Tibial component rotation assessment using CT scan in medial and lateral unicompartmental knee arthroplasty

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Accepted: 9 November 2010

KEYWORDS
Unicompartmental; Knee arthroplasty; Component positioning; Rotation; CT scan

Summary

Background: Rotation of tibial component has not been analysed in literature for unicompartmental knee arthroplasty. The purpose of the study was to determine and compare the rotation of medial and lateral unicompartmental knee arthroplasty (UKA) tibial components. We assumed both components (lateral and medial) were positioned with external rotation.

Patients and methods: Eighteen lateral and 19 medial UKA patients were scanned post-operatively in neutral position with computed tomography enabling lower extremity three-dimensional image acquisition from the hip to the ankle. All the patients were operated by three different senior surgeons using the same surgical technique. From the reconstructions we measured the two-dimensional (2D) rotation of the tibial components.

Results: The rotation of the tibial component was external (mean 6.5°, SD 5.1°) for the medial UKA and external (mean 7.3°, SD 10.3°) as well for the lateral UKA. The difference was statistically insignificant (P = 0.717).

Discussion: This study presents the first 2D in vivo analysis accurately determining and comparing medial and lateral UKA component rotation. Despite a wide range of value, we found both components were indeed externally rotated. The variability in implant positioning was observed despite the rigorous performance of an experienced surgeon using routine techniques in patients selected under routine criteria. Further analysis of these patients for satisfaction...
Introduction

A number of studies demonstrate good results for unicompartmental knee arthroplasty (UKA). The design and positioning of UKA implants is not yet well understood and is continually being refined. The majority of studies of UKA implant positioning are two-dimensional (2D) radiographic analysis in the sagittal and frontal planes [1]. Similarly the kinematics of UKA were more recently studied using fluoroscopy [2–6] in the sagittal and frontal planes. None of these studies focused on implant rotation. Argenson et al. [7] examined the rotation of the tibial component relative to the femoral component during flexion, but not the anatomic position of the implant. Assor and Aubaniac [8] conducted a 2D radiographic study of implant rotation but focused solely on the femoral component. Campbell et al. [9] analyzed UKA positioning using Computed Tomographic (CT) scans but focused only on implant rotation in the medial compartment.

The purpose of this study was to describe the rotational positioning of medial and lateral UKA tibial components. We assumed the tibial implant was slightly externally rotated in both compartments. After performing a CT scan with reconstructions, on the operated knee, image-processing software with three-dimensional (3D) reconstruction capability was used to measure and analyze more accurately the 2D rotation of the components.

Patients and Methods

We studied postoperative CT scans of 37 knees from 31 females and six males. All patients were implanted with an HLS Evolution Uni (Tornier®, St Ismier, France) which has a fixed all polyethylene tibial component. There were 18 lateral and 19 medial compartment UKAs performed. All the patients were operated by three different senior surgeons using the same surgical technique.

The indications for UKA used were stage C and D unicompartmental osteoarthritis (IKDC classification), axial mechanical valgus/varus alignment less than 10 degrees, ligamentous stability, reducibility of the wear compartment in frontal plane, normal or near-normal range of motion, older, less active patient. The absolute contraindications for UKA were: inflammatory disease, history of infection, bicompartamental or tricompartmental osteoarthritis, cruciate and collateral ligament deficiency, important bone loss, extension deficit greater than 10 degrees. The relative contraindications for UKA were: associated patellofemoral osteoarthritis, body weight greater than 80 kg, young and active patients [10].

The patients mean height was 162 cm (SD 8.4; range 147–178) and the mean weight was 65.4 kg (SD 10.5; range 49–93).

For surgery the patient was positioned supine on the table with a lateral support and foot bolster holding the knee in 90° flexion. When using the tibia extramedullary guide, the transverse cut was determined as per routine described techniques [10]. After the transverse cut was performed the tibial cut was completed with the anteroposterior (AP) cut, which determined the rotation of the tibial component. For a lateral UKA, our AP cut was performed just medial to the lateral tibial plateau in the axial direction of the lateral side of the notch (lateral condyle). For a medial UKA, our AP cut was just lateral to the medial tibial plateau in the axial direction of the medial side of the notch (medial condyle).

All patients were scanned by the same senior radiologist (SC). The CT scans were taken with the lower limb fixed with a frame in a neutral position (0° flexion) to avoid measurement bias. The images were taken at a thickness of 1 mm from the superior margin of the patella to the anterior tibial tuberosity. Scans also included images at the hip and ankle of the ipsilateral limb. For 3D analysis, we used image-processing software dedicated to DICOM images, OsiriX (open-source software; http://homepage.mac.com/rossetantoine/osiriX) (Fig. 1). A coordinate system with reference to bony landmarks

Figure 1 Long legs film with measurement of the mechanical femorotibial angle.
The lateral UKA.

[11—13] was used: in the coronal plane we referred to the centers of the ankle and femoral head, and in the sagittal and axial planes we referred to the femoral epicondyles, posterior condyles, as well as the middle of the femoral and tibial shafts.

