Evaluation of kinematic behavior of an artificial medial meniscus implant: a pilot study using open-MRI

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Aims and objectives

In this pilot study we wanted to evaluate the kinematics of a knee implanted with an artificial polycarbonate-urethane (PCU) meniscus device, designed for medial meniscus replacement (Fig.1-2).

We hypothesized that the PCU-implant would have no influence on the overall knee kinematics during static conditions. The kinematic behavior of the implanted knee was compared with the contralateral non-operated knee.

Secondly, we compared the motion pattern, the RD and height of the medial PCU-implant to that of the natural medial meniscus under WB conditions to test the hypothesis that there is no difference in range of motion, RD and height between these two groups.

Images for this section:

Fig. 1: Detail of a polycarbonate-urethane implant designed for medial meniscus replacement

Fig. 2: A polycarbonate-urethane meniscus implant, designed for medial meniscus replacement

Methods and materials

Three patients were included in this prospective case-series study [mean = 52 years; 3 males]. MR imaging data was available at 6 months or more postoperatively.

All PCU-devices were implanted during arthroscopy combined with a mini-arthrotomy.

An open-MRI was used to track the location of the implant during static weight-bearing conditions, within a range of motion of 0° to 120° knee flexion.

Knee kinematics were evaluated by measuring the tibiofemoral contact points and femoral roll-back (Fig.3).

Meniscus measurements (both natural and artificial) included anterior-posterior meniscal movement, RD (Fig. 4), and meniscal height.

Images for this section:

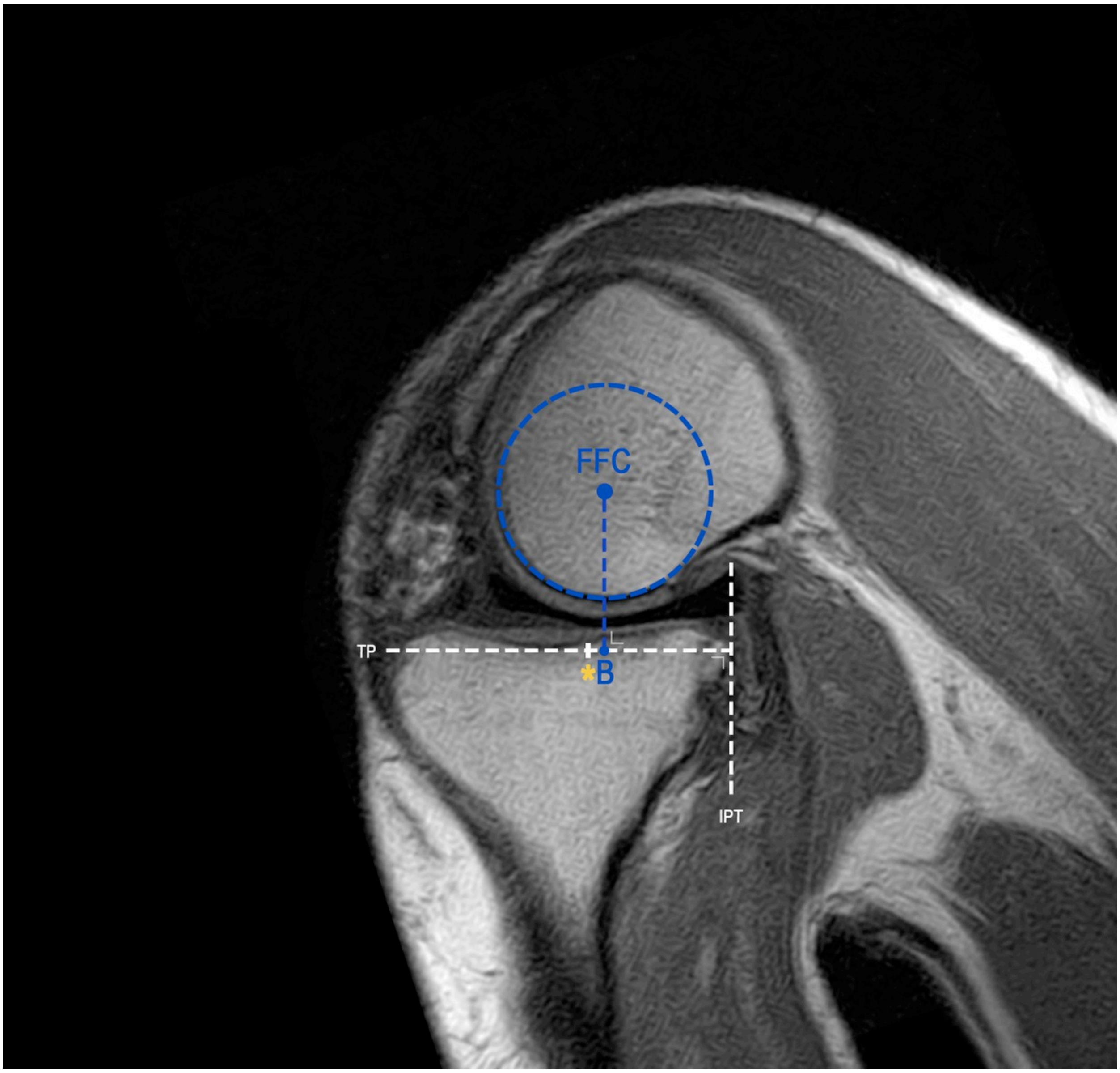

Fig. 3: MR-image of the medial compartment at 120# knee flexion demonstrating the points and guidelines used to measure the flexion facet center (FFC). It demonstrates the measurements which were used to determine the relative motion of the femur and tibia between 0# and 120# knee flexion respectively. IPT= line delineating the ipsilateral posterior tibial cortex. TP: line delineating the surface of the tibial plateau, perpendicular to the IPT. Line B: projection of the FFC on the tibial plateau. Asterisk (*): projection of the contact point between the tibial and femoral subchondral bone plate.

Fig. 4: Measurement method for radial displacement (RD) of the meniscus/implant in the mid-coronal plane. Horizontal dotted line= orientation of the tibial plateau. Perpendicular dotted line = originates at the outer edge of the tibial articular surface; used as a reference for RD. RD= distance between the most peripheral aspect of the meniscus/implant and the reference line.

Results

No significant difference (p>0.05) was demonstrated in femoral roll-back (Fig.5) and tibiofemoral contact points (Fig.6) during knee flexion between the implanted and the non-operated knees.

Meniscal measurements showed no significant difference in RD (Fig.9) and meniscal height (p>0.05) at all knee flexion angles, in both the implanted and non-operated knees (Fig.10-12).

We did however observe that the overall RD of the PCU-implant is larger than the RD of the normal menisci at all flexion angles.

A significant difference (p#0.05) in anterior-posterior movement during flexion was observed between the two groups (Fig.7-8). In the medial compartment of the operated knee, both the anterior and posterior sections of the implant moved significantly (anterior portion=10.4 mm; posterior portion=7.0 mm) backwards, while the medial normal meniscus moved slightly (anterior horn=6.8 mm; posterior horn=5.0 mm) backwards. This suggests that the implant moves more posteriorly during knee flexion in the medial compartment compared to normal knees or allograft transplants, which may have been caused by the free-floating implant design.

Images for this section:

