Surface Modification of Intrasynovial Flexor Tendon Allograft in a Canine Model In Vitro

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INTRODUCTION:
The tendon graft still plays an important role to restore hand function if the damaged tendon can not be directly repaired, or if a primary repair fails. Animal studies have shown that intrasynovial tendon autografts result in better functional restoration compared with extrasynovial tendon autografts, but the availability of intrasynovial autograft tendons is limited. Previous work from our laboratory has demonstrated that decreasing the friction of extrasynovial tendon by surface treatment with a carboxylate derivatized HA (cd-HA) gelatin improves extrasynovial autograft outcomes in an in vivo canine model. Intrasynovial tendon allograft would be another possibility to treat such injuries, but it is not known if a common allograft preparation process, which involves freeze thaw cycling with lyophilization and rehydration to reduce immunogenicity, adversely affects the tendon allograft gliding ability, or whether tendon surface modification cd-HA gelatin has the same beneficial effects on an allograft that it does on an autograft. The purpose of this study was to investigate the effects of cd-HA gelatin treatment of a tendon allograft on tendon gliding in a canine intrasynovial tendon allograft model in vitro. We hypothesized that the allograft preparation process would adversely affect tendon gliding, and that cd-HA gelatin surface modification would restore normal tendon gliding ability to the allograft tendons.

METHODS:
A total of 36 flexor digitorum profundus (FDP) tendons from the 2nd and 5th digits of canine hind paws were harvested and randomly assigned for three groups. 12 tendons were immediately assessed both mechanically and morphologically, and served as the autograft control group. The other 24 FDP tendons were stored at -80 C for two weeks after freeze thaw cycling and lyophilization. These lyophilized tendons were randomly assigned to two groups, one treated with cd-HA-gelatin and the other not treated, to serve as the allograft control group. The frictional force was measured over 1000 simulated flexion/extension motion cycles using an established method[1]. The tendons were then observed morphologically using scanning electron microscopy (SEM).

RESULTS:
The gliding resistance of the FDP tendons immediately following lyophilization was significantly increased compared to the normal FDP tendons (p < 0.05). However the gliding resistance of the lyophilized FDP tendons after surface modification with cd-HA gelatin was significantly decreased compared to the lyophilized tendon without surface treatment (p < 0.05). There was no significant difference between normal FDP tendons and lyophilized FDP tendons treated with cd-HA gelatin. After 1000 cycles of motion, the relations among three groups remained the same (Figure 1). In addition the morphological results showed that the tendon surface treated with cd-HA-gelatin was well covered with a thin layer of cd-HA-gelatin even after 1000 cycles of tendon excursion (Figure 2), and scanning electron microscopy also demonstrated a smooth surface (Figure 3).

DISCUSSION:
We found that freeze thaw cycling and lyophilization changes allograft tendon surface morphology, resulting in increased friction, which may hinder tendon gliding when such tendons are used in vivo. The lyophilized tendons treated with cd-HA gelatin had significantly less friction and showed a restored tendon surface.

CONCLUSIONS:
Lyophilization alters tendon surface morphology and increases tendon friction. Surface modification with cd-HA gelatin reverses this adverse effect, and restores the graft to its normal gliding properties. When tendon allografts are used in a situation where gliding of the allograft is important to subsequent clinical function, treatment of the surface with cd HA gelatin may be beneficial.

REFERENCE:

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Figure 1. Gliding resistance of normal FDP tendon, lyophilized FDP tendon, and cd-HA gelatin FDP tendon in first cycle and after 1000 cycle of tendon motion.

Figure 2. The tendon surface was well covered with a thin layer of cd-HA-gelatin even after 1000 cycles of tendon excursion.

Figure 3. Scanning electron microscope images of the normal FDP tendons, lyophilized tendons, and cd-HA treated tendons after 1000 motion cycles. Magnification: Top row: x 25. Bottom row: x 5000.