

# Postoperative Outcomes of Single and Double Plating Osteosynthesis for Proximal Metaphyseal Tibial Fractures

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## Abstract

**Background:** Optimal management of proximal tibial fractures remains to be a clinical challenge. Most studies on this condition have been conducted on cadaver specimens, and few have compared the clinical outcomes of single and double plating methods in these fractures.

**Objectives:** The current study aimed to compare the postoperative outcomes and complications of the single and double plating methods in the treatment of metaphyseal proximal tibial fracture.

**Methods:** We treated 40 patients with metaphyseal tibial fracture with single or double plating methods (20 in each group). Patients were followed after 2 and 6 weeks, and 3 and 6 months; all were assessed for malunion, nonunion, and malalignment deformities.

**Results:** In the double plating group, numerically better flexion and extension range was not significant ( $p > 0.05$ ). However, in the interpretation of the Lysholm Knee Score questionnaire, a significantly higher proportion of good and excellent postoperative outcomes were found in the double plating group ( $p = 0.041$ ). In the double plating group, 15%, 15%, 40%, and 30% of patients were categorized as having poor, fair, good, and excellent outcomes, respectively. These proportions were 30%, 45%, 15%, and 10% among the single plating group respectively. Moreover, we detected positive valgus stress test in the single plating method in 30% of the cases, compared with 5% in the double plating method ( $p = 0.037$ ). Similarly, we observed that 20% of the cases with positive varus stress test in the single plating method, compared with the double plating method that had no cases who tested positive ( $p = 0.035$ ). The observed significant differences survived after we controlled for the positive stress test using regression models. It should be noted that in the single plating group, one case of valgus malalignment with  $10^\circ$  and one case of varus malalignment with  $5^\circ$  were observed.

**Conclusion:** Our results highlight that the choice of the double plating method to be associated with significantly better outcomes and fewer complications in the treatment of proximal tibial metaphyseal fracture.

**Keywords:** Proximal tibial fracture, Double plate constructs, Locking plate.

## Introduction

Extra-articular proximal tibial fractures are usually caused by high-energy trauma and account for about 5% to 11% of all tibial fractures.<sup>1</sup> Treatment of these fractures is commonly complicated by wound dehiscence, infection, rotational deformity, and tightening of the adjacent joints.<sup>2</sup> Non-surgical treatment of this fracture, including casting and brace, is usually not effective and has been associated with prolonged hospital stay, poor functional outcomes, and higher malunion rates.<sup>3,4</sup> Therefore, the use of surgical treatments in these fractures is highly recommended. Surgical treatments include external fixation, intramedullary nailing, and a variety of non-locking and locking plates.<sup>5</sup> In recent years, minimally invasive plating and intramedullary nailing have been used to treat proximal fractures of tibia;

however, there is still insufficient evidence to recommend a single standard of care in these fractures, and the choice of surgical method in the management of proximal tibial fractures is a matter of ongoing debate.<sup>6,7</sup> The use of intramedullary nailing and plating fixation has been compared in few clinical series, and the clinical decision-making process is dependent mainly on the expertise of the surgical team and soft tissue factors.<sup>8</sup>

Recent randomized clinical trials have shown promising and comparable clinical outcomes with intramedullary nailing (IMN) and proximal tibial plating (PTP) in the treatment of proximal tibial fractures. Intramedullary nailing is one of the most common surgical approaches in these fractures and has been reported to result in shorter hospital stay and faster union time, particularly with the introduction

of recently developed implants.<sup>9</sup> Notably, biomechanical studies comparing the fatigue strength of intramedullary nails and double locking plate in the proximal tibial extra-articular fractures have also demonstrated equivalent fatigue performance and recommended using IMN in cases where malalignment can be avoided.<sup>10</sup> However, IMN could be a challenging technique in proximal fractures of the tibia, despite causing less damage to soft tissue and the lower reported risk of infection; higher malunion rates and malreduction deformities have also been observed with this method.<sup>8,11,12</sup> Conversely, some studies have shown that in cases where the soft tissue damage is moderate or mild, double plating and lateral plating techniques with external fixations may be the best option for surgical treatment. In these studies, it was found that the double-locking plate is more mechanically stable than the intramedullary nails for the treatment of proximal tibial extra-articular fractures.<sup>13,14</sup> Nonetheless, it has been shown that the use of double plating may be linked with higher complications, particularly potential worsening of wound healing and higher infection rates.<sup>15-17</sup>

To date, several studies have reported different methods for the surgical treatment of proximal tibial extra-articular fractures. Although these studies have investigated both single and double plating methods, the comparison of these two methods has mainly been performed mechanically on cadaveric or synthetic bone specimens.<sup>10,13,18,19</sup> To the best of our knowledge, the evidence is not conclusive regarding the treatment of choice for proximal metaphyseal tibial fractures, and much less has been done to compare the independent clinical outcomes of single and double plating methods in these fractures.

### Objectives

To address this gap in the limited clinical evidence, the current study aimed to compare the postoperative outcomes and complications of the single and double plating methods in the treatment of metaphyseal proximal tibial fracture.

### Materials and Methods

In this retrospective study, the sample comprised 40 patients (28 males) with proximal tibial metaphyseal fracture who referred to the Orthopedic Department of Imam Khomeini Hospital in Sari, Iran, from 2014-2019 and underwent single or double plating surgery.

Included were all skeletally mature patients within the age

range of 18 to 80 years with proximal tibial fractures within the last three weeks prior to admission and no concomitant fractures. Patients with the following characteristics were excluded: open fractures, fractures beyond the prior three weeks, pathologic fractures, tibial plateau fractures, presence of severe vascular injury, concomitant fractures, inability to walk before fracture, comorbidities that prevented surgery. Moreover, patients with closed proximal tibial metaphyseal fractures who were treated with a non-plating technique such as intramedullary nailing were also excluded.

The medical records of patients were retrospectively reviewed, and the patients were clinically examined during their post-operative follow-up assessments. Patients were divided into two groups: Group 1 comprised 20 patients (15 males) with proximal tibial metaphyseal fracture who were treated with a single locking compression plate (LCP) using a curvilinear anterolateral incision. Group 2 comprised 20 patients (13 males) who received the double plate treatment using (LCP) and the same curvilinear anterolateral incision in addition to the reconstruction plate and 3.5 or 4.5 T-plates that were fixed using the medial incision. The demographic data of the patients, including age, gender, operative time, duration of hospital stay, and postoperative complications, are presented in [Table-1](#). Patients were followed up after 2 and 6 weeks and 3 and 6 months; all were evaluated for nonunion, malunion, and malalignment deformity, and the range of motion of the knee in flexion and extension were assessed in both groups. Malrotation was defined as an internal/external rotation deformity greater than 5 degrees. The stability of the knee was tested by applying valgus (abduction) and varus (adduction) stress to the knee in extension at 30 degrees of flexion, and positivity was assessed by the degree of joint opening and pain. The Lysholm Knee Score questionnaire was used to evaluate the patients' performance. Based on the interpretation of the questionnaire, patients with Lysholm scores of less than 65, 65-83, 84-94, and 95-100 were categorized as having poor, fair, good, and excellent outcome, respectively.<sup>20</sup> [Figures 1](#) and [2](#) present the pre- and postoperative radiographs of patients in both groups.

Institutional review board (IRB) approval with the registration code of IR.MAZUMS.IMAMHOSPITAL.REC.1398.062 was obtained for the retrospective review of cases, and this study was conducted in accordance with the Declaration of Helsinki. A non-random convenience

sampling method was used in this study and included all patients with available follow-up assessments meeting the inclusion and exclusion criteria who were admitted to the hospital during the study period. The data was analyzed using Statistical Package for the Social Sciences (SPSS) 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were compared using the independent sample t-test and Mann-Whitney U test. To further control for potential confounding variables, multiple regression was used to adjust for the covariates. For the categorical variables, the chi-square test was employed, and Fisher's exact test was employed in cases where assumptions of the chi-square-test could not be met. A *p*-value less than 0.05 was considered statistically significant.

