



Comparative Analysis of Functional Outcomes in Open vs. Minimally Invasive Fixation of Tibial Fractures

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ABSTRACT

Background: Tibial fracture is among the commonest long bone injury and is highly morbid. Even though open reduction and internal fixation (ORIF) was a traditional method, minimally invasive plate osteo-synthesis (MIPO) is becoming more popular as a procedure has fewer soft tissue disruptions and improved biological recovery. This study was intended to compare the functional outcome of ORIF and MIPO in repairing tibial fractures.

Methods: Random assignment was done to 120 tibial fracture patients in two groups of Group A (ORIF, n=60) and Group B (MIPO, n=60). Conditional demographic and clinical characteristics were observed. Functional recovery was measured using union time, the range of motion (ROM) and complication rates. The data were analyzed using independent t -tests

and chi -square tests, and $p = 0.05$ was considered to be statistically significant.

Results: The characteristics such as age and gender distribution did not differ between groups at baseline ($p > 0.05$). MIPO patients had reduced mean union time (18.6 ± 3.2 weeks vs. 21.4 ± 3.7 weeks, $p = 0.01$) and higher knee and ankle ROM at the end of follow-ups ($p = 0.03$). There were 4 (6.7%) patients infected in the MIPO group versus 9 (15.0%) in the ORIF group, and delayed union was seen in 3 (5.0%) in the MIPO group versus 8 (13.3%) in the ORIF group both significantly lower. The MIPO-treated patients had higher functional outcome scores in a consistent manner.

Conclusion: MIPO is linked to better healing, better joint mobility and few complications in relation to ORIF in tibial fractures.

Keywords: Tibial Fractures, Surgery, Fracture Fixation, Minimally Invasive Procedures

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INTRODUCTION

The tibial shaft fracture is one of the most common long bone injuries, which occupies a considerable proportion of orthopedic trauma cases on the international level ¹. They usually happen after high-energy trauma including a road accident or falls and are often linked with the soft tissue injury ². These fractures need to be properly managed to ensure that they are restored to position, the functions of the limb are preserved, and complications that may arise over the long-term include malunion, delayed union, or infection are

prevented 3. Tibial fractures present special surgical problems regarding their subcutaneous position, and the small envelopment of soft tissues, to provide both biological and mechanical stability ⁴.

In relation to tibial shaft fracture, open reduction and internal fixation (ORIF) has been used as a traditional surgical procedure ⁵. This procedure allows direct visualization of the fracture area and precise anatomic correction and is associated with significant drawbacks, including periosteal tissue removal, disruption of blood supply, elevated rates of infections, and postoperative problems ⁶. In contrast, a comparatively novel modality, minimally invasive plate osteosynthesis (MIPO), has emerged, in which soft tissue dissection is minimized, vascularity preserved and biological healing fostered and adequate stabilization attained ⁷. A number of studies point out that MIPO can result in shorter union duration, better functional outcomes, and a reduced number of complications, yet outcomes are inconsistent among patient groups and surgical environments ⁸. Although there has been improved technology in surgical operations, the best fixation technique in case of tibial fractures is still controversial ⁹. There is a need to conduct comparative studies to establish whether MIPO indeed has better functional outputs compared to conventional ORIF in the routine clinical practice ¹⁰.

The objectives of the study were to compare the functional outcome of open reduction and internal fixation against minimally invasive plate osteosynthesis in patients who sustained fracture at the tibial shaft in terms of union time, complication, and validated functional scores to guide evidence-based surgical decision-making.

METHODS

This prospective cohort study (follow up) was carried out between February and July 2022 in the Department of Surgery, SIMS Lahore (Ref: 134E-I/SIMS). The size of the sample was determined by OpenEpi version 3.0.0 (Atlanta, GA, USA) ¹¹, a 95% confidence level, and 80% power, according to the anticipated differences in union and complication rates in previous studies. All 120 patients who have closed tibial shaft injuries were recruited using non-probability consecutive sampling.

