SCIENTIFIC ARTICLE

Side-to-Side Versus Pulvertaft Extensor Tenorrhaphy—A Biomechanical Study

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Purpose We hypothesized that a side-to-side (STS) tendon repair has biomechanical characteristics that match those of a Pulvertaft (PT) weave.

Methods Thirty extensor tendons were harvested (4 extensor digitorum communis and 1 extensor indicis proprius from 6 cadaver arms). Three hand surgery fellows with similar backgrounds of training under the same conditions and precise standardized technique performed the repairs (5 PT and 5 STS per surgeon). After the repairs, the tendons were passed through a graft-sizing guide to determine bulk and results were expressed as a repaired versus native diameter ratio. The specimens were then tested for ultimate strength and fatigue properties. Failure type and mechanical properties were recorded and compared with those of the native tendon.

Results The average peak force to failure was 93 ± 20 N for the STS and 62 ± 32 N for PT group. Relative strength ratio (repair strength compared with native tendon strength) was 37% ± 21% for the STS and 22% ± 11% for the PT group. In the STS group, all failures occurred as a result of tissue failure; however, in the PT, suture failures occurred in 3 tendons before tissue failure. The mean bulk ratio of the repaired site versus native proximal tendon was 37 ± 14% and 40% ± 22% more for the STS and PT groups, respectively. These values for native distal tendon were 28% ± 9.9% and 26% ±24 %, respectively for STS and PT repair. Furthermore, the bulk of the repaired site for the STS and PT groups was 4.2 ± 0.50 and 4.7 ± 1.2 mm, respectively.

Conclusions Side-to-side repair technique showed superior biomechanical properties while demonstrating comparable repair bulk of the tendon coaptation compared with the Pulvertaft weave.

Clinical relevance The results of this study may help guide a surgeon's choice of repair technique when addressing tendon injuries or tendon transfers. *(J Hand Surg Am. 2016;■(■):■−■. Copyright © 2016 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Biomechanics, extensor tendon, Pulvertaft, side to side.

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TENDON RECONSTRUCTIONS RELY ON INITIAL secure fixation of tendon ends while providing a high surface area of overlap without added bulk. It is well-accepted that early movement of tendons is required to allow for healing while preserving gliding function, especially when repairs are performed within the flexor sheath. This early movement, although desirable to minimize adhesions in other locations, is not mandatory. However, this relies on a high initial tensile strength at the repair site. In his efforts to

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optimize reconstruction of extensor tendons or flat tendons, Pulvertaft[1] described a weave with multiple crossing points between the tendons in orthogonal directions that adds initial strength to allow for secure healing. The Pulvertaft weave (PT) has been considered the reference standard for extensor and flat tendon coaptation. Brown et al[2] described a side-to-side (STS) tendon coaptation that showed promising initial mechanical properties. Tensile strength, bulk, and overlap are likely the most important factors in finding the optimal method of flat tendon coaptations, especially when dealing with complex multiple-tendon injuries or in unusual circumstances requiring multiple-tendon coaptations.[3]

The STS method appears to be simpler, with no need for specialized equipment; it is less bulky while not compromising repair strengths and tensile properties. Our primary null hypothesis was that there is no difference in the ultimate strength to failure between STS and PT repair. We also aimed to compare bulkiness of the repaired site between the 2 techniques.

MATERIALS AND METHODS

We harvested extensor tendons from 6 thawed fresh-frozen cadaver arms. Selection of this sample size was based on the convenience and availability of cadaver tendons. Tendons were found at the metacarpophalangeal joint level and traced proximally until the musculotendinous junction. The extensor tendons, which included 4 extensor digitorum communis and extensor indicis proprius tendons (5 tendons/cadaver arm), were transected at the most proximal and distal aspects in each specimen. The harvested tendons were divided in half and secured to a wooden board with a precisely measured 3-cm overlap (Fig. 1).

Three surgeons with equivalent level of training (hand surgery fellows: 2 with orthopedic surgery residency training and 1 with plastic surgery residency training) performed timed repairs of the extensor tendons with the STS technique on the tendons of one cadaver arm (5 tendons) and a PT weave on the other, as described.[1,2] A 2-cm weave was created over the 3-cm overlap for both techniques.

The PT repair was performed as described by Pulvertaft[1] by weaving the distal tendon through 3 incisions rotating 90° to each other through the proximal tendon. Once the weave was complete the tendons were sewn with one double-loop suture at the end of each tendon and 4 horizontal mattress sutures with even spacing through all weave junctions using 3-0 Tevdek suture (Teleflex, Gurnee, IL) (Fig. 2A).

The STS repair was performed as described by Brown and colleagues[2] by passing one tendon end

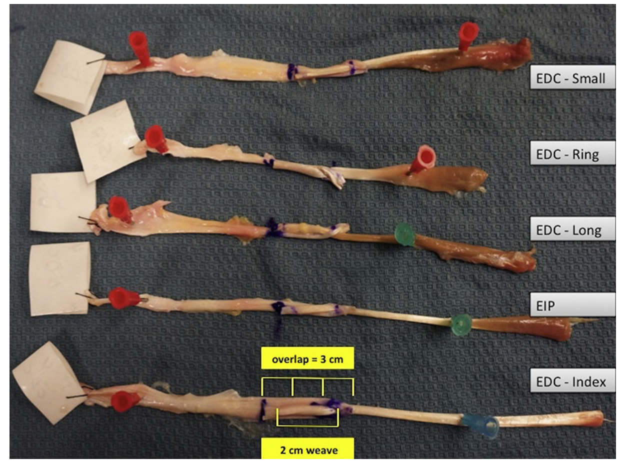

FIGURE 1: Tendon repair setup. Three-centimeter precise overlap measured for each tendon coaptation with a 2-cm zone of tendon weave. EDC, extensor digitorum communis; EIP, extensor indicis proprius.

through a longitudinal stab incision in the other end of the tendon. Unlike the multiple passes used in the PT, the technique described by Brown et al[2] uses only a single weave followed by side-to-side coaptation of the remaining tendon. The distal tendon lay flat (side to side) on the dorsal surface of the proximal tendon. The tendons were secured together with 3-0 Tevdek using 4 cross-stitches running back and forth on both sides. One double vertical mattress suture was placed at each tendon free end to secure the distal and proximal ends (Fig. 2B).

We measured repair bulk by determining native tendon diameter and volume as well as repair diameter and volume by passing the native tendon and the repair through an anterior cruciate ligament graft-sizing guide block. This block has predetermined sizes in 0.5-mm increments; the best-fit size was chosen to determine the size of repair bulk. Because of the high variability of the tendon diameters and morphologies among specimens, these values were expressed as ratios. To compare tendon calibers (cross-sectional area) with the adjacent normal tendon, we calculated the caliber ratio by dividing the repaired site caliber by the adjacent normal tendon caliber. This was done to quantify whether a PT repair is bulkier than an STS repair.

Next, the ends of the tendons were mounted on calipers, which were immersed in liquid nitrogen (for proper anchoring and even force distribution); the repair site was not immersed. A proximal or distal segment of the repaired tendon specimen was also resected and used as an internal control for each tendon. The more robust portion of the tendon was selected if the distal and proximal ends of the tendon

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