Introduction: Elevated-rim liners have been shown to decrease dislocation rates and increase hip stability in total hip arthroplasty[1-3]. However, decreased motion and increased risk of impingement have also been documented with elevated-rim liners[1-3]. With the ideal positioning of the apex of the elevated-rim liner not yet proven, the purpose of this study was to examine the effects of varying elevated-rim liner placement on motion to impingement compared to native range of motion of the normal hip determined from a cadaveric data set.

Materials and Methods: Subjects

Eighteen hips of nine (8 male and 1 female) fresh cadaveric specimens were obtained for this study (average age: 80.6 years and range: 69-94). Ten hips were screened with CT scans and eight hips were screened by the senior author (RLT) by dissection. Eight of the nine specimens were found not to have significant osteoarthritis (OA), hip dysplasia, femoroacetabular impingement (FAI) syndrome or previous surgery providing sixteen hips for ROM comparisons. Cadaveric Specimen Setup and Data Collection BrainLAB reference arrays were affixed to the iliac crest of the pelvis and lateral aspect of the femur for each hip. Soft tissue was removed around the anterior pelvic plane landmarks (bilateral anterior superior or iliac spine (ASIS) and bilateral pubic tubercle (PT) points) and medial/lateral femoral epicondyles to accurately identify the landmarks. An experienced surgeon (RLT) evaluated hip range of motion with the same technique used during total hip arthroplasty surgery to assess range of motion intraoperatively. The study uses three-dimensional (3D) data points to represent the combined motions of the hip of abduction/adduction, flexion/extension and external rotation/internal rotation. The BrainLAB VectorVision® 3.1 Hip Navigation software (BrainLAB AG, Germany) recorded ten 3D data points per second through combinations of hip on the sagittal, coronal and axial planes of motion, and the data was generated in script files. Prosthetic Data Collection Computer aided design (CAD) models of a femoral stem, acetabular cup, 20° elevated-rim polyethylene liner, non-elevated-rim polyethylene liner, 28mm, 32mm and 36mm femoral head prosthetic components were used to reconstruct 3D models within HipNavigation or HipNav (CASurgica Inc., Pittsburgh, PA). The geometries and features of the neck of the femoral stem and acetabular components we used for the study were optimized to minimize the loss of motion.1 Anterior pelvic plane landmarks (bilateral ASIS and bilateral PT points), lesser trochanter, femoral epicondyles, and intramedullary canal were identified to define the body, pelvic and femoral reference coordinate systems for the calculation of hip ROM. All prosthetic components were implanted into a single patient model at the acetabular cup positions of 45° abduction and 20° anteversion and femoral stem position of 15° anteversion. For the 20° elevated-rim liner, seven positions of the apex of the liner were used to compare ROM for left hips (Table 1). HipNav detected impingement and non-impingement points between the prosthetic components of the femoral stem and polyethylene liners for all ranges of motion listed in Table 2. Graphics The output script files from HipNav and VectorVision® were graphed in Maple V Release 5.1 (Waterloo Maple Inc., Ontario, Canada) creating 3D point cloud graphs. The 3D point cloud graphs depicted six motions by having two motions on each axis. Autodesk 3ds Max (Autodesk Inc., San Rafael, CA) and Adobe After Effect 7.0 (Adobe Systems Inc., San Jose, CA) added surfaces to the point clouds to aid in understanding the graphs.

Results: Range of motion of the 16 hips were examined both individually and in a combined point cloud. The combining of specimen ROM data sets were necessary to avoid extrapolation errors to provide a more complete cadaveric ROM point cloud for improved visual comparisons to the prosthetic ROM point clouds. Some exaggeration of ROM was possible using this method, but is negated due to all older male cadavers with little variation between specimens. Table 1 displays the ROM of the non-elevated-rim liner and the elevated-rim liner for each femoral head size and position of the apex of the elevated-rim liner for left hips. For the 28mm femoral head, all 16 hips impinged in all combinations of extension in the 3:00 position, 14 of the 16 hips impinged in both the 4:00 and 5:00 positions and 4 of the 16 hips impinged in the 6:00 position.

Discussion: With the concern of anterior dislocations and impingements without dislocation, it is alarming the large amounts of decreased motion as a result of placing the apex of the elevated-rim posteriorly.2, 3 Malik et al suggested elevated-rim liners should be positioned posteroinferiorly (4:00 position in left hips)