A BIOMECHANICAL COMPARISON OF THE SIDE-TO-SIDE AND PULVERTAFT TENDON TRANSFER REPAIR TECHNIQUES

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INTRODUCTION

The primary goal of tendon transfer surgery is to restore lost function. Strong tendon repairs are required to facilitate rehabilitation by allowing early mobility, preventing adhesions and promoting strengthening and motor learning [1,2]. Prerequisite for early return to activity is a strong and stiff repair that enables efficient transfer of load, through the repair, across the joint(s) of interest and into the bony insertion. The side-to-side (SS) suture repair technique was developed to meet these aims. The purpose of this paper was to quantify the strength and stiffness of the SS repair technique compared to the classic Pulvertaft (PT) suture repair technique.

METHODS

Flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS) tendons were harvested fresh from four cadaveric forearms. All repairs were carried out with the FDS tendon serving as the donor and the FDP tendon as the recipient. Seven SS transfers and 6 PT transfers were performed by an experienced hand surgeon (Figure 1). The length of the overlap region was standardized at 30 mm to permit comparison between methods.

All mechanical tests were carried out using an Instron (Model 1122) material testing machine. Clamps secured the tendons on either side of the repair, and were mounted vertically and immersed in phosphate-buffered saline solution throughout the tests. Slack length of the overall structure was established as the length just prior to the initiation of load resistance. Repairs were tested in tension at a displacement rate of 10 mm/min. First, repairs were conditioned with 5 consecutive cycles of 5% clamp-to-clamp displacement. At the end of the conditioning cycles, repairs were allowed to relax for approximately 25 seconds, and were then elongated to failure.

Deformation of the repair was quantified by tracking elastin dye lines placed on the tendons on either side of the repair region.

Variables measured were: peak load at each of the five conditioning cycles, load of first failure (first detectable drop of force during the failure test), ultimate load (highest force achieved during the failure test), and repair stiffness (slope of the linear region of the load-deformation curve). Comparisons between the SS and PT repair techniques were made using non-paired t-tests with an alpha level of 0.05.

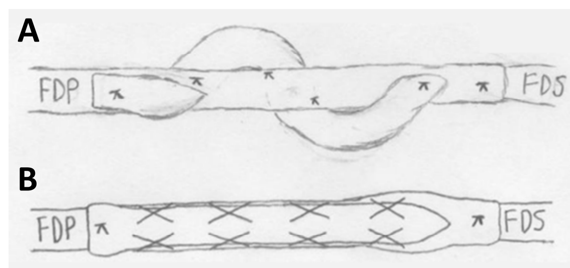

Figure 1. A) Pulvertaft (PT) repair consists of the FDS weaving through 3 incisions in the FDP, and 6 locking sutures; B) Side-to-side (SS) repair consists of the FDS inserting through 1 incision in the FDP, 4 cross-stitch running sutures back and forth down both sides, and 2 locking sutures.

RESULTS AND DISCUSSION

All failures occurred in the repair region, rather than at the clamps or within the tendon substance. Thus, the repair is, in fact, the "weak link" of this construct. It was observed that PT repairs failed at the sutures followed by the FDS tendon pulling through the FDP tendon; SS repairs failed by shearing of fibers within the FDS, whereby fibers that were locked down with the running sutures stayed attached to the FDP, and adjacent, non-locked down fibers sheared away with the FDS.

There were no statistically significant differences in the cross-sectional areas (p=0.99) or initial lengths (p=0.93) between SS and PT repairs. Therefore, all comparisons can be made between un-normalized loads and deformations.

Load at each of the conditioning displacement cycles (range p = 0.011 to p = 0.013), load at first failure (p = 0.001, Figure 2), ultimate load (p < 0.001, Figure 2), and repair stiffness (p = 0.016, Figure 3) were all significantly greater for the SS compared to the PT technique.

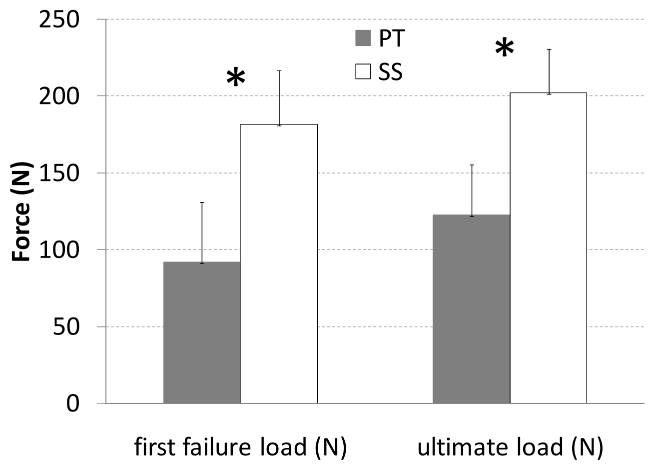

Figure 2. A statistically significant difference (*) was found between the SS and PT repair techniques for both the first failure load and ultimate load. Means and standard deviations are shown.

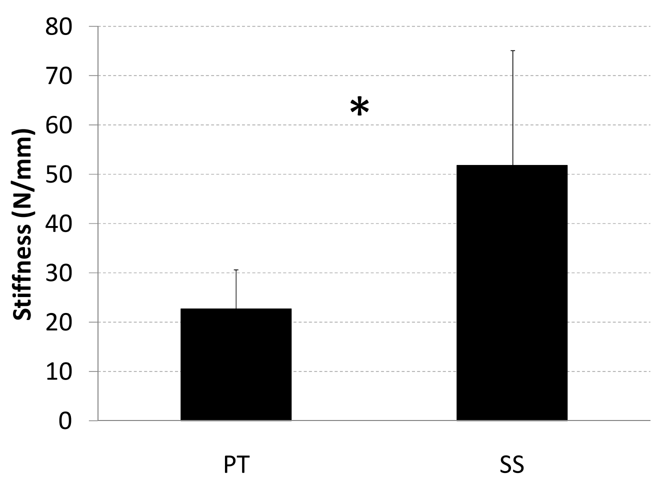

Figure 3. A statistically significant difference (*) in stiffness was found between the SS and PT repair techniques. Means and standard deviations are shown.

CONCLUSIONS

The SS repair technique was significantly stronger and stiffer compared to the standard PT technique. This could permit patients to return to activity sooner after surgery. Ultimately, this will result in greater function and fewer complications. The mean failure loads for both repair techniques were greater than the estimated average maximum isometric force that can be generated by the FDS muscle [3], thus indicating that acute failure of the repair would not be a primary concern post-surgery. However, it is known that tendon repair ultimate stress decreases transiently after repair, and should be considered. A stiffer repair may be beneficial as it enables a more efficient transfer of load from the donor muscle to the recipient tendon, and ultimately to the site of bony insertion. An ideal tendon transfer would deform minimally across the repair site, leaving length changes to occur within the tendons and muscles themselves, which are designed to shorten/lengthen across joints. The SS tendon transfer repair was much stiffer than the PT repair, and will thus transfer muscular loads under smaller deformations and with less absorbed energy. This should enable the SS repair to function better and undergo less cumulative deformation during the healing process, thus facilitating an earlier return to activity post-surgery.

REFERENCES

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ACKNOWLEDGEMENTS

The authors acknowledge Mr. Robert Healey for help with the data collection, Prof. David Amiel for the use of equipment, NSERC Canada for funding a Post-doctoral Fellowship for S.H.M. Brown, Swedish Research Council grant 11200, and NIH grant HD050837.