Introduction: Little is known about the localized changes in bone mass that may occur following tendon or ligament injury. We recently reported significant bone loss in the distal phalanx in a canine model of flexor tendon insertion-site injury and repair [1], and identified three factors that may have contributed to the observed bone loss: 1) limb immobilization, 2) tendon laceration and disruption of the normal load transfer between tendon and bone, and 3) surgical insult caused by the trans-osseous repair method. Our objective in the current investigation was to further quantify the bone loss following flexor tendon insertion site injury, repair and post-operative rehabilitation, and specifically to examine the isolated effects of limb immobilization and tendon laceration. We transected the canine flexor digitorum profundus (FDP) tendon from its insertion, and either repaired it using a trans-osseous suture technique or left it unrepaired. At 5 to 42 days post-injury, we assessed bone mineral density (BMD) and osteoclast number. We hypothesized that limb immobilization and tendon laceration would each contribute independently to the bone loss observed after tendon laceration, repair and rehabilitation.

Methods: Adult mongrel dogs were anesthetized and FDP tendons on the 2nd and 5th digits of the right forelimb were exposed. Tendons were released directly from their bony insertion by sharp dissection, simulating a clean laceration injury. In some dogs the tendons were repaired immediately and in others they were left unrepaired. Studies were approved by our institutional animal studies committee.

Laceration, Repair and Immobilization Group: Thirty-two FDP tendons from 16 dogs were lacerated and repaired using a 4-strand, trans-osseous suture method. Post-operative care consisted of cast immobilization with 10 minutes of daily passive mobilization. Dogs were killed 5, 10, 21 or 42 days after surgery. All four digits from both forelimbs were harvested post-mortem for densitometric analysis of the distal phalanx. Laceration Only Group: Twenty-eight FDP tendons from 14 dogs were lacerated and left unrepaired. In contrast to the Laceration, Repair and Immobilization group, the forelimbs of dogs in the Laceration Only group were not immobilized; dogs were allowed unrestricted cage activities and appeared to be ambulating normally on the first post-operative day. Dogs were killed 7 or 21 days after surgery.

Results: Combined tendon laceration, repair and immobilization caused significant decreases in BMD of 21, 40 and 41% at 10, 21 and 42 days, respectively, compared to contralateral control (p < 0.01; Figure). Immobilization without laceration or repair also caused a significant, albeit lesser, decrease in bone density; BMD was reduced by 4, 13 and 21% at 10, 21 and 42 days (p < 0.05; Figure). Isolated tendon laceration, without repair or immobilization also caused a significant reduction in bone mineral density, although the effect was not observed until 21 days after laceration (p < 0.01; Figure). Consistent with the reduction in BMD, significant increases in osteoclast number were observed in the immobilization only and laceration only groups, and these changes were noted at the earliest time points (Table 1). Immobilization only caused a 5-fold increase in osteoclast number at 10 days, and an 8-fold increase at 21 days (p < 0.05). Laceration only caused a 4-fold increase in osteoclasts at 7 days compared to control, and a 10-fold increase at 21 days (p < 0.05). The significant increase in osteoclast number in the Laceration Only group at 7 days preceded the decrease in BMD, which was not noted until 21 days.

Discussion: Our results (based on a canine model) support the following conclusions: 1) Dramatic bone loss occurs after combined FDP tendon laceration, repair and post-operative immobilization. 2) Limb immobilization and tendon laceration each contribute independently to bone loss. Together, these factors explain approximately one-half of the total bone loss following combined laceration, repair and immobilization. 3) The remaining one-half of the total bone loss may be related to the tendon-bone repair procedure; we believe that the localized reaction to surgical trauma contributes substantially to the bone loss after injury and repair. 4) Bone resorption begins almost immediately following tendon injury. We saw markedly increased osteoclast numbers as early as 7 days after tendon laceration despite normal weight bearing. Thus, if surgical repair is delayed, substantial bone loss may develop at the insertion site. 5) Healing of tendon to bone may be negatively affected if the bone is in a resorptive state, which may explain the poor recovery of tensile properties observed previously [1]. Thus, methods to mitigate post-operative bone resorption warrant consideration.


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