Original Article

Safe Zone for Placement of Anterior Distal Femoral Half Pins

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Background: Anterior external fixator half pins are commonly used to secure a knee spanning external fixator. Knee joint penetration by the pins is a serious complication.

Objective: To determine the safe zone for the insertion of anterior half pins at the distal femur to avoid suprapatellar pouch penetration using fixed anatomical landmarks.

Materials and Methods: The distance from the medial and lateral epicondyle along the femoral axis to the perpendicular line of the superior reflection of suprapatellar pouch was measured in MRI images of 100 knees.

Results: The average distance from the superior pole of the patella to the superior reflection of the suprapatellar pouch was 26.5±7.2 mm (95% CI 25.1 to 27.9). The average distance from superior reflection of the suprapatellar pouch to the medial epicondyle was 47.5±6.3 mm (95% CI 46.2 to 48.7) and to lateral epicondyle was 53.0±6.6 mm (95% CI 51.7 to 54.3).

Conclusion: Insertion of anterior external fixator half pins into the distal femur should begin at least 5.0 cm above the medial epicondyle or 5.5 cm above the lateral epicondyle to avoid knee joint penetration.

Keywords: Safe zone, Anterior external fixation, Half pin, Suprapatellar pouch, Medial epicondyle, Lateral epicondyle

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A unilateral anterior frame external fixator of the femur is widely used in various orthopedic situations, including damage control orthopedic[1], high-energy periarticular fracture of the knee[2], open fracture with severe soft tissue injury[3], and traumatic knee dislocation[4]. A knee joint bridging external fixator is well accepted as the initial treatment of complex fractures or dislocations with soft tissue injury around the knee. The stability of the fixation requires half pin placement as close as possible to the knee joint. Previously, distal femoral pins were placed laterally to minimize quadriceps mechanism injury, but now, there is a preference for direct anterior frame as it provides a more stable mechanical construct and makes realigning the fracture easier. Meticulous care should be taken to avoid intra-articular half pin insertion into the knee joint[2].

Septic arthritis following application of intra-capsular pins or wires is uncommon, but it is a serious complication when it does occur[5]. Several studies have attempted to define the capsular reflection of the knee joint in an effort to provide surgical guidance on how to avoid this complication[5-9]. Guidelines and recommendations for wire insertion at the proximal tibia from the subchondral line have varied from 14 to 70 mm[5,6]. In the distal femur, the distal femoral traction pin should be inserted from medial to lateral at more than 0.7 cm proximal to the adductor tubercle to avoid knee joint penetration[7]. The capsular attachment and reflections of the distal femur in the study were determined through cadaveric analysis where the mean distance from the center of the anterior part of the notch to the superior reflection was 79.5 mm[8]. The safe zone for external fixator pins in the femur was described as the anterior pin beginning 7.5 cm above

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Figure 1. Reference line of the most upper reflection of suprapatellar pouch from the sagittal plane MRI of the knee using the T2 fat sat signal.

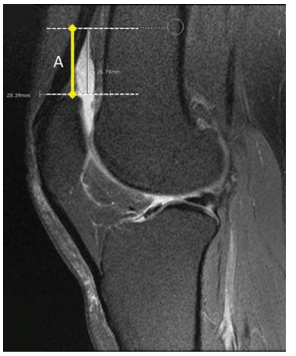

Figure 2. Distance from the superior pole of the patella to the superior reflection of the suprapatellar pouch (A) in the sagittal plane MRI.

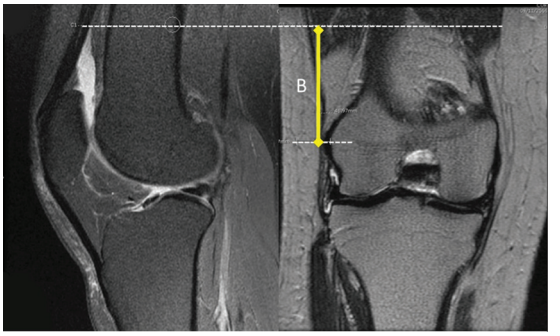

Figure 3. Distance from the medial epicondyle to the reference line of the superior reflection of the suprapatellar pouch (B) in the coronal plane MRI.

the superior pole of the patella[9]. However, since the patella is a mobile structure, this distance may vary according to the knee joint position due to patellar movement. In patients with severe osteoarthritis of the knee, the superior pole of the patella maybe difficult to identify because of the osteophyte. We propose a method of using the medial and lateral femoral epicondyles, which are fixed anatomical landmarks, to determine the safe zone for anterior half pins at the distal femur to avoid suprapatellar pouch penetration.

Materials and Methods

Ethical review board approval was obtained before the start of the present study. The descriptive study included 100 knees that underwent magnetic resonance imaging (MRI) examination between January 2012 and March 2013. Exclusion criteria were knee joints with a previous injury, deformity, infection, or tumor. The first step in the present study was to correctly identify the bony surface anatomical landmarks of the of medial and lateral epicondyles with the landmarks from the MRI. Two small cotton balls were attached to the skin of the volunteers at the medial and lateral epicondyles to serve as surface landmarks, then an MRI of the knee was performed. The equivalence of the landmarks on the skin and the bony landmarks from MRI were then confirmed at the medial and lateral epicondyle. For all MRI images, the distance from the medial femoral epicondyle, lateral femoral epicondyle, and superior pole of patella to the superior reflection of the suprapatellar pouch were measured. These distances can be reliably determined using MRI. The authors determined the most superior reflection of the pouch from the sagittal plane from the T2 fat sat signal, and then made the reference line (Figure 1). The distance from superior pole of the patella to the reference line was measured (distance "A" in Figure 2). This reference line was then correlated with the medial and lateral epicondyle on the coronal plane to determine the distance from the medial epicondyle to the reference line (distance "B" in Figure 3) and from lateral epicondyle (distance "C" in Figure 4).

Statistical analysis

Collected data were analyzed for statistical significance using two sample t-test or Pearson's correlation, as appropriate. Statistical analysis was performed with EpiData Software English V.2.2 Rel.1 (Build 171).

Results

There were 65 males and 35 females with average age of 33.04±10.32 (range 20 to 61). There was no statistically significant difference in any of the distance parameters between genders ($p>0.05$) (Table 1). The average distance from the superior pole of the patella

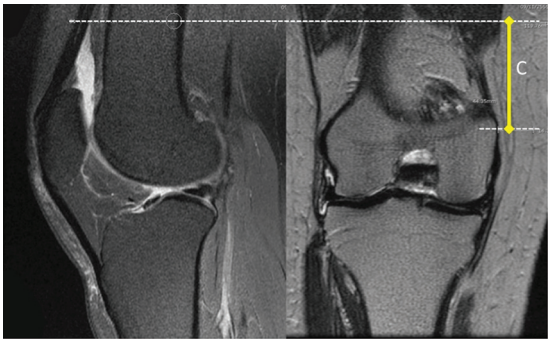

Figure 4. Distance from the lateral epicondyle to the reference line of the superior reflection of the suprapatellar pouch (C) in the coronal plane MRI.

to the superior reflection of the suprapatellar pouch (A) was 26.5±7.2 mm (95% CI 25.1 to 27.9). The average distance from the superior reflection of the suprapatellar pouch to the medial epicondyle (B) was 47.5±6.3 mm (95% CI 46.2 to 48.7) and to lateral epicondyle (C) was 53.0±6.6 mm (95% CI 51.7 to 54.3) (Table 2).

Table 1. There were no statistically significant differences in measured parameters between genders (p>0.05)

	Male Mean±SD	Female Mean±SD	p-value
Age (year)	32.7±10.3	33.0±10.3	0.875
Superior pole patella (A) (mm)	25.6±7.3	28.1±6.9	0.089
Medial epicondyle (B) (mm)	46.7±6.3	48.5±6.3	0.246
Lateral epicondyle (C) (mm)	52.3±6.5	53.3±6.9	0.719

SD=standard deviation

Table 2. Measured distances from the suprapatellar reflection

Distance to superior refection of the pouch (mm)	Mean±SD	95% CI
Superior pole patella (A)	26.5±7.2	25.1 to 27.9
Medial epicondyle (B)	47.5±6.3	46.2 to 48.7
Lateral epicondyle (C)	53.0±6.6	51.7 to 54.3

CI=confidence interval; SD=standard deviation

Discussion

An external fixator allows for fracture and soft tissue stabilization in polytrauma with several complex injury patterns[1]. Temporary external fixation of intra-articular fractures and dislocated joints has gained popularity in the past decade as the initial management in the staged protocol[2,4,10]. For the knee-spanning external fixator, however, there appears to be little consensus regarding the optimal site of half pin placement in the femur. Previously, lateral placement of the half pin was recommended to minimize further injury to the quadriceps mechanism[11], but others now prefer direct anterior frames. The anterior pin configuration allows for easier reduction with distraction, flexion, and extension. A survey of active Orthopaedic Trauma Association (OTA) members found that nearly two-third of the surgeons responding (64.1%) preferred anterior placement of the femoral pin, whereas 39.1% favored lateral pin placement[10].

Because septic arthritis resulting from pin tract infection following iatrogenic intra-capsular penetration of the knee is serious, although rare, meticulous care must be taken to avoid violating the joint capsule. Hutson et al[12] published a prospective cohort study that documented three patients out of 145 patients who had developed septic arthritis of the knee following external fixator. Previously published studies have indicated that knee joint capsule insertion into the proximal tibia is somewhat controversial. Hyman et al[6] reported that insertion of external fixator pins within sixty to seventy millimeters of the proximal tibial articular surface was associated with a high probability of knee joint penetration, while DeCoster et al[13] found that the proximal 14 mm of the tibia could be unsafe due to possible knee joint penetration. Stavlas and Polyzois[5] also recommended that a 14 mm distance from the subchondral line in the knee joint is sufficient and safe for the tibial pin or wire.

There have been few studies published regarding the safe zone of the external fixator pins in the femur. Beltran et al[9] reported the safe zone for anterior half pin placement in 20 fresh frozen cadavers was an average distance from the superior pole of the patella to the superior reflection the suprapatellar pouch of 46.3±13.1 mm (range 20 to 74). The longest synovial reflection should extend 74 mm above the patella, and the pin should begin 7.5 cm above the superior pole of the patella. The patella is a surface anatomy feature that is easy to palpate. However, it is mobile, and its position will change with different degrees of knee flexion or when the joint is swollen with knee effusion. In the present study, the average distance from the superior pole of the patella to the superior reflection of the suprapatellar pouch was 26.5±7.2 mm (95% CI 25.1 to 27.9), which is 20 mm less than that reported by Beltran et al. This data support that the correlation between the superior pole of the patella to the reflection may not be a reliable landmark.

Another cadaveric study of capsular attachments of the distal femur was performed by Lowery et al[8] They reported that the average distance from the center of the anterior part of the notch to the superior reflection was 79.5 mm (range 48.1 to 120.7). This distance can be measured in a cadaver or through the use of intraoperative radiography, but it cannot be determined using surface landmarks.

The present study found that the distance from the superior reflection of the suprapatellar pouch to the medial epicondyle (B) averaged 47.5±6.3 mm (95% CI 46.2 to 48.7 mm) and to lateral epicondyle (C) averaged 53.0±6.6 mm (95% CI 51.7 to 54.3). The lateral epicondyle was slightly proximal to the medial epicondyle and both surface landmarks were easily identified, especially the medial epicondyle. The advantage of using these parameters is that the factors described in the present study can be replicated during surgery without difficulty. When a knee injury or fracture around the knee occurs, swelling may obscure some of the landmarks, e.g., the superior pole patella and the epicondyles. These bony landmarks may be the available option to use when applying an anterior half pin external fixator. When both landmarks can be palpated, the authors recommend using the medial epicondyle as the first landmark since it is the pertinent landmark on the medial side.

Limitations of the present study include that most of the MRIs were of patients with delayed knee ligamentous injury and that the joints were not distend by hematoma or effusion, which may expand the suprapatellar pouch as usually be the case in acute injuries or fractures. Further study in cadavers is recommend by using our landmarks.

Conclusion

Insertion of anterior external fixator half pins into the distal femur should begin at least 5.0 cm above the medial epicondyle or 5.5 cm above the lateral epicondyle to avoid knee joint penetration.

What is already known on this topic?

The safe zone of external fixator pin placement above the knee joint is done by using only one reference point from upper pole of the patella.

What this study adds?

There are two more references using the medial femoral epicondyle and the lateral femoral epicondyle as the reference for safely inserting the external fixator pin. These two references are constant and easily palpable especially the medial epicondyle.

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Conflicts of interest

The authors declare no conflict of interest.

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