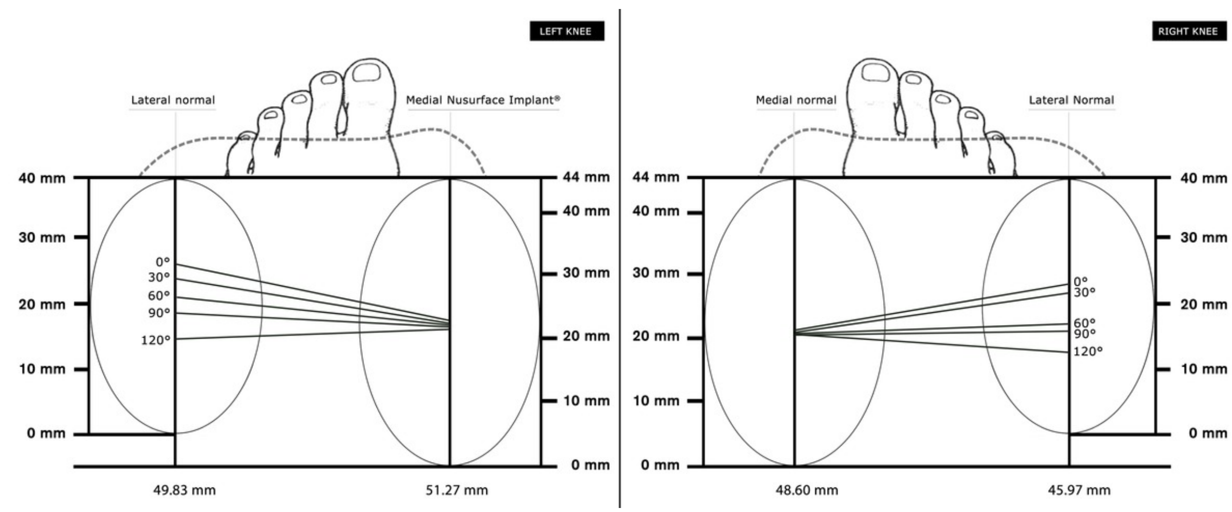

Fig. 5: Graphical representation of the location of the flexion facet center on the tibial plateau, as a function of knee flexion.

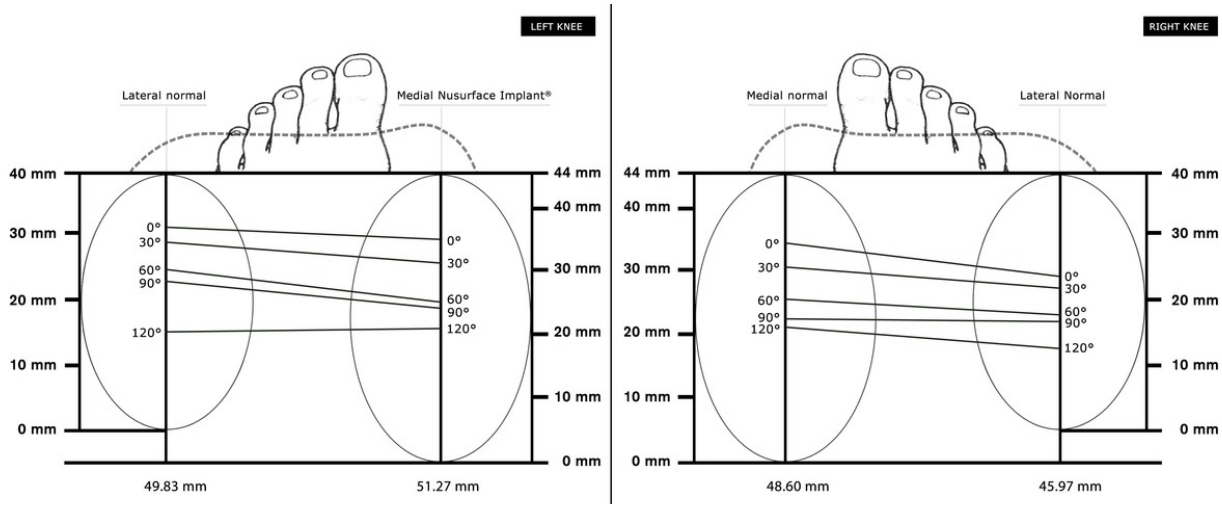

Fig. 6: Graphical representation of the location of the projection of the contact point between the tibial and femoral subchondral bone plate on the tibial plateau, as a function of knee flexion.

