GLIDING CHARACTERISTICS AFTER FLEXOR TENDON REPAIR IN CANINE IN VIVO

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Introduction
Surface characteristics of the flexor tendon can have important consequences that affect the outcome of tendon repair surgery, especially in zone 2, where two flexor tendons slide within a fibro-osseous pulley system. A smooth surface may not only decrease friction but also may decrease damage to the gliding surface due to abrasion and adhesion. The gliding resistance between the tendon and pulley is one way to quantify the quality of the tendon surface. Although gliding resistances for various suture techniques have been investigated in vitro, the effects of repair method and postoperative therapy on the gliding surface have not been reported in vivo.

Material and Methods
Adult mongrel dogs were used in this study. In each, one forelimb was operated on. A radial neurectomy was performed to prevent postoperative weight bearing on the operated limb. The second and fifth flexor digitorum profundus (FDP) tendons were exposed between the proximal and distal ends. The laceration was such that the repair site would pass beneath the proximal annular pulley during digit flexion and extension. Each tendon was then repaired with either a modified Kessler (MK) (5-0 Ticron) or Becker (MGH) (5-0 nylon) core suture technique and supplemented with a circumferential epitendon simple running suture (6-0 nylon). In half the dogs, the wrist was fixed with a 3 mm threaded K-wire in about 45 degrees flexion (FIX group), while the other half were allowed free wrist movement. Rehabilitation was performed for 5 minutes daily starting on the first day postoperatively, with passive motion of the operated digits from full flexion to full extension in the FIX group and a synergistic wrist motion (passive extension of the digits with wrist flexion, passive flexion of digits with wrist extension) (SWM) in the wrist free groups. The dogs were sacrificed at 1, 3, or 6 weeks postoperatively. After sacrifice, the operated digits were dissected with the FDP, FDS tendons, and proximal pulley preserved. Then, the gliding resistance between the FDP and proximal pulley was measured using the method of Uchiyama et al. The normal contralateral paws served as controls, after which the same procedures were performed with the modified Kessler and MGH suture techniques and the gliding resistance was tested again. Therefore, in total there were total of five conditions, including intact, immediately after repair (0 time), 1 week, 3 weeks, and 6 weeks after surgery, two repair types, and two rehabilitation methods, making a total of 20 groups in all. There were 11 digits in each group. Ten digits in each group were tested for gliding resistance, while one specimen from each group was fixed in 4% paraformaldehyde in phosphate buffer, dehydrated in graded ethanol and a critical point dryer, glued onto stubs, coated with gold in a SCD040 Balzer Sputterer and viewed by a Hitachi 4700 scanning electron microscope (SEM) at 10-30 kV.

Results
The gliding resistance after tendon repair significantly increased from normal for both suture techniques at all time points (p<0.05). The gliding resistance at 0 time was greater than at 3 and 6 weeks for both suture techniques and for the MK suture at one week (p<0.05). Within repair type there were no significant differences between therapy groups at any time point, except for the MGH suture technique at six weeks, in which the SWM group was significantly less than the FIX group (p<0.05). Comparing the two different suture techniques, the gliding resistance of the MK repair was significantly less than that of the MGH repair in all of the groups (p<0.05) except at 6 weeks in the SWM group (Fig.1).

Discussion
A partial laceration model was used so that coaptation would be more nearly perfect, and so that we could isolate the factors of repair surface effect and postoperative therapy from such confounding features as repair strength, repair bulk at the suture line, and accuracy of repair coaptation. We observed that the gliding resistance was a reflection of the roughness of the gliding surfaces of the tendon and pulley. This work also suggests that the gliding surface starts remodeling soon after surgery. With the MK suture technique, gliding resistance significantly decreased within one week of surgery. However, with the MGH repair, there was no significant difference until three weeks, suggesting that the higher frictional suture technique might delay gliding surface remodeling. Based on the SEM images, we believe that surface remodeling started with tissue formation at the conjunction of the suture and tendon which made this confluence smoother. Over time, the suture material became completely or nearly completely covered by this tissue (Fig. 2).

Conclusions
The gliding surface after tendon repair undergoes remodeling with time. A higher friction suture technique may delay this process due to resulting roughness of the tendon and pulley surfaces. In this study a lower friction repair combined with higher excursion postoperative therapy was associated with visibly smoother gliding surfaces and significantly lower gliding resistance than a higher friction/lower excursion alternative. We believe that lower friction repairs, combined with higher excursion therapy, may be similarly advantageous clinically.

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