The Effect Of Pelvic Tilt On Acetabular Component Orientation In Hip Arthroplasty – A Radiological Analysis Using EBRA

INTRODUCTION
Studies have highlighted the importance of acetabular component orientation for implant survival/wear in hip arthroplasty and have described ‘safe zones’ for optimum cup placement based on radiographic assessments. The radiographic appearance of acetabular position is also influenced by the patient position during AP pelvis radiography which can be either supine or standing. The current description of “safe zones” does not take into account the influence of patient position on acetabular orientation. This difference in patient position would lead to a difference in the pelvic tilt. Zero pelvic tilt occurs when the anterior plane is parallel to the coronal plane. A negative tilt indicates forward rotation at the ASISs and pelvic extension, whilst a positive tilt indicates pelvic flexion. It has been previously shown that the pelvis can move from a position of -5° (±9.5°) tilt when supine to a position of -3° (±11.9°) when standing and to a position of +29° (±12.2°) when sitting. Such changes in pelvic position would have an effect on the resulting spatial orientation of the cup and hence affect measurements, analysis and subsequent recommendations. As a result, an acetabular component may be ‘in-zone’ with the patient in the supine position, but may be ‘out-of-zone’ when the same patient is standing. The aims of this study were to 1. Measure the changes in cup orientation (inclination & anteversion) between lying and standing positions in a cohort of patients with hip resurfacing arthroplasties and 2. Develop a model to assess and measure the changes in cup orientation that occur with different degrees of pelvic tilt.

METHODS
All cup measurements were made using EBRA (Ein-Bild-Roentgen-Analyse) by two observers with excellent interclass correlation coefficients. Acetabular component orientation was measured in 13 patients (7 males; 6 females) with adequate quality supine and standing radiographs (patient cohort). The changes in inclination and anteversion between supine and standing were calculated as:

\[ \text{ΔInclination} = \text{Standing Inclination} - \text{Supine Inclination} \]
\[ \text{ΔAnteversion} = \text{Standing Anteversion} - \text{Supine Anteversion} \]

In order to investigate the influence of pelvic tilt, synthetic x-rays of a pelvis with an acetabular component were generated. A 3D model of a pelvis orientated with anterior and posterior superior iliac spines at the same height in the frontal plane had a 56 mm diameter Birmingham hip resurfacing (BHR) implanted at 40° of inclination and 15° anteversion. Pelvic tilt was applied to this 3D model by rotating its vertices about an axis through the hip joint centers. An orthographic projection matrix was used to produce a 2D image of the pelvis and acetabular component. The resulting image was analyzed using EBRA-cup to determine inclination and anteversion.

RESULTS
For the patient cohort, mean supine acetabular inclination was 45.5° (29.9° - 58.8°) and standing inclination was 47° (33.4° - 59.2°). Mean supine anteversion was 14.8° (6.6° - 31.6°), whilst standing anteversion was 19.3° (9.9° - 33°). Anteversion was 4.5° (1.7° - 12.2°). Acetabular inclination and anteversion increased in 12/13 patients moving from supine to standing position. Females had a greater difference in both ΔInclination (p=0.02) and ΔAnteversion (p=0.02) in comparison to males.

In the pelvic model, acetabular component orientation. (inclination/anteversion) varied from 38.4°/6.5° to 44.3°/30.3°. The change in cup inclination and anteversion with an increasing pelvic tilt is demonstrated in Figures 2 & 3. There was a linear correlation between acetabular anteversion and pelvic flexion (rho=1.00, p<0.0001). For every degree of pelvic tilt change, as the model moved from an extended pelvic position of -16° to a flexed position of +16°, the anteversion increased by 0.7°.

DISCUSSION
This study highlights the changes in cup orientation that occur between lying and standing position. Cup inclination and anteversion increased upon standing in 12/13 patients. In the patient cohort the mean ΔAnteversion was +4.5°, and since data from the model indicates that every +0.7° change of anteversion reflects a +1° change of pelvic tilt; on average the pelvic tilt changed (i.e. the pelvis flexed) by +6.4° upon standing increasing anteversion. The mean amount of pelvis flexion was greater amongst females rather than males (10° Vs 3°).

REFERENCES:
1. Lewinnek G et al,. Dislocations after total hip replacement arthroplasties. JBJS(Am) 60;217-220, 1978