The Influence of Malrotation and Material of the Femoral Component on Patellofemoral Contact Mechanics and Wear During Gait

INTRODUCTION:
Malrotation of the femoral component is a cause of patellofemoral maltracking after Total Knee Arthroplasty (TKA). Its precise effect on patellofemoral (PF) contact mechanics and wear has not been well quantified. The aim of this study was to investigate the effect of malrotation of the femoral component on PF contact area and pressure - and particularly on wear - in TKA by in vitro simulation of a full gait cycle using a knee simulator. Moreover, the influence of the counterface material - Cobalt Chrome (CoCr) or Oxidized Zirconium (OxZr) - on PF wear was investigated during a wear simulation of 4 million cycles.

METHODS:
Femoral components were cemented onto metal fixtures, specially designed to be able to position the components in different angles of axial rotation. Patellar buttons and femoral components were then mounted in a Prosim knee simulator.

In order to investigate PF contact mechanics, seven axial rotation configurations were tested: neutral (femoral component parallel to the epicondylar axis), 2.5° endo- and exorotation, 5° endo- and exorotation and 7.5° endo- and exorotation.
Patellar contact location, contact area and contact pressure were measured dynamically with a Tekscan sensor covering the patella during 20 gait cycles at a rate of 100 frames per cycle. This was measured for each alignment with mediolateral movement either blocked or constrained with linear springs (k = 8 N/mm). Maximum contact area was determined as the total area over the entire patella where pressure was recorded during peak load. The contact pressure was defined as the average pressure recorded on the entire patella at peak load.

For three alignments (neutral, 5° endo- and exorotation), a PF wear test of 4 million cycles in bovine serum (diluted to 40%) was done with three CoCr and three OxZr components on conventional ultra-high molecular weight polyethylene (UHMWPE). Every 0.5 million cycles the test lubricant was replaced, the patellar samples were cleaned and polyethylene wear was measured gravimetrically. A linear regression model was used to calculate the wear rate of each patellar sample. Aggregate wear rates were determined for each test condition by pooling the measurements of all three patellar samples.

RESULTS:
For all six endorotation and exorotation configurations, the contact area was significantly lower and the contact pressure significantly higher than in the neutral position (p < 0.001, Figs 1 and 2).

In the patellofemoral wear test, the highest average wear rate was found in the group of endorotated CoCr femoral components (0.54 mm³/Mcycle), but this is still only 11% of a typical tibiofemoral wear rate with the same CoCr component (5 mm³/Mcycle) [1]. The following trends in the average wear rates could be observed: the average wear rate for CoCr (0.34 mm³/Mcycle) was higher than for OxZr (0.19 mm³/Mcycle) (Fig 3). The average wear rate for 5° endorotation (0.35 mm³/Mcycle) was higher than for 5° exorotation (0.21 mm³/Mcycle) and neutral alignment (0.23 mm³/Mcycle). None of these differences in average wear rate reached statistical significance (p=0.05), though.

DISCUSSION:
Our results indicate that both internally and externally malrotated femoral components significantly decrease contact areas and significantly increase contact pressures in the patellofemoral joint. These significant changes in contact pressure didn’t translate in significant changes in wear. Overall, patellofemoral wear is very small compared to tibiofemoral wear.

SIGNIFICANCE:
This work provides a better understanding of patellofemoral contact pressures and wear in TKA’s with malrotated femoral components and can help in identifying possible causes of patellofemoral complications after TKA, such as anterior knee pain.

REFERENCES: