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ORIGINAL ARTICLE

# The anatomical relationship of the neurovascular structures in direct posterior lateral gastrocnemius split approach for posterolateral tibial plateau fractures

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**Abstract**
*Purpose* To evaluate the distances between the incision and neurovascular structures in direct posterior split-gastrocnemius approach for tibial plateau fractures.
*Methods* Thirteen fresh-frozen cadavers were used in the study. The distance between the neurovascular structures medial and lateral to the incision was measured from the tibial joint line and at a level 5 cm distal to the joint line.
*Results* The mean distance between the incision and medial neurovascular structures was 10.09 ± 3.47 mm (range 5.63–16.51 mm) at the level of the tibial joint line and 10.39 ± 2.57 mm (range 5.79–14.09 mm) at a level 5 cm distal to the joint line. The mean distance between the incision and the common peroneal nerve was 13.44 ± 4.17 mm (range 6.28–20.72 mm) at the level of the tibial joint line and 19.56 ± 5.24 mm (range 12.58–26.74 mm) at a level 5 cm distal to the joint line.
*Conclusions* In isolated posterolateral tibial plateau fractures, it is possible to apply anatomical reduction and buttress plating on the posterior surface with a direct posterior split-gastrocnemius approach. With a thorough understanding of the regional anatomy, this approach can be safely performed by experienced orthopaedists.

**Keywords** Tibial plateau fracture · Posterolateral · Surgical approach

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## Introduction

Posterolateral tibial plateau fractures are an uncommon fracture type, constituting only 7% of all tibial plateau fractures [1]. Adequate anterior or anterolateral fixation of these fractures can be extremely difficult. In addition, biomechanical testing has shown posterior buttress plating to be more stable than lateral buttress plating [2]. Therefore, in displaced posterolateral tibia plateau fractures, it is advantageous to apply anatomical reduction and buttress plating to the posterior surface. Previous studies have described the use of fibular osteotomy with a posterolateral approach for these fractures [3, 4]. In practice, clinicians who wish to avoid complications related to fibular osteotomy prefer a posterior approach in the prone position [1, 5–8]. The approach presented here differs from other approaches in that the lateral head of the gastrocnemius muscle and the soleus muscles is split. After the medial and lateral neurovascular structures were visually identified, they were not suspended because a natural barrier of muscle tissue was formed between them and the approach area when splitting the gastrocnemius muscle.

In this study, the proximity of the direct posterior lateral gastrocnemius split approach to neurovascular structures was examined using fresh-frozen cadavers. The main aim was to measure the distance between the neurovascular structures medial and lateral to the incision.

## Materials and methods

Thirteen fresh-frozen cadavers were provided by the Acibadem University and used to examine the proximity

**Table 1** Demographic data

| | |
|---|---|
| Age | 73.46 ± 12.35 (51–94) |
| Sex: male | 9 |
| Female | 4 |
| Side: right | 9 |
| Left | 4 |
| Body mass index | 25.23 ± 6.22 kg/m$^2$ (18–34) |

of the direct posterior lateral gastrocnemius split approach to neurovascular structures.

Of the 13 fresh-frozen cadavers, 4 (30.8%) were female and 9 were (69.2%) male. The mean age of the cadavers at death was 73.46 ± 12.35 years (range 51–94 years), and the mean body mass index was 25.23 ± 6.22 kg/m$^2$ (range 18–34). Measurements were taken on the right side of nine (69.2%) cadavers and on the left side of four (30.8%) cadavers. The demographic data are shown in Table 1.

