INTRODUCTION
The main advantage of hip resurfacing is that the femoral neck is retained and bone stock is preserved which makes it an ideal early interventional procedure for younger patients. A disadvantage of preserving the femoral neck is that the head/neck ratio is larger than that of a conventional total hip replacement. This reduces the available range of motion (ROM) for the reconstructed joint compared with that of a total hip replacement. One of the critical factors in terms of providing adequate ROM is the position of the acetabular cup. If cup anteversion is too great, impingement will occur during flexion. Conversely, if there is not enough anteversion, impingement will occur during flexion.

There have been numerous studies linking steep acetabular inclination with elevated wear of metal on metal (MOM) bearings [1]. The effect of steep inclination is exaggerated for MOM bearings as the acetabular bearing surface of MOM devices is less than hemispherical, effectively reducing superior coverage of the bearing compared with traditional hemispherical polyethylene devices.

There is therefore a need for instrumentation to assist the surgeon in placing the acetabular cup to (a) allow maximum ROM and (b) minimize wear of the bearing. This study describes novel instrumentation that aims to achieve these requirements and testing that demonstrates that optimum cup position can be achieved even with malalignment of the pelvis on the operating table.

METHODS 1: DESCRIPTION OF INSTRUMENTATION
Stage 1 determines the cup position during a trial reduction. A Judd nail retractor is left in the pelvis during the trial reduction. A single-use laser pointer is attached to the top of this nail, is free to move and can be locked in position. A trial acetabular cup, with a handle protruding at a fixed angle from the face of the cup, is placed in the acetabulum. At the end of this handle is another single-use laser pointer that projects a laser beam parallel to the axis of the cup onto the wall/ceiling of the operating theatre. Keeping the handle parallel to the medio-lateral axis to control inclination angle, the leg is moved through the desired flexion/extension. The anteversion of the trial cup is adjusted until a position is found where flexion/extension ROM is possible without impingement and satisfactory abduction-adduction is achieved with stability. Once this position is found, the Judd nail laser (fixed to the pelvis) is adjusted until its projected point, on the wall/ceiling, coincides with that from the trial handle. The Judd nail laser is then fixed in position, the hip dislocated and trial components removed.

Stage 2 aligns the definitive acetabular cup. The introducer has a laser pointer pointing parallel to its axis (away from the patient) and is attached to the definitive cup. The definitive cup is placed in the acetabulum and the introducer adjusted until its projected laser coincides with that from the Judd nail. The cup is then in the same orientation as determined during the trial reduction and can be impacted.

METHODS 2: TESTING OF INSTRUMENTATION
To show the instrumentation was capable of positioning the acetabular cup in the same position as the trial component, the trial component was placed in a reamed cavity of a polyurethane foam block with its face parallel to the face of the foam block. The laser point was projected onto a screen 1m from the block and the position marked. The introducer was then placed in the same block with the cup face parallel to the face of the block and the laser point projected onto the same screen. By measuring the distance between the points the angular deviation between the trial and the cup could be measured.

In a second stage of testing, we aimed to show that the instrumentation could place the acetabular cup regardless of mal-positioning of the pelvis. Instrumentation was used to determine the orientation of the acetabular cup as described above in polyurethane foam models of the hip in a Mita Hip Workstation (part# M-00137). It was assumed the desired ROM comprised 85% flexion and 15% extension and the trial cup was positioned to this effect. When performing the ROM to determine the position of the cup, the hip station allowed the femur to be moved relative to the pelvis. When the cup was positioned in the acetabulum, the pelvis was positioned in lateral decubitus and ROM in flexion and extension assessed and the inclination of the cup face to the transverse plane measured. The test was repeated for the following positions of the pelvis: lateral decubitus, rotated by +10º and -10º about the superio-inferior (S-I) axis and rotated by +10º and -10º about the medio-lateral (M-L) axis (5 pelvis positions in total). The test was repeated using a conventional aural guide and results compared.

RESULTS
The accuracy of the definitive cup was found to be within +/- 2º of the trial cup when the laser beams were projected onto a surface ≥2m away. This was considered acceptable and would be the case in an operating theatre.

Figure 1 shows the flexion and extension facilitated when the pelvis was rotated in different angles of malalignment. The new instrumentation maintained a ratio of 80:20 flexion extension in all cases. The ratio of flexion extension provided by the conventional instrumentation varied with pelvis mal-position such that the flexion extension ratio was 55:45 in the worst case. The cup inclination was between 30º and 40º in all cases.

DISCUSSION & CONCLUSIONS
The new instrumentation allows for superior acetabular cup orientation compared to conventional instruments and can place the cup even when the pelvis is misaligned. The new instrumentation also has advantages over computer navigation, in terms of (a) cost, (b) time added to the procedure and (c) not requiring location of the pelvic plane. The last point has been cited as one of the biggest limitations in computer navigating the acetabular cup.

A limitation of the study was that rotation about the anterior-posterior (AP) axis was not considered. This would have increased the sensitivity of the test to cup inclination. However, intraoperative measurements of pelvis movement during hip arthroplasty have indicated that the rotation about the AP axis is small compared to the rotations considered [2].

When used with a patient who is positioned carefully on the operating table before the drapes are placed, the new instrumentation offers a viable alternative to computer navigation at a fraction of the cost and therefore represents a necessary and notable improvement on current technology.

REFERENCES

Laser guided instrumentation for optimum acetabular cup orientation in hip resurfacing
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