EFFECT OF TENSILE LOAD ON STRENGTH OF SUTURE FIXATION IN A CANINE FLEXOR TENDON EX VIVO MODEL

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INTRODUCTION:
In flexor tendon repair, it is important to maintain the strength of the suture repair in order to tolerate the force applied to the tendon during postoperative rehabilitation. Normally, however, the tendon weakens in the first few weeks after repair, which can lead to gap formation. Although the strength of numerous repair techniques has been studied in vitro, the effects of early degradation of the tendon cannot be studied using an in vitro model. In vivo studies have reported the mechanical properties of repaired tendon early after the operation, but in vivo models cannot easily isolate the specific issue of the strength of suture fixation within the tendon. Moreover, such models are costly. Ex vivo tissue culture model can evaluate this factor, and can also examine the degradation of the tendon. Previous ex vivo studies have also shown that tensile load inhibited tendon catabolism. In this study we cultured tendon segments for 7, 14, and 21 days, in order to test the strength of suture fixation. The purpose of this study was to assess the relationship between the strength of suture retention and the tensile load in tissue culture.

MATERIALS AND METHODS:

Tissue culture
We harvested flexor tendons from 12 mixed-breed dogs weighing between 25 and 30kg, which were euthanized for other IACUC approved studies. Immediately after euthanasia, the flexor digitorum profundus tendons of the third and forth toes of both hind paws were harvested under sterile conditions. A total of 42 tendons were used in this study. The tendons were cut into 30mm segments, each centered on Okuda’s zone D [Okuda et al. J Orthop Res 1987:60-8]. For Day 0 examination, 6 tendon segments were used. Eighteen tendon segments were cultured under static tensile load and another 18 tendon segments were cultured without tensile load. Tendons were washed three times using PBS before culture in 50mL polypropylene conical tubes (FALCON, Franklin Lakes, NJ). Both ends of the tendon were sutured with a simple loop (Figure 2) of 3-0 Ethibond® (Ethicon Inc, Somerville, NJ), with, for half the tendons, one end attached to a 50 gram dead weight in the medium (Figure 1). The medium consisted of minimal essential medium (MEM) with Earle’s salts (GIBCO, Grand Island, NY), 10% fetal calf serum, and 5% antibiotics (Antibiotic-Antimycotic, GIBCO, Grand Island, NY). The tendons were incubated at 37°C with 5% CO2 and 95% air at 100% humidity. The medium was changed every other day. Twelve tendons (six from each group, with and without weight) were removed from culture at day 7, 14, and 21.

Strength of suture fixation
The tendon was sutured with a simple loop (Figure 2) of 3-0 Ethibond®. The tendon was cut 3mm distal from the sutured site. The suture was attached to the tensile load transducer, and the tendon was fixed on the bottom of the apparatus by the clamp. The length of the tendon from the sutured site to the clamped site was set at 5mm (Figure 3). A 0.1 N preload and 0.1-0.3 N cyclic load was applied three times before testing. The suture construct was distracted at a rate of 0.2mm per second, and the maximum pull-out strength was measured. During testing, tendons were kept moist by soaking in PBS or by using PBS spray.

RESULTS:
The maximum pull-out strength of the tendon was 8.62±0.94 N (Day0), 6.76±0.79 N (Day7 without load), 6.50±0.89 N (Day14 without load), 6.14±0.46 N (Day21 without load), 6.84±0.87 N (Day7 with load), 6.00±0.97 N (Day14 with load), 5.43±0.82N (Day21 with load). There was not a significant difference at any time point across groups with and without load (Figure 4). The strength at day-0 was significantly higher than that at day 7, day 14, and day-21 (p<0.05). There was no significant difference among day-7, day-14, and day-21.

Statistics
A Mann-Whitney U-test was used for statistical analysis of the different time points. An analysis comparing pull-out load across the four time points (Day0, 7, 14, and 21) was performed using a Kruskal-Wallis test. Results with p < 0.05 were considered significant.

DISCUSSION:
This model may be useful to study suture techniques and suture materials prior to more formal in vivo study. The result of this study showed that the strength of the suture fixation decreased in tendon culture within the first week, without regard to the static load applied to the tendon. This suggests that degradation of the tendon is occurring, and that the application of a static load in these culture conditions does not inhibit the degradation. In future studies we plan to examine the effect of cyclic loading and mRNA expression of the cultured tendon segment.

ACKNOWLEDGEMENT:
This study was supported by Mayo Foundation.

53rd Annual Meeting of the Orthopaedic Research Society
Poster No: 0883