INTRODUCTION:
Gap formation is a common and severe complication after flexor tendon repair that can affect the outcome and prolong tendon healing. A gap of 3 mm can cause a repaired tendon to fail to glide, or to rupture, due to catching on the pulley edge[1]. The purpose of this study was to investigate the effect of a pre-tensional force applied to the suture during tendon repair on the repair strength and gap formation.

METHODS:
A total of 48 flexor digitorum profundus (FDP) tendons from 12 human cadaver hands were used following IRB approval. The tendons were dissected and cut 50 mm proximal to their insertion. A core tendon suture (Ethibond 3-0) was introduced into the proximal and distal tendon ends separately using the modified Pennington looping technique. The sutures in each tendon end were loaded by hanging a weight for 10 seconds, and then the two tendon ends were connected using a two strand overhand knot plus 2 square knots (Figure 2). Subsequently, and finally, a running suture (Prolene 6-0) was applied (Figure 1). Four different loads were selected: 0 N, 5 N, 10 N and 15 N, for the comparison effect of loading magnitude.

After repair, the tendon was mounted on a servohydraulic testing machine (MTS Systems, Eden Prairie, MN) The specimens were gripped at the repair site. (Figure 3) The tendons were distracted at a rate of 20 mm/min until complete rupture of the repair site had occurred. A displacement sensor (DVRT, Microstrain, Williston, VT) was attached just above and under the core suture (approximately 15mm deep). A machine (MTS Systems, Eden Prairie, MN) The specimens were gripped ends separately using the modified Pennington looping technique. The tendons were distracted at a rate of 20 mm/min until complete rupture of the repair site had occurred. Throughout testing, tendons were kept moist with saline mist. The measured gap formation was compared for different amounts of tension load.

The outcomes analyzed included force at gaps of 1, 2 and 3 mm; the peak force; and the gap at peak force. Separate analyses were performed for each outcome. Because each of the 12 cadavers contributed 4 digits to the experiment, each outcome was analyzed using a one-way repeated measures analysis of variance (ANOVA) to evaluate the association of the amount of suture pre-load with the outcome. Significant results were analyzed further using a multiple comparisons procedure. All statistical tests were two-sided and p-values less than 0.05 were considered statistically significant.

RESULTS: (Table 1, Figure 4)

<table>
<thead>
<tr>
<th>Force at 1mm gap</th>
<th>0N preload</th>
<th>5N preload</th>
<th>10N preload</th>
<th>15N preload</th>
</tr>
</thead>
<tbody>
<tr>
<td>F at 1mm</td>
<td>36.8N</td>
<td>30.5N</td>
<td>36.1N</td>
<td>40.0N</td>
</tr>
<tr>
<td>(SD 11.7)</td>
<td>(SD 16.2)</td>
<td>(SD 11.2)</td>
<td>(SD 16.6)</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION:
The force needed to reach a 2 mm gap after flexor tendon repair increases as the pre-tension applied to the suture/tendon interface increases, and is the highest when a 15 N preload is applied to the sutures before tying the knot. The force needed to reach a 3 mm gap is significantly higher if any preload is applied, and is the highest at 10 N preload. 10 N to 15 N pre-tension appear to be the most effective to eliminate tendon gap formation.

The peak force sustainable by the repair also seems to be improved by pre-tensioning the sutures before tying the knot. The peak force increases as the pre-tension increases, and is the highest when a 15 N preload is applied.

SIGNIFICANCE:
These findings suggest that pre-tensioning a suture at the suture/tendon interface before tying the knot has a beneficial effect on both the tendon gap formation and the peak force before failure. These findings also suggest that a pre-tension of 10 N to 15 N is most effective.

ACKNOWLEDGEMENTS:
This study was funded by a grant from the Mayo Foundation.

REFERENCES: