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Femoral Component Axial Rotation in the Gap-Balancing Approach to Total Knee Arthroplasty: Measurement by Computed Tomography

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ABSTRACT

Background: Rotational malalignment of total knee arthroplasty (TKA) is a potential cause for revision surgery; therefore, it is important to have valid criteria for evaluation of normal component rotational alignment. Because computed tomography (CT) is considered the most accurate method to assess the rotational alignment of prosthetic components, the objectives in this study were define the femoral component (FC) rotation by measuring the posterior condylar angle (PCA) and the condylar twist angle (CTA) in a patient population that underwent gap-balancing TKA; determine the reliability of the FC rotation by using these measurements; evaluate the inter-relationship between the PCA and CTA; and finally evaluate the frequency and agreement in identification of the medial epicondyle sulcus (MES).
Methods and Results: In this retrospective study, 2 radiologists examined 50 CT scans. Mean PCA values of −2.26° and −2.56° (internal rotation) and CTA values of −5.54° and −6.28° (internal rotation) were attained by 2 observers with a higher interobserver concordance for the PCA. Both measurements were considered to be reliable. There was moderate interobserver agreement for MES identification, with the MES present in 64% and 78% of patients, as identified by 2 observers.
Conclusion: Mean FC rotation values as evaluated by PCA were −2.26° and −2.56° and as evaluated by CTA were −5.54° and −6.28°. PCA and CTA measurement by CT is reliable; however, the use of PCA is preferable because of the higher observer concordance. PCA can be inferred by subtracting 3° or 4° from the CTA. MES was identified in 64% and 78% of patients, with only moderate interobserver agreement.

Rotational malalignment of total knee arthroplasty (TKA) is correlated with patellofemoral maltracking and knee pain [1] and is a cause of revision TKA [2,3]. If revision surgery is proposed because of component malrotation, it is important to have a reliable and reproducible method to measure such malrotation before recommending surgery [4]. It is also important to have criteria for normal component rotational alignment, which may vary if gap-balancing or measured gap-resection approaches are used [3,5,6]. The gap-balancing approach and the measured gap-resection approach are the 2 main strategies for performing TKA [7].

Advocates of the measured gap-resection approach recommend placement of the femoral component (FC) either parallel to the transepicondylar axis, perpendicular to the Whiteside anteroposterior axis, or approximately 3°-4° externally rotated relative to the posterior condylar angle (PCA). In this approach, the prosthetic PCA is predicted to be parallel or near parallel to the transepicondylar axis [7,8].

With the gap-balancing approach, the FC is positioned parallel to the resected proximal tibia, with each collateral ligament equally tensioned [7,8]. In this approach, the prosthetic posterior condylar axis is not necessarily parallel or near parallel to the transepicondylar axis, as alignment with the transepicondylar axis is not the primary objective of the approach. The transepicondylar axis is not a reference, and it is not necessary that it be parallel to the FC, although this is a possibility [5,6].

With the gap-balancing approach for TKA, several authors have shown that the angle between the transepicondylar axis and the FC axis varies widely in patients and does not result in patellofemoral

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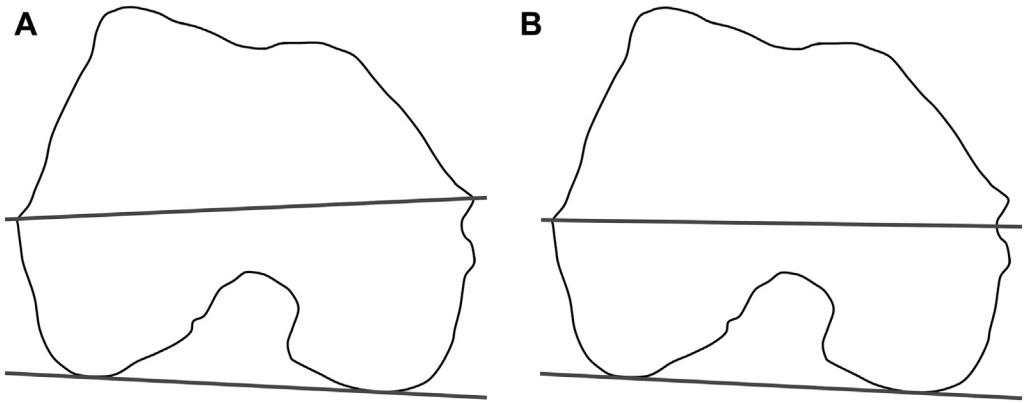

