Rotating Platform Total Knee Prostheses Reduce Axial Rotational Constraint Torque

Shouchen Dun, Engineer | DePuy Orthopaedics, Inc., Warsaw, IN

Abstract:
The current study compared in-vitro tibiofemoral axial rotational constraint between two posterior stabilized rotating platform knee prostheses and their fixed-bearing counterparts. It was demonstrated that both rotating platform knees induced significantly less constraint torque compared to their fixed-bearing counterparts. The highly constrained design of the fixed-bearing knees substantially limited their range of axial rotation. These results provide further evidence that rotating platform knee prostheses could reduce load transmitted to the bone-implant interface.

Methodology:

- Tested components:
  - SIGMA® PS size 3 fixed-bearing construct and SIGMA PS size 3 rotating platform construct, a type of mobile bearing knee
  - SIGMA TC3 size 3 fixed-bearing construct and SIGMA TC3 size 3 rotating platform construct, a type of mobile bearing knee

- Experimental setup (Fig. 1): Femoral construct was attached to the actuator of an MTS test system. Tibial construct was secured on a translation table that was mounted on the base plate of the MTS system.

- Experimental procedure: Test started with femoral component positioned at the dwell of the insert and tibiofemoral axial rotation at 0 degree. With a 667 N tibiofemoral compressive force applied and held, femoral component was externally rotated at 100 degree flexion/min for 20 degrees or until the constraint torque reached 9.4 Nm1,2, whichever occurred first. Four tibiofemoral flexion angles were tested: 0, 45, 90, and 120 degrees.

- Data analysis: Peak constraint torque was compared between fixed-bearing and mobile-bearing.

Fig. 1 Experimental Setup
Results:

- Representative Torque – Rotation relationship at 0 degree knee flexion is depicted in Fig. 2.

- The peak constraint torque of both SIGMA PS and TC3 fixed-bearing was significantly greater than that of their rotating platform counterparts at all tibiofemoral flexion angles (p<0.001) (Fig. 3 and 4).

- Due to implant design constraints the SIGMA PS fixed-bearing reached the torque limit of 9.4 Nm at 10 degrees before the femoral component fully rotated externally to 20 degrees at 90 and 120 degree flexion; TC3 fixed-bearing reached the torque limit of 9.4 Nm before the femoral component fully rotated externally to 20 degrees at all flexion angles due to implant design constraints.

- SIGMA PS rotating platform knee reduced peak torque by 79% and 77% at 0 and 45 degree flexion, respectively, compared to SIGMA PS fixed-bearing knee; At 90 and 120 degree flexion, the peak torque of SIGMA PS rotating platform was at least 70% and 57% less, respectively, compared to fixed-bearing.

- TC3 rotating platform reduced peak torque by at least 87%, 82%, 65%, and 52% at 0, 45, 90, and 120 degree flexion, respectively, compared to its fixed-bearing counterpart.
Discussion:

Mobile-bearing knee prostheses have been shown to reduce stresses transmitted to the fixation interface, which could improve implant stability and decrease the incidence of implant loosening. Russo et al. reported improved fixation at the bone-implant interface with mobile-bearing knees, which was attributed to stress reduction provided by constraint reduction with a mobile tibial insert. Bottlang et al. showed that under 10 degree tibial external rotation, the mobile-bearing knee induced 33% less compressive strain than the fixed-bearing knee. The mobile-bearing knee also reduced torque in the proximal tibia during knee rotation by 68–73% compared with the fixed-bearing knee.

The current results were consistent with previous findings. It was observed that during tibiofemoral axial rotation, the SIGMA PS rotating platform knee reduced peak torque by 79% and 77% at 0 and 45 degree tibiofemoral flexion, respectively, compared to fixed-bearing knee. At 90 and 120 degree flexion, the peak torque of Sigma PS rotating platform was at least 70% and 57% less, respectively, compared to fixed-bearing. TC3 rotating platform reduced peak torque by at least 87%, 82%, 65%, and 52% at 0, 45, 90, and 120 degree flexion, respectively, compared to its fixed-bearing counterpart.

Conclusion:

The current study provided further evidence that mobile-bearing knee prostheses could reduce load at the bone-implant interface.
References:


2. DePuy Sigma PS Patient Weight Study.

3. Data on File at DePuy Orthopaedics, Inc. WR110006.

4. Data on File at DePuy Orthopaedics, Inc. WR110009.

5. Data on File at DePuy Orthopaedics, Inc. WR110010.

6. Data on File at DePuy Orthopaedics, Inc. WR110024.
