Flexor Digitorum Superficialis Repair Outside the A2 Pulley After Zone II Laceration: Gliding and Bowstringing

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Purpose To evaluate the changes in maximum flexion angle, gliding coefficient, and bowstringing after a combined repair of both flexor tendons with the flexor digitorum superficialis (FDS) rerouted outside the A2 pulley in cadaveric hands.

Methods We performed 4 different repairs on cadaveric hands, with each repair tested on 9 unique digits. In total, 12 cadaveric hands and 36 digits were used. The thumb and little finger were removed from each hand and excluded from testing. Group 1 was sham surgery. Group 2 combined flexor digitorum profundus (FDP) and FDS laceration and repair with both slips of the FDS repaired inside the A2 pulley. Group 3 was FDP repair with one slip of the FDS repaired inside A2 and the other slip left unrepaired. Group 4 was FDP repair with both slips of the FDS rerouted and repaired outside the A2 pulley. Maximum flexion angle, gliding coefficient, and bowstringing were measured in simulated active digital motion for each group.

Results Rerouting and repairing the FDS outside the A2 pulley (group 4) significantly lowered gliding coefficient compared with repairs with both slips inside A2, with values similar to sham surgery. We observed no significant differences in maximum flexion angle among the 4 groups. Increased bowstringing was observed with both slips of the FDS repaired and rerouted outside the A2 pulley.

Conclusions In this cadaveric model, repair of both slips of the FDS outside the A2 pulley improved the gliding coefficient relative to repair within the A2 pulley, which suggests decreased resistance to finger flexion. Repair of the FDS outside the A2 pulley led to a slight increase in bowstringing of the FDS tendon.

Clinical relevance We describe a technique for managing combined laceration of the FDP and FDS tendons that improves gliding function and merits consideration. *(J Hand Surg Am. 2015;40(4):653–659. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Flexor tendon laceration, flexor tendon repair, flexor digitorum superficialis, zone II.

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The management of flexor digitorum superficialis (FDS) injury in zone II remains controversial. In the setting of combined FDS and flexor digitorum profundus (FDP) injury, there is consensus that the FDP should be repaired with a multistrand core suture technique. No clear consensus exists regarding management of the FDS. The literature supports management of the FDS by repair of both slips of the FDS,[1] repair of one slip of the FDS

with excision of the other slip,[2–4] or complete excision of the FDS.[5,6] Excision of the FDS avoids the bulk conferred by a repair within the confines of the tight A2 pulley. However, repair of the FDS must take into consideration the balance between bulk and strength, given the 4% re-rupture incidence seen after repairs of the FDP and FDS in zone II.[7]

We currently employ an alternative technique in select patients to manage the FDS tendon when retraction into the palm or proximally has occurred. In such cases we reroute and repair both slips of the FDS outside the A2 pulley, leaving the repaired FDP inside the A2 pulley. To facilitate rerouting of the FDS, a small sheath defect must be created within the pulley system, disrupting both the C1 and A3 pulleys. Recent reports describe the effects of pulley modification, both intentional and traumatic, on flexor tendon function in zone II.[8–10] Furthermore, Lowrie and Lees[11] described the best current knowledge regarding the role of individual pulleys. Taken together, the literature suggests that some degree of pulley modification may be tolerated, and that among the annular pulleys A3 has a limited functional role. One proposed role for A3, without established clinical importance, is to elevate the volar plate during finger flexion, creating space for rotation of the middle phalanx.[12]

The rationale for this surgical technique is the improved gliding associated with a less bulky tendon repair under the A2 pulley, along with the belief that bowstringing is a greater problem for FDP than the FDS at the A2 pulley. Given the re-rupture incidence after zone II flexor tendon repairs of the FDS and FDP, the question of discarding half of the FDS tendon versus repair of both slips of the FDS tendon outside the pulley seems open.

We tested our current surgical technique in a cadaveric model, which allowed assessment of gliding coefficient[13] and bowstringing. We formed a 2-part hypothesis: First, the gliding coefficient should decrease with the FDS rerouted outside the A2 pulley compared with the traditional repair inside the pulley. Second, sufficient anatomic constraints are conferred by the presence of the A1 pulley and the anatomic insertion of the FDS tendon at the base of the middle phalanx such that only a modest amount of bowstringing should result from rerouting the FDS outside the A2 pulley.

MATERIALS AND METHODS

Specimen preparation

We obtained cadaveric forearm specimens through the university's Anatomical Gift Program in compliance with institutional policies. The distal upper extremity was harvested at the midforearm from 6 lightly embalmed cadavers. The wrist was immobilized in neutral by external fixation applied dorsally from the radius to the third metacarpal. The metacarpophalangeal joints were immobilized in 30° flexion with Kirschner wires. A screw was passed through the second, third, fourth, and fifth metacarpal heads in an ulnar to radial direction. The volar forearm was dissected to identify the musculotendinous junction of the FDP and FDS tendons associated with each digit. All muscle was stripped from the tendons and crossing tendons were identified and released. With the fingers in full flexion, the proximal ends of the FDP and FDS tendons associated with each digit were sutured together and attached to a small S-hook for testing purposes. The thumb and little finger were then disarticulated from the hand. The volar surface of the digits was dissected free of soft tissue to expose the flexor tendon sheath.

Tendon laceration, repair, and FDS rerouting

We identified and resected the C1 and A3 pulleys (Fig. 1A, B) because it has been previously shown that incision of the A3 pulley minimally effects gliding and bowstringing.[14] For each experimental group, laceration and repair of the FDS and FDP tendons were performed 5 mm distal to the A2 pulley with the fingers in full extension (Fig. 1B). The FDS was repaired with a 2-strand modified Kessler technique with 4–0 FiberWire (Arthrex, Naples, FL)[15] and the FDP was repaired with a 4-stranded repair in which a basic 2-strand core suture was supplemented by a horizontal mattress suture with 4-0 FiberWire with a running locking epitendinous stitch with 6-0 Prolene (Ethicon, Edinburgh, UK).[16] To reroute the FDS, the 2 strands proximal to the laceration were passed between the A1 and A2 pulleys and sutured to their distal ends such that the FDS reentered the pulley system at C2 (Fig. 1C).

Biomechanical testing

We mounted the immobilized cadaver specimen by attaching the external fixator to a ring stand so that the fingers had full range of motion. The proximal tendon was loaded using the S-hook with the direction of force consistent with the direction of the anatomical pull. Loads were applied in 50-g increments up to a final load of 700 g (Fig. 2). We used the neutral unloaded tendon as the starting point; after each incremental load, we captured a digital image from the lateral view to record the flexion angle. Specimens were continuously irrigated