REPAIR OF FLEXOR DIGITORUM PROFUNDUS TENDON AVULSIONS FROM BONE: AN EX-VIVO BIOMECHANICAL ANALYSIS

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INTRODUCTION: Avulsions or distal transections of the flexor digitorum profundus (FDP) tendon are typically repaired by direct suture of the tendon to the distal phalanx. The mechanical requirement of tendon-bone repairs is that they be able to withstand forces generated during post-operative rehabilitation(1) without allowing gap formation, suture pullout or suture rupture. The optimal repair technique to withstand these in-vivo forces, however, is unknown. Our objective was to determine the time zero tensile mechanical properties of four-strand tendon-bone repair site constructs carried out with 3-0 and 4-0 sutures, and with modified Kessler and modified Becker grasping techniques. We hypothesized that the 3-0 modified Becker grasping suture, a technique not described previously for the reattachment of tendon to bone, would demonstrate improved biomechanical properties compared to the 4-0 or modified Kessler techniques.

METHODS: Forty canine hindpaw digits were harvested immediately after sacrifice, and were stored at -20º C prior to simulated avulsion, repair and tensile testing. Digits were thawed to room temperature, and the FDP tendon was transected sharply from its insertion on the distal phalanx. Using a randomized assignment, tendons were repaired to bone using either a 3-0 or 4-0 suture (Supramid, S. Jackson Inc., Alexandria VA) and either a modified Kessler or modified Becker four-strand grasping technique (Figure 1). All sutures were passed through the distal phalanx using Keith needles and were tied over a dorsally placed button. Tendon-bone repairs were tested to failure in tension (Instron 8500R). Ultimate force, rigidity, strain at 20N and strain at failure were recorded. Analysis of variance was performed to determine the effect of suture caliber and grasping technique on biomechanical measures.

RESULTS: All modified Kessler repairs failed by suture pullout from the tendon, whereas all modified Becker repairs failed by rupture of the suture at the tendon-bone junction. The 3-0 modified Becker repair group demonstrated significantly greater ultimate failure force than the other groups (p<0.01) (Figure 2), and greater rigidity than both 3-0 and 4-0 modified Kessler repair groups (p<0.05). Becker repairs had reduced strain at failure compared to Kessler (p=0.004). In contrast, strain at 20N did not significantly differ between groups. Data are summarized in Table 1.

DISCUSSION: In this time-zero comparison of modified Kessler and modified Becker tendon-bone repairs performed using 3-0 and 4-0 sutures, we noted several consistent findings: 1) The four-strand modified Becker grasping suture performed with 3-0 Supramid demonstrated significantly higher failure force than other techniques tested, and improved repair site strength when compared to conventional techniques of tendon-bone reattachment. 2) The ultimate strength of the modified Becker grasping suture performed with 3-0 suture was significantly greater than the force needed to withstand early active digital motion following surgical FDP-bone reattachment(2). 3) Neither suture caliber nor repair technique had a significant effect on strain at 20N force, suggesting that early gap formation at the tendon-bone repair site may occur regardless of technique. The clinical relevance of this finding is not known. 4) The clinically significant increase of repair site strength demonstrated by the modified Becker technique using 3-0 suture may allow more aggressive post-operative rehabilitation regimens to be utilized following the repair of FDP avulsions.

<table>
<thead>
<tr>
<th></th>
<th>BECKER 3-0</th>
<th>BECKER 4-0</th>
<th>KESSLER 3-0</th>
<th>KESSLER 4-0</th>
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<tbody>
<tr>
<td>RIGIDITY (N/(mm/mm))</td>
<td>145.6 * ± 34.5</td>
<td>120.0 ± 22.0</td>
<td>107.8 ± 23.7</td>
<td>92.2 ± 15.6</td>
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<td>STRAIN AT 20N (%)</td>
<td>22.8 ± 6.2</td>
<td>24.8 ± 4.2</td>
<td>23.1 ± 6.6</td>
<td>28.7 ± 6.7</td>
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<td>STRAIN AT MAX (%)</td>
<td>56.6 * ± 12.2</td>
<td>51.6 * ± 9.4</td>
<td>75.3 ± 17.1</td>
<td>66.6 ± 20.1</td>
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*P<.05 compared to Kessler groups
Table 1: Summary of biomechanical data (Mean +/- SD)

Figure 1: Illustration of the two suture techniques: four-strand modified Becker repair and four-strand modified Kessler repair.

Figure 2: Ultimate failure force vs. suture size and technique (Mean & SD). * P<0.01


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