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## ORIGINAL ARTICLE

# Biomechanical comparison of plate-screw and screw fixation in medial tibial plateau fractures (Schatzker 4). A model study

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## KEYWORDS

Medial tibial plateau fractures;  
 Bone model;  
 Fixation

## Summary

**Introduction:** The objective of this biomechanical study was to compare the respective efficiency of plate-screw fixation and screw fixation in an experimental model of a Schatzker type 4 fracture. Hypothesis: screw fixation and plate fixation have a similar load to failure.

**Materials and methods:** This study compares the stability of Schatzker type 4 medial tibial plateau fractures fixed with either 36.5 mm cancellous bone screw with a 16 mm threaded segment or with six-holed buttress T-plate-screw system. A Schatzker type 4 fracture was modeled on an artificial bone model. In a first group of 10 fracture models, following the anatomical reduction, fractures were stabilized with screws with washers. In the second group, of 10 fracture models, fractures were stabilized with T-plate. After fixation ascending axial compression was applied on bone models (Instron machine).

**Results:** Load bearing capacity was  $1397.6 \pm 194.4$  N in the Group 1 and  $2153.2 \pm 204.4$  N in the Group 2. The difference between the two groups was statistically significant ( $p < 0.001$ ).

**Discussion:** According to this result, experimental load bearing of bone models indicate that plate-screw fixation system has a significantly higher stabilization capacity than fixation with three screws alone. Our hypothesis was not confirmed. In order to maintain anatomical repositioning, plate-screw system is a more stable fixation method than the screw in medial tibial plateau fractures Schatzker 4

Level of evidence: 1.

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## Introduction

Fractures of tibial plateau are intraarticular fractures that require anatomic reduction and stable fixation to prevent the development of osteoarthritis in the late postoperative period [1]. Although, numerous cases of lateral tibial plateau fractures have been reported in the literature, there is limited data concerning fractures of medial tibial plateau. Various methods ranging from conservative treatment to diverse surgical techniques have been described and their long-term outcomes have been published throughout the historical development of treatment for lateral plateau fractures [2]. Recently, favorable outcomes have been reported following minimally invasive arthroscopy-assisted closed reduction and percutaneous screw fixation of the lateral tibial plateau fractures [1]. Minimal invasive methods offer fast postoperative recovery in addition to reduced risk of infection. Limited studies published recommend open reduction and fixation with plate-screws for the treatment of medial plateau fractures.

## Hypothesis

We hypothesized screw fixation provides sufficient stability in medial tibial plateau fractures as in lateral plateau fractures; we thus compare the biomechanical properties of plate-screw osteosynthesis and screw osteosynthesis in a bone model.

## Materials and methods

A cortical/cancellous type artificial bone (Synbone, Switzerland) was used as the bone model. Synbone type 1111 used in this experimental study is a cortical-hard cancellous bone model with a tibial plateau width of 74 mm and diaphyseal diameter of 27 mm.

Medial plateau fracture (Schatzker type 4 fracture) was simulated in the bone model (Fig. 1). An oblique cut starting from 5 cm distal to the joint line of the medial tibial plateau was extended to the medial of tibial tubercle. Fragment created by this cut had a triangular shape. Reduction of the fracture was accomplished by clamps and provisional K-wires.

Following reduction, two groups were formed to compare two methods. Ten fractures in the first group were fixed by three 6.5 mm cancellous screws with 16 mm partial threads. Distance between the proximal screws was 2 cm and



**Figure 1** Tibia bone model used for the study.



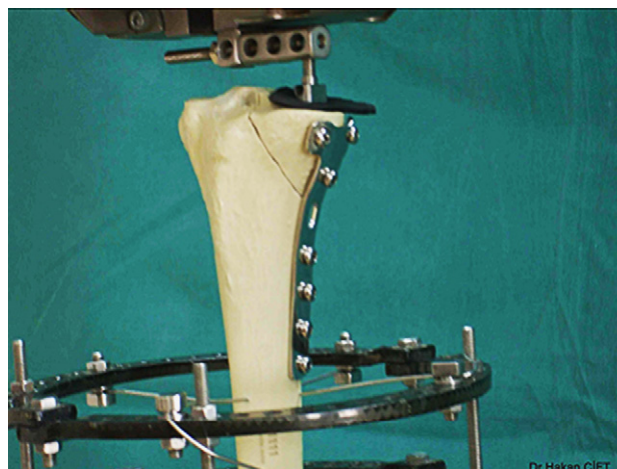
**Figure 2** Fixation with three 6.5 mm cancellous screws.

screws were inserted 1 cm distal to the joint. Third screw was inserted to the apex of the triangular fragment (Fig. 2).

Fractures of the remaining ten bone models in the second group were stabilized by a six-hole T-plate with three cancellous screws placed to the proximal and four cortical screws placed distal to the fracture line (Fig. 3).

