Methods

Eighteen patients with reproducible squeaking in their ceramic-on-ceramic total hip arthroplasties were recruited from a previous study investigating the incidence of noise in large-diameter ceramic bearings [1]. All 18 patients had a Delta Motion acetal component (DePuy Orthopaedics, Warsaw IN), with head sizes 40–48mm. All had a reproducible squeak during deep flexion. A control group of 36 patients with Delta Motion bearings who had never experienced a squeak were recruited from the silent cohort of the same original study [1]. They were matched as presented in Table 1. For data analysis, a student’s t-test (two-tailed) was used to investigate any statistical significance between the groups.

All 54 patients were modelled performing two functional activities using the Optimized Ortho Postoperative Kinematics Simulation software (Optimized Ortho, Australia), Fig 1. A postoperative CT scan enabled 3D coordinates of soft tissue and bony landmarks to be virtually identified for each patient in Scanpil (Simpleware, UK). Three lateral radiographs, Fig 2, provided pelvis and lumbar spine parameters in the functional positions, used as inputs to define the patient-specific kinematics in the simulation. Using these inputs, the software calculates the dynamic force at the replaced hip throughout the two activities and plots the contact patch on the bearing using a Hertzian contact algorithm [8], as it traces across the articulating surface, Fig 3. As all the squeaking subjects did so in deep flexion, the minimum posterior Contact Patch to Rim Distance (CPRD) can be calculated as the minimum distance between the edge of the contact patch and the true rim of the ceramic liner, Fig 3. A posterior CPRD with a negative value is indicative of posterior edge-loading.

Conclusions

1. Edge-loading is dependent upon not just the three-dimensional motion of the femur, but also the force vector across the hip and the kinematics of the pelvis. All three factors influence the likelihood of edge-loading during an activity of daily living by changing the location of the bearing contact patch in relation to the true rim of the liner.

2. Sagittal pelvic kinematics are highly variable between individuals and between different functional activities. Given these individual pelvic rotations have a substantial effect on the functional orientation of the acetabular cup, the likelihood of edge-loading as a patient rises from a chair or during gait is specific to each individual.

3. The functional anteverision in the squeaking group at the time of “seat-off” was significantly less than the silent control group, leading to an increased incidence of posterior edge-loading and a mean CPRD of -2.3mm. This was primarily attributable to the increased anterior tilt of the pelvis in the seated position of the squeaking group.

4. Acetabular cup orientation during activities associated with edge-loading is likely very different from when supine, Fig 4. Patients with large anterior pelvic tilts in deep flexion might be more susceptible to posterior edge-loading and squeaking in ceramic-on-ceramic bearings, as a consequence of a significant decrease in cup anteverision. If these patients can be identified pre-operatively, cup orientation and bearing choice could be customised to accommodate these individual patterns.

References