The operated tibial plateau was digitized at the resection level in the axial plane and the AP intraoperative cut was digitized (Fig. 2). The implanted tibial component used was full-thickness polyethylene and so there was no secondary artifact from metal-backed components. In the axial plane, the posterior rim of the tibial plateaus were used as anatomical references to determine the rotation of the tibial implant as described by Yoshioka et al. (Fig. 2). The rotation was thus measured by the angle between a perpendicular line to the tangent to the posterior tibial plateaus and the tangent to AP tibial implant. The rotation was considered as positive when externally rotated.

Statistical analysis was performed using the Student’s t-test and Pearson’s correlation with Microsoft Excel (Microsoft Corp, Redmond, WA, USA). Comparison was performed between the medial UKA and the lateral UKA components. Correlations between variables were calculated using the Pearson product moment coefficient of correlation (r). The significance level was set at $P<0.05$.

### Results

The tibial implant rotation was positioned in external for both medial and lateral UKA(Table 1). The rotation of the tibial component was external (mean 6.5°, SD 5.1°) for the medial UKA and external (mean 7.3°, SD 10.3°) as well for the lateral UKA.

This difference was statistically insignificant ($P = 0.717$).

### Discussion

A CT scan allows us to analyze the tibial implant positioning in the axial plane accurately. When assessing the rotation of a tibial component postoperatively there are several landmark references that can be used radiographically. In total knee arthroplasty (TKA) the tibial component rotation has been analyzed several times [14,15]. Reference points used at the proximal tibia that have been: the transepicondylar axis projection, the medial border of the anterior tibial tubercle, the center part of the patellar tendon, the tibial insertion of the posterior cruciate ligament (PCL), the medial and lateral parts of the tibial plateaus and the posterior rim of the tibial plateaus. There is a high variability of the PCL tibial insertion and can be difficult to locate on a CT scan [14]. We used the posterior rim of the tibial plateaus as described by Yoshioka et al. [16] as they are two large reference points inferior to the implant that can be easily replicated between patients and validated by Jazrawi et al. [17] for TKA tibial component rotation. An added advantage for these reference points is that the all polyethylene tibial component allows accurate reconstruction without artifact from a metal-backed component. However, we did not take into account the transverse tibial axis and so the tibial torsion.

In our series, the tibial implant was externally rotated for both medial and lateral UKA. There was significant variations for both medial and lateral UKAs. External rotation with mean 6.5° and SD 5.1° for the medial UKA and external rotation with mean 7.3° and SD 10.3° for the lateral UKA. Due to the large standard deviation of the rotation the difference between the two compartments was statistically insignificant ($P = 0.717$). Outliers such as the lateral UKA with external rotation 33° (Fig. 3) may be a cause of unrecognized pain or early component failure.

Such extreme rotation may be missed on routine radiological follow-up (Fig. 3). This illustrates our belief that the AP cut, even in the hands of an experienced surgeon, is one of the most imprecise cuts made in a UKA. Campbell et al. [9] also reported great variation of the tibial component orientation but he does not discuss in detail about it in his article.

The ideal UKA rotational implant positioning is still to be determined. The tibial implant rotation is guided by the AP cut. There is little scientific support to assess the ideal position, which is a result of the technique of aiming the saw towards the hip joint for the AP cut. In our technique, the cut was done with the knee fixed in flexion at 90°. This relies on the surgeons estimation of the hip joint position, flexion of the knee, and rotation of the femur and tibia while the cut is made. Estimation of the hip joint is difficult when the patient has been draped and the position of the limb depends on the surgeons preference of introperative positioning (e.g. hanging or fixed limb). These all contribute to

<table>
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<tr>
<th>Table 1 Tibial implant rotation of both compartments.</th>
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<td>Tibial Rotation (n = 37)</td>
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<td>6.9° (7.94; −13.9–30.3°)</td>
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significant variations in rotational positioning of the tibia at the time of the AP cut. In an attempt to decrease this as a cause of variability we used the axial notch of or the condyle as an additional guide, despite this there was still significant variability of component rotation. Comparison of this data with clinical studies will reveal if rotation is an important factor in patient satisfaction or implant survivorship. The biomechanical consequences of such variation in positioning have not been studied and it is a possible unknown aetiology for ongoing pain or early failure of an UKA.

This study presents the first 2D in vivo analysis comparing medial and lateral UKA component rotation. However, comparison with long term clinical data in our study is missing and it is the main weakness of the study. Our work has determined a range of values for tibial implant rotation that were obtained using routine techniques by an experienced surgeon [10]. Further analysis of patient satisfaction and implant survivorship in relation to implant positioning may give us further insight for the ideal range of rotation of the tibial component. If it is found that the ideal range cannot be maintained with current surgical techniques then there is a case for the use of a navigation system.

Conflict of interest statement

Ethical Board Review statement: institutional ethical board review was not required for that study. Humans involved in the study were included as a standard and allowed protocol in France.

Funding: One author (PN) receives personal financial support related to the study. P.N. Financial interest in Tornier company.

References