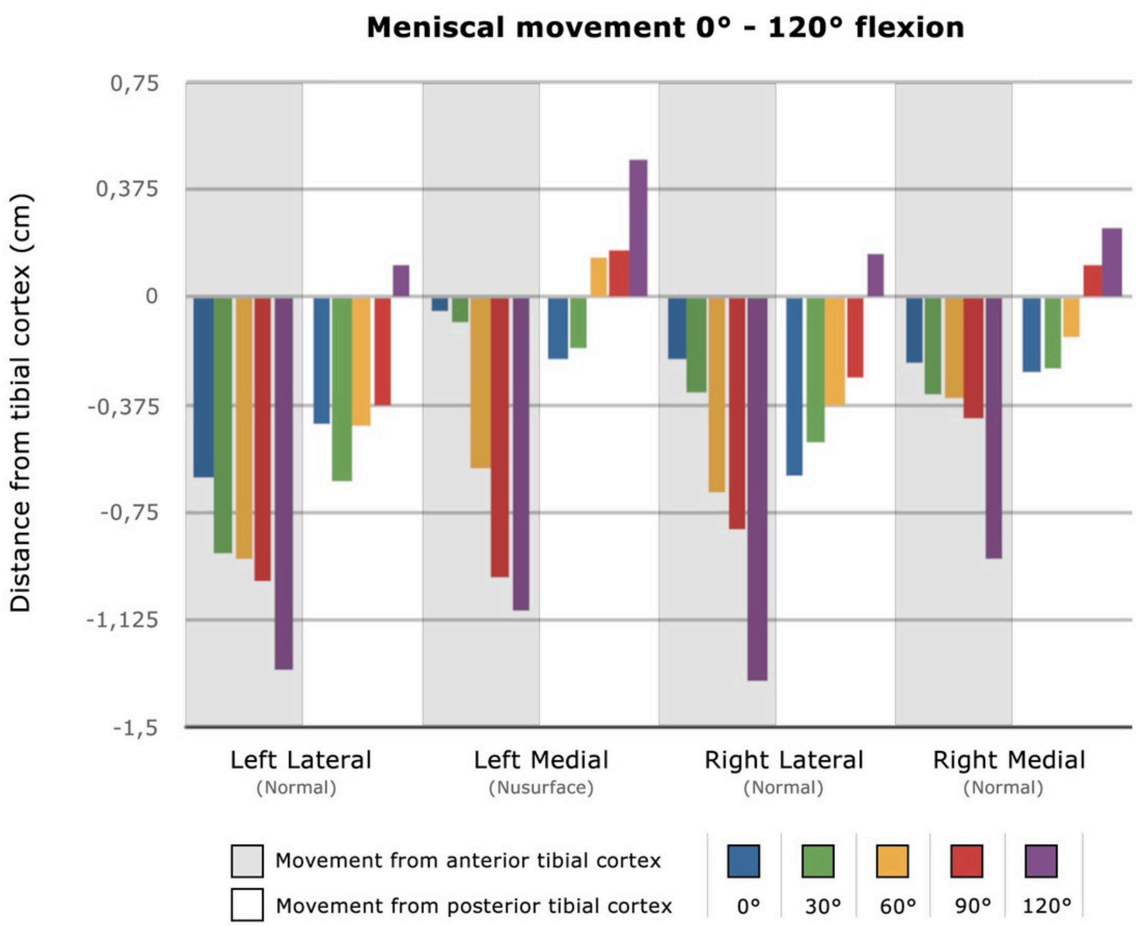

Fig. 7: Graphical representation of meniscal movement between 0# and 120# flexion under weight-bearing conditions.

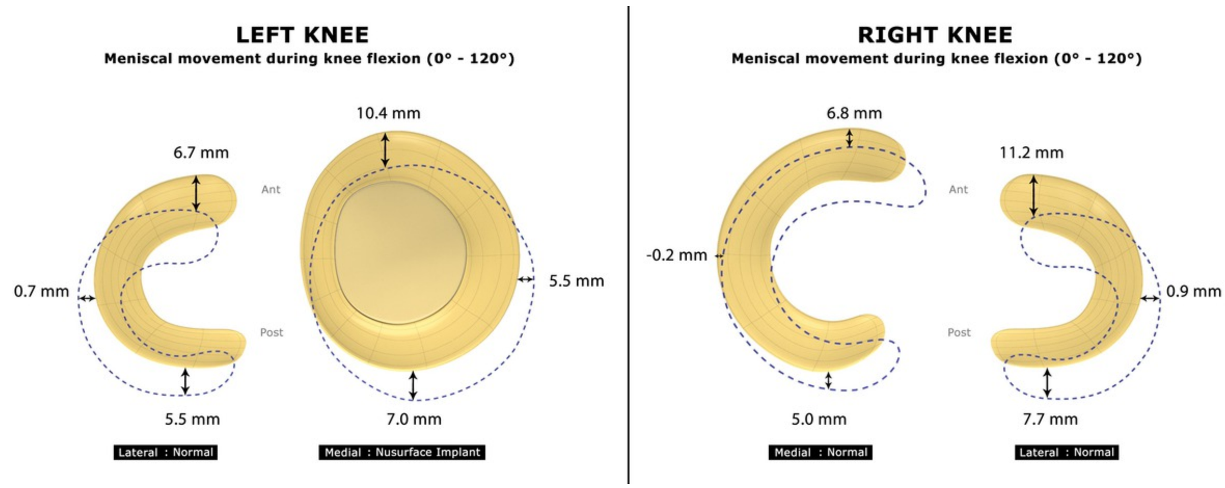

Fig. 8: Representation of meniscal movement between 0# and 120# flexion under weight-bearing conditions.

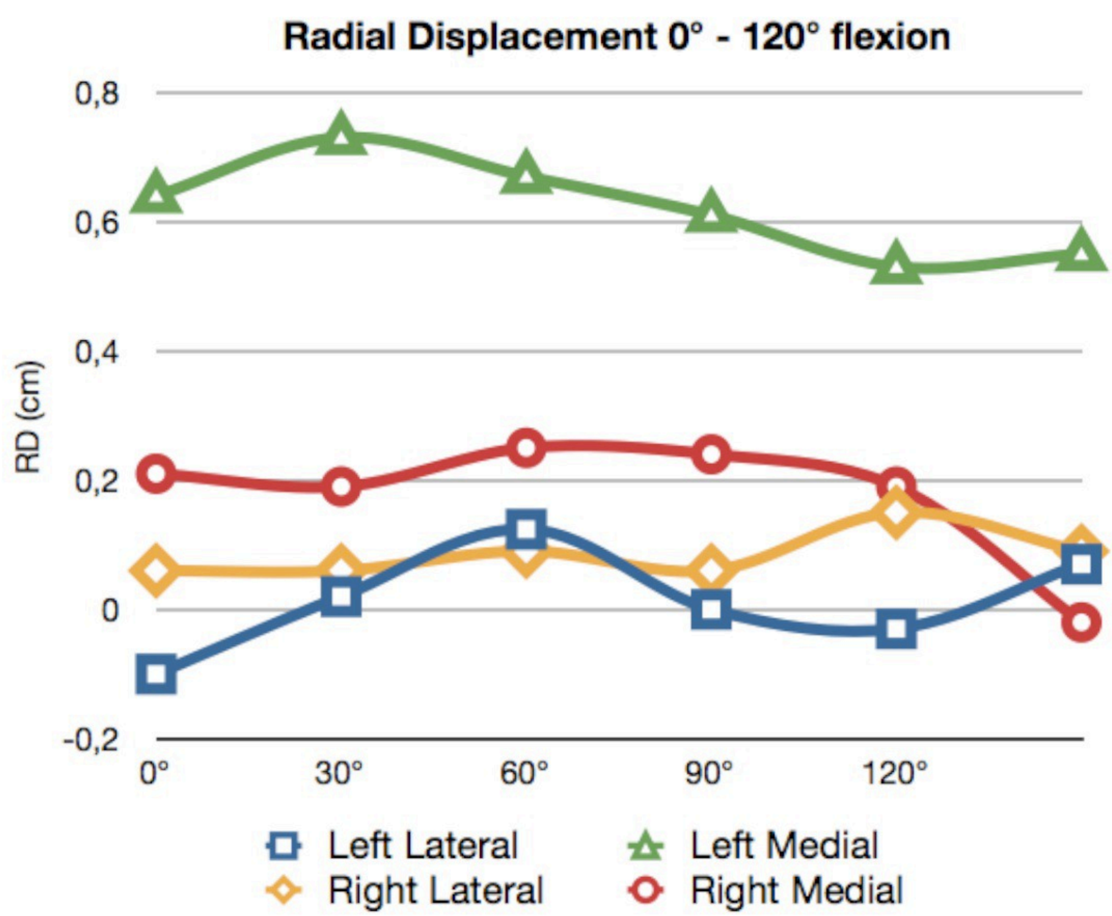

Fig. 9: Evolution of mean radial displacement of the natural meniscus (right medial, right lateral, and left lateral) and the PCU-implant (left medial), throughout the range of motion 0-120# flexion.

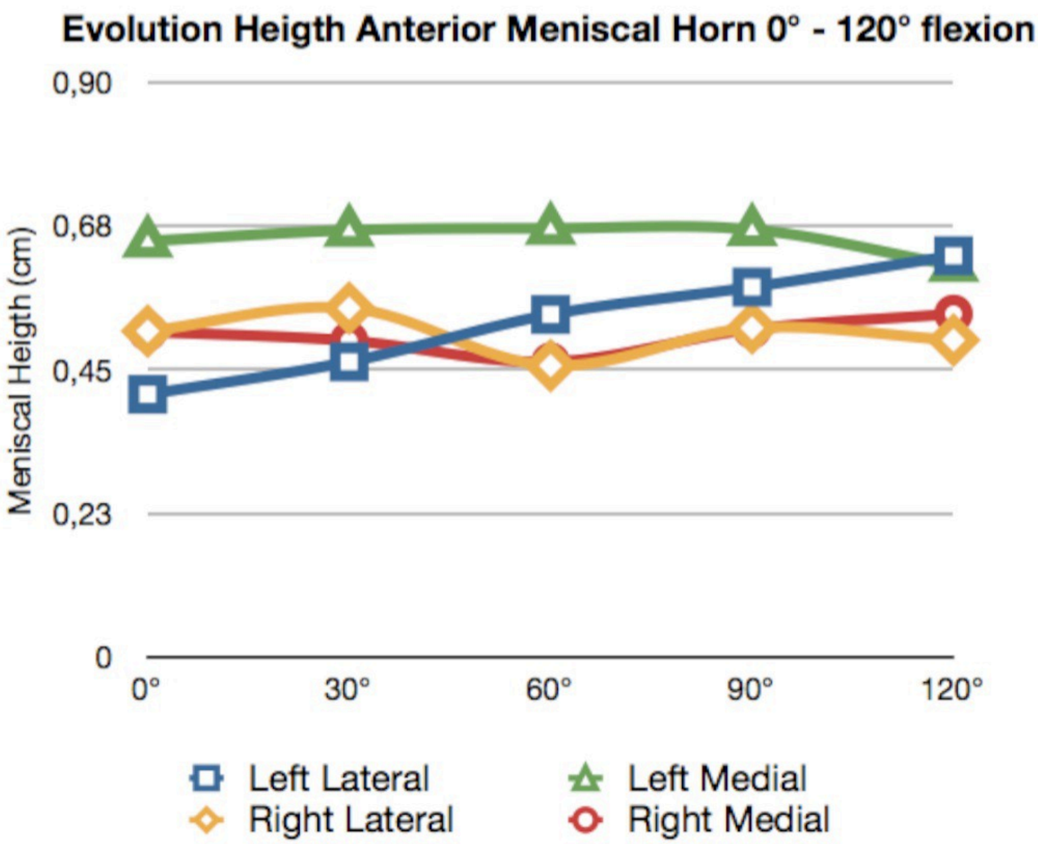

Fig. 10: Evolution of the mean height of the natural meniscus (right medial, right lateral, and left lateral) and the PCU-implant (left medial) throughout the range of motion 0-120# flexion, as measured in the region of the anterior horn.

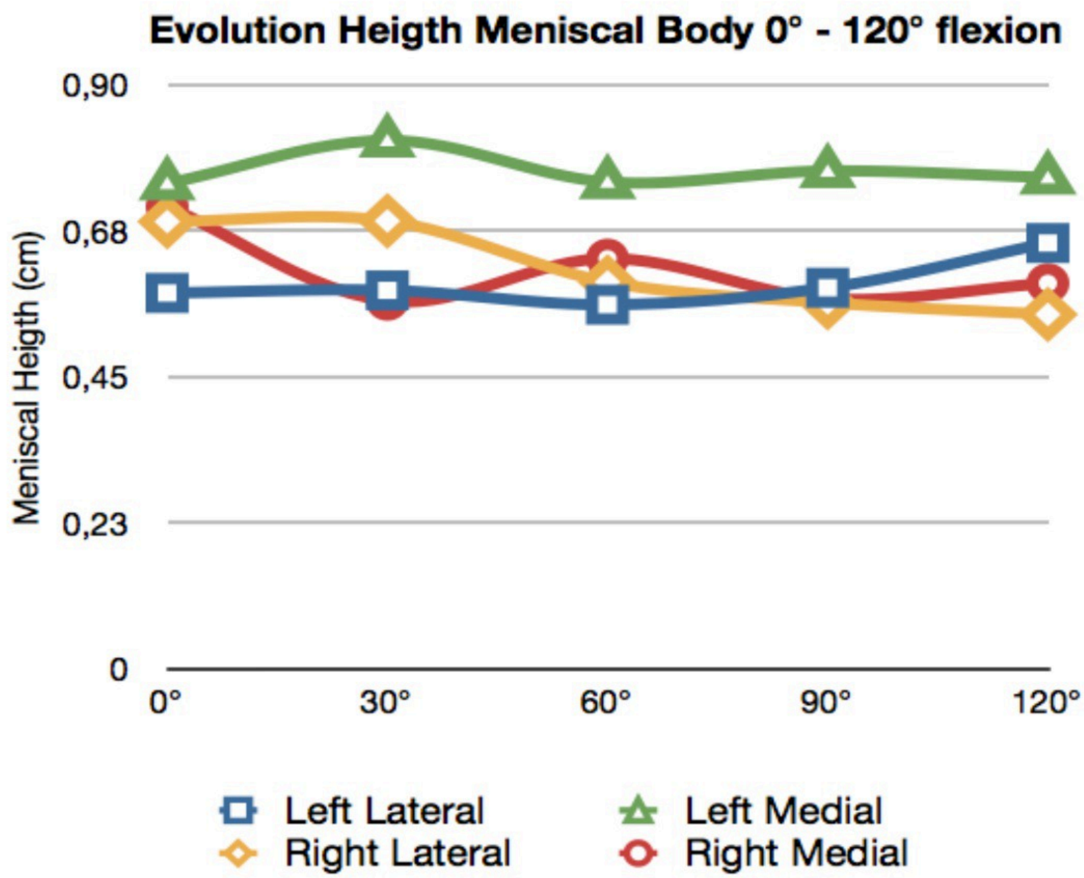

Fig. 11: Evolution of the mean height of the natural meniscus (right medial, right lateral, and left lateral) and the PCU-implant (left medial) throughout the range of motion 0-120# flexion, as measured in the region of the midbody section.

