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Measurement techniques to determine tibial rotation after total knee arthroplasty are less accurate than we think☆,☆☆

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ABSTRACT

Background: The present study assessed the inter- and intra-observer reliability of tibial and femoral rotation measures after total knee arthroplasty (TKA), and evaluated the correlation between these measurement techniques and their clinical relevance.
Methods: Femoral rotation and tibial rotation were determined on 42 2D CT-scans made three-months after TKA. Reliability of the radiological measurements (including Berger's method, the anatomical tibial axis and the tibial tuberosity trochlear-groove) was assessed with 15 randomly selected patients measured twice by three observers. Functional outcomes were scored one-year postoperatively with the KSS, VAS pain, VAS satisfaction, KOOS, and Kujala.
Results: The inter- and intra-observer reliability of the rotational measurements ranged from good to excellent (ICC 0.67–0.98). Tibial rotation measured with the Berger technique was most reliable (ICC inter = 0.91; ICC intra = 0.96). No strong correlations were found between the different rotational measures or the clinical outcomes and rotational outliers.
Conclusions: Tibial rotation is most reliable measured with the technique described by Berger. There were no strong correlations found between the different tibial rotation measures or between the clinical outcomes and the rotational outliers. Further research is needed to gain more insight into optimal positioning and measuring rotation in TKA for clinical practice.

1. Introduction

Malalignment due to an internally rotated femoral component, after total knee arthroplasty, may provoke knee pain, synovitis and patellofemoral complications [1,2]. Whereas internal rotation of the tibial component has been associated with postoperative knee stiffness and pain [3–7]. Although no consistent guidelines exist for malalignment after total knee arthroplasty (TKA), generally it is recommended to avoid internal rotation of the tibial component and to place the femoral component in two to five degrees of external rotation [6]. However, the relation between (mal)alignment and clinical outcomes is not clear and the amount of rotation to cause clinical problems is unknown [6,8].

The optimal method to determine rotation of the tibia and femoral component is a matter of debate [9–12]. The medial third of the tibial tubercle, the posterior tibial condylar line, transverse axis of the tibia, patellar tendon, the malleolar axis and the second

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metatarsal have all been described as anatomical landmarks for correct tibial component rotation [13]. The method described by Berger, using the medial third of the tubercle, is used most frequently to determine tibial rotation [1,2]. An alternative is the anatomical tibial axis (ATA), first described by Cobb et al. [14]. One might expect that the ATA would be more reliable compared to Berger's tibial angle since the measurement seems less complex; fewer CT-slides and fewer steps are needed. Although the ATA and Berger both determine the tibial rotation, the relationship between these two radiological measurements has never been investigated. In addition to the ATA and Berger's tibial angle, the tibial tuberosity–trochlear groove (TT–TG) distance can be used to determine combined femoral and tibial rotational alignment. The TT–TG is often used in patellofemoral pathology to diagnose patellar maltracking. Nevertheless, none of the methods is recognized as the ultimate reference [6,12].

Besides the optimal method, the optimal imaging modality (2D-CT or 3D-CT-scans) to determine rotation of the tibial and femoral component is a matter of debate [10,11,15,16,8]. Recently, 3D-CT-scans gained popularity and showed more reliable and reproducible assessment of tibial and femoral rotation alignment than 2D-CT [10,8,17]. However, 3D-CT is less commonly used in daily clinical practice due to limited availability of specialized software and limited experience in performing these measurements on 3D-CT.

In our search for a feasible, reliable and clinically relevant radiological technique to measure rotation, we proposed three consecutive aims for this study. The first aim was to investigate the intra- and inter-observer reliability of measurements used to assess the femoral and tibial rotation alignment with 2D-CT-scans (e.g., Berger's transepicondylar axis and tibia angle, the ATA and the TT–TG) after TKA. Secondly, the correlation between the tibial rotation measurement techniques (Berger's angle and ATA) was evaluated. Finally, the effect of rotational alignment on clinical outcome was examined. We hypothesized that patients with an alignment within the recommended range had better clinical outcomes.

2. Patients and methods

2.1. Patients

Forty-two patients (22 left and 20 right knees) were included in this retrospective study; 20 males and 22 females with an average age of 63 ± 4 years [18]. The patients had received a cemented posterior stabilized (PS) TKA because of degenerative joint disease (Genesis II™, Smith and Nephew, Memphis, TN, USA). 2D-CT-scans obtained three months postoperatively and clinical outcomes scored one year postoperatively were available for all patients. Approval of the hospital's investigational review board and the Medical Ethical Review Board of Slotervaart and Reade was obtained and patients gave their written consent.

2.2. Outcome measures

2.2.1. Radiological measurements

An extensive description of the measurement protocol is presented in Appendix 1. Femoral rotation was determined using the method described by Berger, measuring the angle between the posterior condylar axis and the surgical epicondylar axis [2]. Measurements evaluating the tibial rotation included Berger's angle, the ATA and the tibial tubercle–trochlear groove distance (TT–TG) [1,2,14,19]. Berger's angle is based on the geometric centre of the proximal tibial plateau, the distal level of the tibial tubercle and the posterior axis of the tibial component [1]. The ATA is the angle calculated from the axis between the lateral condylar centre and medial condylar centre, and the posterior axis of the tibial component [14]. To determine the geometric centre of the proximal tibial plateau for Berger's angle and the lateral and medial condylar centre for the ATA, the slide just below the cement interface was used in which the circumferential tibial cortex was clearly identifiable. The TT–TG is defined as the distance between the deepest point of the trochlea and the centre of the tibial tubercle [19,20].

CT-scans were obtained to assess the component rotation of both femur and tibia. Imaging was performed with a helical 2D-CT-scanner (Aquilion 32, Toshiba Medical Systems Corporation, Tokyo, Japan): 135 kV, slice thickness 0.5 mm, and 250 mA. Radiological measurements were performed using IMPAX software (Agfa Healthcare, Mortsel, Belgium), measurements were done to the nearest 0.1°/mm.

2.2.2. Inter- and intra-observer reliability

To evaluate intra- and inter-observer reliability, three independent observers performed the radiological measurements twice, with an interval of at least two weeks, in 15 randomly selected patients. The observers were an orthopaedic resident, a fellow musculoskeletal radiologist and a researcher in the orthopaedic field.

2.2.3. Functional outcomes

Functional outcomes were scored one year postoperatively with the Knee Society Score (KSS), VAS pain, VAS satisfaction, the patella score (Kujala) and the Knee injury and Osteoarthritis Outcome score (KOOS) with the five subscales pain, symptoms, ADL, sports and quality of life.

2.3. Statistical analyses

Intra- and inter-observer agreement was evaluated using a Bland–Altman analysis, calculating limits of agreement (LoA) [21]. In addition, the margin of equivalency (MoE) within and between the observers was determined by calculating the proportion of