Fig. 1. Illustration demonstrating the condylar twist angle (A) and the posterior condylar angle (PCA) (B). The condylar twist angle is the angle between the anatomical transepicondylar axis and the PCA. The anatomical transepicondylar axis is defined by a line that connects the prominences of both the medial and lateral epicondyles. The PCA is the angle between the surgical transepicondylar axis and the PCA. The surgical epicondylar axis is defined by a line that connects the prominence of the lateral epicondyle and the medial epicondylar sulcus.

malalignment [5,6,9,10]. Berger et al [3] reported that patients with lateral patella tracking and tilting have an excessive combined component (femoral and tibial component) internal rotation (IR) of −1° to −4° (minus sign indicates IR). Those with patella subluxation have −3° to −8° of excessive IR, patella dislocation at −7° to −16°, and component failure at −8° to −17°. According to Berger et al, the native rotation value for the PCA is −0.3° (±1.2°) in women and −3.5° (±1.2°) in men. For techniques that aim for an FC that is parallel to the transepicondylar axis, an IR greater than these native IR values results in excessive IR of the FC [3]. This correlation between clinical findings and the IR of the TKA components was not found in studies using the gap-balancing approach [5,6].

There are 2 angles that express the rotational alignment of the FC, namely, the PCA and the condylar twist angle (CTA) (Figs. 1 and 2) [3,5,6,11–15]. Several authors have published data using the PCA [3,5,12–15], while others have used the CTA [6,11–13], thus creating doubts as to the normal FC rotation, as these 2 angles are distinct (Figs. 1 and 2).

Computed tomography (CT) is considered by many as the most accurate method to assess the rotational alignment of prosthetic components after TKA [1,3,5,11], although Konigsberg et al [4] recently raised the question of whether CT measurements are reliable for component rotation measurements after TKA. The PCA cannot always be measured, as the medial epicondyle sulcus cannot always be identified after TKA [12,13,16]. There are no published English-language data reporting the measurement of both the PCA and CTA by CT in patients who underwent the gap-balancing approach for TKA. There are also no studies showing the interrelation of these 2 angles in patients who have undergone gap-balancing TKA. Similarly, the level of confidence for identification of the medial epicondyle sulcus is unknown.

Therefore, the objectives of this study were as follows: (1) to define the FC rotation by means of the PCA and CTA in a patient population that underwent gap-balancing TKA; (2) to determine the reliability of FC rotation measurements by CT; (3) to evaluate the inter-relationship between the PCA and CTA; and (4) to evaluate the frequency and agreement in identification of the medial epicondyle sulcus.

The respective hypotheses for the above objectives were as follows: (1) the PCA and CTA vary widely in patients who underwent gap-balancing TKA; (2) CT is reliable for the measurement of the PCA and CTA; (3) there is a relationship between the PCA and CTA; and (4) there are many cases in which the medial epicondyle sulcus cannot be identified, and the definition of presence or absence of the sulcus varies according to the observer.

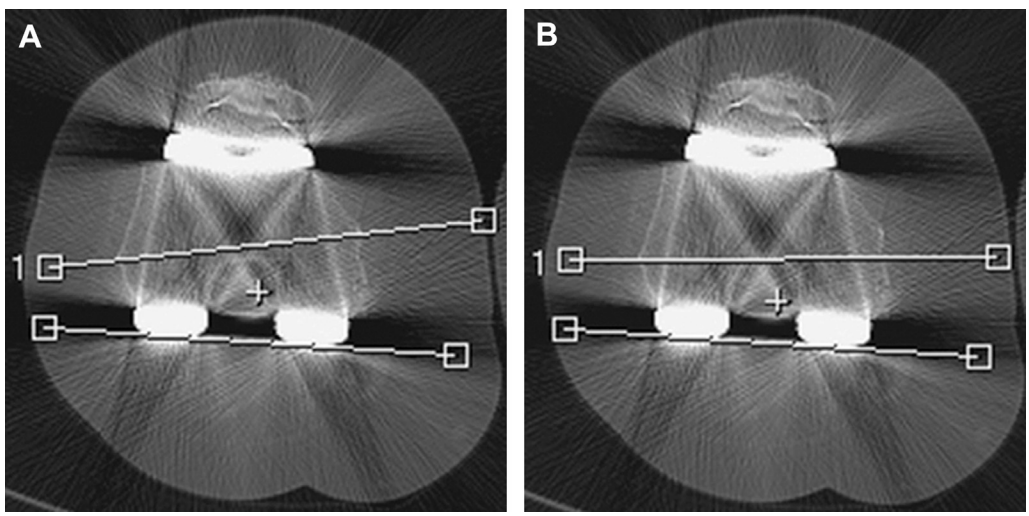

Fig. 2. CT images demonstrating the condylar twist angle (A) and PCA (B).