INTRODUCTION:
While often treated non-operatively, certain displaced scapular fractures have shown improved clinical results with open reduction and internal fixation [1, 2]. Common methods of internal fixation for fractures of the scapula include non-locking and locking fracture plates. Locking scapula plate designs have several advantages over other repair techniques. First, they are site-specific and pre-contoured, which reduces soft-tissue irritation. Soft-tissue irritation is a common patient complaint, ultimately resulting in revision surgery in 7.1% of all scapular fracture cases [3]. A second advantage of locking plate designs is that the fixed angle design also helps create a more stable construct in thin cortical bone. Lastly, the anatomical fit of the locking scapula plates allows for reconstruction of comminuted fractures.

Good anatomical fit between the plate and the bone is needed to reap the aforementioned benefits of the locking scapula plate design. The purpose of this study is to evaluate congruency of current scapula plate designs on multiple subjects. Cadaveric scapulae were CT scanned in torso and measurements of congruency were made virtually using 3D image processing software. Cadaveric specimens were used due to the difficulty in obtaining CT scans of healthy scapulae from clinical patients. Four plates were investigated to focus efforts on design improvements (Figure 1).

METHODS:
A total of twelve scapulae within six fresh frozen cadaveric torsos were CT scanned using a clinical scanner (MX8000 IDT 16 CT, Philips) with slice thickness of 1mm in 0.5mm increments and 0.57mm/pixel in-phase spatial resolution. The scans were imported into a commercial 3D image processing software system (Mimics 12.1, Materialise) to create 3D triangulated surface mesh reconstructions of the scapulae (1.5mm/side approx. triangle size).

Locking scapula plates (Acumed, Hillsboro, Oregon) were scanned using a 3D digitizer (680x480 pixels, Vivid 9i, Konica-Minolta) to create computer-aided design (CAD) representations of the hardware. Four pairs of plates (left and right) were scanned: glenoid (G), medial border (MB), lateral border (LB), and scapular spine (S). Each plate was then virtually applied onto its respective location on the scapula by a trained orthopaedic surgeon (see Figure 1).

Plate congruency was quantified for each specimen using commercial 3D image analysis software (3-Matic, Materialise). The order of operations was as follows. First, the back surface of the plate was projected onto the scapula in the direction normal to the plane of the plate creating a volume of the gap. Then, the perpendicular distance of this volume was obtained at every triangle in the mesh (Figure 2).

RESULTS:
The scapular spine plate had the highest P2 and well as the lowest mean gap distance. Statistically significant differences were found between this plate and the glenoid and medial border plates, but it was similar in both mean distance and P2 to the lateral border plate. The medial border plate had the highest mean distance as well as the lowest P2.

DISCUSSION:
Overall, the medial border plate performed the worst in terms of anatomic fit. However, the plates for the scapular spine, lateral border, and glenoid showed acceptable precontoured fit when analyzing mean distance to plate and percentage of plate within 2mm of the bone (P2). The medial border plate presented the greatest challenge for placement. The bend and rotation of the plate attempting to contour to the medial border and inferior surface of the spine creates a complex relationship. The angle of the plate along the medial border and spine also did not seem to correlate well with the angles of our specimens. We found the angle of the plate to be excessively acute in most cases. This likely explains the least appropriate fit measurements in our study.

A similar study by Schmutz et al looking at a virtual fit assessment of distal medial tibia plates had similar results with regard to percentage of plate fitting within 2mm from bone [4]. With 21 specimens, this percentage ranged between 19 and 60 with a mean of 39.8%. Our data shows plates conforming within a comparable range.

With locking plate technology being used in a widespread variety of anatomic locations, the locking scapula plate system can allow for a fixed-angle construct, which can help minimize soft tissue irritation, guide reduction, and reduce operating room time. This study shows that the glenoid, lateral border, and scapular spine plates are adequate in terms of congruency. However, design improvements may be necessary for the medial border plate. Future work for this study includes an increase in sample size.

REFERENCES: