INTRODUCTION
With improvements in arthroscopic techniques and injury recognition, arthroscopic subscapularis tendon repair has become more popular. Although these techniques are being used clinically, the relative strength of arthroscopic versus the traditional, open techniques has yet to be investigated for the subscapularis tendon. Previous biomechanical studies have focused on the supraspinatus tendon and have yielded mixed results in terms of the relative strength of open versus arthroscopic repairs. Past studies have also utilized memory-based pressure films that are less accurate in the analysis of real-time pressure and area measurements. The goal of this study was to compare the biomechanical performance of open, transosseous fixation (TO) with that of the arthroscopic, single-row suture anchor (SA) technique for subscapularis repair. Physiologic loading conditions for the subscapularis tendon, namely external rotation, were simulated, and repair site integrity was directly assessed via repair site gap formation and tendon-bone contact pressure profiles.

METHODS
Six matched pairs of human cadaveric shoulders (68 ± 12 y.o., 4 male, 2 female) were dissected, leaving the rotator cuff muscles and tendons intact. The subscapularis was then elevated from the scapula and separated from the surrounding muscle. For each pair of shoulders, right and left shoulders were randomly assigned to one of two treatment groups: 1) a single-row suture anchor repair (SA) with two 5.0 mm titanium corkscrew anchors with double loaded No. 2 FiberWire (Arthrex, Naples, FL), tied using arthroscopic technique with a sliding double half hitch knot and 4 alternative half stitches, and 2) a transosseous (TO) repair with three bone tunnels and Modified Mason-Allen stitches tied using the horizontal mattress configuration. All operations were performed by a single orthopaedic surgeon.

Subscapularis repair constructs were mechanically tested in external rotation. The distal end of the humerus was cast in potting material (Smooth Cast 300, Smooth-On) and attached to the rotational actuator of a hydraulic press (MTS Bionix 858, MTS, Eden Prairie, MN). To grip the subscapularis tendon during mechanical testing, the medial aspect of the tendon was attached to a 2.5 cm-wide nylon strap with a modified Krackow stitch using No.2 FiberWire sutures (Figure 1). The strap was then gripped with a soft tissue fixation system using two distally located screws to ensure fixation. The clamp was mounted in-line with a uniaxial load cell (SSM-500, Interface Force Measurements). The clamp and load cell were positioned to hold the subscapularis at the anatomically correct position with respect to the humerus. The repairs were preloaded to 60 N before being cyclically loaded in external rotation under force control from 76 to 183 N at 0.1 Hz for 50 cycles. This was immediately followed by torque to failure at a rate of 0.5 mm/sec.

RESULTS
Results for all metrics are presented in Table 1. SA and TO repair techniques were statically equivalent (p>0.05 for differences) for all metrics except conditioning elongation. The conditioning elongation of TO repairs was found to be significantly lower than that of SA repairs (0.64 ± 0.40 mm vs. 2.38 ± 1.58 mm, respectively; p<0.05 paired t-test; Figure 2). Pressure sensors provided real-time pressure area and peak pressure analysis. Both techniques failed to restore the original anatomic footprint (94.2 ± 37.4% TO; 65.9 ± 27.9% SA). There were also no significant changes in peak-to-peak contact area variation despite differences in elongation.

DISCUSSION
The results of our study demonstrated that while TO and SA repairs have the same ultimate strength, the former technique may allow for less gap formation during repetitive, physiologic loading. This finding may be due to the greater number of fixation points established by the TO technique. However, neither TO nor SA repairs restore the tendon’s original anatomic footprint. Despite increased conditioning elongation in SA repairs, there was no significant difference in peak-to-peak contact area variation between the two techniques. This finding may have implications for post-operative rehabilitation, as external rotation may not change the contact area of the repair.

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