INTRODUCTION
Hemiarthroplasty of the hip is commonly utilized as a bone conserving surgery when the patient has robust acetabular cartilage. Hemiarthroplasty can be unipolar or bipolar. The advantages of bipolar over unipolar hip hemiarthroplasty are the reduction of the shear stress on the acetabular cartilage and increased range of motion [1, 2]. The increased range of motion with bipolar designs can lead to impingement of the femoral component neck with the inner bearing, resulting in contact fatigue and delamination wear of the inner UHMWPE bearing. Furthermore, the inner bearing UHMWPE can undergo articular wear similar to total hip replacement. Historical use of gamma-in-air sterilized UHMWPE bipolar designs has highlighted both of these problems, as shown in the retrieved implant on the right side in Figure 1. The issue of articular wear between the femoral component and the Ultra High Molecular Polyethylene (UHMWPE) insert can be adequately addressed by the use of highly crosslinked UHMWPE (XLPE) inserts. However, because XLPE has lower tensile, fatigue, and toughness properties than virgin (non-irradiated) UHMWPE, the damage associated with neck impingement is less likely to be resolved by their use. This study investigated the performance under neck impingement conditions of XLPE, virgin UHMWPE, and shelf-aged gamma-in-air UHMWPE.

MATERIALS AND METHODS
A test setup was designed to examine the mechanical strength of the UHMWPE liners under severe neck impingement conditions. Standard 32 mm ID THR acetabular cups and liners were used as worst-case analogs of the inner bipolar bearing. CoCr femoral heads were locked onto stems and placed into fixed acetabular constructs, as shown in Figure 2. A biaxial MTS servohydraulic load frame was used to apply axial forces and rotation to the construct. This allowed the femoral necks to impinge against and drag across the UHMWPE liners. The liners (n=5) tested were virgin polyethylene (V-PE), 10 Mrad remelted crosslinked polyethylene (XLPE), and 7 year shelf aged gamma-in-air sterilized polyethylene.

Up to 100,000 axial cyclic loads with peak load values of 75 lbf, 125 lbf, and 200 lbf (stress ratio R=0.1) were applied in concert with 10 degrees of rotational movement.

RESULTS
All liner materials showed signs of severe plastic deformation under the simulated neck impingement test. Cracking near the periphery of the liners occurred in the XLPE and aged gamma-in-air liners, but not in the V-PE liners. The aged gamma-in-air liner exhibited the most material damage under various loads. Table 1 shows the results of the simulated severe neck impingement on both V-PE and XLPE liners under a peak fatigue load of 125 lbf at 12,000 cycles. The deformed area and the area in contact with the stem’s neck for V-PE and XLPE are similar. The length of the deformed peripheral edge of the XLPE is significantly greater than that recorded for the V-PE (p<0.05). The footprints of the neck impingement on the V-PE and XLPE liners are shown in Figure 3.

DISCUSSION
All materials showed severe deformation under simulated neck impingement. The aged gamma-in-air polyethylene showed the most damage. This study demonstrated that the higher tensile, fatigue, and toughness properties of V-PE translate to greater resistance against neck impingement damage. However, the use of V-PE would result in greater articular wear than XLPE. Because bipolar designs afford greater angular range of motion and impingement, there is increased likelihood of dislocation of the inner bearing if it is not sufficiently constrained by a “captured” design. When a captured bipolar design is utilized, this study suggests that unique properties of both V-PE and XLPE can be utilized favorably in a single design. Such a component is shown in Figure 3. An XLPE insert is assembled into an outer CoCr shell, followed by traditional THR inner head. Overlaying this is a V-PE head-capture insert. In such design the inner THR head articulates against XLPE, giving it the requisite wear reduction. And, in cases of neck impingement the V-PE overlay insert would impart greater resistance to fatigue and delamination damage.

REFERENCES