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An unambiguous technique for locating the adductor tubercle and using it to identify the joint line

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ABSTRACT

Background: If the adductor tubercle could be accurately located, it would be a useful landmark for identifying the joint line during knee arthroplasty. This study aimed to develop an intraoperative technique to improve its locating accuracy.
Methods: Evaluation of bone specimens and cadaveric knees revealed that the proximal slope of the adductor tubercle (PSAT) turns from the medial surface vertically into the superior surface of the medial condyle, which forms a distinctive edge. This provided an ideal landmark that could be unambiguously engaged using a tipped instrument. Using the PSAT as a reference point, we measured the distance to the joint line (the proximal–distal condylar length; PDCL) in eight pairs of cadaveric knees, and evaluated the inter-observer variability. Next, we measured 120 knees undergoing total knee arthroplasty to test this technique in a normal population. Finally, we divided each PDCL by the respective anterior–posterior condylar length (APCL) to create a ratio that could predict the PDCL regardless of knee size.
Results: The intra-class correlation coefficient (ICC) was 0.86 for the cadaveric measurements. The mean PDCL from the operated knees was 46 mm (coefficient of variance (CV): eight percent). The mean PDCL/APCL ratio was 0.77 (CV: six percent). The high ICC and low CV indicated that using the PSAT was a reliable technique.
Conclusion: The PSAT is an ideal surgical landmark. The tipped instrument engagement technique with it may help to unambiguously locate the adductor tubercle in order to identify the joint line during knee arthroplasty.

1. Introduction

Restoration of the distal femorotibial joint line is an important goal for knee arthroplasty, in order to maximize postoperative function and avoid complications [1–7]. Various landmarks around the knee have been used to identify the joint line during surgery, and the medial epicondyle is the most popular landmark [4,8–15], although its use has several inherent disadvantages. First, this landmark is a mild elevation that does not involve a distinct protrusion. Second, it is overlaid with thick soft tissue from the insertion of the medial collateral ligament, which can complicate the identification of the medial epicondyle using palpation [12,16–19]. Third, knees requiring revision surgery commonly have severe bone defects, which may involve the medial epicondyle and limit its reliability as an anatomical landmark [20,21]. Therefore, it would be useful to have another technique for identifying the joint line.

The adductor tubercle is another bony protrusion on the medial femoral condyle, and has also been used as a landmark for locating the joint line. In this context, the adductor tubercle is located farther away from the joint line, compared to the medial epicondyle, and is less likely to be affected in knees with significant bone loss. Thus, the adductor tubercle may be a good alternative to the medial epicondyle, although it is not well-known and is infrequently used as an anatomical landmark [5,6,11]. This may be related to the fact that the adductor tubercle is an even lower-profile bony prominence, has a surface that is also covered by layers of soft tissue, and has a relatively peripheral location in the operative field; these factors all greatly increase the difficulty of accurately locating the adductor tubercle using palpation [11].

Iacono et al. recently published several reports that thoroughly described the adductor tubercle and promoted its use [22–24], although they did not address the potential limitations of this landmark or propose an accurate method for locating it [22–24]. Thus, a less ambiguous technique for locating the adductor tubercle might allow surgeons to confidently exploit the advantages that it provides, without concerns

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regarding its potential drawbacks. Therefore, this study aimed to develop a technique for accurately locating the adductor tubercle (by evaluating bone specimens and cadaveric knees) and to prospectively identify the distance from the adductor tubercle to the joint line in a normal population of patients.

2. Materials and methods

2.1. Preliminary development using dried bone specimens

We initially evaluated the relevant structures using dried bone specimens from our anatomy laboratory. This evaluation revealed that the adductor tubercle was only slightly elevated from the medial surface of the medial condyle, and that it was difficult to palpate. Similarly, previous studies have suggested that it may only be 'a facet' in many cases, rather than a projection [25]. However, a further examination revealed that the proximal slope of the adductor tubercle (PSAT) turned from the medial surface of the medial condyle vertically into the superior surface of the medial condyle, which formed a distinctive edge that might serve as an ideal landmark (Figure 1). Therefore, instead of palpation, a tipped instrument could be used to locate and engage the bony edge. Here, the superior surface of the medial condyle referred to the bony surface of the posterior condyle facing cranially, and had rarely been accessed in most surgical procedures.

2.2. Locating the PSAT in cadaveric knees

We subsequently used four fresh-frozen cadaveric knees to determine whether the PSAT could be readily located on a fleshy limb. Each knee was approached through a midline skin incision and medial parapatellar arthrotomy. The medial surface of the joint was exposed after medial and proximal retraction of the joint capsule. The landmark was located using the nose of a hemostat (the tipped instrument), which was inserted through a thin layer of soft tissues to contact the bony surface of the presumed adductor tubercle. The nose of the hemostat was then slid along the bony surface until it slipped into the superior surface of the medial condyle, which indicated that it had engaged the PSAT. We were able to easily locate the PSAT using this technique, and subsequent open dissection confirmed that the instruments had engaged the desired landmark in all four knees (Figure 2).