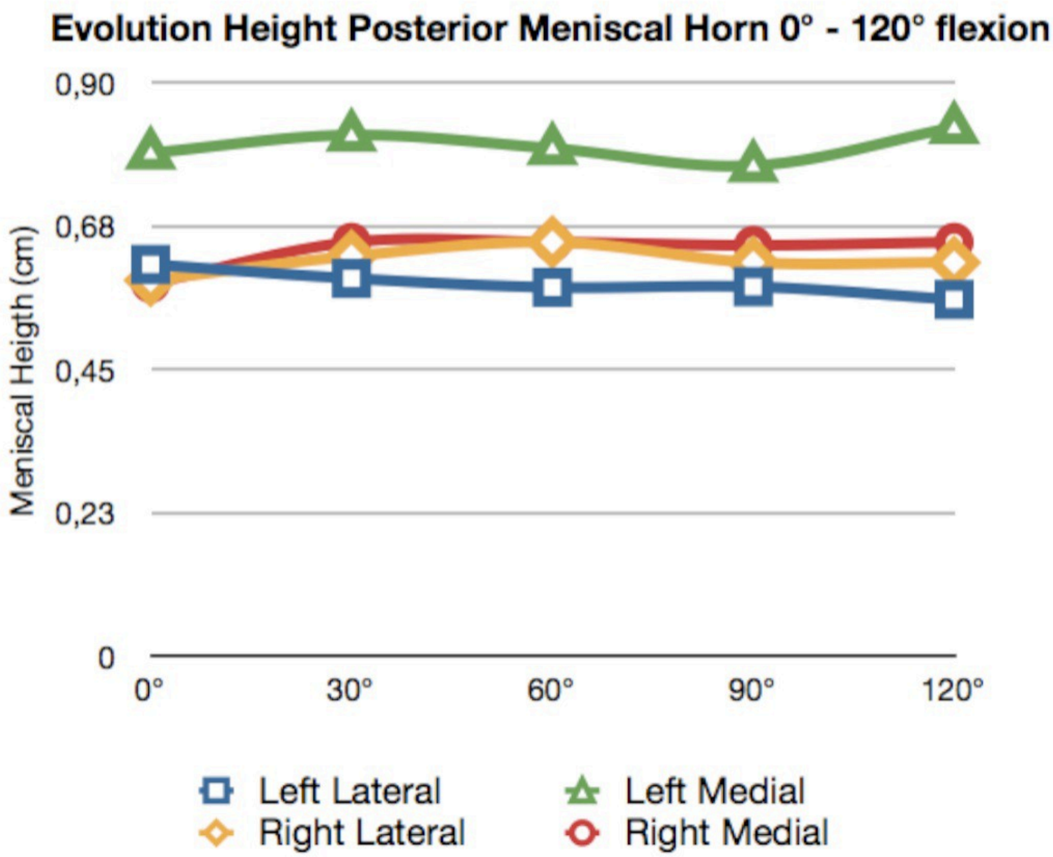

Fig. 12: Evolution of the mean height of the natural meniscus (right medial, right lateral, and left lateral) and the PCU-implant (left medial) throughout the range of motion 0-120# flexion, as measured in the region of the posterior horn.

Conclusion

To conclude, we state that the artificial PCU-implant, designed for medial meniscus replacement, had no influencein-vivoon femoral roll-back or tibiofemoral contact points in this pilot study.

This suggests that the knee joint maintains its kinematic properties following implantation with a PCU-meniscus implant during static loading conditions. Also, the implant did not undergo significant radial displacement or lose height during knee flexion. The anterior-posterior meniscal movement increased slightly between the implant and the normal meniscus.

Future research is required however to investigate the behavior of the PCU-implant in a larger population and during dynamic conditions.

Personal information

References

1. Abrams, G.D., Frank, R.M., Gupta, A.K., Harris, J.D., McCormick, F.M., Cole, B.J., 2013. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. Am J Sports Med. Jul 17. [Epub ahead of print]
2. Freeman, M.A., Pinskerova, V., 2005. The movement of the normal tibio-femoral joint. J Biomech. 38:197-208.
3. Johal, P., Williams, A., Wragg, P., Hunt, D., Gedroyc, W., 2005. Tibio-femoral movement in the living knee. A study of weight bearing and non-weight bearing knee kinematics using 'interventional' MRI. J Biomech. 38:269-276.
4. Linder-Ganz, E., Elsner, J.J., Danino, A., Guilak, F., Shterling, A., 2010. A novel quantitative approach for evaluating contact mechanics of meniscal replacements. J Biomech Eng. 132:024501
5. Petty, C.A., Lubowitz, J.H., 2011. Does arthroscopic partial meniscetomy result in knee osteoarthritis? A systematic review with a minimum of 8 years' follow-up. Arthroscopy. 27:419-424.