DIRECT TENDON REATTACHMENT TO METALLIC IMPLANT AUGMENTED WITH rhOP-1 AND ALLOGENIC BONE PLATE IN A CANINE MODEL

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INTRODUCTION: Functional outcome of endoprosthetic reconstruction in limb salvage may be improved through secure and lasting soft tissue reattachment directly to the metallic implant surface. Tendon direct reattachment to a metallic surface of a titanium prosthesis (enhanced tendon anchor, ETA) using autogenous bone graft augmened with bone marrow achieved 42% of normal intact strength (1).

In this study, we hypothesized that the reconstitution of normal transitional tissues of tendon insertion to bone could be accomplished by the application of allograft bone plate augmented with recombinant human osteogenic protein-1 (rhOP-1) without the use of autogenous bone graft and marrow, which may lead to equivalent or improved tensile strength of prosthetic reconstruction. We compared the biomechanical and radiographic results of tendon reattachment using a modified ETA implant and an allograft bone plate between two augmentation methods, one used rhOP-1 and the other autogenous cancellous bone and marrow.

METHODS: The University’s Animal Care and Use Committee approved all surgical and experimental procedures. The initial tendon fixation strength of the modified ETA was determined in-vitro with six canine motion units (scapula-muscle-tendon-humerus), detaching supraspinatus tendon from its insertion and reattaching it to the ETA device loaded on an MTS testing machine and then testing the specimens in tension to failure at a rate of 100 %/sec.

Twelve mixed-breed adult dogs underwent supraspinatus tendon reattachment unilaterally to a modified ETA device fastened at the proximal humerus over the greater tuberosity. Tritanium Dimensionalized Metal™ (Stryker-Howmedica-Osteonics, Mahwah NJ) (pore size 250-350µm, porosity > 65%) was sintered over the surface of the modified ETA, to allow bone and soft tissue anchorage through ingrowth. Allograft bone plates filled with OP-1 (3.5mg) mixed in collagen type I putty (1.0g) (experimental group (E), N=6) or autogenous cancellous bone and marrow (control group (C), N=6) were sandwiched between the tendon and the porous surface of the modified ETA prosthesis fixed by a bridging plate (Figure 1).

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RESULTS: Two dogs, one from each group, were excluded from the final analysis. The bridge plate came off at 3 weeks after surgery, the distal 4 cm of the tendon together with the attached prosthesis, were dipped into saline solution in a temperature controlled water bath at 37°C for 5 min. Specimens were tested in tension to failure at a strain rate of 100%/sec and the failure mechanisms were analyzed. The intact contralateral supraspinatus muscle specimens were tested as well, to have a reference value. The volume of the supraspinatus muscle was also measured.

The supraspinatus muscle specimens. Thus, the use of rhOP-1 had the same effect of bone marrow in the improvement of overall mechanical strength of the direct tendon reattachment to the modified ETA.

Both groups had a near normal physiological function of the shoulder. In the experimental group this could be favored by the bony and soft tissue adherences to the surrounding surface of the proximal humerus, which bypassed the prosthesis tendon attachment site. This finding opens new application possibilities that should be studied in the future.

REFERENCES:

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Figure 1: Schematic model of tendon reattachment to modified ETA.

Radiographic evaluation and gait analysis were performed before surgery and every 3 weeks during a 16-week period. Euthanasia was performed at 16 weeks. The supraspinatus muscles were dissected free from their scapula attachment. All the surrounding bony tissue that bypassed the direct tendon-prosthesis reattachment was separated from the proximal humerus surface.

To test the tendon insertion in tension to failure, specimens muscle portion was deep frozen at -20°C to increase its fixation strength (2). Immediately before testing, the distal 4 cm of the tendon together with the attached prosthesis, were dipped into saline solution in a temperature controlled water bath at 37°C for 5 min. Specimens were tested in tension to failure at a strain rate of 100%/sec and the failure mechanisms were analyzed. The intact contralateral supraspinatus muscle specimens were tested as well, to have a reference value. The volume of the supraspinatus muscle was also measured.

RESULTS: Two dogs, one from each group, were excluded from the final analysis. The bridge plate came off at 3 weeks after surgery in one dog of the control group, and a fracture of the bone callous at 12 weeks after surgery was present in one dog from the experimental group.

The ultimate in-vitro attachment strengths were not significantly different between the experimental and control group. At 15 weeks after surgery, the calcified area around the tendon on the experimental group was significantly larger (84%, p<0.0001) than the control group (Figure 2). An initial decrease in weight bearing in the left forelimb (reconstructed) was observed 3 weeks after surgery and then increased significantly at 6 weeks (p<0.05) in both groups (Figure 3). Although, there is no significant difference, there is a trend towards a higher weight bearing percentage in the experimental group compared to the control, especially at 9 weeks (p=0.11). At 16 weeks, the muscle volume of the operated limb was significantly smaller in both groups compared to the intact side (p<0.05). Both groups had equivalent functional activity, which was close to normal. During harvesting, we found in the experimental group, a massive bone bridge macrostructure between the tendon and the proximal humerus. However, the ultimate tensile strength of tendon reattachment directly to the modified ETA prosthesis was only 38% and 24% of the intact contralateral side in the control and experimental groups, respectively. When the ultimate strength was normalized by the intact contralateral side, no difference was detected between the experimental and control groups.

DISCUSSION: The overall mechanical strength of tendon reattachment to the modified ETA obtained in the experimental group was equivalent to that in the control group, and both were significantly lower than that in the intact specimens. Thus, the use of rhOP-1 had the same effect of bone marrow in the improvement of overall mechanical strength of the direct tendon reattachment to the modified ETA.

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Figure 2: C= control, E= experimental.

Figure 3: C= control, E= experimental.