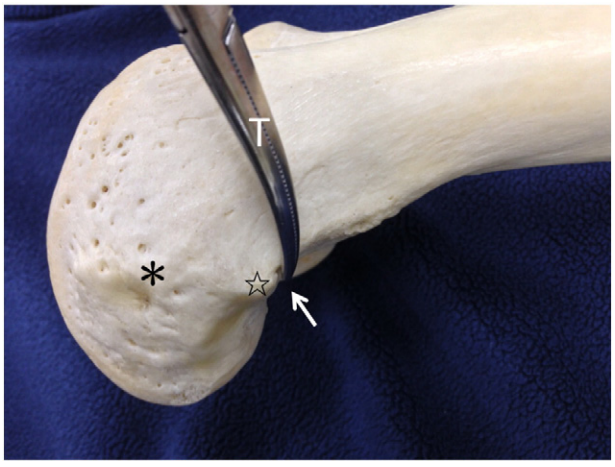

Figure 1. A dry bone specimen that displays the anatomy of the proximal slope of the adductor tubercle (indicated by the arrow), which is engaged using a tipped instrument (T). *, the medial epicondyle; ☆, the adductor tubercle.

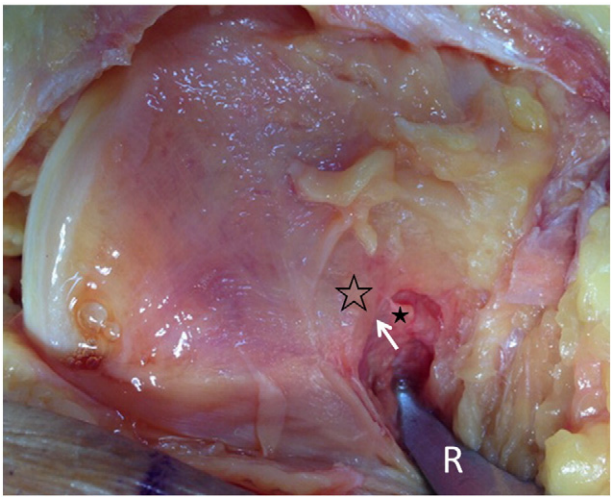

Figure 2. Open dissection is used to verify the location of the proximal slope of the adductor tubercle (arrow). The use of a Hohmann retractor (R) shows a portion of the superior surface of the medial condyle and the relevant anatomy. ☆, the adductor tubercle; ★, the stump of the adductor magnus tendon.

2.3. Simulated surgical dissection to determine the distance to the joint line and inter-observer variability

We also performed simulated surgical dissection of both knees from eight fresh-frozen cadavers (five males and three females; age at death, 49–88 years; average, 69 years). An incision was created in each knee, and the adductor tubercle was identified using our new technique. When we located the PSAT, we used a caliper to measure the distance to the most distal femoral condylar surface along the longitudinal axis of the femur. This distance was defined as the distance to the joint line, and is the proximal–distal condylar length (PDCL).

Two surgeons participated in this part of the study. All measurements were performed in triplicate, and the mean values were used. The first surgeon performed the measurements on one randomly selected knee from each cadaver, and the second surgeon performed the measurements on the other knee, in order to avoid any confounding from the first surgeon's measurements. As the knees from the same patient presumably had identical anatomies, we assumed that each surgeon evaluated the same group of specimens, which allowed us to examine the inter-observer variability of this technique.

2.4. Clinical measurement of the distance to the joint line

To evaluate this technique in a normal patient population, we recruited patients who were preparing to undergo primary total knee arthroplasty for end-stage osteoarthritis at our university teaching hospital. This part of the study was approved by our institution's ethics review board, and all patients provided their written informed consent. However, we excluded patients with a severe varus deformity (a femorotibial angle of >15°) and previous surgeries or fractures over the femoral condyle, in order to only evaluate knees with normal morphology. A total of 120 patients were considered eligible and were evaluated using our new technique (89 women and 31 men; mean age, 71 years; range, 46–88 years) during January–December 2013. All operations and measurements were performed by one surgeon, and all patients received a posterior stabilized condylar knee prosthesis (U2; United Orthopedic Company, Taiwan) that was placed using the measured resection technique [26]. The procedure was performed through a small incision with mid-vastus arthrotomy. The surgeon used our technique to locate the PSAT and measure the PDCL (Figure 3) after the components had been cemented and the wound was about to be closed. The anterior–posterior condylar length (APCL) of the femoral