ABSTRACT

Purpose. To measure the femoral posterior condylar cartilage (PCC) thickness and the posterior condylar offset (PCO) and determine the correlation between the 2 parameters in 530 normal subjects using magnetic resonance imaging (MRI).

Methods. Records of 287 male and 243 female patients (mean age, 40.7 years) who underwent MRI for traumatic soft tissue knee injuries not involving the femoral PCC and did not have symptomatic knee arthritis were reviewed.

Results. The PCC thickness was comparable in the lateral and medial sides (2.04 vs. 1.99 mm, p=0.13). Males had thicker PCC in the medial (2.05 vs. 1.92 mm, p=0.0006) and lateral (2.16 vs. 1.86 mm, p<0.0001) sides than females. Age did not correlate with PCC thickness. The bony PCO was larger in the medial than lateral side (25.8 vs. 22.6 mm, p<0.0001). Males had a larger PCO than females in the medial side only (26.1 vs. 25.5 mm, p=0.0195). The bony PCO did not correlate with PCC thickness.

Conclusion. Femoral PCC thickness was comparable in the medial and lateral sides. Males had thicker PCC in the medial and lateral sides than females.

Key words: cartilage, articular; knee; magnetic resonance imaging

INTRODUCTION

In arthritic knees, the use of the posterior condylar axis as a reference for femoral component rotation is a reliable technique in total knee arthroplasty (TKA).1–4 When asymmetric femoral posterior condylar cartilage (PCC) loss occurs (such as in valgus knees), the use of the posterior condylar axis to determine femoral component rotation becomes less accurate.5,6 Some surgeons propose removing cartilage from both posterior condyles down to subchondral bone when cartilage attrition occurs, and then referencing femoral component rotation from this ‘bony posterior condylar axis’. Two magnetic resonance imaging (MRI) studies have investigated the PCC thickness: one for osteochondral autograft sites of the knee.
and elbow, and the other for differences in posterior condylar offset (PCO) between radiography and MRI.

Quantitative data for normal PCC thickness for males and females are important when using the posterior condylar axis as a reference in valgus knees with asymmetric cartilage loss, or when using patient-specific instrumentation based on computed tomography. Newer prosthetic knee designs aim to re-create normal joint kinematics, yet most studies of PCC and PCO have taken place in arthritic knees and have used suboptimal imaging techniques. This study hypothesised that medial and lateral femoral PCC thickness is equal in normal knees. This study aimed to measure the femoral PCC thickness and the PCO and determine the correlation between the 2 parameters in 530 normal subjects using MRI.

MATERIALS AND METHODS

Records of 287 male and 243 female skeletally mature patients (mean age, 40.7 years) who underwent MRI for traumatic soft tissue knee injuries not involving the femoral PCC and did not have symptomatic knee arthritis were reviewed. Proton-density, fat-suppressed MRI (GE Hdx 1.5 T MRI system, General Electric, Waukesha [WI], USA) was performed with the knee in full extension. Femoral PCC thickness and PCO were measured by an orthopaedic resident and reviewed by an orthopaedic surgeon using the Osirix Dicom Viewer (Osirix Foundation, Geneva) and rounded to 0.01 mm.

Based on the protocols for MRI measurement of PCC thickness, the deepest part of the medial and lateral posterior condyles was identified in the sagittal plane. These points were then viewed in the coronal plane to ensure that they were centred in their respective condyles. The PCO was assessed in the midsagittal plane where the femoral posterior cortical axis was drawn (Fig. a). This axis was then translated medially and laterally to the slice chosen to measure the PCC thickness. In these MRI slices, 2 measurements were taken perpendicular to the posterior cortical axis (Fig. b): the first was the distance from the posterior cortical axis to the articular surface, and the second was the PCC thickness at this level (Figs. c and d). The bony PCO was then calculated by subtracting the PCC thickness from the total distance. The means between the PCC and PCO measurements were compared using the Student’s t test. Linear regression analysis was used to correlate PCC thickness with patient age or gender. A p value of <0.05 was considered statistically significant.

RESULTS

The PCC thickness was comparable in the lateral and medial sides (2.04 vs. 1.99 mm, p=0.13), with a mean:standard deviation difference being 0.05±0.61 mm. Males had thicker PCC in the medial (2.05 vs. 1.92 mm, p=0.0006) and lateral (2.16 vs. 1.86, p<0.0001) sides than females. Age did not correlate with PCC thickness in the medial (R²=0.006) or lateral (R²=0.001) side.

The bony PCO was larger in the medial than lateral side (25.8 vs. 22.6 mm, p<0.0001). Males had a larger PCO than females in the medial side (26.1 vs. 25.5 mm, p=0.0195) but not in the lateral side (22.58 vs. 22.65 mm, p=0.39). The bony PCO did not correlate with the PCC thickness in the medial (R²=0.005) or lateral (R²=0.106) side such that larger knees did not have thicker PCC.

When the PCC thickness and PCO were combined, the medial side was larger than the lateral side (27.8 vs. 24.6, p<0.001). The distance from the posterior cortical axis to the articular surface was longer in males than females in the medial side (28.1 vs. 27.5, p=0.005) but not in the lateral side (24.7 vs. 24.5, p=0.2).

DISCUSSION

Determination of PCC thickness and symmetry between the medial and lateral condyles is important in TKA. The total PCO is a combination of the bony condyles and the PCC thickness; PCO affects available knee flexion in TKA. Most anatomic studies are conducted in arthritic individuals in whom cartilage and even bony erosion have taken place, and measurement is usually made by radiography and computed tomography that may underestimate normal PCO. Our results suggested that pre-TKA templating may underestimate the normal PCO by approximately 2 mm, due to the cartilage. PCC remnants can alter femoral component rotation when the posterior condylar axis is referenced intra-operatively. The PCC is not taken into account for patient-specific cutting guides based on preoperative computed tomography. There is a significant difference in femoral component rotation when the PCC is included in patient-specific instrumentation, leading to a mean external rotation error of 1.1º in varus osteoarthritic knees. Using computed tomographic arthrography, the medial and lateral PCC was measured to be 0.39 and 1.55 mm, respectively. In valgus knees with asymmetric cartilage loss on the lateral PCC, this may lead to
internal rotation errors of the femoral component and subsequent patellofemoral and flexion gap complications.

Kinematic TKA requires knowledge of anatomy of the normal condylar and articular cartilage. Resecting accurate bone and cartilage to match the femoral component thickness restores the posterior femoral joint line. Thus, PCC must be taken into account when measuring resection depth.\textsuperscript{14,15} Understanding that the PCC is symmetrical and is approximately 2 mm thick in normal knees allows surgeons to use the kinematic arthroplasty axis to recreate the posterior femoral joint line more accurately.

There are 3 studies that have used MRI to assess PCC thickness or PCO in non-arthritic knees. In a study aimed to correlate PCO and tibial plateau slope in 80 individuals (mean age, 38.9 years) without knee pathology,\textsuperscript{16} the mean PCO was 27.4 mm in the medial side and 25.2 mm in the lateral side; there was no difference between males and females. However, PCC thickness was not measured. In a study measuring femoral PCC thickness in 111 individuals,\textsuperscript{7} the lateral PCC was thicker than the medial PCC (2.15 vs. 1.95 mm), but the results were not stratified in terms of gender. In a study evaluating the difference between PCO measured by radiography and MRI in 32 individuals,\textsuperscript{8} the mean medial and lateral PCO was 29 and 26 mm, respectively, and the medial PCC was thicker than the lateral PCC (2.3 vs. 1.9 mm). In our study, males had thicker PCC in the medial and lateral sides than females. This finding may be useful in future modification of gender-specific femoral

Figure  Magnetic resonance images showing (a) the posterior cortical axis in the midsagittal plane, (b) a perpendicular line from the posterior cortical axis to the articular surface, and measurement of the (c) medial and (d) lateral posterior condylar cartilage thicknesses and posterior condylar offset.
components, and understanding the gender-related rate of osteoarthritis, restoration of the PCO in TKA, femoral component rotation, and kinematic TKA designs.

There were several limitations to our study. The rotation of the knee during MRI was not controlled for beyond normal scanning protocols. This could have caused an alteration in the distance measured from the femoral posterior cortex to the medial and lateral condyles. The standard deviations were 2.98 and 2.88 mm for the medial and lateral PCO, respectively; the cause of such a wide variation (such as femoral rotation) is not known. One study carefully controlled such rotation so that the sagittal slices were orientated along the surgical transepicondylar axis. However, the true flexion/extension axis of the knee does not occur around the epicondyles. In addition, our measurements were limited by the quality of the scanner and occasional movement artefact, which could potentially contribute to minor errors in assessment of cartilage thickness. The gender difference in PCC thickness did not correlate to the overall femoral size in the anteroposterior or mediolateral dimension. It correlated to the bony PCO only, which was inferred to be a surrogate for total anteroposterior dimension.

CONCLUSION

Femoral PCC thickness was comparable in the medial and lateral sides. Males had thicker PCC in the medial and lateral sides than females.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES