%) patients were excellent, 12(44.4%) patients were fair and 10(37.0%) patients were poor. In Multidirectional Nail, 22(81.5%) patients were excellent and 5(18.5%) patients were fair. The Association of AAOS Lower limb questionnaire at 36 weeks with group was statistically significant (p<0.0001) (Table 4).

Table 4. Association between AAOS Lower limb questionnaire at 36 weeks

	Group		
AAOS Lower limb questionnaire at 36 weeks	**Locking Plate**	**Multidirectional Nail**	**TOTAL**
Excellent	5	22	27
Row %	18.5	81.5	100.0
Col %	18.5	81.5	50.0
Fair	12	5	17
Row %	70.6	29.4	100.0
Col %	44.4	18.5	31.5
Poor	10	0	10
Row %	100.0	0.0	100.0
Col %	37.0	0.0	18.5
TOTAL	27	27	54
Row %	50.0	50.0	100.0
Col %	100.0	100.0	100.0

In Locking Plate, 6(22.2%) patients were Complication. In Multidirectional Nail, 2(7.4%) patients were Complication. The Association of Complication with group was not statistically significant (p=0.1254) (Table 5).

Table 5. Association between Complication: Group

	GROUP		
Complication	**Locking Plate**	**Multidirectional Nail**	**TOTAL**
No	21	25	46
Row %	45.7	54.3	100.0
Col %	77.8	92.6	85.2
Yes	6	2	8
Row %	75.0	25.0	100.0
Col %	22.2	7.4	14.8
TOTAL	27	27	54
Row %	50.0	50.0	100.0
Col %	100.0	100.0	100.0

In Locking Plate, the mean Age (mean±SD) of patients was 36.4815±7.2979. In Multidirectional Nails, the mean Age (mean±SD) of patients was 37.8889±7.2075. The mean age difference between groups was not statistically significant (p=0.4790) (Table 6).

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Table 6. Distribution of mean Age

		Number	Mean	SD	Minimum	Maximum	Median	p- value
Age	Locking Plate	27	36.4815	7.2979	24.0000	49.0000	37.0000	0.4790
	Multidirec tional Nail	27	37.8889	7.2075	24.0000	49.0000	37.0000	

In Locking Plate, the mean lower extremity functional scale at 4 Weeks (mean±SD) of patients was 49.1481±4.8175. In Multidirectional Nails, the mean lower extremity functional scale at 4 Weeks (mean±SD) of patients was 56.8889±4.4750. The difference in mean lower extremity functional scale at 4 Weeks with both groups was statistically significant (p<0.0001) (Table 7).

Table 7. Distribution of mean Lower extremity functional scale at 4 Weeks

		Number	Mean	SD	Minimum	Maximum	Median	p-value
Lower extremity Functional scale at 4 Weeks	Locking Plate	27	49.1481	4.8175	42.0000	58.0000	48.0000	<0.0001
	Multidirec tional Nail	27	56.8889	4.4750	48.0000	68.0000	58.0000	

In Locking Plate, the mean lower extremity functional scale at 36 Weeks (mean± SD) of patients was 58.2963±6.0753. In Multidirectional Nails, the mean lower extremity functional scale at 36 Weeks (mean±SD) of patients was 67.2222±4.8937. The difference in mean lower extremity functional scale at 36 Weeks with both groups was statistically significant (p<0.0001) (Table 8).

Table 8. Distribution of mean Lower extremity functional scale at 36 Weeks

		Number	Mean	SD	Minimum	Maximum	Median	p-value
Lower extremity functional scale at 36 Weeks	Locking Plate	27	58.2963	6.0753	50.0000	70.0000	57.0000	<0.0001
	Multidirec tional Nail	27	67.2222	4.8937	60.0000	75.0000	67.0000	

Discussion

Our study showed that in Locking Plate, 8(29.6%) patients were 21-30 years old, 10(37.0%) patients were 31-40 years old and 9(33.3%) patients were 41-50 years old. In Multidirectional Nail, 6(22.2%) patients were 21-30 years old, 11(40.7%) patients were 31-40 years old, and 10(37.0%) patients were 41-50 years old. The Association of Age in years with group was not statistically significant (p=0.8245). In Locking Plate, 11(40.7%) patients were female and 16(59.3%) patients were male. In Multidirectional Nail, 10(37.0%) patients were female and 17(63.0%) patients were male. The Association of sex with group was not statistically significant (p=0.7801).

