MRI ANALYSIS OF ZONE III PALMAR ANATOMY WITH HAND FLEXION AND EXTENSION

Introduction

It has been noted that the clinical sequelae of a laceration injury sustained to Zone III of the palm is highly dependent upon palmar anatomy. Hence anatomic changes in palmar anatomy as a function of hand movement would be expected to alter the extent and type of injury. Accordingly, we evaluated the tendon location in Zone III of the palm with respect to the corresponding neurovascular bundles in two functional positions of the hand, corresponding to flexion and extension. Although the palmar anatomy exhibited in a position of rest has been well documented by MRI methods, functional positions have as yet to be detailed.

Methods

Experiments were performed on 10 non-embalmed cadaveric hands in order to determine optimal imaging conditions and parameters. Images were acquired with the hand in positions of rest, flexion and extension. A custom-made jig was used to ensure reproducible positioning and standardized grip force. For hand flexion, the wrist was maintained at 30º of dorsiflexion by applying traction to the wrist extensors. For hand extension, a neutral position of the wrist was maintained while force was applied to the finger extensor tendons. Flexion and extension results were compared with results obtained with the hand in the neutral position. After initial imaging, latex was injected into the palmar digital arteries, via the radial and ulnar arteries, in order to confirm the position of the neurovascular bundles. MR images were repeated retaining exact slice geometry. The hands were then frozen in the flexed or extended position and histologic slices were obtained corresponding to the MR imaging plane. MR images were obtained using a 1.9 Tesla, 31-cm Bruker BioSpec MRI scanner (Bruker Medizintechnik GmbH, Ettlingen, Germany) with a shielded gradient set (20 cm inside diameter) with an available gradient strength of 100mT m^{-1}, and an imaging resonator (15 cm inside diameter). Cadaver images were obtained at room temperature using a two-dimensional T_1 weighted spin echo sequence, with TR/TE = 500/23, FOV 15 x 15 cm providing an in-plane resolution of 270 microns in both read and phase-encode directions using a 512 x 512 matrix. 12 transverse slices of 1.1 mm thickness were obtained with 2.5 mm slice spacing. Data planes were carefully selected consistently between samples. 16 signal averages were used, for a total imaging time of approximately 1 hour.

Results

Significant changes in tendon depth with respect to neurovascular bundle position were observed between the neutral position and hand flexion and extension. In all cases, tendons shifted to a more superficial position upon extension, were intermediate in flexion, and were deepest with the hand in the neutral position. Corresponding to this, in the neutral position the neurovascular bundles lie superficial to the flexor tendons, but with extension these bundles become deeper than the tendons. This effect is most pronounced on the ulnar aspect of the hand. The relative anatomy of these structures is demonstrated in Figs. 1**a** and 1**b**.

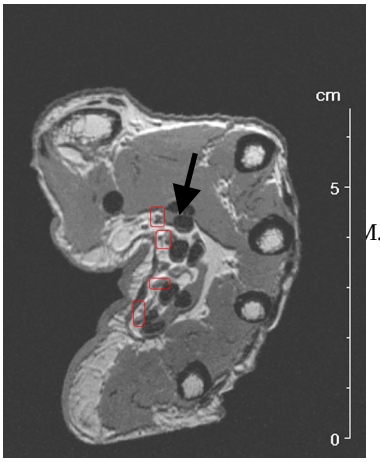

Fig. 1**a**

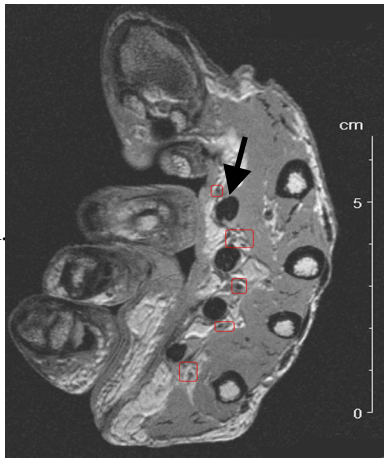

Fig. 1**b**

Fig. 1 Transverse MR section through the palm (4mm below 5th metacarpal head) showing the relative anatomy of flexor tendons [large black arrow] and neurovascular bundles [red circle] in Zone III **a)** in the neutral **b)** extended position of the hand.

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Conclusion

We have demonstrated that significant changes occur in the relative positions of the flexor tendons and associated neurovascular bundles of the hand upon flexion and extension. Tendon motion is constrained primarily by the palmar fascia and overlying skin, permitting substantial variation in position corresponding to hand position. Displacement with respect to the skin surface, as has been demonstrated here, may have significant implications for the characteristics of injury to both the tendons themselves and to their associated neurovascular bundles as a function of hand position. These results provide a potential explanation for the clinical observation of a greater propensity towards flexor tendon injury in lacerations sustained during hand flexion or extension, including gripping, as compared to injuries sustained with the hand the in neutral position.

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