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Trochlear Inclination Angles in Normal and Dysplastic Knees

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Abstract: Trochlear morphology impacts component position in patellofemoral arthroplasty. We devised a measurement of the trochlear inclination angle (TIA) and determined the average TIA in normal and dysplastic knees. Three hundred twenty-nine consecutive magnetic resonance imagings of normal and dysplastic knees were evaluated. The TIA was measured by 2 reviewers. The Student *t* test was used, and intraobserver reliability measurements were made. The mean TIA in normal and dysplastic knees was internally rotated 11.4° (range, 6°-20°) and 9.4° (range, 4°-15°), respectively. The mean TIA did not differ significantly by sex or age. Trochlear inclination angles in both normal and dysplastic knees tend toward internal rotation. Positioning a trochlear patellofemoral arthroplasty component flush with the articular surface of the native trochlea would result in internal rotation malposition. **Keywords:** trochlear inclination angle, patellofemoral, knee arthroplasty (replacement), maltracking, patellofemoral arthroplasty.

The clinical results of patellofemoral arthroplasty (PFA) are impacted by a variety of factors, including patient selection, surgical indications, trochlear prosthesis design features, trochlear and patellar prosthesis alignment and position, and soft tissue balance [1]. The critical distinction between success and failure after PFA lies in whether the patellar prosthesis tracks well relative to the trochlear implant. Maltracking of the patellar prosthesis, other than slight tilt and mild subluxation, will compromise function and outcome well within 6 months of surgery [2]. If the patella tracks well, the primary mechanism of failure will be later progressive tibiofemoral arthritis; aseptic loosening and patellar prosthesis wear are uncommon.

Several PFA trochlear design features can impact patellar tracking, including its sagittal radius of curvature; proximal extension; width; thickness; tracking angle; asymmetry; constraint; and, perhaps most importantly, whether it is an "inlay" or "onlay" style prosthesis [1,3,4]. Inlay trochlear prostheses are inset into the anterior surface of the trochlea, flush with the surrounding articular cartilage; therefore, its rotation is based off the patient's native anatomy (Fig. 1A). Alternatively, onlay designs are positioned perpendicular to the anteroposterior (AP) axis (or parallel to the transepicondylar axis), as is commonly done in total knee arthroplasty (TKA) (Fig. 1B).

As femoral component malrotation can lead to patellar maltracking and subluxation in TKA [5-7], so can trochlear component malposition impact patellar tracking in PFA. Maltracking of the patella is a common mechanism of failure in inlay style trochlear designs, occurring in as many as 17% to 32% of knees with inlay style PFA [3,8,9] and occurs in less than 1% with onlay style trochlear designs [3,10]. A trochlear inclination angle (TIA) may provide another reference for component positioning.

We asked the following questions: (1) using a large cohort of magnetic resonance imaging (MRI) studies, can we establish a reliable measurement of the trochlear inclination angle (TIA); (2) what is the average TIA in both normal and dysplastic knees, and does the TIA differ with respect to sex and age? Although not the direct focus of this study, we also sought to understand what the implications of the TIA are in establishing component rotation in PFA and whether the TIA informs us in the decision between onlay- and inlay-style PFA designs. Our hypothesis is that there is variation in TIA, which may play an important role in

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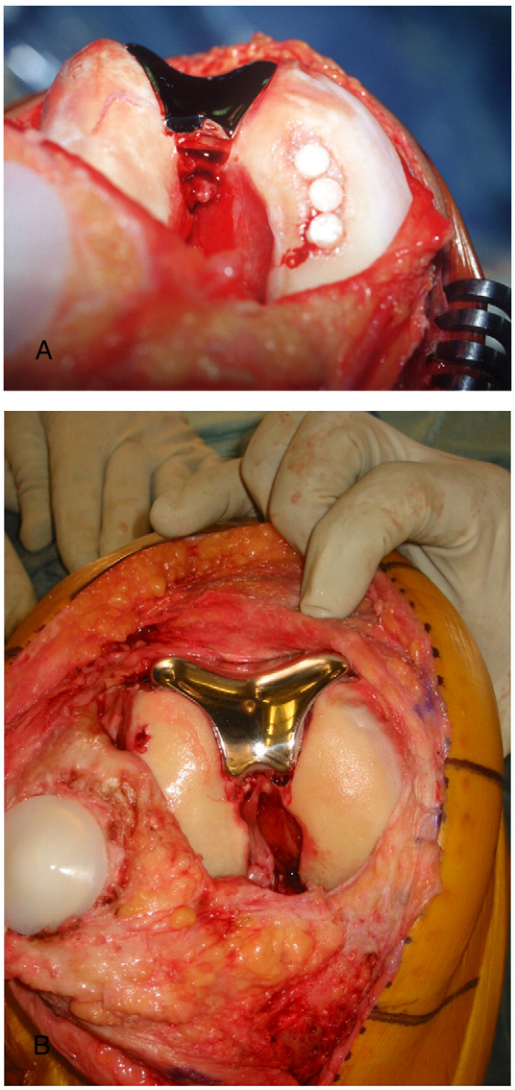