Megas P et al. (12) found that the mean age of participants was 44.1(±16.95) years, and the majority were males (56.3%). Most (81.3%) patients had an associated fracture in the distal fibula. The time of surgery and fracture union for intramedullary nails was significantly less when compared to the plating. The Olreud & Molander and RUST scores were significantly higher in the patients with IMIL nails.

Yang SW et al. (13) showed that the mean age of the patient was 48.4 years and the majority were male

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(55%). The majority (83.33 %) of the patient had associated fibula fractures. The mean time for surgery was 74.63min in LCP, which was significantly less (P value = 0.00252) in ETN 61.76 minimum average time for union 18.46 weeks in ETN compared to 22.46 weeks in LCP, which was significant (P value = 0.001698). The average time for total weight bearing in ETN was 10.6 weeks, and in LCP was 13.56 weeks, which was significantly less in ETN (P value = 0.00356). The Olerued & Molander score were significantly higher in ETN (p-value = 0.0486). In plating, five patients showed superficial skin infection, three showed deep infections, two showed skin necrosis and implant exposure, and five had ankle stiffness. In nailing, only four patients showed superficial skin infection, and nine had anterior knee pain. In Locking Plate, 11(40.7%) patients were female and 16(59.3%) patients were male. In Multidirectional Nail, 10(37.0%) patients were female and 17(63.0%) patients were male. The Association of Sex with group was not statistically significant (p=0.7801).

Gorczyca JT et al. (14) found that excellent and good results were considered satisfactory results, while unsatisfactory included fair and poor results. Thus, there were satisfactory results in 15 patients (71.43%) and unsatisfactory results in six patients (28.57%). Treatment of distal tibial fractures using an intramedullary nail with multidirectional distal locking screws (expert nail) is a safe and accepted method alternative to conventional nails and plating technique. It provides additional biomechanical stability than conventional nails and plate osteosynthesis.

Hansen M et al. (15) found the mean union time, infection rate, malunion and nonunion rate, and total weight bearing time. No patient in the two groups developed a nonunion. None of the patients obtained a fair or poor outcome. Fifty-two patients obtained an excellent result (69.3%), and twenty-three obtained a good result (30.6%).

Ruedi TP et al. (16) found that the preferred surgical approaches were chosen based on the fracture morphology, determined from standard radiographic views and computed tomography. In addition, careful atraumatic soft-tissue handling and modern fixation techniques for the metaphyseal component such as minimally invasive plate osteosynthesis, further facilitate healing.

Robinson CM et al. (17) found that patients were followed up for clinical and radiological evaluation. In the IMLN group, the average union time was 18.26 weeks compared to 21.70 weeks in the plating group, which was significant (P < 0.0001). The average time required for partial and total weight bearing in the nailing group was 4.95 weeks and 10.09 weeks, respectively, which was significantly less compared to 6.90 weeks and 13.38 weeks in the plating group (P<0.0001). Compared to the plating group, fewer complications in implant irritation, ankle stiffness, and infection were seen in the interlocking group.

Ovadia DN et al. (18) found no statistically significant differences in complications, including the number of postoperative infections (9% in the nail group with 13% in the plate group). Further surgery was common in the plate group at twelve months (8% in the nail group with 12% in the plate group). Among the patients with the age of sixteen years or older with an acute, displaced, extra-articular fracture of the distal tibia, neither nail fixation nor locking plate fixation resulted in superior disability status at six months. Other factors may need to be considered in deciding the optimal approach.

Conclusion

We found that fair outcome was more in multidirectional nails compared to locking plate for the AAOS Lower limb questionnaire at four weeks, which was not statistically significant. It was found that the excellent outcome was more in Multidirectional Nails compared to Locking Plate for the AAOS Lower limb questionnaire at five weeks, which was also not statistically significant. It was found that the excellent outcome was more in Multidirectional Nails compared to Locking Plate for the AAOS Lower limb questionnaire at 36 weeks, which was statistically significant. In our study, the complication was less in Multidirectional Nails than in Locking Plates, which

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was not statistically significant. The mean lower extremity functional scale at four weeks was more in Multidirectional Nails than in Locking Plates, which was statistically significant. The mean lower extremity functional scale at 24 Weeks and 36 Weeks was more in a Multidirectional Nail than Locking Plate, which was statistically significant. We recommend more detailed studies with more population and wider time ranges in more hospitals.

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No Declared

Conflict of interest

The authors have no conflict of interest in this study.

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