

Accuracy of Visual Estimates of Partial Flexor Tendon Lacerations

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Purpose To determine whether hand surgeons could accurately and consistently estimate the size of partial flexor tendon lacerations.

Materials and methods Thirty-two partial flexor tendon lacerations were made in the flexor digitorum profundus tendons of a fresh-frozen cadaveric hand. Four hand surgeons and 5 residents estimated the size of the lacerations. Estimates were repeated 3 days later. Magnified images of the laceration cross-section were used to calculate the true size of each laceration. Inter- and intrarater reliability were calculated using the intraclass correlation coefficient. Accuracy was measured with the mean bias error and the mean absolute error.

Results Interrater and intrarater reliabilities were both high. There was a high level of consistency for both surgeons and residents. In terms of accuracy, there was a 3% bias toward underestimation. The mean absolute error was 11%. There was no statistically significant difference between the accuracy of attending hand surgeons and that of residents. Participants were less accurate when estimating lacerations close to a 60% laceration threshold for surgical repair (lacerations in the 50%–70% range). For lacerations within this range, an incorrect management decision would have been made 17% of the time, compared with 7% of the time for lacerations outside that range.

Conclusions The accuracy and reliability of surgeon estimates of partial flexor tendon laceration size were high for surgeons and residents. Accuracy was lower for lacerations close to the threshold for repair.

Clinical relevance Visual estimation is acceptable for evaluating partial flexor tendon lacerations, but it may be less reliable for lacerations near the threshold for repair. Therefore, surgeons should be cautious when deciding whether or not to repair partial lacerations in the borderline range. (*J Hand Surg Am.* 2015;40(12):2421–2426. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)

Key words Flexor, tendon, laceration, estimation, partial.

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REPAIRING A MINOR PARTIAL FLEXOR tendon laceration can weaken the tensile strength of the tendon and can increase bulk resulting in poor gliding and increased work of flexion.^{1–3} Therefore, only substantial lacerations that weaken the tendon to the point that it is at risk for rupture (or that cause catching on the tendon sheath) should be repaired.^{4–8} The recommended threshold for repairing a partial flexor tendon laceration varies. Many authors advocate repair if the laceration involves more than 50% to 60% of the tendon's

cross-sectional area,^{9–13} but recommendations range from 30% to 95%.^{14–18}

The purpose of this study was to determine whether hand surgeons could accurately and consistently estimate the size of partial flexor tendon lacerations.

MATERIALS AND METHODS

Partial flexor tendon laceration model

One fresh-frozen hand was obtained from the institution's willed body program and allowed to thaw for 24 hours. Bruner incisions were made over volar aspect of the index, middle, ring, and little fingers to expose the flexor tendon sheaths from the distal phalanges into the midpalm. The flexor tendon sheaths were divided longitudinally, exposing the flexor tendons. Using a scalpel, 8 partial flexor tendon lacerations of varying sizes were made in the flexor digitorum profundus tendons of each finger from zone I through zone III, creating a total of 32 partial lacerations. The lacerations were oriented transversely to the long axis of the tendon. A random number was used to generate 32 percentage values, ranging between 1% and 99%. An effort was made to create lacerations that approximated the depth assigned by the random number generator. In this way, 32 partial flexor tendon lacerations were created with a wide range of laceration depths. The true depth of each laceration was unknown at the time of estimation and was precisely measured later in the experiment.

Estimation of laceration size

Four hand surgeons and 5 plastic surgery residents (postgraduate year 2, $n = 2$; 3, $n = 2$; 4, $n = 1$) estimated the size (percent involvement of cross-sectional surface area) of the lacerations under loupe magnification and with the use of standard surgical instruments including calipers and ruler, although none of the participants ended up using the calipers. Participants were invited to repeat the size estimates in order to evaluate intrarater reliability. The second session was performed 3 days after the first session and the tendon lacerations were evaluated in reverse order to reduce recall bias. All aspects of the study were approved by our institutional review board.

Measurement of true laceration size

The flexor digitorum profundus tendons containing the lacerations were then removed from the hand and fixed in formalin (10% neutral buffered formalin; 24 hours). The laceration surfaces were painted with black ink (black permanent ink; Newell Rubbermaid Inc., Freeport, IL). Ink was used rather than a histological stain in



FIGURE 1: Magnified photograph of the tendon cross-section through the partial laceration. The inked surface represents the partial laceration.

order to avoid stain penetration outside the zone of laceration. Next, using a scalpel, the tendon was completely divided through each laceration. This converted each partial laceration into a complete laceration with an inked surface representing the surface area of the partial laceration (Fig. 1). Magnified electronic images of each inked tendon cross-section were obtained, and digital image processing software (Photoshop; Adobe Systems Inc., San Jose, CA) was used to calculate the percentage of the total cross-sectional surface area of each partial tendon laceration.

Statistical methods

Inter- and intrarater reliability were measured by calculating the intraclass correlation coefficient (ICC, 2,1) for absolute agreement.¹⁹ Interrater reliability was calculated for all participants and for surgeon and resident subgroups separately. Intrarater reliability was calculated for all participants separately. An ICC less than 0.40 was considered poor, an ICC between 0.40 and 0.59 was considered fair, an ICC between 0.60 and 0.74 was considered good, and an ICC greater than 0.74 was considered excellent.^{19,20}

Accuracy was measured by calculating the mean bias error (MBE) and the mean absolute error (MAE). Accuracy was measured for all participants and for the surgeon and resident subgroups separately. Comparisons of MBE and MAE were performed using the Student *t* test, and *P* values less than .05 were considered statistically significant.

Finally, the estimation accuracy for lacerations that were close to the 60% threshold for surgical repair (50%–70% true size range) were analyzed separately and compared with lacerations that fell outside this range. This comparison was performed in order to

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