INTRODUCTION
Dislocation remains a major early complication after total hip arthroplasty (THA), and range of motion (ROM) before impingement is an important indicator of joint stability. Factors contributing to dislocation can be classified as patient-related factors such as bony anatomy, design-specific factors such as head-neck ratio and neck-angle, and surgeon-related factors such as component placement. To study the relative importance of these factors, we analyzed the effects of patient anatomy, implant design, and component orientation on hip ROM.

METHODS
Femoral and acetabular geometry was constructed after segmenting CT scans of 16 hips using MIMICS (Materialise, Belgium). CAD models of four different total hip arthroplasty component designs were obtained from Stryker Orthopaedics (Mahwah, NJ) and virtually implanted in the 3D CT reconstructed anatomic models. The major design differences were in head diameter (28 and 32mm), neck diameter (12.5 and 11mm), and neck-stem angle (127° vs. 132°). A previously reported contact detection model was used to measure restriction in hip ROM due to prosthetic or bony impingement.

RESULTS
On analysis of plain AP radiographs, mean head size was 51±4mm, mean neck diameter was 41±4mm, mean anatomic acetabular inclination was 41°±2, and mean acetabular depth ratio was 460±60. Hip flexion correlated moderately with acetabular abduction angle and the angle of the flare of the iliac wing (R² = 0.59, p = 0.03). Hip abduction correlated moderately with the angle of the flare of the iliac wing and the length of the arc from the tip of the greater trochanter to the ilium (R² = 0.50, p = 0.05).

DISCUSSION
A universal cup position that results in optimal range of motion in all patients may not exist. Aligning the components directly to patient anatomy resulted in excellent range of motion, except in adduction, which was acceptable. Since patient-related factors overshadowed implant design, cup position should be tailored to the individual patient and corrected only to address the direction of restricted range motion (without jeopardizing implant wear performance and interface stability).

In general, subject-to-subject variation was substantially greater than variation between CAD designs (differences in head-neck ratio) or component orientation (between ideal and anatomic). This was due to the fact that bony impingement was more common than prosthetic impingement. Modest gains (∼4°) in range of motion were achieved by increasing head size over the standard 28mm. These gains were most commonly noted in extension and abduction, the directions in which prosthetic impingement was more often the restricting factor than in flexion and adduction.

Preoperative radiographs could not predict postoperative hip ROM as measured on 3D CT reconstructions. The moderate correlation of hip flexion and abduction to some of the plain radiographic measurements was not enough to accurately predict range of motion on a subject-specific basis. These results may lead to enhancements in surgical navigation techniques.

We ignored any influence of soft tissues on hip range of motion. In addition, we only analyzed the range of motion before impingement. Hip dislocation involves levering of the head out of the socket after impingement and a larger head size may improve resistance to dislocation even if the range of motion to impingement remains the same.

REFERENCES
2) Kessler et al, J Orthop Research, 2008

Fig 2: Hip range of motion. When the cup and stem were implanted for best fit to the subject’s anatomy (i.e. aligned to the native acetabular abduction and anteversion and femoral anteversion), excellent range of motion was achieved in almost all directions. In adduction, range of motion was acceptable. Re-aligning the cup to “optimal” surgical recommendations of 45° abduction and 20° anteversion reduced mean hip ROM, mainly in extension and abduction. Increasing head size from 28mm to 32mm increased range of motion between 0 and 3.6° (most commonly in extension and abduction).

Reducing neck diameter only increased extension and abduction (maximum mean increase = 6°). A 127° neck angle had mixed results: modestly increasing flexion at the expense of abduction.

On analysis of plain AP radiographs, mean head size was 51±4mm, mean neck diameter was 41±4mm, mean anatomic acetabular inclination was 41°±2, and mean acetabular depth ratio was 460±60. Hip flexion correlated moderately with acetabular abduction angle and the angle of the flare of the iliac wing (R² = 0.59, p = 0.03). Hip abduction correlated moderately with the angle of the flare of the iliac wing and the length of the arc from the tip of the greater trochanter to the ilium (R² = 0.50, p = 0.05).