Fig. 1. A, Intraoperative image of inlay-style trochlear component positioned flush with anterior cartilage surfaces of trochlear flange, resulting in internal rotation relative to the AP axis. B, Intraoperative photograph showing an onlay-style trochlear component positioned perpendicular to the AP axis of the femur.

intraoperative component placement. Surgeon error cannot adequately account for this variation in anatomy, with resulting internal rotation component errors that provides a reason for patellar maltracking that may occur with inlay-style PFA designs.

Materials and Methods

We examined the knee MRI studies of 329 consecutive patients (age, 18-93 years; mean, 48.8 years). There were 146 male knees (age, 17-92 years; mean, 49.9 years) and 183 female knees (age, 18-85 years; mean, 47.3 years). Of the 329 knees, 164 knees were in patients younger than 50 years, and 165 knees were in patients older than 50 years. There were 279 control knees (age, 17-92 years; mean, 50.5 years) and 50 knees with dysplastic patellofemoral morphology (age, 13-69 years; mean, 36.9 years).

Dysplastics were classified according to the Dejour system of trochlear dysplasia [11]. Using a lateral radiograph, superimposing the medial and lateral femoral condyles, 4 types of dysplasia are described. Type A involves a "crossing sign," the convergence of the trochlea and lateral femoral condyle projections, suggesting a flat or convex trochlea; the more distal the crossing, the more severe the dysplasia. Type B exhibits the crossing sign as well as a supratrochlear spur, a bony projection anterior to a line drawn along the anterior femoral cortex. Type C has features of the crossing sign and a double contour of the trochlea, indicative of dysplasia of the medial trochlear wall. In type D morphology, a crossing sign, supratrochlear spur, double contour, and a sharp step-off of the trochlea can be seen.

All images were collected using a 3-T MRI scanner. The TIA was measured on these MRI studies with a predefined measurement protocol (Fig. 2A and B). The axial MRI cut that demonstrated the greatest height of the lateral femoral condyle was used for measuring this angle. The *TIA* was defined as the angle formed by the line perpendicular to the AP axis (ie, Whiteside's line) and the line connecting the anterior most portions of medial and lateral femoral condyles. These anteriormost points were selected as the point of measurement because these would represent the anterior position of the trochlear prosthesis when using an inlay style component. On fat-suppressed, T2-weighted images, cartilage appears as a thick stripe of intermediate signal next to subchondral bone, which has high signal intensity. This allows for delineation and measurement of 2 separate TIAs: 1 angle that includes the articular cartilage overlying the femoral condyles and 1 that excludes the articular cartilage (Fig. 2A and B). Differences in the thickness of the cartilage between the 2 condyles will account for the difference of the 2 TIAs measured in a given knee. Angle measurements were obtained independently by 2 observers (1 radiologist and 1 orthopedic surgeon). No measurements were made by the senior orthopedic surgeon.

The Student *t* test was used to compare the trochlear inclination angles among subgroups, with significance set at $P < .05$. Statistical analysis was performed using SPSS version 15.0 (SPSS, Inc, Chicago, Ill). An intraclass correlation coefficient (ICC), a 1-way random model for the 2 observations, was calculated for interobserver reliability for these continuous data.

Results

According to the system of Dejour, the trochlear morphology of the dysplastic patients was as follows: 19 patients, type A; 3 patients, type B; 23 patients, type C; and 5 patients, type D. There was no significant