

## Research Paper

# Comparing Single-locking and Double-locking Plate Fixation Methods in Patients With Proximal Tibial Fractures



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## ABSTRACT

**Background:** Proximal tibial fractures account for 1% of all fractures. Different treatments have been proposed for this fracture.

**Objectives:** The present study aims to evaluate the clinical and radiological results of single-locking and double-locking plate fixation methods in patients with proximal tibial fractures.

**Methods:** The present study was carried out on 40 patients with proximal tibial fractures referred to Imam Khomeini Hospital in Sari, Iran. They were divided into two groups of double-locking fixation with 3.5-mm Locking Compression Plate (LCP) and single-locking fixation with 4.5-mm LCP. They were followed up for at least 6 months after surgery. At the time of admission, they were assessed using Lysholm Knee Scoring Scale and Visual Analogue Scale. Radiographs were taken from all patients and the articular surface, and fracture healing.

**Results:** Of 40 patients, 17 and 23 were treated with 3.5-mm and 4.5-mm LCPs, respectively. The mean Lysholm score in the groups with 3.5-mm and 4.5-mm LCPs was  $84 \pm 8.2$  and  $78.3 \pm 16.2$ , respectively. There was no statistically significant difference between the two groups ( $P > 0.5$ ).

**Conclusion:** The radiological and functional outcomes were almost the same for single-locking and double-locking plate fixation methods. Both methods can be used to treat the tibial plateau fracture. The treatment can be selected according to the surgeon and the patient's request

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## 1. Introduction

**E**xtra-articular proximal tibial fractures are usually caused by high-energy trauma and account for about 5%-11% of all tibial fractures [1]. Treatment of these fractures are commonly complicated by wound dehiscence, infection, rotational deformity, and tightening of the adjacent joints [2]. Non-surgical treatment of this fracture, including casting and bracing, is usually not effective, and has been associated with prolonged hospital stay, poor functional outcomes, and higher malunion rates [3, 4]. Therefore, it is highly recommended to use surgical treatments in these fractures. Surgical treatments include external fixation, Intramedullary Nailing (IMN), and a variety of non-locking and locking plates. In recent years, minimally invasive plating and intramedullary nailing have been used to treat proximal tibia fractures; however, there is still insufficient evidence to recommend a single standard of care for these fractures; the surgical method is a subject for ongoing debate [5, 6]. The clinical decision-making process is mainly dependent on the expertise of the surgical team and the soft tissue factors [7].

So far, several studies have reported different methods for the surgical treatment of extra-articular proximal tibial fractures. Recent randomized clinical trials have shown promising and comparable clinical outcomes of IMN and plate fixation in the treatment of proximal tibial fractures. The IMN is one of the most common surgical approaches for these fractures and results in less hospital stay and faster union time; particularly with the introduction of the recently developed implants [8]. Biomechanical studies comparing the fatigue strength of the intramedullary nails and double locking plates in the proximal tibial extra-articular fractures have also demonstrated equivalent fatigue performance and recommended the IMN in cases that malalignment could be avoided [9]. However, IMN can be a challenging technique; despite less damage to the soft tissues and lower reported risk of infection, higher malunion rates and mal-reduction deformity have been observed in this method [6, 7, 10].

On the other hand, some studies have shown that in cases where the soft tissue damage is moderate or mild, the techniques of double locking plate fixation and lateral locking plate fixation as external fixators may be the best option for surgical treatment. In these studies, it was found that the double locking plate fixation is more stable than the IMN for the treatment of extra-articular proximal tibial fractures in terms of mechanical stability [11]. Nonetheless, it has been shown that the use of

double locking plate fixation is associated with higher complications including the potential worsening of wound healing and higher infection rates [12, 13]. Although these studies have investigated both single and double locking plate fixation methods, their comparison has only been performed mechanically on the cadaveric or synthetic bone specimens [9, 11, 14].

To the best of our knowledge, there is no study regarding the treatment of choice for extra-articular proximal tibial fractures and fewer study has been done to compare the independent clinical outcomes of single- and double-plate fixation methods for these fractures. To address this gap, the current study aims to compare the postoperative outcomes and complications of single- and double-plate fixation methods in treatment of extra-articular proximal tibial fractures.

## 2. Methods

This is retrospective study. The study population included all skeletally mature patients suffered from extra-articular proximal tibial fractures in the past three weeks prior to admission. Patients with the following characteristics were excluded: Open fractures, fractures for more than three weeks, pathologic fractures, tibial plateau fractures, presence of severe vascular injury, concomitant fractures, inability to walk before fracture, and comorbidities that prevented surgery. The patients with closed proximal tibial fractures who were treated with a non-plating technique such as IMN were also excluded. In this regard, 40 eligible patients (28 males and 12 females) with extra-articular proximal tibial fracture were selected from those referred to the Orthopaedic Department of Imam Khomeini Hospital in Sari, Iran during 2014-2019 who underwent single or double-plate fixation surgery. They were divided into two groups; Group 1 included 20 patients (15 males and 5 females) who were treated with a single Locking Compression Plate (LCP) after extra-articular proximal tibial fracture. Group 2 included 20 patients (13 males and 7 females) who had two LCP.

Demographic data of patients including age, gender, surgery duration, length of hospital stay, and postoperative complications were recorded. Patients were followed up after 2 and 6 weeks, and 3 and 6 months. All were evaluated for non-union, mal-union and malalignment deformity. Lysholm Knee Scoring Scale (LKSS) was used to evaluate the patients' knee performance [15]. The data were analyzed in SPSS v.20 software (IBM Corp., Armonk, NY, USA). Continuous variables were compared using independent sample

t-test and Mann-Whitney U test. For the categorical variables, chi-square test was employed. A  $P < 0.05$  was statistically significant.

### 3. Results

In this study, participants were 40 patients divided into two groups of double-plate fixation ( $n=20$ ) and single-plate fixation ( $n=20$ ). Demographic characteristics of patients are presented in Figure 1. The range of knee flexion and extension were assessed in both groups. The range of flexion and extension were higher in the double-plate fixation group, but we did not find any statistically significant difference between the two groups ( $P > 0.05$ ) (Table 1). Moreover, the total score and subscale score of LKSS were compared between the two groups, but we did not find any significant difference between the two groups ( $P > 0.05$ ) (Table 2). The patients' LKSS scores were categorized to evaluate their knee performance. In the single-plate fixation group, 30%, 45%, 15%, and 10% had poor, fair, good, and excellent results, respectively. In the double-plate fixation group, 15%, 15%, 40%, and 30% had poor, fair, good, and excellent results, respectively. In this group, the good and excellent postoperative outcomes were higher, and this difference was statistically significant ( $P = 0.041$ ) (Table 2).

In the single-plate fixation group, there was a positive result for the valgus stress test in 6 (30%) patients, while it was positive only in one patient in the double-plate fixation group, and the difference was statistically significant ( $P = 0.037$ ) (Figure 2). We did not observe higher incidence of early postoperative wound complications in the double-plate fixation group, and none of patients developed hematoma formation, wound necro-

sis and infection. It should be noted that, in the single-plate fixation group, one case of valgus malalignment with 10 degrees and one case of varus malalignment with 5 degrees were observed.

### 4. Discussion

The present study aimed to compare the postoperative outcomes and complications in patients undergoing double- and single-plate fixation surgeries due to extra-articular proximal tibial fractures. Overall, the results showed comparable knee flexion and extension ranges between the two groups and there was no any significant differences in the postoperative ranges of motion. However, in the double-plate fixation group, the good and excellent postoperative outcomes based on the LKSS score was significantly higher. We did not observe higher incidence of postoperative wound complications in the double-plate fixation method. In one study, minimally invasive surgery of tibial plateau fractures advised [16].

The patients undergoing double-plate fixation surgery had significantly better postoperative outcomes and less complications. This is consistent with the results of prior biomechanical studies that reported superior fixation strength of the double-locking plate fixation method compared to single-locking plate fixation [17]. Similarly, Chen et al. evaluated the lateral fixation strength of the double-locking plate fixation in extra-articular proximal tibial fractures. By using different load transmissions, they demonstrated that the double-locking plate was superior to the IMN in terms of biomechanical stability [11, 18]. In another study, Penidle et al. compared the biomechanical stability of extra-articular proximal tibia fractures treated by double plate construct, locking plate system, hybrid external fixator, and single lat-

