INTRODUCTION:
Currently, a vast array of rotator cuff anchors, stitch types, and configurations exist for arthroscopic rotator cuff repair. To date, there is little data that proves one repair construct or anchor system is superior to another (1-3). Therefore, a biomechanical analysis was undertaken to examine several constructs currently utilized using both single row and double row configurations.

METHODS:
Fourteen pairs of human cadaveric shoulders (mean age 58.6; range 28-81 years) were used to investigate four repair techniques in matched pair fashion (Figure 1). Seven pairs were repaired with one of two single-row methods, Parafix or Smartstitch/Magnum 2 (OPUS) (Arthrocare Corp., Austin TX). The single-row repairs consisted of anchors being placed at the anterior and posterior edges of each tendon and the third equally spaced between the first two. Suture was passed 13 mm from the lateral edge of the tendon and either hand tied (Parafix, P-SR) or secured with knotless anchors (OPUS, O-SR). Another seven pairs, for the double-row group, were configured with a medial row of two hand-tied Biocork anchors loaded with Fiberwire (Arthrex, Naples FL) placed at the articular junction. The lateral anchors of one double row group (O-DR) consisted of two independent knotless (OPUS) anchors (4) again placed 13 mm from the lateral edge of the tendon. The other double row group (A-DR) had the medial row tails criss-crossed and secured laterally with “push-locks” (Arthrex, Naples FL).

The humerus was then transected at 6 cm below the inferior border of the humeral head and potted with PMMA in a 6 cm long section of 2” dia. PVC pipe. It was then mounted in a custom-designed fixture on an Instron model 1321 material testing machine (Instron Corp., Canton MA) retrofitted with TestStarII digital controller (MTS Corp., Eden Prairie MN). The supraspinatus tendon was secured to the Instron actuator shaft with custom-designed cyroclamps and the humerus fixed at 45 deg to result in properly directed tendon loads. For noncontact measurements of repair displacement, black glass beads were adhered medially adjacent to the repair on the supraspinatus tendon and laterally on the stationary bone adjacent to the tendon edge. Each specimen was first loaded at 1 mm/sec until 180N, then cyclically loaded from 10 to 180N at 0.5 Hz for 500 cycles (1.2). They were then loaded at 1mm/sec until failure of the repair was achieved. Digital recordings of bead movement during tests (Panasonic PV-GS35 Digital Pcmorder, Panasonic Corp. of North America, Secaucus NJ) were analyzed via NIH Image-J 1.33U software and its associated Object Tracker plug-in (National Institutes of Health, Bethesda MD) to quantify residual repair displacement at the end of cyclical loading and repair displacement during the failure test. Stiffness was calculated from the failure test as the slope of the load versus repair displacement curve. The effect of repair method on cyclic repair displacement, stiffness, and load to failure were analyzed via incomplete blocked ANOVA. If a significant effect was achieved (p<0.05), a Tukey-Kramer post-hoc pairwise comparison was performed to analyze differences between repair methods.

RESULTS:
Single-row repairs behaved similarly during biomechanical evaluation with only about half of the specimens surviving cyclic testing before being loaded to failure (four of seven for P-SR, three of seven for O-SR). All double-row specimens survived cyclic loading and were loaded to failure. For residual repair displacement due to cyclic loading, repair method was not shown to have a significant effect (ANOVA p>0.3) (Table 1). Stiffness evaluated from 50N to 200N during load to failure revealed no significant effect of repair method (ANOVA p>0.5) (Figure 2). A trend toward an effect for peak load during load to failure was indicated (p=0.052) (Figure 2).

DISCUSSION:
This study examined commonly performed techniques for rotator cuff repair. The similarity in stiffness between single-row and double-row configurations and the modestly higher residual repair displacement of the double-row configuration can likely be attributed to two factors. Firstly, there were three-strands in the single-row and two-strands in the double-row configurations. The additional strand may have resulted in comparable stiffness for the single row constructs. Further, additional knots used for the anchor system in the double-row configurations may have initially required more cinching down on the suture. However, it remains that only 50% of the single-row repairs survived 500 cycles. The results of this study suggest that double row repairs have more consistent performance in cyclic loading. For highest repair strength and maximal load at failure, this study implies that the double-row is superior to the single-row configurations. The two double-row repairs that were tested showed no significant difference between configurations when comparing displacement during cyclical loading, stiffness and load to failure.

<table>
<thead>
<tr>
<th>Repair Method</th>
<th>Stiffness (N/mm)</th>
<th>Peak Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-SR</td>
<td>4.9 (1.8)</td>
<td>750</td>
</tr>
<tr>
<td>O-SR</td>
<td>5.5 (2.6)</td>
<td>625</td>
</tr>
<tr>
<td>O-DR</td>
<td>7.2 (2.5)</td>
<td>700</td>
</tr>
<tr>
<td>A-DR</td>
<td>7.0 (1.9)</td>
<td>700</td>
</tr>
</tbody>
</table>

REFERENCES:

ACKNOWLEDGEMENTS:
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