Do mobile-bearing knee arthroplasty motions change with activity?

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INTRODUCTION: There have been many reports on clinical results and fluoroscopic kinematic analyses of mobile bearing total knee arthroplasty (TKA), with a focus on contrasting different implant designs. As patients perform a wide range of activities during daily living, and knee kinematics are controlled by active and passive soft-tissues in addition to joint surfaces, it is critically important to understand variations in knee kinematics and function during different activities. Therefore, this study asks a specific question regarding two types of mobile bearing prostheses: Do mobile-bearing knee arthroplasty motions change with activity?

Materials and Methods: The kinematics of 20 knees (10 patients) with well-functioning bilateral TKA with a minimum follow-up of 5 years were analyzed during non-weight bearing knee extension, weight bearing knee extension, weight bearing knee flexion, and weight bearing stair ascent. All patients were operated upon by an experienced surgeon (Y.I.), using the same knee replacement system but using two different configurations; the LCS™ RP prosthesis and LCS™ meniscal-bearing prosthesis. Each patient had one rotating-platform (RP: RP Group) and one meniscal-bearing (MB: MB Group) variant of the same prosthesis design. The clinical characteristics are summarized in Table 1. Patients’ knee motions were recorded using lateral fluoroscopy during the three activities. These three activities were performed from flexion to extension. The three-dimensional position and orientation of the knee segments were determined using model-based shape-matching techniques. Two-way repeated measure ANOVA was conducted to determine if there were any differences of patellofemoral contact position among activities. The level of significance was set at p<0.05.

Results: Condylar translations changed little in RP knees with different activities (Fig.1-a, b). On the other hand, medial and lateral condyles in MB knees moved posteriorly from flexion to extension during the non-weight bearing and stair activities (Fig.2-a, b). MB knees showed little condylar translation during the weight bearing activity (Fig.2-a, b). Compared to RP knees, MB knees showed increasingly posterior condylar locations with increasing activity dynamics: non weight bearing (n.s.d.) to weight bearing (medial condyle significantly more posterior) to stair activity (medial and lateral condyle locations significantly more posterior). Anterior-posterior translations in the MB knees were larger (medial condyle 7.0±0.2mm, lateral condyle 5.1±0.2mm) than those in RP knees (medial condyle 2.0±0.1mm, lateral condyle 1.0±0.1mm) for the different dynamic conditions. Tibial external rotations in RP knees showed 4.8° rotation during non-weight bearing activity, 2.1° rotation during weight bearing activity and 2.9° rotation during stair activity (Fig.1-c). Tibial external rotations in MB Knee showed 2.2° rotation during non-weight bearing activity, 1.5° rotation during weight bearing activity and 2.9° rotation during stair activity (Fig.2-c).

Discussion: In this study, condyles in RP and MB knees moved posteriorly with knee extension during the non-weight bearing and stair activities. The magnitude of condylar translation in MB knees was larger than in RP knees. Greater anterior drawer of the tibia in the MB knees likely results from decreased anterior/posterior constraint from the mobile-bearing articulation. This is a common observation in unconstrained TKA designs, which some authors attribute to absence of the anterior cruciate ligament (ACL) and loss of intrinsic knee stabilizers after TKA (1).

MB knees showed increasingly posterior condylar locations with increasing activity dynamics - non weight bearing to weight bearing to stair climbing activities. It is likely that the stair activity and weight-bearing activity utilizes greater muscular cocontraction than the non-weight bearing activity, which may explain the kinematic differences. It is possible the MB knees may require less quadriceps power, as a larger moment arm may result from the more posterior contact position of the condyles (2). However, joint stabilizing hamstrings cocontraction could minimize or reverse this potential advantage.

Condylar locations during weight bearing and stair activities in RP knees were consistent. This is likely due the articular constraint provided by the polyethylene bearing, which rotates but is relatively conforming in the AP direction. RP knees might also be less affected by muscle cocontraction and variation in ligament tension than MB knees.

Dynamic conditions had a greater effect on knee kinematics in meniscal bearing prosthesis than rotating platform prosthesis. These differences might influence patient strength, stability, endurance and range of motion. To fully understand knee replacement function, clinical performance and implant durability, it is important to characterize knee motions across the spectrum of activities that are important for patient function. In vivo kinematics studies should not only explore TKA design differences, but also the important role activity (dynamics, muscle and ligament tension, etc.) plays in knee function.

References

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Fig.1-a
Fig.1-b
Fig.1-c
Fig.2-a
 Fig.2-b
Fig.2-c

Table 1: Average clinical values for the study subjects

<table>
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<th>Age</th>
<th>Preop ROM</th>
<th>Postop ROM</th>
<th>Postop Time</th>
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<th>Preop FTA</th>
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<td>116</td>
<td>2</td>
<td>43</td>
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</table>

Preop, preoperative; Postop, postoperative; ROM, range of motion ; HSS, Hospital for Special Surgery

were performed using the Knee Society radiographic assessment

Abbreviations: Preop, preoperative; Postop, postoperative; ROM, range of motion ; HSS, Hospital for Special Surgery

* The radiographic analyses

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