After fixation bone model was cut at a level 17 cm distal to medial plateau and a circular external fixator consisted of two rings was applied to adapt the bone model to the Instron 8516 device (Fig. 3). Two K-wires placed 12 cm distal and one K-wire placed 16.5 cm distal to medial tibial plateau were fixed to rings under tension. Bone model with circular external fixator was mounted on the test device.

Bones were loaded by a tension, compression and fatigue test device (Brand and model: Instron 8516), which provided 100 kN dynamic/124 kN static maximum loading capacity (Fig. 4). Compression test was used for the present study. Unilateral load was applied on the central part of medial



**Figure 3** Image of the fracture line stabilized by plate and screws.

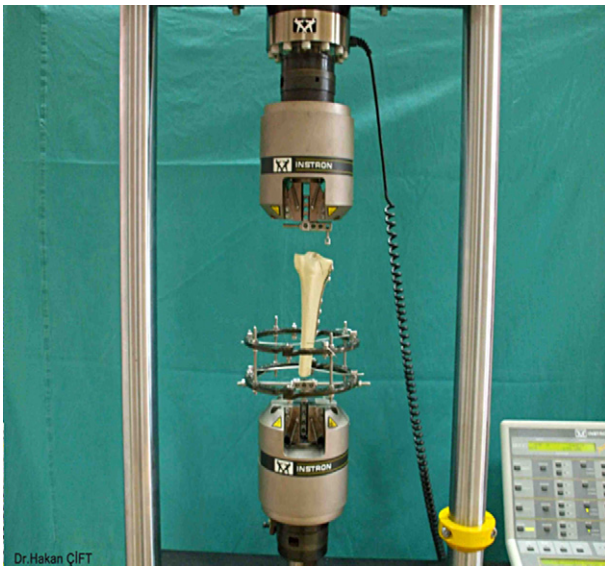


Figure 4 Photograph of the Instron device.

plateau through a rubber component. Gradually increased axial compressive loads were applied on each specimen. For biomechanical failure criteria, Test device was connected to a computer where the load was continuously monitored and applied. The moment at which anatomic reduction was lost (biomechanical failure of the bone fixation) was definite by the point of start of a sudden decrease in the loading curve. The load just before this sudden decrease was noted for each specimen and was used to compare the two groups.

Independent samples *t* test was used for the statistical analysis of the groups. A *p* value of <0.001 was set as the level of significance.

**Results**

Endurance limit of bone models was  $1397.6 \pm 194.35$  N for Group 1 (Fig. 5) and  $2153.2 \pm 204.35$  N for Group 2 (Fig. 6). Difference between the groups was statistically significant ( $p < 0.001$ ). Experimental load endurance of bone models fixed by plate was significantly higher compared to bone models fixed only by screws (Fig. 7).

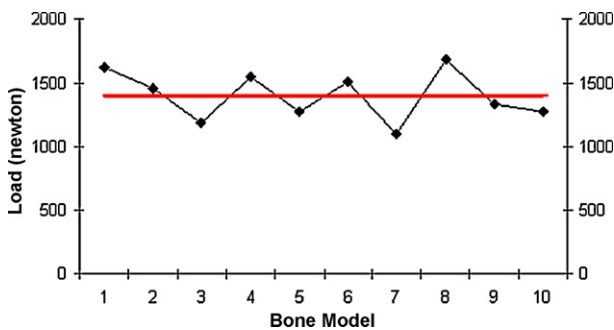


Figure 5 Load at which reduction of bone models was lost in Group 1 (N).

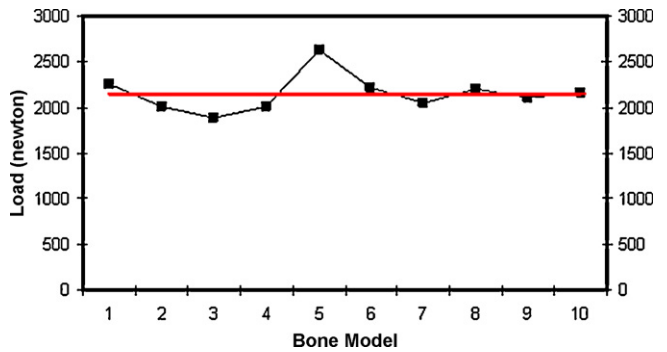


Figure 6 Load at which reduction of bone models was lost in Group 2 (N).

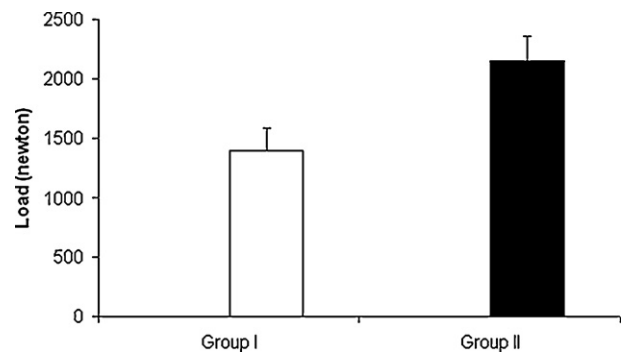


Figure 7 Load endurance of groups, \*:  $p < 0.001$ .