## Results

In this study, the records of 40 patients who had double plate and single plate surgeries (20 in each group) were retrospectively reviewed. The ranges of flexion and extension were higher in the double plating group, but no statistically significant difference was observed between the two groups ( $p > 0.05$ ; Table 1). In the single plating method, the valgus stress test was positive in 6 (30%) cases, whereas it was positive in one patient in the double plating group, which was statistically significant ( $p=0.037$ ). Similarly, 4 cases (20%) were observed to have a positive varus stress test in the single plating method, but no cases tested positive in the double plating group ( $p=0.035$ ). It should also be noted that in the

single plating group, one case of valgus malalignment with 10 degrees and one case of varus malalignment with 5 degrees were observed. Critically, higher incidence of early postoperative wound complications was not observed in the double plating group, and none of the cases developed hematoma formation, wound necrosis, or infection.

The subscales and total score of the Lysholm Knee Score questionnaire were compared between the two groups, and no significant differences were found between the two groups in any subscales. In the subsequent analyses using multiple regression to adjust for the positive stress test, no significant differences were observed in any of the Lysholm Knee score subscales as well ( $p > 0.05$ ; Table 2). Furthermore, the patients' scores were categorized to evaluate patient performance based on the interpretation of the Lysholm Knee Score questionnaire. In the single plate method, 30%, 45%, 15%, and 10%, respectively, and in the double plate method 15%, 15%, 40%, and 30%, respectively, had poor, fair, good, and excellent results. In the double plating group, the good and excellent postoperative outcomes were higher, and this difference was statistically significant ( $p=0.041$ ; Table 3A). To further investigate the potential confounding effects of higher positive stress test in the single plate group, another round of analyses was performed after removing cases with positive stress tests in both groups. Critically, the statistically significant difference in the higher proportion of good and excellent outcomes in the double plate group survived this adjusted analysis ( $p=0.011$  Table 3B).

**Table-1.** Demographics data and Post-operative outcomes the single and double plating groups

	Single-plate (N=20)	Double-plate (N=20)	P-value
<b>Gender</b>			
Male	15	13	
Female	5	7	0.731 <sup>a</sup>
<b>Age</b>	39.3 (14.9)	42.1 (16.8)	0.588 <sup>b</sup>
<b>Hospital stay (days)</b>	3.95 (0.7)	4.2 (1.2)	0.447 <sup>b</sup>
<b>Range of motion of knee</b>			
Flexion	87.3 (55.1)	107.75 (34.6)	0.712 <sup>c</sup>
Extension	175.5 (7.4)	176.75 (8.8)	0.623 <sup>c</sup>
<b>Positive stress test</b>			
valgus	6 (30%)	1 (5%)	
varus	4 (20%)	0	0.035 <sup>a</sup>
<b>Malalignment</b>			
valgus	1 (10 degrees)	0	
varus	1 (5 degrees)	0	

<sup>a</sup> Fisher's exact test, <sup>b</sup> Independent sample t-test, <sup>c</sup> Multiple regression was used to adjust for the positive stress test as a potential confounding variable, Continuous data presented in mean (SD) and categorical data as N(%)

**Table-2.** Subscales of Lysholm Knee Score in the single and double plating groups

	Single-plate (N=20)	Double-plate (N=20)	P-value <sup>a</sup>
<b>Limp</b>	3.7 (0.97)	3.15 (1.63)	0.21
<b>Support</b>	4.4 (1.23)	3.8 (1.96)	0.64
<b>Locking</b>	11.05 (3.97)	11.2 (5.02)	0.58
<b>Instability</b>	18.25 (8.47)	17 (8.49)	0.33
<b>Pain</b>	16.25 (7.41)	14.5 (7.59)	0.68
<b>Swelling</b>	6.6 (3.84)	7.8 (2.74)	0.15
<b>Stair climbing</b>	5 (3.58)	5.9 (4.02)	0.45
<b>Squatting</b>	3.4 (0.94)	3.8 (1.28)	0.78
<b>Total Lysholm Knee score</b>	68.65 (23.8)	67.15 (21.93)	0.76