Anatomical dissections were performed in the prone position. First of all, in the posterior knee joint the midpoint between the anatomical midline and the fibular head was determined. From this midpoint, a longitudinal skin incision of approximately 8 cm was performed (Fig. 1). The lateral head of the gastrocnemius muscle was split by blunt dissection. During this procedure, the medial and lateral neurovascular structures (at the medial side; arteria poplitea, vena poplitea and nervus tibialis; at the lateral side nervus peronealis communis) were identified, but not suspended (Fig. 2). In addition, when splitting the gastrocnemius muscle, a natural barrier of muscle tissue was formed between these anatomical structures and the approach area (Fig. 3). By raising the popliteus muscle of the deep muscle group and reflected to the downwards, the posterior plateau was reached (Fig. 4). The distance between the neurovascular structures medial and lateral to the incision was measured from the tibial joint line and at a level 5 cm distal to the joint line. A buttress plate was placed on the posterior tibia, and distal screws were advanced 5 cm distal from the flat-section approach of the joint line. This helped to standardize the measurements and define the reference point for the distances. In addition, we measured both the distance between the skin and the posterior aspect of the tibia, and the skin thickness. The measurements were taken using digital caliper (InSize®) and without damaging the anatomical structures and without retraction. The distances evaluated without separation of the structures within soft tissues. All study measurements were confirmed by three experienced orthopaedists.

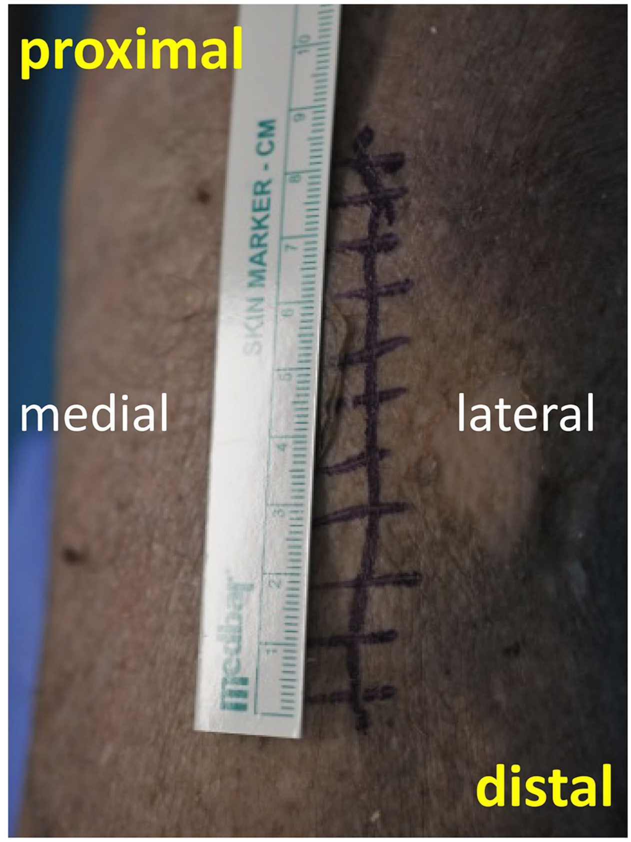



**Fig. 1** First of all, the midpoint between the anatomical midline and the fibular head was determined. From this midpoint, a longitudinal skin incision of approximately 8 cm was performed

We also used the direct posterior lateral gastrocnemius split approach in seven cases with isolated lateral posterior plateau fractures. Four patients were males, and mean age was 27.3 (20–35) years. Perfect anatomical reduction and stabile fixation achieved easily with this exposure (Figs. 5, 6). Any complications were not observed in our cases.

In the evaluation of the study data, IBM SPSS Statistics 22 (IBM SPSS; Turkey) was used with descriptive statistical methods (mean, standard deviation, frequency).

## Results

The mean distance to the medial neurovascular structures was 10.09 ± 3.47 mm (range 5.63–16.51 mm) at the level of the tibial joint line and 10.39 ± 2.57 mm (range 5.79–14.09 mm) at a level 5 cm distal to the joint line (Table 2; Fig. 6).

The mean distance to the common peroneal nerve was 13.44 ± 4.17 mm (range 6.28–20.72 mm) at the level of the tibial joint line and 19.56 ± 5.24 mm (range

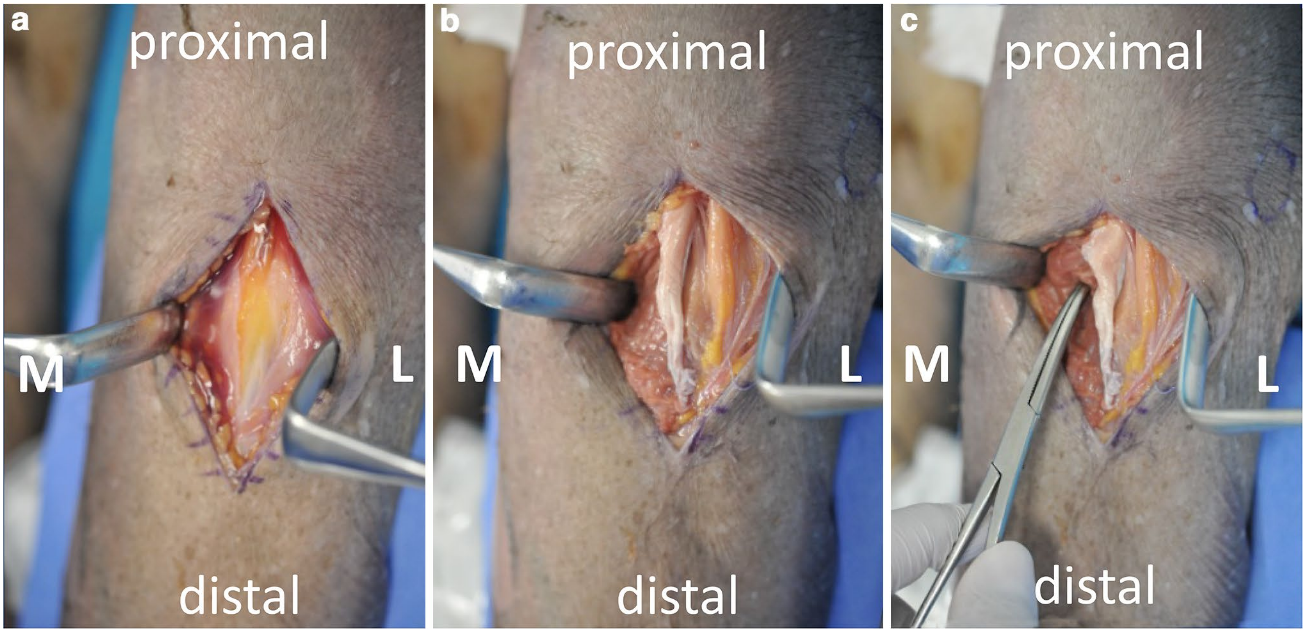
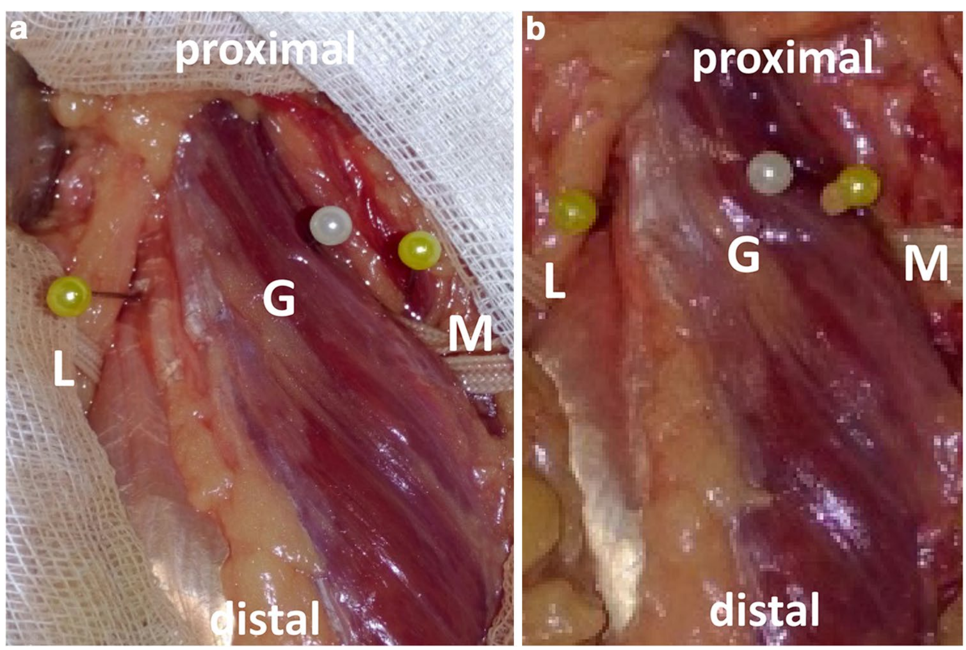



**Fig. 2** After incision of the fascia, the lateral and medial neurovascular structures were identified by careful dissection (**a**). At the lateral side, nervus peronealis (**b**) and, at the medial side arteria poplitea, vena poplitea and nervus tibialis were identified, but not suspended (**c**)

**Fig. 3** Lateral head of the gastrocnemius muscle was split by blunt dissection. The distance of the incision from the lateral to medial neurovascular structures was examined (**a**, **b**). *G* gastrocnemius muscle, *L* lateral, *M* medial neurovascular structures were shown. Distance between GL and GM was examined




12.58–26.74 mm) at a level 5 cm distal to the joint line (Table 2; Fig. 6).

The mean distance between the skin and the bone was 31.7 ± 8.79 mm (range 19.39–49.1 mm) at the level of the tibial joint line and 46.58 ± 12 mm (range 31.17–69.55 mm) at a level 5 cm distal to the joint line (Table 2).

The mean skin thickness was 9.71 ± 3.2 mm (range 5.7–14.6 mm) at the level of the tibial joint line and 10.7 ± 3.88 mm (range 5.86–16.67 mm) at a level 5 cm distal to the joint line (Table 2).

## Discussion

The aim of the treatment for tibial plateau fractures is to achieve anatomical reconstruction of the joint surface,

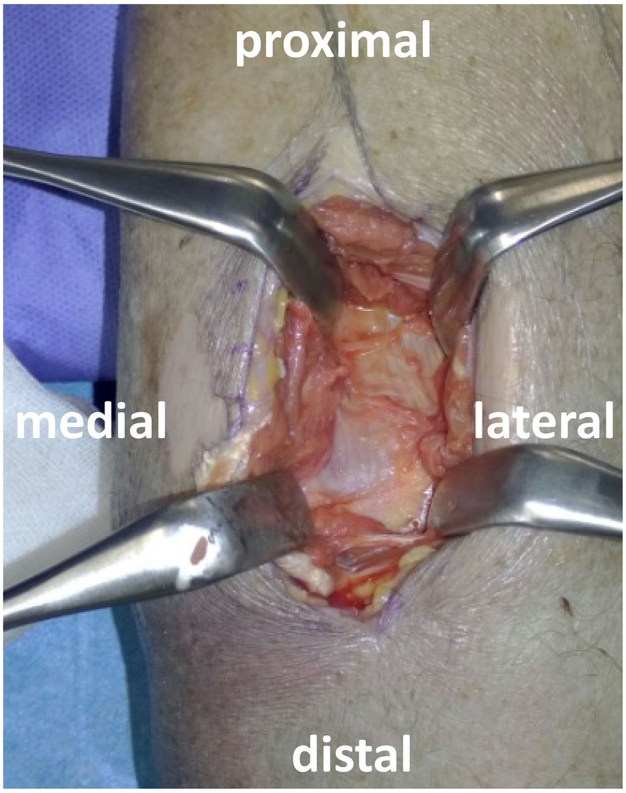



**Fig. 4** Posterior plateau was reached. An incision of approximately 8 cm allowed sufficient surface area to be exposed for plate osteosynthesis open reduction and buttress fixation

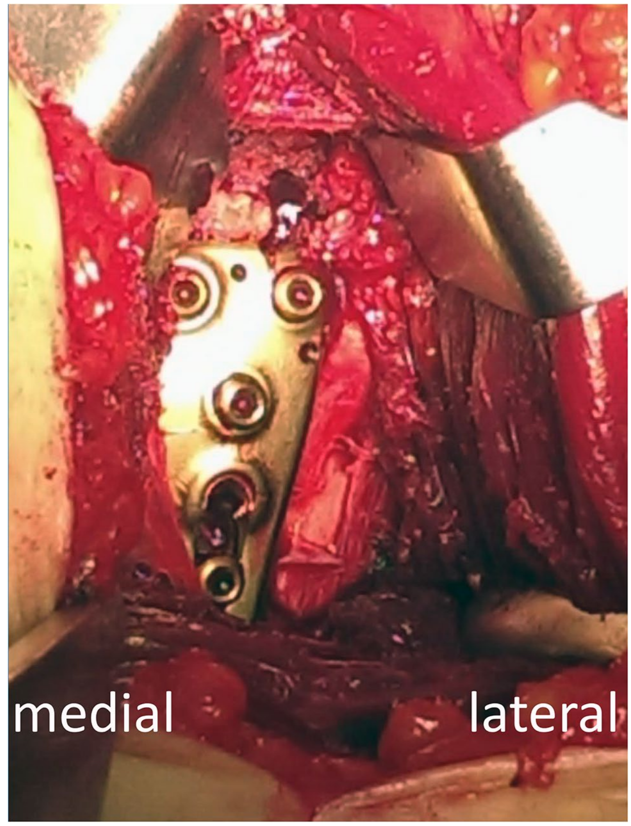



**Fig. 5** Application of a plate with the direct posterior lateral gastrocnemius split approach

restoration of the extremity axis and stable fixation to allow early joint movement. Optimum results are obtained by direct reduction and appropriate planning.

The most widely used classification systems for tibia plateau fractures are the Schatzker and Orthopaedic Trauma Association systems [9, 10]. In these systems, fractures are described in the sagittal plane [11]. However, some fractures are posteromedial or posterolateral and extend into the coronal plane. Therefore, classifications made in the sagittal plane ignore these fractures. In a study using computed tomography, Luo et al. created a three-column classification, namely the lateral, medial and posterior columns [12]. The three-column classification is a useful method when selecting the correct approach.

Posterolateral tibial plateau fractures are rare [1]. As approaches for these fractures, fibular osteotomy with a posterolateral [3, 4] or prone direct posterior approach has been described [1, 5–8, 13]. However, because fibular osteotomy can lead to complications such as iatrogenic injury to the peroneal nerve and non-union of the osteotomy,

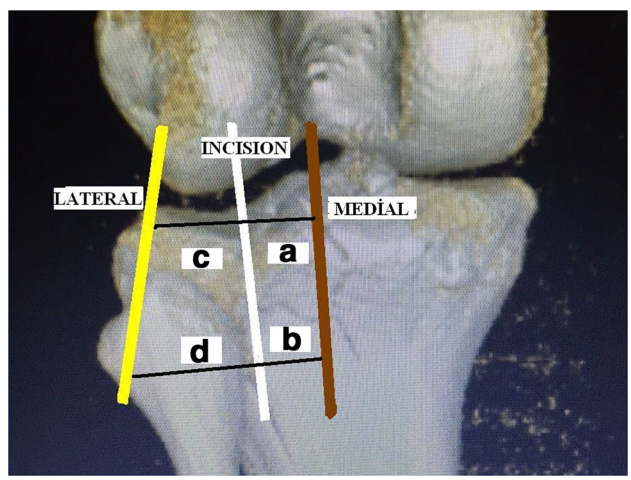



**Fig. 6** Visualization of the measurements. **a** Distance to the medial neurovascular structures at the level of the tibial joint line. **b** Distance to the medial neurovascular structures at a level 5 cm distal to the tibial joint line. **c** Distance to the lateral neurovascular structures at the level of the tibial joint line. **d** Distance to the lateral neurovascular structures at a level 5 cm distal to the tibial joint line

**Table 2** Measurements of the parameters

| | Min–max (mm) | Mean ± SD (mm) |
|---|---|---|
| Distance to the medial neurovascular structures at the level of the tibial joint line | 5.63–16.51 | 10.09 ± 3.47 |
| Distance to the medial neurovascular structures at a level 5 cm distal to the tibial joint line | 5.79–14.09 | 10.39 ± 2.57 |
| Distance to the lateral neurovascular structures at the level of the tibial joint line | 6.28–20.72 | 13.44 ± 4.17 |
| Distance to the lateral neurovascular structures at a level 5 cm distal to the tibial joint line | 12.58–26.74 | 19.56 ± 5.24 |
| Distance between skin and bone at the level of the tibial joint line | 19.39–49.1 | 31.7 ± 8.79 |
| Distance between skin and bone at a level 5 cm distal to the tibial joint line | 31.17–69.55 | 46.58 ± 12 |
| Skin thickness at the level of the tibial joint line | 5.7–14.6 | 9.71 ± 3.2 |
| Skin thickness at a level 5 cm distal to the tibial joint line | 5.86–16.67 | 10.7 ± 3.88 |

direct posterior approaches seem more effective. When using a direct posterior approach, after identification of neurovascular structures, the gastrocnemius is retracted medially before the soleus origin (and when necessary the popliteus) is raised [6–8].

In the present study, the medial and lateral neurovascular structures were visualized when the lateral head of the gastrocnemius was split by blunt dissection, but did not need to be suspended. In addition, when splitting the gastrocnemius muscle, a natural barrier of muscle tissue was formed between the working area and the neurovascular structures. These are the major advantages of the direct posterior lateral gastrocnemius split approach. Probably, the disadvantage of this approach could be the vertical split in the gastrocnemius muscle. This approach could denervate the muscle. On the other hand, we split muscle with limited incision to not denervate entire muscle. We split only about 8 cm of the muscle. We also experienced this approach in clinical practice in seven cases with isolated lateral posterior plateau fractures. We formerly published our initial cases as a case report with this approach [14]. We also observed that this approach is relatively safe and has lower risk. Any complications were not observed in our cases.

In a cadaver study by Sun et al., a modified posterolateral approach was examined. They reported that anatomical reduction and buttress fixation could be achieved when using this approach in posterolateral tibial plateau fractures [15]. However, the study provided insufficient details about the distance of the incision from the medial and lateral neurovascular structures; therefore, in the current study, we examined this distance. The results indicate that the medial neurovascular structures were close (10.09 ± 3.47 mm at the level of the tibial joint line and 10.39 ± 2.57 mm at a level 5 cm distal to the joint line) to the incision; however, there was a safe distance from the incision to the peroneal nerve (13.44 ± 4.17 mm at the level of the tibial joint line and 19.56 ± 5.24 mm at a level 5 cm distal to the joint line). Therefore, with sufficient visualization of the peroneal nerve during dissection, there is no need for suspension. However, the close proximity of the medial neurovascular structures means that dissection should be performed with care when using this posterior approach. An incision of approximately 8 cm allowed sufficient surface area to be exposed for plate osteosynthesis open reduction and buttress fixation.

In isolated posterolateral tibial plateau fractures, it is possible to apply anatomical reduction and buttress plating to the posterior surface via a direct posterior lateral gastrocnemius split approach. This approach serves a sufficient visualization of the peroneal nerve during dissection. However, the close proximity of the medial neurovascular structures means that dissection should be performed with care when using this posterior approach. We do not recommend to do a preparation of neurovascular structures during osteosynthesis. With a thorough understanding of the regional anatomy, this approach can be safely and carefully performed experienced orthopaedists.

**Compliance with ethical standards**

**Conflict of interest** Güzelali Özdemir, Barış Yılmaz, Turgut Akgül, Serdar Yılmaz, Özgür Çiçekli and Abdulkadir Dost declare that they have no conflict of interest.

**Ethical standards** In this article, there was no conflict with ethical standards of the Committee on Publication Ethics guidelines. No benefits or funds were received in support of this study.

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