**Discussion**

In this study, we aimed to detect whether percutaneous screws provided sufficient stability in medial tibial plateau fractures following anatomic reduction, in an attempt to address the scarcity of relevant data in the literature.

We used Synbone instead of cadaver to find the results unique. Results can be changed by the different quality of the cadaver bones. In Synbone, every response to load distribution is same, so we could measure pure strength of the materials. However, in a cadaver study, all the soft tissues (capsules, ligaments) can affect the results.

Unilateral load was applied on the central part of medial plateau through a rubber component. Gradually increased axial compressive loads were applied on each specimen. While walking knee always have cycling loads. Cycling charges were not used in this study, so this is limit of the study.

In the past, many classification systems have been suggested for tibial plateau fractures. At present, Schatzker and AO classifications are frequently referred in the literature. We used Schatzker classification as it is an easily understandable method that helps selection of the treatment method [3]. In Schatzker type 4 fractures, the eminentia can be included to the fracture line. In our experimental study, we didn't include the eminentia in the fracture line.

Fractures of medial tibial plateau are relatively uncommon [1]. As medial part of the joint is subjected to higher loads and lack of a buttress such as provided by the fibular head to lateral plateau has reinforced the concept of

rigid fixation in these fractures because these fractures are unstable. [1].

Schatzker type 4 fractures are usually unstable fractures formed by high-energy trauma [2]. Knee joint is subjected to loads four to six times of body weight during walking [4]. In standing position, medial tibial plateau carries  $75 \pm 12\%$  of the total force transmitted across the knee joint [5]. Higher loads on the medial side of the joint and lack of a buttress, such as fibular head that provides to the lateral side, indicate rigid fixation of these fractures. However, we were not able to retrieve an experimental study in the English literature that proved these assessments.

Schatzker type 4 fractures usually occur due to high-energy trauma. Complications following plate osteosynthesis of these fractures include wound infection and compartment syndrome [6–14].

Various biomechanical studies concerning tibial plateau fractures are reported in the literature, but none of these include Schatzker type 4 fractures. In one of the biomechanical studies on tibial plateau fractures, Ali et al. compare solid foam bone, composite bone and reinforced solid foam bone to develop a standardized experimental model for tibia plateau fractures. They conclude that solid foam bone may be used to compare various treatment methods of tibial plateau fractures [15]. Mueller et al. compare the treatment techniques for bicondylar tibia plateau fractures: double plate and lateral fixed angle blade demonstrate no significant difference in terms of fracture stability [16].

Boisrenoult et al. compare the efficacy of screw-plate fixation versus double screw fixation on a model of type 2 Schatzker fracture of the lateral tibial plateau. Ten screw-plate fixations using a lateral plate and 10 double-screw fixations (6.5mm screws) were made on 10 pairs of non-embalmed cadaver knees after simulation of type 2 Schatzker fractures. The strength of each fixation was tested with a compression device. There was no statistical difference between the screw-plate and the double-screw fixations. The biomechanical stability of the double-screw fixation is as good as that obtained with screw-plate fixation for the treatment of fractures of the lateral tibial plateau [17].

In our study we tried to find out whether three screw fixations provide sufficient stabilization as compared to plate fixation; and if they do, arthroscopic reduction and percutaneous fixation used for type 1, 2 and 3 fractures can be an alternative method for the treatment of type 4 fractures. However, load endurance limit of bone models in Group 1 that were fixed by screws were significantly lower compared to load endurance limit of Group 2 that were fixed by plates.

As we have stated above, higher loads on the medial side of the joint and lack of a support such as fibular head provide to the lateral side of the joint, necessitate the use of rigid fixation for Schatzker type 4 fractures. Screw fixation alone cannot provide sufficient stability required for rigid fixation.

## Conclusion

Schatzker 4 fractures of medial tibial plateau require a stable fixation as it bears the 75% of the total load transmitted across the knee and there is no supporting structure such as fibular head supporting the lateral tibial plateau. Fractures

involving the joints require anatomic reduction. Method of fixation should offer sufficient strength to maintain this reduction. Three screws do not provide adequate stability. Rigid fixation with plate and screws following anatomic reduction should be preferred for Schatzker type 4 fractures. Our hypothesis was not confirmed in this experimental study.

## Conflict of interest statement

None.

## Authors' contributions

HC and BK contributed to conception and design, carried out the literature research, manuscript preparation and manuscript review. HC and BK did the experimental study in the laboratory. MHD made the analysis of the graphics. HC, KO and FE were involved with the writing of the manuscript. OC revised the manuscript for important intellectual content.

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