<sup>a</sup> Multiple regression was used to adjust for the positive stress test as a potential confounding variable, Data presented in mean (SD)

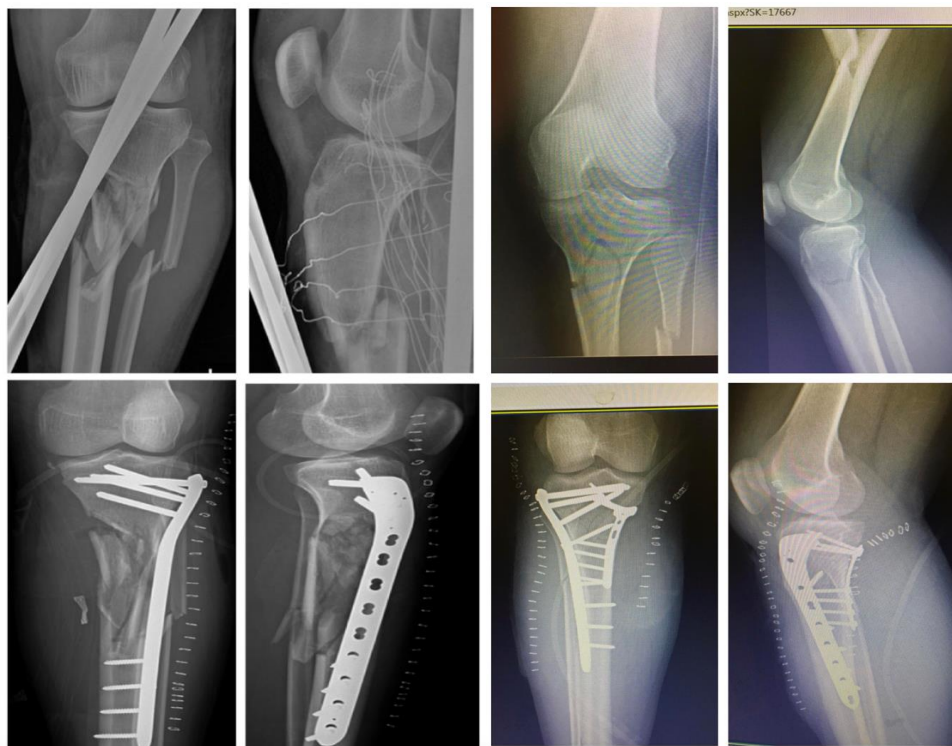
**Table-3A.** Postoperative outcomes Based on the Interpretation of the Lysholm Knee Score Questionnaire in the single and double plating groups

	Poor	Fair	Good	Excellent	P-value
<b>Single-plate (N=20)</b>	6 (30%)	9 (45%)	3 (15%)	2 (10%)	0.041 <sup>a</sup>
<b>Double-plate (N=20)</b>	3 (15%)	3 (15%)	8 (40%)	6 (30%)	0.048

**Table-3B.** Postoperative outcomes based on the Interpretation of the Lysholm Knee Score Questionnaire in the single and double plating groups *after removing cases with positive stress test*

	Poor	Fair	Good	Excellent	P-value
<b>Single-plate (N=10)</b>	4 (40%)	5 (50%)	1 (10%)	0	0.011 <sup>a</sup>
<b>Double-plate (N=19)</b>	3 (15.8%)	2 (10.5%)	8 (42.1%)	6 (31.6%)	0.009 <sup>b</sup>

<sup>a</sup> Chi-square test, <sup>b</sup> Fisher's exact test, Data presented is number of cases (%)



