INTRODUCTION:
While it is commonly believed that implants made with design that mimic normal anatomy will provide the best function and durability, most current humeral prosthetic heads have a spherical head shape. Therefore, the purpose of this study was to biomechanically compare a customized semi-elliptical prosthetic head that mimics the non-spherical shape of the native humeral head to a spherical humeral head in shoulder hemiarthroplasty. We hypothesized that the semi-elliptical head will better replicate the biomechanics of the native humeral head than the spherical head after hemiarthroplasty.

METHODS:
Six fresh-frozen cadaveric shoulders were chosen using a custom surgical simulator from CT reconstruction to match the radius and thickness of the native humeral head to the prosthetic humeral heads for the hemiarthroplasty. Soft tissues were dissected while preserving the musculotendinous insertions of the rotator cuff, deltoid, pectoralis major, and latissimus dorsi muscles. The coracohumeral and coracoacromial ligament were also preserved. The specimens were mounted on the custom testing system which allows humeral abduction and axial rotation in multiple planes of elevation under simulated anatomic muscle loading by independently applying loads to each line of action (Figure 1). A proximal humerus splitting technique was used to preserve the glenohumeral joint capsule after hemiarthroplasty. Prior to hemiarthroplasty procedure, the proximal humerus was split longitudinally without violating the glenohumeral joint capsule and securely tied back together using multiple cable ties and tested as a control group. Two different prosthetic heads were implanted in the same stem cemented to preserve the geometric center of the humeral head (Figure 2). Both the semi-elliptical and spherical heads were tested in random sequence. Testing was performed in 0°, 30° and 60° of glenohumeral abduction in the scapular plane (SP), coronal plane (CP), and 30° forward flexion from the scapular plane (FF). Range of motion (ROM) and glenohumeral joint kinematics of the humeral head apex (HHA) and the geometric center of the humeral head (GCHH) of the native-split, semi-elliptical, and spherical heads were measured at rotational positions from maximum internal rotation (IR) to maximum external rotation (ER). A repeated-measures ANOVA with a Tukey post hoc test was used for the statistical analysis.

RESULTS:
The semi-elliptical head had no statistical differences in ROM at all abduction angles compared to the native-split head (p<0.05), while the spherical head significantly decreased IR by 7.3° at 0° of abduction (p=0.03) and by 5.7° at 30° of abduction in the SP (p=0.009), and ER by 7.3° at 30° (p=0.048) and by 9.3° at 60° of abduction (p=0.012) in the CP. A statistical difference between the semi-elliptical and native-split head in the HHA position was only found in mid-IR at 60° of abduction in the SP (p=0.028). Statistical differences between the spherical and native-split head in the HHA were found in max-ER at 0° of abduction (p=0.022), 30° of abduction in FF (p=0.038), and 60° of abduction in the SP (p=0.03) and the CP (p=0.037). Similar to the HHA positions, all the statistical differences in the GCHH location between the spherical and native-split head were found in ER at 30° of abduction in the SP anteriorly (p=0.028) and superiorly (p=0.047), 30° of abduction in the CP anteriorly (p=0.011) and superiorly (p=0.04), and 60° of abduction in the CP anteriorly (p<0.001), while the semi-elliptical head showed significant difference in max-ER at 30° of abduction in the SP anteriorly (p=0.038) and mid IR at 30° of abduction in FF inferiorly (p=0.039).

CONCLUSION:
Under simulated anatomic muscle loading condition with intact glenohumeral joint capsule, the semi-elliptical head provided a superior rotational range of motion while more closely replicating the native-split HHA and GCHH kinematics compared to the spherical head.

SIGNIFICANCE: A semi-elliptical humeral head shape for shoulder hemiarthroplasty may improve rotational range of motion and kinematics at the extremes of motion.