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A New Anterolateral Approach for Type C Fractures of the Distal Femur

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To provide an anatomic basis for treating type C distal femoral fractures by a new anterolateral approach. Twenty surgical procedures were performed in 10 adult cadaveric specimens using a new anterolateral approach followed by dissection of all lower limbs. The main anterolateral muscles and ligaments were observed. Vessels and nerves related to the new anterolateral approach were also evaluated. Full exposure of the distal femur was achieved. The iliotibial band was protected, and damage to the quadriceps femoris was reduced. The distance between the common peroneal nerve and the new incision line at the level of the lateral epicondyle of the femur was ($\bar{\chi} \pm s$) 8.19 ± 0.79 cm (range, 7.48–9.57 cm). This new anterolateral approach to the distal femur is safe. Although it induces slight soft tissue damage, its exposure is excellent. Knee rehabilitation can be performed in the early postoperative period.

Key words: Distal femur fracture – New anterolateral approach – Anatomy

The number of high-energy traumas causing distal femoral fractures is increasing.[1,2] The estimated frequency is 3% of femoral fractures.[3] Müller[4] classified these fractures according to their location and pattern. Their classification broadly divides distal femoral fractures into type A (extra-articular), type B (condylar or partial articular), and type C (bicondylar or complete articular). Types A and B permit less-invasive repair procedures, such as less-invasive stabilization systems and intramedullary nailing,[5] but type C refers to comminuted fractures of both the lateral and medial femoral

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Table 1 Demographic data of the 10 cadaveric specimens

	Sex	Age, y	Height, cm	Weight, kg
1	M	78	171	65
2	M	61	168	69
3	F	66	160	55
4	F	72	162	57
5	F	78	159	49
6	M	80	176	72
7	M	63	159	54
8	M	81	166	67
9	F	73	165	70
10	M	58	164	63

M, male; F, female.

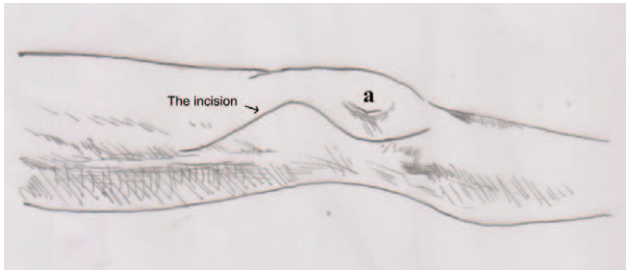

Fig. 1 Skin incision of the new anterolateral approach (lateral view of the thigh): (a) patella.

condyles in association with severe soft tissue injuries. This type of fracture requires anatomic reduction of the articular surface, internal fixation, and early functional rehabilitation to improve outcomes and reduce the incidence of posttraumatic complications.[6–8]

Although indirect reduction maneuvers are available for type C fractures of the distal femur, direct exposure with visualization of the articular surface and fracture fragments is recommended to ensure anatomic reduction.[8,9] Adequate exposure can reduce the operation time and address fractures anatomically, reducing the rates of malunion, nonunion, and infection.[9,10] Many approaches to the distal femur have been described. Lateral and anterolateral approaches are commonly used, but full exposure is difficult, and soft tissue injury may occur, potentially leading to malunion, nonunion, knee dysfunction, and other problems.[11] To minimize soft tissue injury, widely expose the joint, operate easily, and implement early postoperative functional exercise, we designed a new anterolateral approach termed the "S-shaped approach." We performed a cadaveric anatomic study to confirm the technical feasibility of this approach.

Materials and Methods

Ten embalmed adult cadaveric specimens (6 male and 4 female) were obtained from the Department of Anatomy of Nanchang University Medical School (Table 1). All studies were performed bilaterally (*i.e.*, 10 cadavers and 20 limbs). All specimens were confirmed to have no previous knee surgeries or scars. The specimens were placed in the supine position on the dissecting tables. All approaches and dissections were performed by the senior author, a fellowship-trained orthopedic traumatologist. The new anterolateral approach was first performed on each specimen, and a dissection to the lower limb was then performed. We observed the anatomic characteristics of the main anterolateral muscles and ligaments and their relationships with the approach. The distances of the main vessels and nerves in relation to the approach were also measured with a vernier caliper.

Description of Approach

A 20- to 25-cm S-shaped incision was made on the lateral aspect of the thigh. The incision curved forward and downward to the superolateral aspect of the patella, then extended to the inferolateral aspect of the patella. It ended at Gerdy's tubercle (Fig. 1). While protecting the iliotibial band (ITB), the deep fascia was cut to visualize the underlying spatium intermusculare between the vastus lateralis and rectus femoris, the lateral part of the quadriceps extension, the lateral patellar retinaculum, and the lateral superior genicular artery. Three sequential steps were then performed to gain improved access to the distal femur. First, the spatium intermusculare was incised. Upon reaching the underlying layer, the lateral margin of the distal segment of the vastus intermedius was incised to expose the underlying bone (Fig. 2). Second, sharp dissection was performed in the lateral patellar and quadriceps extension regions (Fig. 3). Finally, the distal femur and the articular surface were fully revealed by turning the patella over to the inside after incision of the knee joint capsule and lateral patellar retinaculum. At this point, full exposure was achieved (Fig. 4).

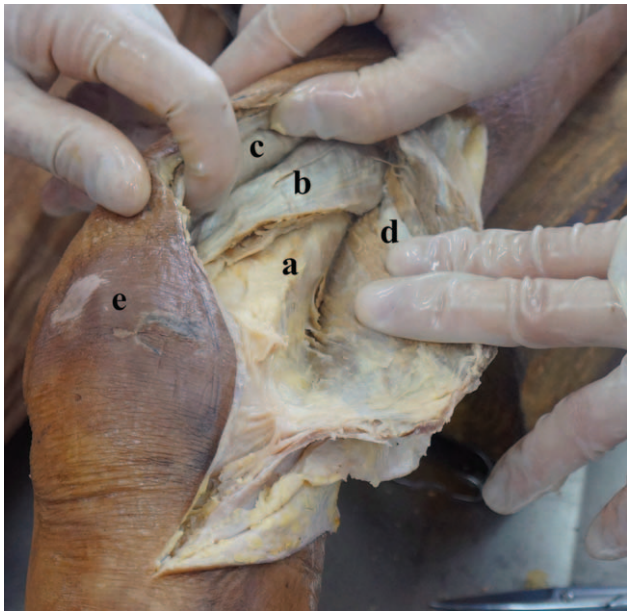

Fig. 2 This approach incises the lateral margin of the distal segment of the vastus intermedius to expose the underlying bone: (a) distal femur, (b) vastus intermedius, (c) rectus femoris, (d) vastus lateralis, and (e) patella.

Results

Muscles and ligaments related to the new anterolateral approach

The ITB is a band of dense fibrous connective tissue at the lateral aspect of the thigh. The minimum distance between the medial aspect of the ITB and the spatium intermusculare (the vastus lateralis and rectus femoris) in this study was ($\bar{\chi} \pm s$) 5.21 ± 0.56 cm (range, 4.25–6.42 cm). No ITB was damaged during the surgery (Fig. 3). The rectus femoris, vastus medialis, and vastus lateralis lie at the anterior, medial, and lateral aspect of the thigh,

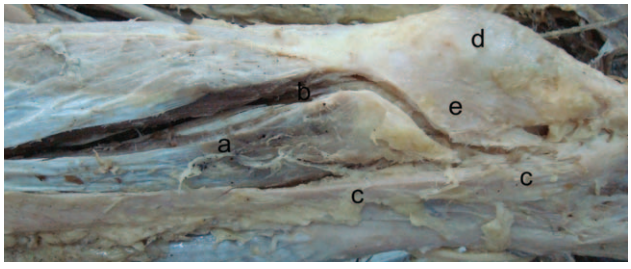

Fig. 3 Deep aspect of the new anterolateral approach and the surrounding structures: (a) vastus lateralis, (b) incision line along the spatium intermusculare, (c) iliotibial band, (d) patella, and (e) lateral patellar retinaculum.

Fig. 4 Different optimal viewing angles for the surgeon with the new anterolateral approach. The distal femur and the articular surface are available for direct visualization.

respectively. The vastus intermedius lies deep to the rectus femoris, and its origin comprises three quarters of the anterior aspect of the shaft of the femur (Fig. 5). The new anterolateral approach was performed at the lateral margin of the distal segment of the vastus intermedius. The lateral patellar retinaculum can be divided into superficial and deep layers. These layers were cut off during the new anterolateral approach.

Vessels and nerves related to the new anterolateral approach

The patellar blood supply is extremely abundant. All specimens contained at least 6 genicular arteries that coursed through an anastomotic ring. Only the superior lateral genicular artery was in the way of the approach and was ligated. The common peroneal nerve arises from the sciatic nerve and courses down along the inside of the biceps femoris in the superior lateral aspect of the popliteal fossa. The distance between the common peroneal nerve and new incision line at the level of the lateral epicondyle of the femur was ($\bar{\chi} \pm s$) 8.19 ± 0.79 cm (range, 7.48–9.57 cm).

Discussion

The treatment of type C fractures of the distal femur has always been difficult. These fractures are always unstable and comminuted, leading to poor outcomes.[7,8,12] Because the fracture line is articular, it is difficult to completely restore the activity and function of the joint. Many previous studies have reported that the occurrence rates of malunion, nonunion, dysfunction, and infection of the knee joint are high, with incidences ranging from 29% to 38%.[13–17]

The extensor apparatus of the knee joint (EAOKJ) includes the quadriceps femoris and its tendon, the patellar ligament, the patellofemoral and tibiofemoral joints, and other structures. EAOKJ injury is

