Evaluation of Work of Flexion in Flexor Tendon Graft with Different Junction Repair Techniques

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Disclosures:  J. Wu: None. A. Thoreson: None. K. An: None. P.C. Amadio: 4; Merck, J&J. 7; Elsevier, JBJS. C. Zhao: None.

Introduction: Flexor tendon reconstruction is indicated when primary repair cannot be performed or failed following flexor tendon injuries. There are two repairs in tendon reconstruction; one is between the graft tendon and host tendon proximally and the other is graft tendon with host bone distally. Different proximal and distal repair techniques have been studied in terms of mechanical strength. The effect, if any, of these techniques on graft gliding ability, an important parameter that affects tendon repair or graft results, has been less well studied. Therefore, the purpose of this study was 1) to investigate the work of flexion, an outcome measure of tendon gliding ability, after flexor tendon reconstruction using commonly reported techniques (Bunnell at distal repair and Pulvertaft at proximal repair) compared to newly developed repair techniques (bone/bone repair at distal repair and step-cut at proximal repair) [1,2]; and 2) to study the effect of surface modification with carbodiimide-derivatized synovial fluid plus gelatin (cd-SF-G) [3] on the work of flexion after flexor tendon reconstruction. The work was done using a canine in vitro model.

Methods: Sample Preparation: 16 forepaws separated below the wrist were harvested from 8 mixed-breed dogs (weight 21-26 kg), which had been euthanized for other IACUC-approved studies. The paws were frozen at -80ºC and thawed at 4ºC one day before repair. The second and fifth digits were randomly divided into four groups based on repair techniques. Group A: traditional graft repairs (TGR) distal - Bunnell repair (Fig. 1aA) and proximal - Pulvertaft repair (Fig. 1aB); Group B: modified graft repairs (MGR)(distal - graft tendon with distal bony attachment repair (Fig. 1bA) and proximal - step-cut repair (Fig. 1bB); Groups C TGR (group A) was coated with cd-SF-G which consists of 46% native synovial fluid (SF), 10% gelatin, 1% 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC) and 1% N-hydroxysuccinimide (NHS) in 0.1 M 2-[N-morpholino]ethanesulfonic acid (MES) buffer (pH 6.0); and Group D: MGR (group B) was coated with cd-SF-G. FDPs from third and fourth digits were harvested to be used as tendon grafts.

Measurement of Digit Work of Flexion (WOF): WOF testing was performed based on a previously established method [3]. (Fig. 2). The actuator pulled the tendon proximally, causing digit flexion. Data from the linear potentiometer and proximal load transducer were recorded at 100 Hz. During testing, the trajectory of digit motion was recorded simultaneously (from extension to flexion) with a passive marker kinematic data collection system (Motion Analysis Corporation, Santa Rosa, CA). WOF data were calculated from tendon displacement vs loading curve during digit flexion and then normalized by total proximal interphalangeal joint (PIP) and DIP joint motion angle.

Data Analysis: One-way ANOVA was used and followed by a Tukey-Kramer post hoc test. The statistical significance level was set at P<0.05.
**Results:** Group B had significantly lower WOF compared to Group A (p<0.05) (Fig. 3). The Group C and D coating of the intrasynovial tendon with cd-SF-G can decrease the WOF, but no significant difference was found between the different surgical technique groups.

**Discussion:** This is the first study to investigate the effect of repair techniques on the digit work of flexion after flexor tendon reconstruction. We found that a tendon graft with the bony attachment preserved for FDP reattachment in zone 1 combined with SC at the graft’s proximal junction improved the digit function compared to traditional repair techniques. This technique may facilitate early postoperative rehabilitation after tendon graft, thereby leading to fewer adhesions and better digit function. The intrasynovial FDP surface coated with cd-SF-G tends to improve the gliding function but not reach a significant difference in this in vitro model. A limitation of this study was that this in vitro model does not allow us to consider the effects of tendon healing. It has been reported that bone-to-bone healing interface is superior to the tendon-to-bone healing interface, which has been generally recognized as a difficult healing interface. As for the proximal allograft tendon repair, the SC also places the healing interface between tendon midsubstances rather than between surfaces. Thus, healing in the latter may be inhibited, especially after surface modification.

**Significance:** The modified surgical techniques of repairing distal and proximal junctions of a tendon graft improved digit function. Surface modification with cd-SF-G further improved graft gliding ability.

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**Figure 1a:** Tendon-Distal phalanx attachment with tendon-bone button (Bunnell), FDP-to-FDP repair using the PW. A: Bunnell Repair; B: PW Repair

**Figure 1b:** Tendon-distal phalanx attachment with allograft tendon with distal bony attachment. FDP-to-FDP repair using SC. A: tendon with bony attachment repair with Bunnell technique, B: SC repair
Figure 2: WOF tester. 1) actuator, 2) load transducer, 3) digit, 4, 5 and 6) proximal, middle and distal “T” with reflective markers, 7) weight

Figure 3: Normalized WOF in intact tendon (Group A and Group B), distal tendon repair with Bunnel and proximal repair with PW, distal repair with bony attachment and proximal repair with SC.

The asterisk denotes a significant difference (p<0.05).

ORS 2015 Annual Meeting
Poster No: 0491