The Effects of Synovium Transplants on Tendon Healing In Vitro

Ikeda, J; Zhao, C; Moran, S; An, K-N; Amadio, P C
Mayo Clinic, Rochester, MN
Senior Author: zhaoc@mayo.edu

INTRODUCTION:
Injuries to the finger flexor tendons are common, and sometimes result in considerable disability. Although flexor tendon healing follows similar stages of wound healing as other tissues, tendinous tissues require a longer time to heal than other connective tissues, which may be due to their hypocellular and hypovascular nature. The nutrition of flexor tendon comes from intratendinous blood flow from vincula and from diffusion of the synovial fluid in the flexor synovial sheath. After flexor tendon injury, these nutritional sources could be jeopardized, further affecting tendon healing as well. Intrinsinc tendon healing is important, since the adhesions of extrinsic healing hinder hand function. Almost 30 years ago Lundborg described an in vivo model in which tendons could heal without adhesions. Although others questioned the model’s validity, many subsequent studies have shown that flexor tendons do have the capacity for intrinsic healing, and more recent studies have shown that synovial cells can accelerate connective tissue healing. The purpose of this study was to investigate whether synovium implantation between repaired tendon ends could stimulate and accelerate tendon healing in a canine in vitro model.

MATERIALS AND METHODS:
Eight mixed-breed dogs weighing between 25 and 30 kg were used with the approval of our IACUC. Two groups were studied: 1. Repaired tendons with synovium implanted between tendon ends. 2. Repaired tendons without any implantation between tendon ends. The tendons were evaluated in repair failure strength (n=16) and histology (n=2) after 2 weeks and 4 weeks in tissue culture.

Tissue Harvest and Surgical Technique
Immediately after euthanasia of the dogs, the II, III, IV, and V fore paw digits were exposed from a lateral incision. The FDP tendons were transected at the MCP joint and distal attachment respectively, and removed from the flexor sheath. The flexor synovium around the FDP tendon was immediately lacerated at the PIP joint level, in which regions the synovium is composed of two fibrous bundles. Then, the repaired tendons were trimmed to a 30 mm length, with the repair site at the center.

Tissue Culturing
The repaired tendons were then mounted in a custom-made frame to maintain the tendon in a straight alignment (Figure 1). The frame was placed in a 100 mm Petri dish for incubation in 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), and incubated at 57°C in a 5% CO₂ humidified atmosphere. The culture medium was changed every 5 days.

Biomechanical Testing
At the end of the culture period, the specimens were removed from the culture medium for strength testing. A single loop suture was placed at the each end of the test specimen to connect the tendon to a custom-designed micro-tester. Before testing, the tendon repair sutures were cut on both sides without disrupting the repair site, in order to assess the strength of the healing tissue rather than the suture.

Histological Analysis
The tendons for histology were fixed in 10% formalin, embedded in paraffin and sectioned longitudinally. Sections were stained with hematoxylin and eosin, and examined for cell distribution and cell counts in the tendon ends.

Statistical Analysis
A mixed linear model was used to analyze the strength of load among the 2 treatment groups (without, or with synovium) at 2 time points (2 or 4 weeks) while dog and digit of the tendon were considered as random effect. If a significant treatment effect and time point effect was observed, post ad hoc pairwise comparisons were also studied using Duncan’s multiple comparison procedure. If the two time points, dogs and digits of tendon do not play a role, we might consider comparing the treatment difference only. A p value ≤ 0.05 was considered as statistical significant.

RESULTS:
The strength of the repaired tendons with the synovium patch was significantly higher than the repaired tendons without a patch at both 2 and 4 weeks (p < 0.0001). The strength of the repaired tendons at 4 weeks was significantly higher than that at 2 weeks in both with and without synovium groups (p < 0.0001) (Figure 2). Histology showed greater cellularity at the repair site with synovium implantation compared to the tendons repaired without implantation (Figure 3).

DISCUSSION:
Banes et al demonstrated that synovial cells are able to synthesize fibronectin, which can induce cell spreading and adhesion. Richard, et al also investigated whether the synovium of the flexor tendon plays a role in flexor tendon healing using in vivo model, and found that synovial cells migrated into the lacerated tendon ends and enhanced tendon healing. More recent studies have shown that tenocytes obtained from synovium have a high proliferation and differentiation potential. This study showed that implantation of synovium harvested from the flexor tendon sheath just around the repair site could improve flexor tendon healing in an in vitro model.

CONCLUSION:
Synovium can to improve tendon healing when it is implanted at the repair site, and this potential technique might have clinical application with primary tendon repair in the future.

REFERENCES:

ACKNOWLEDGEMENT:
This study was supported by a grant from Mayo Foundation.