OBJECTIVES
Malorientation of the acetabular component in Total Hip Replacement (THR) may contribute to premature failure. But malorientation problems usually occur in functional positions not shown on standard radiographs. We used functional dynamic analyses to investigate and understand the role of patient specific pelvic dynamics in three failing total hip replacements prior to their revision.

METHODS
All 3 patients were modelled performing three functional activities using the Optimized Ortho Postoperative Dynamic Simulation software. The software uses standard medical imaging to produce a patient-specific rigid body dynamics analysis of the subject standing, performing a sit-to-stand task and a step-up with the contralateral leg (Fig 1). A computed tomography scan and 3 lateral X-rays were taken for each patient - standing, flexed seated and step-up (Fig 2). Pelvic and lumbar spine parameters were measured on each of the functional images and used as inputs to define the patient-specific kinematics in the simulation. The software calculates the dynamic force at the replaced hip throughout the activities and plots the bearing contact path, using a Hertzian contact algorithm [3], as it traces across the articulating surface (Fig 3). The Contact Patch to Rim Distance (CPRD) [2] can then be determined by calculating the smallest distance between the edge of the contact patch and the true edge of the liner (Fig 3). A negative CPRD indicates edge-loading.

CASE STUDY 1 – THE SAGITALLY UNBALANCED HIP
60 year old female, bilateral Metal-on-Metal THR. Right cup was revised for recurrent anterior dislocation, but over the next 2 years the revision cup showed radiological signs of loosening. The patient experienced groin pain and clunking. Standing pelvic radiographs showed posterior pelvic tilt (Fig 4). EOS imaging showed degenerative spine disease with a severe flat back deformity and loss of lumbar lordosis (Fig 5). This caused an excessive posterior pelvic tilt of -31°, a compensatory mechanism to maintain the centre of gravity over the hip axis (Fig 6). Consequently, the patient was back pain and was deemed at risk of further posterior migration of the cup.

CASE STUDY 2 – THE FAILING LARGE HEAD METAL-on-METAL HIP
60 year old female, large Metal-on-Metal THR. Routine X-ray showed ideal component orientations. Asymptomatic calcac loss on X-rays led to investigations which revealed a pseudotumour and raised cobalt levels. A dynamic pelvic analysis performed using the Optimized Ortho software showed a statically well oriented acetabular component (39° inclination and 27° anteverision referenced to the supine coronal plane) (Fig 7). But at “seat-off” in the dynamic simulation the patient’s functional cup anteverision was reduced to only 11° as a result of a large increase in posterior pelvic tilt (Fig 2b). The Optimized Ortho polar plot indicated that the patient was severely edge-loading (CPRD = -0.7 mm) (Fig 7b). Successful revision with a metal/polyethylene bearing.

CASE STUDY 3 – THE SQUEAKING CERAMIC-on-CERAMIC HIP
61 year old female, CoC left THR. Squeaking began 2 years later, was activity related and became painful. The squeaking was reproducible at full extension during gait. Orientation appeared satisfactory on a routine pelvic AP X-ray (Fig 8a). A dynamic pelvic analysis performed using the Optimized Ortho software revealed a 14° posterior change in pelvic tilt when moving from supine to the standing position, increasing the functional inclination and anteverision of the cup by 9° and 10° respectively (Fig 9). Consequently when standing the functional cup orientation was 50° inclination and 46° anteverision, and the Optimized Ortho polar plot implied anterosuperior edge-loading in extension (CPRD = -0.3 mm) (Fig 8b). Interestingly this patient also had a large increase in pelvic tilt at the time of “seat-off”, and came close to posterior edge-loading (CPRD = 2.3 mm).

CONCLUSIONS
1. Sagittal pelvic kinematics are highly variable between individuals and between different functional activities. These individual pelvic rotations have a substantial effect on the functional orientation of the acetabular component.
2. Previously defined “safe zones” might not be appropriate for all patients as they don’t account for the dynamic behaviour of the pelvis.
3. Seemingly “well oriented” cups on routine X-ray can be functionally maloriented due to a patient’s individual pelvic kinematics.
4. The Optimized Ortho software is a useful tool for analysing the failing THR and for planning patient specific acetabular cup orientation.

REFERENCES