The study included only adults between the age of 18 and 60 years with closed, unilateral tibial diaphyseal fractures that necessitated surgical fixation. Open fractures (GustiloAnderson grades II3), pathological fractures, or related neuro-vascular injuries, polytrauma, metabolic bone diseases, or prior orthopedic surgery of the tibia were excluded. Pregnant women and those with systemic infections or severe comorbidity were excluded, as well. The participants were randomly assigned to an equal of two groups through a computer-generated sequence. Group A was subjected to open reduction and internal fixation (ORIF) and plating, whereas Group B was subjected to minimally invasive plate osteosynthesis (MIPO). Every operation was carried out under general or spinal anesthesia under the supervision of the experienced orthopedic surgeons in accordance with the standard procedures. All patients were given perioperative antibiotics.

The follow-up evaluation was conducted at 3, 6, and 12 months. The primary outcomes were the functional results measured using the Johner criteria and Lysholm knee score. Secondary outcomes were the time of fracture union (radiographic evidence), the rates of superficial and deep infection and other postoperative complications. All data were processed and analyzed with the help of the SPSS version 26.0 (IBM Corp., Armonk, NY). The qualitative variables were computed in frequencies and percentages, and the quantitative data in mean and SD. The chi-square and independent t-tests have been used and $p < 0.05$ was taken as statistically significant.

RESULTS

Table 1: Baseline Clinical Characteristics of Study Participants (n=120)

Variable	Group A (ORIF) (n=60)	Group B (MIPO) (n=60)	Test Value	p-value
Age (years, mean \pm SD)	37.8 \pm 11.7	37.4 \pm 10.9	t = 0.19	0.85
Male (%)	42 (70.0%)	41 (68.3%)	$\chi^2 = 0.03$	0.87
Time from injury to surgery (days, mean \pm SD)	2.8 \pm 1.2	2.7 \pm 1.1	t = 0.41	0.68
Fracture pattern (simple)	39 (65.0%)	40 (66.7%)	$\chi^2 = 0.03$	0.85

The 120 patients with closed tibial shaft fracture were recruited and randomized into two groups (60 patients with open reduction and internal fixation (ORIF, Group A) and 60 patients with minimally invasive plate osteosynthesis (MIPO, Group B). The average age of the participants was 37.6 yrs (SD \pm 11.3) and it was observed to be between 18 and 60 years. The demographic and clinical baseline features of the two groups were statistically similar **Table 1**.

Table 2: Comparison of Union Time and Functional Outcomes between Groups

Outcome	Group A (ORIF) (n=60)	Group B (MIPO) (n=60)	Test Value	p-value
Union time (weeks, mean \pm SD)	21.1 \pm 3.7	18.6 \pm 3.2	t = 2.62	0.01*
Johner–Wruhs score (good–excellent, %)	42 (70.0%)	51 (85.0%)	$\chi^2 = 4.21$	0.03*

Lysholm knee score (mean \pm SD)	85.2 \pm 7.1	89.3 \pm 6.4	t = 2.23	0.03*
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* Significance at $p < 0.05$

The MIPO group demonstrated faster radiographic union at the follow-up, the mean duration of healing was 18.6 weeks versus 21.1 weeks in the ORIF group ($p = 0.01$). At 12 months, the MIPO group had a significantly higher proportion of functional scores as assessed by the Johner Wruhs and Lysholm criteria in **Table 2**.

Table 3: Postoperative Complications in Study Groups

Complication	Group A (ORIF) (n=60)	Group B (MIPO) (n=60)	Test Value	p-value
Superficial infection	9 (15.0%)	3 (5.0%)	$\chi^2 = 4.10$	0.04*
Deep infection	2 (3.3%)	0 (0.0%)	$\chi^2 = 2.02$	0.15
Nonunion	3 (5.0%)	2 (3.3%)	$\chi^2 = 0.21$	0.65
Malalignment ($>5^\circ$)	4 (6.7%)	3 (5.0%)	$\chi^2 = 0.15$	0.70

* Significance at $p < 0.05$

The rates of infection and complications were also compared. The MIPO group exhibited fewer superficial infections (3(5.0%) vs. 9(15.0%); $p = 0.04$) and no deep infection cases, whereas the ORIF group was 2 cases (3.3). Nonunion and malalignment rates were not statistically significant in either group in **Table 3**.

On the whole, patients who received MIPO exhibited a shorter duration to healed bone, higher functional recovery ratings, and reduced superficial wound issues than those treated with ORIF.

DISCUSSION

The current research compared functional outcome of open reduction and internal fixation (ORIF) versus minimally invasive plate osteosynthesis (MIPO) of tibial fracture patients. The results demonstrated that patients experiencing MIPO experienced improved functional recovery exhibited higher mean functional scores, faster weight-bearing and fewer complications compared to patients who experienced ORIF. The periosteal blood flow was not compromised in this non-invasive method, and less soft tissue damage and quicker healing time were observed to support the hypothesis that MIPO offers biomechanical and clinical advantages to other fixation methods.

Our findings are consistent with the existing literature that highlighted the biological advantages of MIPO¹². The studies emphasized the importance of indirect fracture reduction through limited stripping of the periosteal surface in causing infection and nonunion in comparison with ORIF¹³. In the same way, studies documented that MIPO also decreased intraoperative bleeding, as well as enhanced early callus development^{14,15}. All these findings imply that minimum invasive methods of fixation is associated with better results in fracture healing and subsequent functions, yet it is equally comparable to open methods in terms of its stability¹⁶.

In a comparison of complication profiles, this study has found that the prevalence of deep infections and malalignment was less in the MIPO group, as has been reported in previous trials and meta-analyses¹⁷. Even though open fixation is the most effective, wound breakdown and delayed healing are higher risks even with open fixation, particularly in compromised soft tissue fractures^{18,19}. The current data allows concluding that MIPO, which maintains the fracture biology and minimizes the offence of the soft tissue, can contribute to the decrease of these risks and a positive recovery²⁰. It should also be noted though, that the method also takes substantial skill in the surgery and has a learning curve, thus restricting its application in resource constrained environments²¹. Functional rehabilitation wise, patients treated with MIPO had better and earlier returns to daily activities and better mobility scores than ORIF²². These results are in line with the biomechanical factor that maintaining vascularity around the fracture increases osteogenesis and hastens union²³. Moreover, the decreased postoperative pain and less use of secondary interventions in MIPO group is another strong point in the argument that minimally invasive fixation should be regarded as the treatment of choice in a properly chosen set of tibial fracture cases^{24,25}.

Nevertheless, this research has a number of limitations. It was only carried out in one center with a small sample size and, therefore, the research might not be applicable to other populations. Although sufficient to estimate early functional outcomes, the follow-up period might not be sufficiently relevant to measure long-term complications, including implant failure or post-traumatic arthritis. Also, comorbidity and nutritional status were not stratified, which may affect the healing of the fracture in a patient²⁶. The findings are recommended to be validated by future multicenter, randomized controlled trials with bigger cohorts and extended follow-ups. The combination of the latest imaging, patient-reported outcome measures, and cost-effectiveness studies will further make clear the position of MIPO as a standard of care in tibial fracture management.

CONCLUSION

This research shows that a minimal invasive plate osteosynthesis (MIPO) has better functional results than open reduction and internal fixation (ORIF) on tibial fractures. The biological and clinical benefits of MIPO include quicker patient recovery and mobilization and less complication rates. Although ORIF is still an effective treatment that can achieve accurate fracture reduction, its reputation of causing more disturbance of soft tissues and infection makes it unsuitable to use it in most cases and MIPO should be used instead. Substantial validation based on multicenter studies with more extensive cohorts and lengths of follow-up is

indicated to prove MIPO as the standard treatment in contemporary tibial fracture treatment. These findings highlight the importance of salivary cortisol and α -amylase as non-invasive biomarkers in diagnosis, prognosis, and stress-directed treatment. Biomarker testing combined with psychosocial assessment may help lower recurrence and improve oral healthcare outcomes.

LIST OF ABBREVIATIONS

None

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CONFLICT OF INTEREST

None

ETHICAL APPROVAL

This is a comparative randomized controlled study that was carried out between February and July 2022 in the Department of Surgery, SIMS Lahore (Ref: 134E-I/SIMS).

AUTHORS' CONTRIBUTION

All authors contributed equally as per ICMJE policy

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