PATELLAR TRACKING IN DEEP KNEE FLEXION

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Introduction: The prosthetic design influences the kinematics behavior of the knee after total knee arthroplasty and has evolved to reflect the shape of the normal femur. Past interests regarding patellofemoral prosthetic design in total knee arthroplasty seems to have focused on the patellar component and the anterior aspect of the femoral component. Because contact stress within the patellofemoral joint increases gradually during knee flexion, the current patellofemoral joint designs should be modified, especially in deep knee flexion, in order to minimize the contact stress of the patellofemoral joint and in order to provide a better range of motion. However, to our knowledge, there has been no study in vivo, which has described patellar tracking and the precise geometry of the patellofemoral joint in deep knee flexion. The purpose of this study was to evaluate patellar tracking in deep knee flexion and the femoral condylar geometry in the axial plane on magnetic resonance imaging (MRI).

Subjects and methods: Thirty knees in fifteen healthy volunteers, with no history or physical signs of patellar problems or knee surgery were investigated. There age ranged from 21 to 55 (mean 37) years old. MRI was performed with the knee flexed at 0, 45, 90 and 135 degrees. The axial slice at the center of the patella was selected for analysis. Three parameters were measured for patellar tracking analysis. The tilting angle of the patella against the anterior condylar line of the femur (patellar tilting angle), the shift of the patella against the patellar groove (patellar shift), and the distance from the patella to the patellar groove (antero-posterior translation) were measured. Two parameters were used to describe the surface geometry of the femoral condyle on MRI at 135 degrees of flexion. Condylar depth was measured in order to represent the depth of the articular surface within the intercondylar notch (Figure 1). The shapes of the patellofemoral articular surfaces of the femoral condyle were also evaluated by those curvatures. The radius of curvature was measured at points on the articular boundary (Figure 2). The point that had the shortest radius was identified in each condyle and the distance between that point and the midpoint of the intercondylar notch was measured.

One factor analysis of variance (ANOVA) and Fisher’s PLSD as a post-hoc test were used for analysis of the patellar tilting angle, patellar shift, and antero-posterior translation among each of the flexion angles. Unpaired t-test was used for analysis of the condylar depth and patellar groove width when comparing those in the lateral condyle with those in the medial condylye. P value of less than 0.05 was considered statistically significant.

Results: The patella gradually tilted medially as the knee was flexed. There was a significant difference in the patellar tilting angle between 90 degrees and 90 degrees, and between 135 degrees and the other angles (Figure 3A). The patella did not shift a great deal until 90 degrees of flexion, but the patella shifted laterally at 135 degrees. There was a significant difference in patellar shift between 135 degrees and the other angles (Figure 3B). The patella gradually sank into the patellar groove as the knee was flexed (Figure 3C). There was a significant difference in antero-posterior translation between each of the angles, except between 45 degrees and 90 degrees.

Condylar depth was significantly deeper in the lateral condyle than in the medial condyle in all cases. Lateral condylar depth was 8.1 ± 1.4 (mm) (mean ± standard deviation), and medial condylar depth was 5.9 ± 1.6 (mm) (mean ± standard deviation). In the medial condyle, the radius of curvature changed gradually at each point along the articular surface (Figure 2), whereas in the lateral condyle, the radius of curvature differed sharply around the point, which had the shortest radius of curvature. Patellar groove width was significantly longer in the lateral condyle than in the medial condyle. Lateral patellar groove width was 19.7 ± 2.9 (mm) (mean ± standard deviation), and medial patellar groove width was 10.4 ± 3.0 (mm) (mean ± standard deviation).

Discussion: The articular configuration of the patellofemoral joint has not been fully evaluated in deep knee flexion. The results reveal that the articular surface of the lateral condyle began to curve steeply farther from the center of the intercondylar notch, while the edge of the articular surface lay deeper within the intercondylar notch than that of the medial condyle. The geometry of the patellar groove seems to be adequate to fit the patellar geometry. Such asymmetrical geometry causes the lateral half of the intercondylar space to be larger than the medial half, and alters the patellar tracking drastically in deep knee flexion.

The prosthetic design of total knee arthroplasty should take into account this articular geometry in order to improve the range of motion and avoid any patellofemoral complications.

Figure 1. Condylar depth. It represents the distance from the anterior condyle line (solid line) to the medial edge of the articular surface of the lateral condyle, and to the lateral edge of the articular surface of the medial condyle.

Figure 2. Patellar groove width. Figure 2A: The length of lines represents the radius at the points. The point, which had the shortest radius, was identified in both condyles. The point in the lateral condyle is expressed as L, while that in the medial condyle is expressed as M. Figure 2B: The distance from the midpoint of the intercondylar notch to L, and to M and were measured.

Figure 3. Parameters were measured for patellar tracking analysis. Each point or error bar represents the mean of thirty knees and is shown as the mean ± standard deviation (*: p<0.05, **: p<0.0001 when compared with 0'). Figure 3A- Patellar tilting angle. There was a tendency for the patella to gradually tilt medially, as the knee was flexed. Figure 3B- Patellar shift. Figure 3C- Antero-posterior translation. The patella sank into the patellar groove, especially at 135°.

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