EFFECT OF A NEW REPAIR TECHNIQUE AND AN EARLY ACTIVE MOBILIZATION PROTOCOL OF CANINE FLEXOR TENDONS - IN CADAVERIC AND ANIMAL STUDIES

*Wada, A., +Kubota, H., Miyanishi, K., Hoshino, S., Hatanaka, H., Iwamoto, Y., *+Department of Orthopaedic Surgery, Faculty of Medicine, 3-1-1 Maidashi, Higashi-ku, Fukuoka, 812-8582, Japan; 81-92-641-1151 (Ext. 5488), Fax: 81-92-642-5507, E-mail: hkubota@ortho.med.kyushu-u.ac.jp

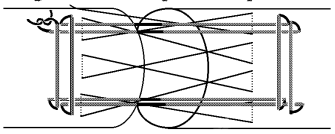
Introduction

Current flexor tendon suture techniques consist of a multiple-strand core suture and a circumferential suture designed to withstand the stress produced by an early active mobilization protocol. Repaired tendons by the 6 strand core suture technique were obtained satisfied results clinically, however, this technique was more complicated and more traumatic compared with the conventional 2 strand core suture. We decreased the number of core sutures and developed a new repair technique that was easy to handle, yet enough strong to allow an active mobilization protocol. The purpose of this study was to evaluate the biomechanical properties and histological healing of flexor tendons repaired by this technique using an early active mobilization protocol in cadaveric and animal studies.

Methods

Our new repair technique is shown in Fig.1. The technique consisted of four-strand core suture by double modified Kessler method with only one suture thread, in combination with the cross-stitch circumferential suture. A 5-0 coated braided polyester was used as a core suture, and a 6-0 polypropylene monofilament was used as a circumferential suture.

Fig. 1 Our new repair technique



In cadaveric study, fresh frozen 24 canine flexor digitorum profundus (FDP) tendons of 8 paws were used. A transverse laceration was made in zone 2. All tendons were repaired by 3 suture techniques below. The 3 subgroups (A-C) were compared by biomechanical testing.

Group A 2 strand modified Kessler only
Group B 4 strand double modified Kessler only
Group C 4 strand double modified Kessler + cross-stitch (our new technique)

In animal study, 18 FDP tendons of fourth and fifth digits from 9 mongrel dogs were surgically exposed, and a transverse laceration was made in zone 2. All tendons were repaired by this new technique (Group C). Postoperatively, the dogs were allowed an active mobilizaion immediately under a spica cast control. Twelve tendons were harvested for biomechanical testing at 14, 28 and 42 days (N=4), and 6 tendons for histologic examination at 14, 28 and 42 days (N=2). Four fresh canine cadaver FDP tendons of fourth and fifth digits were used as day 0 controls.

Biomechanical testing: Repaired tendons in cadaveric study and harvested tendons in animal study were secured in tendon clamps on the Tensile Testing Machine and loaded to failure at a constant cross head. Force deformation curves were generated and analyzed for gap and breaking strengths, in addition to stiffness of the linear slope. Differences in the measurement parameters were statistically evaluated using ANOVA with significance set at $p = 0.05$.

Histological Examination: Harvested tendons in animal study were fixed in 10% buffered formalin, embeded in paraffin, sectioned and evaluated with standard hematoxylin and eosin to show cellular proliferation and with Masson's trichrome to show blue-stained collagen fibers.

Results

In cadaveric study, the results of tensile properties are shown in Table 1. The values of this new technique (Group C) were significantly stronger than the values of the 2 strand Kessler only or the 4 strand double Kessler only (Groups A and B) in all respects. This new technique (Group C) was almost four times as strong as the 2 strand Kessler only (Group A) according to the values of breaking strength.

Table 1 Subgroups of repair tendons and tensile properties

Subgroup (number)	Gap strength (kgf)	Breaking strength (kgf)	Stiffness (kgf/mm)
A (8)	0.19±0.07 *	1.30±0.18 *	0.31±0.07 *
B (8)	0.50±0.16 †	2.92±0.29 †	0.77±0.13 †
C (8)	2.07±0.46 †	6.03±0.55 †	1.77±0.28 †

* The values of Group A were significantly less than any other groups † $p<0.05$

In animal study, macroscopic appearance showed a smooth gliding sruface with no adhesions and no gross synovial tissue around the repair site in all time specimens. Furthermore, it showed a poor gap formation between tendon ends. It appears that the repair site directly united. Histologically, the number of endotenon cells increased compared with epitenon cells as the time passed. Masson's stain showed increased longitudinally oriented blue-stained collagen fibers at the repair site. Tendon callus and gap formed poorly in all time specimens (Fig. 2). Biomecanically, there was no significant change in breaking strength from day 0 to day 42, and a general increase in gap strength significantly occured from day 0 to day 42 (Fig. 3).

Fig. 2 Day 42 specimen (×40)

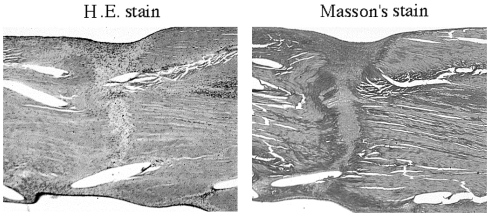
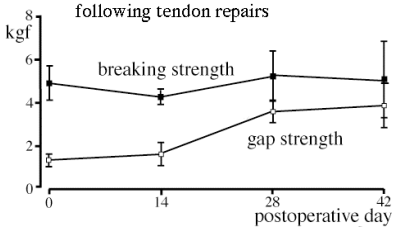


Fig. 3 Tensile properties at various time intervals following tendon repairs



Discussion

Repaired tendons by this technique had 2.1 kgf gap strength and 6.1 kgf breaking strength in cadaveric study and could overcome the strength (mean of 1.9 kgf and maximum of 3.5 kgf) to be expected during an active mobilization. In animal study, breaking strength did not diminish and gap strength increased significantly throughout 42 days. This study supported the concept that an active mobilization improved the strength of repaired tendons. An important observation of this study is that macroscopic and histological appearances. The tendon surfaces were smooth without adhesions and the tendon ends united directly. Increased endotenon cells near the repair site and poor tendon callus formations demonstrate that endotenon cells might play a more important role than epitenon cells in intrinsic healing response in a good milieu. The combination of this technique and an early mobilization protocol stimulates intrinsic healing and has a potential to apply clinical cases.

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This experiment was reviewed by the Committee on the Ethics of Animal Experiments in the Faculty of Medicine, Kyushu University and carried out under the control of the Guidelines for Animal Experiments in the Faculty of Medicine, Kyushu University and under Law No. 105 and Notification No. 6 of the Japanese Government.