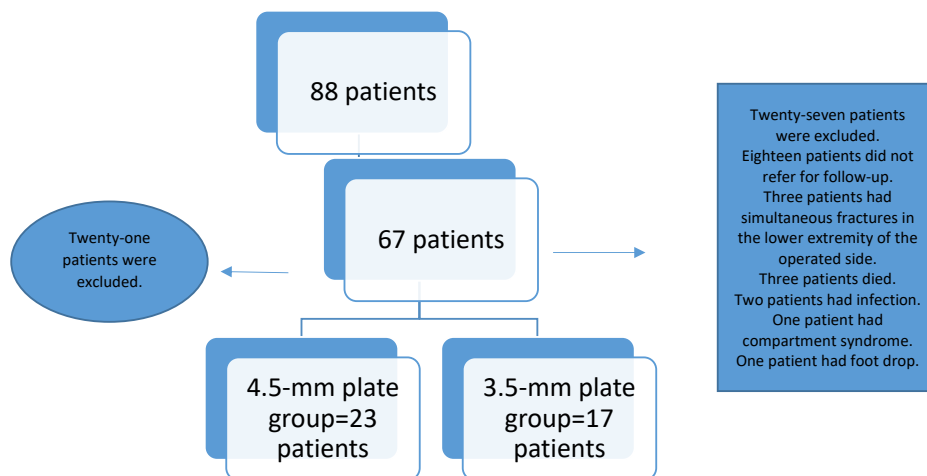


Figure 1. Patient included in study

**Table 1.** Fracture categorized by shatzker classification

	Plate 3.5		Plate 4.5	
	Single plate	Double plate	Single plate	Double plate
Type1	2(11.8)	0(0)	2(8.7)	0(0)
Type2	5(29.4)	0(0)	11(47.8)	0(0)
Type 3	1(5.9)	0(0)	0(0)	0(0)
Type4	2(11.8)	1(5.9)	1(4.3)	0(0)
Type5	0(0)	4(23.5)	1(4.3)	3(13)
Type6	0(0)	2(11.8)	3(13)	2(8.7)
total	10	7	18	5

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**Table 2.** LYSHOME Score base on plate

	Plate 3.5		Plate 4.5	
	Single plate	Double plate	Single plate	Double plate
Excellent	2(11.8)	0(0)	0(0)	2(8.7)
Good	3(17.6)	5(29.4)	9(39.1)	1(4.3)
Fair	5(29.4)	2(11.8)	5(21.7)	2(8.7)
Poor	0(0)	0(0)	3(13)	1(4.3)

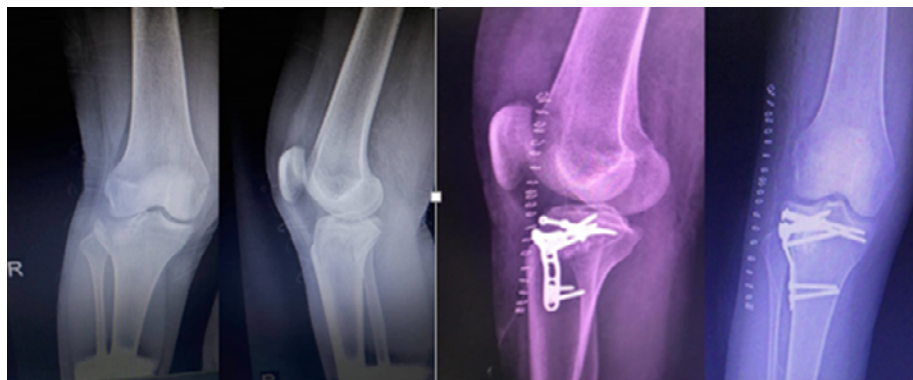
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eral periarticular plate. Their investigation revealed that the double-plate construct was more stiffer than other constructs and with resistance to axial displacement, varus and posterior rotation for unstable fractures. Moreover, consistent with our findings, the locking plate and the lateral periarticular plate provided reliable biomechanical stability for completely unstable fractures compared to the external fixators [14].

Currently, there are contradictory results concerning the treatment of choice for extra-articular proximal tibial

fractures. Despite the evidence on the potential superiority of the double-plate fixation method, there are several inconsistencies in the literature. The difference in patients' fracture status, underlying diseases, the surgeon's skill, and the quality of plates as well as different postoperative care in the studies may explain the discrepancies between the studies.

Similar to the most of clinical trials, this study's limitations were the retrospective design and selection bias of



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**Figure 2.** AP and lateral radiographs of a 38-year-old patient after car accident. Patient treated with medial 3.5 plate

the surgical team to choose double- or single-plate fixation methods. This indicates the need for future prospective randomized clinical trials with larger sample sizes to provide more robust evidence about the recommended surgical technique that can result in acceptable alignment with minimal complications.

## 5. Conclusion

The double-plate fixation surgery has better postoperative outcomes and fewer complications in the treatment of extra-articular proximal tibial fractures compared to single-plate fixation surgery. However, the overall outcomes are nearly similar. Further studies with larger sample sizes and a prospective design are recommended to provide more evidence.

## Ethical Considerations

### Compliance with ethical guidelines

This study was approved by the ethics committee of Mazandaran University of Medical Sciences (Code: IR.MAZUMS.IMAMHOSPITAL.REC.1398.1781). The procedures were in accordance with the Declaration of Helsinki.

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### Authors' contributions

All authors contributed equally to the writing, data collection, and drafting. The final manuscript was reviewed and approved by all the authors

### Conflict of interest

The authors declared no conflicts of interest.

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