GLIDING RESISTANCE OF FLEXOR TENDON WITH DIFFERENT KNOT LOCATION, SUTURE MATERIAL AND SIZE

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Introduction: Newer multiple-strand suture techniques have been developed to increase the tensile strength for the application of early controlled passive and active mobilization. With some multiple-strand suture methods the repair site becomes bulky and knots are made on the tendon surface. In the Kessler technique there are two knots on the lateral side of the tendon. In the Tsugé technique there is one knot on the volar side of the tendon. In the augmented Becker technique there are two knots on both sides. A knot located within the laceration site has a theoretical benefit of less friction, and thereby perhaps decreased adhesion formation (1). Knots interrupt smooth excursion as they pass beneath the pulley. The purpose of this study was to investigate the effect of knot location, suture material and suture size on gliding resistance between pulley and flexor tendon.

Materials and Methods:

Study 1: 72 flexor profundus tendons from 9 dogs were used. The dogs were sacrificed for other purposes. The second, third, fourth and fifth digits of each hindpaw were dissected. The flexor digitorum profundus (FDP), A2 pulley and proximal and middle phalanx were preserved. Six different suture materials and sizes were used: 4-0 Nylon (N4), 4-0 Mersilene (M4), 4-0 Ticron (T4), 5-0 Nylon (N5), 5-0 Mersilene (M5), 5-0 Ticron (T5). In this study six randomly selected tendons were used for each suture. Each specimen was mounted on a previously described and validated gliding resistance testing machine (3). Load transducers were positioned on the distal (F1) and proximal (F2) ends of the tendon. The proximal transducer was attached to the mechanical actuator and the distal transducer was attached to a 500g weight. With the arc of contact fixed at 50 degrees, the tendon was moved toward the actuator (flexion) and then moved distally (extension) and the load and excursion were recorded. The gliding resistance between pulley and intact flexor tendon was initially measured in the saline bath. Then using random assignment, the knots were made on either the volar surface, on one lateral side, or on both lateral sides of flexor tendon and the gliding resistance was remeasured.

Fig. 1 1) knot on volar side  2) knot on one side  3) knot on both sides

Each knot was tied three times, with the first tie of a double loop (surgeon’s knot). The average difference between the tensions F2 and F1 was the gliding resistance of tendon with knot under pulley was measured. A three factor analysis of variance was used to detect differences due to suture material, suture size and knot location.

Study 2: Friction coefficients of the three suture materials (4-0 Nylon, 4-0 Mersilene and 4-0 Ticron) against a Nylon rod were measured using the same testing machine. Tension F1 and F2 were measured for five positions of the arc of contact (20°, 30°, 40°, 50°, 60°). The natural log of F2/F1 was plotted against the arc of contact and the slope represented the friction coefficient.

Results: The average gliding resistance of tendon with a volar knot was 47.7g, with a knot on one side was 36.1g, and with a knot on both sides was 64.4g. The average gliding resistance using 4-0 and 5-0 suture size was 60.0g and 38.8g, respectively. All differences between knot location and size groups were statistically significant (p < 0.001) (Fig. 2). The average gliding resistance of tendons using Nylon suture was the lowest, followed by Ticron and Mersilene suture (p < 0.01). The friction coefficient of monofilament Nylon was lower than that of the braided polyester sutures Ticron and Mersilene (Table 1)

Discussion: Factors causing high gliding resistance of a tendon repair include knots on the tendon surface, increased tendon volume, and irregularity of repair site. Using multiple-strand suture methods, the repair site is apt to become bulky and increase tendon volume. Knots on the tendon surface must pass through the pulley canal thereby disturbing smooth passage. Knot triggering at the pulley entrance is a main gliding resistance (3) The gliding resistance of tendon with a volar knot is higher than that with a lateral knot because the volar knot was caught at the pulley entrance easier than the lateral knot clinically. Triggering of knots at the pulley entrance may reduce tendon excursion during postoperative mobilization. Poor excursion in turn may induce adhesion formation. The placement of knots and choice of suture materials affects gliding resistance following suture repair. The combination of one lateral knot with smaller suture size and low friction suture materials was the best for promoting tendon excursion. This combination may be preferential in considering various tendon repair constructs. Nylon suture, having not only a higher breaking strength than polyester (4) but also lower gliding resistance may deserve renewed consideration in tendon repair.

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Table 1 Friction coefficient of three suture materials

<table>
<thead>
<tr>
<th>Suture Material</th>
<th>Nylon</th>
<th>Ticron</th>
<th>Mersilene</th>
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<tbody>
<tr>
<td>Friction coefficient</td>
<td>0.108</td>
<td>0.129</td>
<td>0.130</td>
</tr>
<tr>
<td>R²</td>
<td>0.908</td>
<td>0.979</td>
<td>0.995</td>
</tr>
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