**Figure-1.** Preoperative and postoperative radiographs of patients with proximal metaphyseal tibial fracture treated with (A) single-plate and (B) double-plate method



**Figure-2.** Preoperative and postoperative radiographs of a patient with proximal tibial fracture extending into the articular surface (Schatzker type VI tibial plateau) treated with double-plate method

## Discussion

The present study aimed to compare the postoperative outcomes and complications in patients undergoing double and single plating surgery for proximal tibial metaphyseal fractures. Overall, the results showed comparable knee flexion and extension ranges between the two groups, and no significant differences were observed in the postoperative range of motion. However, in the double plating group, the rates of good and excellent postoperative outcomes based on Lysholm scoring were significantly higher. Moreover, a significantly higher number of cases with positive valgus and varus stress tests were found with the single plating method. Remarkably, a higher incidence of postoperative wound complications was not observed with the double plating method.

The current results suggest that patients undergoing double plating surgery have significantly better postoperative outcomes and fewer complications. These findings are consistent with the results of prior biomechanical studies that have reported the superior fixation strength of the double plating method compared with the single locking compression plate (LCP).<sup>18</sup> Similarly, Chen et al. evaluated the lateral fixation strength of the double-locking plate in proximal tibial extra-articular fractures. By using different

load transmissions, they demonstrated that the double-locking plate was superior to intramedullary nailing in terms of stability from a biomechanical perspective.<sup>13</sup> In another study, Penidle et al. compared the biomechanical stability of double plate, locking plate, external hybrid fixator, and lateral periarticular single plate in the extra-articular fractures of the proximal tibia. Their investigations revealed that the double plate construct is more resistant than other methods and can withstand against axial displacement, varus, and posterior rotation in both stable and unstable fractures. Consistent with our findings, the use of locking plate and lateral periarticular plate provided reliable biomechanical stability in completely unstable fractures in comparison with external fixators.<sup>21</sup>

Currently, the literature is mixed concerning the treatment of choice in extra-articular proximal tibial fractures.<sup>5</sup> Despite the accumulating evidence on the potential superiority of the double plating method, there are several inconsistencies in the literature, and desirable outcomes using single lateral plates have also been reported. For example, in a recent clinical trial Lee et al. reported relatively satisfactory clinical and radiologic outcomes in 39 patients with proximal tibial fractures treated with single unilateral 3.5-mm locking plates. They observed a mean Lysholm knee score of 75.8, knee range of motion of 122.5°, and only a single case with malreduction. Their results are comparable with the outcomes observed in the current study.<sup>22</sup> In addition, it has been argued that the use of intramedullary nailing could offer a more favorable biomechanical outcome given the central load axis of the bone compared with plating with which the fixation implant is at the side. Consequently, weight bearing with early healing could be safer with IMN versus plating.<sup>10</sup> In general, patients' fracture status, the type of potential underlying diseases, the skill of the surgeon, and the quality of the plates used during surgery as well as the different postoperative care practices among the studies might explain the observed heterogeneity in the literature.

Similar to most of the previous clinical studies on the same topic, this study is limited by the retrospective design and selection bias of the surgical team in choosing either double or single plating methods. Moreover, patients in the current study were unbalanced regarding the significantly higher frequency of the positive valgus and varus stress tests in the single plate group; we controlled for this potential confounding factor using multiple regression to adjust for

this covariate in the analyses. These issues warrant future prospective randomized clinical trials with larger sample sizes to provide more robust evidence in favor of the recommended surgical technique that could result in acceptable alignment with minimal complications.

## Conclusions

The results of the present study add to the growing body of evidence that indicates the choice of double plating surgery compared with single plating is associated with significantly better postoperative outcomes and fewer complications in the treatment of proximal tibial metaphyseal fractures. However, the overall outcomes are nearly equivalent, and these findings warrant future studies with larger sample sizes and prospective randomized trials to confirm the current evidence-based clinical recommendations.

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## Authors' Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations.

## Conflict of Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

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