In-vivo Kinematics of Posterior-Stabilized Total Knee Prosthesis Designed For Japanese

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Introduction: Total knee arthroplasty (TKA) is one of the most successful and beneficial treatments for osteoarthritic knees. We have developed posterior-stabilized (PS) total knee prosthesis for Asian patients, especially Japanese patients, and have used it since November, 2010. The component was designed based on the CT images of osteoarthritic knees, aiming to achieve deep flexion and stability. The purpose of this study was to analyze in-vivo kinematics of this new prosthesis.

Methods: We analyzed a total of 28 knees implanted with PS TKAs: Fourteen knees with the new PS prosthesis (group A), and the other fourteen knees with a popular PS prosthesis as a control group (group B). Preoperative data of both groups were not significantly different. Flat-panel radiographic knee images were recorded during five static knee postures including full extension standing, lunge at 90° and maximum flexion, and kneeling at 90° and maximum flexion. The three-dimensional position and orientation of the implant components were determined using model-based shape matching techniques (Fig. 1). The results of this shape-matching process have standard errors of approximately 0.5° to 1.0° for rotations and 0.5 to 1.0 mm for translations in the sagittal plane [1]. Unpaired t-tests were used for statistical analysis and probability values less than 0.05 were considered significant.

Results: The maximum implant flexion angles were not significantly different. However, they tended to be greater in group A than group B (Fig. 2a), averaging 117 ± 8° and 109 ± 14° at maximum lunge (p=0.054), and 119 ± 7° and 110 ± 14° at maximum kneeling (p=0.061), in groups A and B, respectively. The medial condylar posterior translations were greater in group A than group B (Fig. 2b), averaging -7 ± 3mm and -3 ± 3mm at maximum lunge (p<0.05), and -6 ± 2mm and -4 ± 3mm at maximum kneeling (p<0.05), respectively. Lateral condylar AP translations were not significantly different between the two
groups except at 90° kneeling (Fig. 2c). Femoral center AP translations were greater in group A than group B (Fig. 2d), averaging -6 ± 1mm and -3 ± 2mm at 90° lunge (p<0.05), and -7 ± 1mm and -2 ± 1mm at 90° kneeling (p<0.05), respectively. Femoral external rotations were significantly smaller in group A than group B (Fig. 2e), averaging 8 ± 7° and 14 ± 5° at 90° lunge (p<0.05), and 2 ± 6mm and 6 ± 3mm at 90° kneeling (p<0.05), respectively. Valgus/varus rotations were small and not significantly different between the two groups (Fig. 2f).
Discussion: Both implants are designed to achieve deep flexion, preventing edge loading until 155° flexion. Post/cam engagement occurs at 75° flexion in both systems and the implant shapes are similar. Positive correlations have been reported between increasing femoral posterior translation and greater maximum knee flexion [2]. The cam/post design of the new implant is configured to provide approximately 8mm of posterior femoral translation at 120° flexion which, on average, was slightly greater than observed in the control knees. Slightly greater lunge and kneeling flexion in knees with the new design may be a manifestation of this greater posterior femoral translation. Previous studies have failed to demonstrate axial rotation as a predictor of greater flexion [2]. Likewise, our data do not show a relationship between axial rotation and maximum flexion. The new TKA designed for Japanese knees appears to perform comparably to a traditional high-flexion PS design, but may show some improvement in functional flexion due to greater posterior femoral translation.

Significance: This study is useful for development of implant designs and prediction of post-operative knee kinematics.

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