In-vivo Evaluation Of The Kinematic Behavior Of An Artificial Medial Meniscus Implant: A Pilot Study Using Open-mri

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Disclosures:

Introduction: The main goal of this study was to evaluate the kinematics of a knee implanted with an artificial polycarbonate-urethane (PCU) meniscus implant which was developed for medial meniscus replacement. The implant is designed as a compliant non-anchored femur-conforming device which can be implanted through a minimal invasive arthrotomy (Fig. 1). Previous in-vitro experiments of the implant confirmed its ability to distribute pressure under static loading, with similar characteristics compared to the natural meniscus [1]. Additional in-vitro evaluation of the implant’s stability under dynamic conditions was conducted using a robotic knee simulator to study the effect of joint preparation, implant size, and type of activity [2]. However, there is currently no clinical data for the movement of the implant in-vivo. Since the PCU-implant is currently under clinical investigation as part of a Multi-Center prospective study, the evaluation of its motion trajectory using an open-MRI can provide important information regarding its functionality in-vivo.

Methods: Three patients who underwent an arthroscopy combined with a mini-arthrotomy for implantation of a PCU medial meniscus implant (NUsurface®, Active Implants Corp., Memphis TN, USA) were included in this prospective case-series study [mean = 52 years; 3 males]. For all patients, Magnetic resonance (MR) imaging data were available at 6 months or more postoperatively. All patients were operated at the same centre by 1 experienced surgeon (PV) and must have the contralateral knee intact. Study approval was obtained from the Hospital Ethics Committee. Magnetic resonance imaging was performed at 6-12 months postoperatively. Images were acquired on a 0.7 T MR scanner (Upright MRI, Fonar Corporation, Melville, NY, USA) in the following positions: the knee in a supine non-weight-bearing (NWB) neutral position and at 120 degrees of flexion, the knee in an upright WB position in neutral rotation at full extension (0°) and at 30, 60, 90 and 120 degrees of knee flexion. A specially-constructed support frame was used to support the subject during scan in WB condition. The patients’ contralateral normal knee was also scanned in all positions as a reference. The images were analysed with the Osirix DICOM Viewer (OsiriX 3.9.4; The OsiriX Foundation; Geneva, Switzerland). All images were reviewed and all measurements were performed by one observer. The following parameters were considered. Extension facet center (EFC) and Flexion facet center (FFC) - The EFC and FFC were determined on sagittal MR scans of the medial femorotibial compartment. Contact point (CP) - The place at which the medial and lateral subchondral plates of the femur and tibia most closely approach each other on the sagittal MR. Meniscal height - The height of the anterior and posterior horns, and the meniscal body was measured, just like the height of the PCU-implant at the anterior portion, midportion and posterior portion. Radial displacement - On coronal MR images, the distance between the tibial plateau and the outer edge of the meniscus/implant (RD) was determined for both the PCU-implant and the corresponding normal meniscus.

The nonparametric Friedman test for multiple testing was used to compare RD, the CP’s and the FFC’s at all five positions (0-30-60-90-120° knee flexion). The same test was also used to compare the meniscal height and the meniscal movement at all five positions. To decide which groups were significantly different from each other, the paired Wilcoxon test was used and a Bonferroni correction was applied to correct for multiple testing (4 hypotheses); thus a p-value of 0.05/4=0.0125 was considered statistically significant. All data are expressed in terms of mean and standard deviation (SD). All reported p-values are 2-tailed. The significance level was set at 0.05.

Results: In both the implanted and the non-operated knees, the medial femoral condyle (FFC) did not move anteroposteriorly during knee flexion (p=0.102). No difference in medial FFC was observed between the operated and non-operated knees (p=0.865). The lateral femoral condyle (FFC) moved significantly (p<0.001) backwards, respectively, 11.38±2.15 mm in the operated knees versus 10.59±3.40 mm in the non-operated knees (p=0.009). In both the operated and non-operated knees, the CPs moved significantly (p=0.05) in both the implanted and non-operated knees, at all angles of flexion. There was a significant difference (p=0.05) in A-P movement during knee flexion between the implanted and the non-operated knees (Fig. 2): Both the anterior and posterior sections of the implant moved significantly backwards (anterior horn=10.4 mm; posterior horn=7.0 mm), while the medial normal meniscus moved slightly backwards (anterior horn=6.8 mm; posterior horn=5.0 mm). This suggests that the implant moves more posteriorly during knee flexion in the medial compartment compared to the natural meniscus. All of the aforementioned measurements in the implanted knees, which were taken at a maximum flexion (120°) under WB and NWB...
conditions, were compared statistically to elucidate the effect of load-bearing on the location of the meniscus. None of the parameters were found to differ statistically between the two groups.

**Discussion:** The artificial PCU-implant, designed for medial meniscus replacement, had no influence on femoral roll back or tibiofemoral contact points, thus suggesting that the knee joint maintains its kinematic properties following implantation with a PCU-meniscus implant. Also, the implant did not influence radial displacement and showed no deformation during knee flexion. The anterior-posterior meniscal movement increased slightly between the implant and the normal meniscus. In summary, it is concluded that, in-vivo, the artificial meniscus behaves almost identically as the natural meniscus, with the exception of slightly more posterior translation under flexion.

**Significance:** It is concluded that, in-vivo, the artificial meniscus behaves almost identically as the natural meniscus, with the exception of slightly more posterior translation under flexion

**Acknowledgments:** None

**References:**
2. Elsner et al., 2012. In-vitro stability testing of a non-fixed meniscal implant: the effect of surgical technique and knee condition. 2012 ICRS meeting, May 12-15, Montreal,
LEFT KNEE
Meniscal movement during knee flexion (0° - 120°)

RIGHT KNEE
Meniscal movement during knee flexion (0° - 120°)

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