The Effect of Core Suture Technique and Type on the Gliding Resistance during Cyclic Motion Following Flexor Tendon Repair: A Cadaveric Study

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INTRODUCTION:
The ideal method of tendon repair must provide not only strength but also smoothness. FiberWire® (Arthrex, Naples, FL), a suture made from long-chain polyester in a braided polyester jacket, has been found to have superior strength in materials testing and other studies. Previous research has demonstrated that 3-0 FiberWire has a lower frictional coefficient than 3-0 coated, braided polyester (Ethibond, Ethicon, Somerville, NJ). The friction of the MGH repair was reported to be significantly higher than that of modified Kessler repair because the MGH repair had more suture material exposed outside the tendon surface. The size of suture material is also important. One study reported that a 3-0 Ethibond suture was 41% stronger than a 4-0 Ethibond suture when human FDP tendons were repaired using a modified Kessler technique. However, thicker suture add bulk to the repair and may increase the resistance to tendon gliding. The purpose of this study was to investigate the effects of two different core suture designs using three different suture types on tendon gliding resistance and tendon repair strength, using a human cadaver model of zone 2 repair and 1000 cycles of simulated tendon motion.

METHODS:
A total of 60 flexor digitorum profundus (FDP) tendons from the 2nd, 3rd, 4th, and 5th digits of human cadavers were dissected with their associated FDS, A1/A2 pulley complex and the proximal and middle phalanges, which were fixed with a Kirschner wire and then randomly assigned to six groups. We measured the gliding resistance using the method of Uchiyama et al., before and after repair during 1000 cycles of simulated flexion-extension motion, linear breaking strength and resistance to gapping of six different tendon repair constructs: the modified Kessler repair using 3-0 coated, braided polyester (Ethibond, Ethicon, Somerville, NJ) (3-0 Ethibond MK), 3-0 coated, braided polyester/nonfilament polyethylene composite (FiberWire, Arthrex, Naples FL) (3-0 FiberWire MK) or 4-0 FiberWire (4-0 FiberWire MK); and the Massachusetts General Hospital (MGH) repair using 3-0 Ethibond (3-0 Ethibond MGH), 3-0 FiberWire (3-0 FiberWire MGH) or 4-0 FiberWire (4-0 FiberWire MGH). (Figure 1) All core and epitenoid suture knots were formed from reef knots (1=1=1).

These two factors (suture technique and suture material/caliber) were analyzed using two-factor analysis of variance (ANOVA). Because four digits from one hand of 15 unique cadavers were used, it was necessary to account for the within-cadaver correlation among the digits in the analysis. This was accomplished utilizing generalized estimating equations (GEE) in a generalized linear models framework. Separate analyses were conducted at each of 3 levels of testing cycle (1, 100 and 1000) and also after normalizing the results to the results of the intact state. Strength and stiffness were analyzed in the same manner. In addition, the effect of testing cycle was evaluated separately for each experimental condition using one-factor ANOVA. For each model, contrast statements were generated to perform pairwise testing of each level of the independent variables. All statistical tests were two-sided and the threshold of statistical significance was set at \( \alpha = 0.05 \).

RESULTS:
Gap formation was not observed after any repair. The 3-0 Ethibond MGH suture had significantly higher gliding resistance than the 3-0 FiberWire MGH suture (p=0.039) and the 4-0 FiberWire MGH suture (p<0.0001) at 1000 cycles. The 3-0 Ethibond MGH suture had significantly higher maximum strength than the 3-0 FiberWire MK suture (p=0.046) and the 4-0 FiberWire MK suture (p=0.0001). The 3-0 FiberWire MGH suture and the 4-0 FiberWire MGH had significantly higher maximum strength than the 3 MK groups respectively. The gliding resistance of the three MGH groups was significantly higher than that of the three corresponding MK groups. The differences in gap force at 2 mm, maximum strength and stiffness were not statistically significant. (Table 1)

DISCUSSION:
The MGH repair has more gliding resistance than an MK repair, even when comparing large diameter suture in the MK repair with smaller diameter suture in the MGH repair. In this study, suture design (MGH vs MK) was more important in predicting repair strength and gliding resistance than the nature or caliber of the suture material that was used.

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Figure 1. Schematic drawings of the two core suture methods.

A. The modified Kessler suture
B. The MGH suture

Figure 2. Mean gliding resistance of the FDP tendons in the six groups at different cycles of tendon motion.

Figure 3. Left: mean gliding resistance of the FDP tendons in the MK and MGH sutures for intact tendons and repaired tendons at 1, 100 and 1000 cycles. Right: mean force for 2 mm, maximum strength and stiffness in the two groups.

Table 1. Gliding resistance, force for 2mm gap, maximal failure strength and stiffness (Mean±SD)

<table>
<thead>
<tr>
<th>Suture method</th>
<th>Gliding resistance (N)</th>
<th>Force for 2mm gap (N)</th>
<th>Maximal failure strength (N)</th>
<th>Stiffness (N/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-repair</td>
<td>[0.24±0.13]</td>
<td>[0.87±0.31]</td>
<td>[32.8±15.26]</td>
<td>[28.7±9.68]</td>
</tr>
<tr>
<td>1 cycle</td>
<td>[0.31±0.13]</td>
<td>[0.81±0.27]</td>
<td>[31.7±10.92]</td>
<td>[41.7±7.67]</td>
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<tr>
<td>100 cycles</td>
<td>[0.25±0.14]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
</tr>
<tr>
<td>1000 cycles</td>
<td>[0.26±0.13]</td>
<td>[0.78±0.24]</td>
<td>[28.6±4.97]</td>
<td>[54.3±7.37]</td>
</tr>
<tr>
<td>3-0 Ethibond MK</td>
<td>[0.25±0.13]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
</tr>
<tr>
<td>3-0 FiberWire MK</td>
<td>[0.26±0.16]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
</tr>
<tr>
<td>3-0 FiberWire MGH</td>
<td>[0.26±0.13]</td>
<td>[0.78±0.24]</td>
<td>[28.6±4.97]</td>
<td>[54.3±7.37]</td>
</tr>
<tr>
<td>4-0 FiberWire MK</td>
<td>[0.26±0.13]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
</tr>
<tr>
<td>4-0 FiberWire MGH</td>
<td>[0.26±0.13]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
</tr>
<tr>
<td>5-0 FiberWire MK</td>
<td>[0.26±0.13]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
</tr>
<tr>
<td>5-0 FiberWire MGH</td>
<td>[0.26±0.13]</td>
<td>[0.81±0.24]</td>
<td>[29.5±6.54]</td>
<td>[59.8±7.56]</td>
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