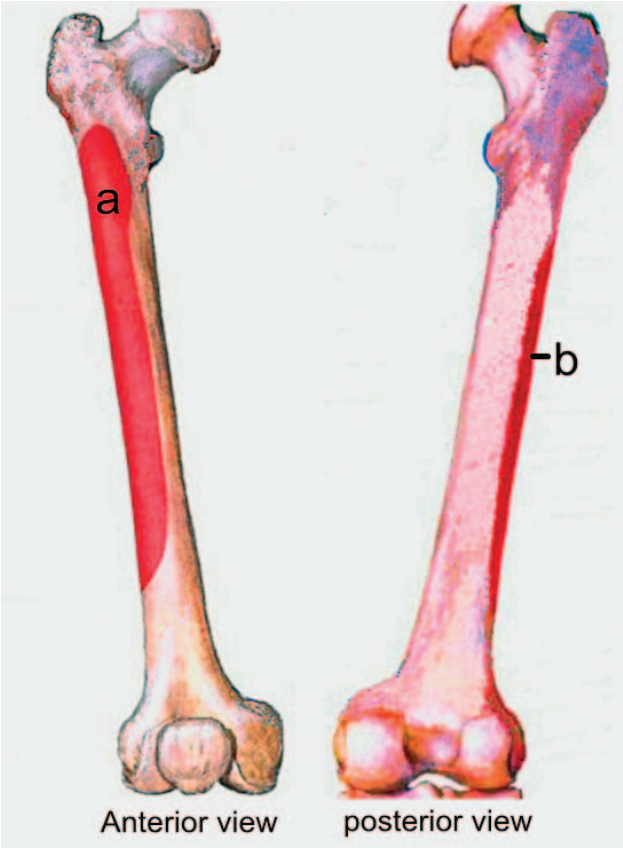

Fig. 5 The vastus intermedius muscle originates from a line of attachment on the (a) anterior and (b) posterior aspects of the femur.

the main cause of knee dysfunction. There are several reasons for knee dysfunction after type C distal femoral fractures. First, both trauma and surgery can injure the quadriceps femoris, particularly the vastus intermedius. Second, contracture and adhesions may be severe after prolonged immobilization.[18,19] The ITB is especially important when the knee is in full extension. Therefore, injury to the ITB will influence the activities of the knee joint.[20–22] Additionally, displaced distal femur fractures require anatomic reduction of the articular surface. Multiple authors have shown that articular incongruity leads to poor outcomes, such as posttraumatic arthritis.[7,8,13] In essence, type C fractures of the distal femur require anatomic reduction, stable internal fixation, and early postoperative exercises for functional rehabilitation.

Many traditional surgical approaches are currently used. However, each approach has its anatomic inadequacies. Both the anterolateral and anteromedial approaches require development of a longitudinal split between the rectus femoris and vastus lateralis, followed by splitting of the muscle belly of the vastus intermedius. This split damages the quadriceps femoris and may lead to scarring and poor quadriceps function. The lateral approach involves splitting of the ITB and muscle belly of the vastus lateralis. Although the lateral approach can reduce damage to the EAOKJ, it damages the ITB and insufficiently exposes the medial compartment of the knee. Additionally, the posterolateral approach described by Marcy[23] provides poor access to the intercondylar notch and medial compartment of the knee, where intra-articular fracture planes are common and may be initially missed.[24,25] Moreover, this approach may damage the sciatic nerve. Therefore, a better surgical approach is needed.

The present study has demonstrated the following advantages of the new anterolateral approach to type C distal femoral fractures. First, the approach is safe. There are no major nerves or vessels in the operative field with the exception of the superior lateral genicular artery, which is ligated. However, the patella has multiple blood supplies and is thus minimally affected. Second, this approach protects the ITB and reduces the damage to the quadriceps femoris, especially to the vastus intermedius. It, thus, not only protects the integrity of the EAOKJ and maintains the stability and function of the knee after the operation, but it also reduces the severity of postoperative scar formation. Third, the distal femur and the articular surface are fully revealed by dragging muscles and turning the patella over to expose the inside. Thus, fractures can be adequately visualized and internal fixation can be reliably performed. Moreover, injured ligaments and menisci can be simultaneously repaired. For all of these reasons, the new anterolateral approach allows for dirigation or other forms of rehabilitation to the muscles and knee in the early postoperative period.

There are a number of weaknesses in the present study. As a cadaveric study, it relied on the limbs of older patients—the average cadaver age among our subjects was 71 years, which is much older than the average age of trauma patients. However, distal femur fractures secondary to low-energy mechanisms are increasing in the elderly population, and this study indicates that the new anterolateral approach for type C fractures of the distal femur is a viable option in this expanding patient population. Another weakness is that, because of the embalming

procedure, the anatomic specimens were not fresh, which may have caused some differences from clinical patients. Additionally, the lack of anatomic specimens with fractures or soft tissue injuries may have caused further differences from clinical patients.

In conclusion, this study has demonstrated that in a cadaveric model, the new anterolateral approach is safe, allows for full exposure, and facilitates early functional rehabilitation. However, future clinical studies are needed to confirm these results and determine the true efficacy of utilizing this new anterolateral approach for type C fractures of the distal femur.

Acknowledgments

Luo Song, MM, and Zhang Bin, MD, contributed equally to this paper and share first authorship.

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