texas orthopaedic journal®

ORIGINAL RESEARCH

A Novel Variation of the 3rd Palmar Interosseous Muscle, with Functional Analysis of the Effect on Moment Arms About the Metacarpophalangeal Joint

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ABSTRACT

A new variation of the 3rd palmar interosseous muscle was encountered during a cadaver dissection. In this variation, the muscle had a point origin on the palmar side of the base of the 4th metacarpal, in contrast to the normal broad origin along the 5th metacarpal. Moment arm curves derived from simulation models of normal and variant muscle-tendon paths suggest that the variant origin provided functionally greater moment arm over most of the range of motion.
Keywords: Hand anatomy; Hand biomechanics; Interossei muscles.

INTRODUCTION

While performing a cadaver dissection, we encountered a variant origin of the 3rd palmar interosseous muscle. This variant originated from a point on the palmar side of the base of the 4th metacarpal, rather than the normal broad origin along the shaft of the 5th metacarpal. A literature search indicated that this particular variation has not been previously reported. In order to explore the mechanical effect of this variant, we used our computer hand simulation to model the normal and variant muscle-tendon paths.

Identification of the Variant Origin of the 3rd Palmar Interosseous Muscle

We performed a dissection of the left upper extremity (thawed fresh tissue specimen) of an 85-year-old female. Skin and subcutaneous tissue were carefully removed. The palmar aponeurosis was excised, extrinsic tendons were reflected from their origin, and the individual intrinsic muscles were isolated. The 1st and 2nd palmar interossei muscles

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were normal; however, the 3rd palmar interosseous muscle originated distinctly from the base of the palmar side of the 4th metacarpal bone and lacked origin from any portion of the 5th metacarpal bone, as shown in Figure 1. This is in contrast to the normal broad origin along the palmar and radial shaft of the 5th metacarpal. A search of the literature for prior reports of this type of variation brought up several variations of the dorsal interossei, but none matching this particular palmar variant.

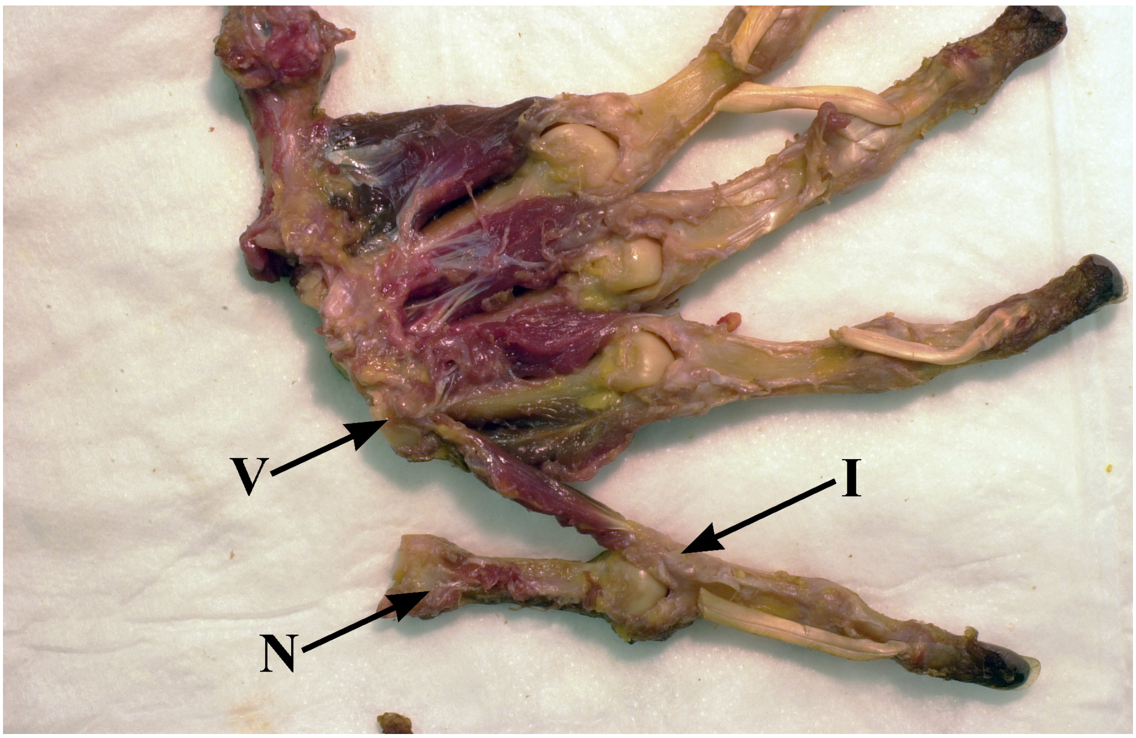

Figure 1. A variant origin of the 3rd palmar interosseous muscle (**V**) compared with normal origin (**N**). Insertion is at (**I**).

Simulation of Normal and Variant Muscle-Tendon Paths and Moment Arm Curves

In order to elucidate the functional contribution of the variant origin, we simulated the moment arm curves of the normal and variant versions of the 3rd palmar interosseous. Our simulation software is an interactive, three-dimensional (3D), simulation of musculoskeletal kinematics [1]. Within this tool, 3D bone surfaces derived from CT images processed by Mimics software and defined in stereolithography files are arranged in a hierarchical structure with up to three rotational axes per bone [2]. Axes are be manually positioned and oriented in accordance with literature and geometry, and rotation limits set to approximate normal range of motion. Muscle-tendon paths are defined by a sequence of control points and may be represented either as a sequence of line segments or by one of several parametrized cubic spline models. Special control points, which we refer to as "virtual" points, are designed to remain beyond the bone surface to minimize intersections of the path with the bone, and will slide about the surface of a bone rather than penetrate it. The magnitude of the moment arm throughout the range of motion of a joint is determined as the derivative of the excursion with respect to angle in radians.

The normal 3rd palmar interosseous muscle was modeled with five separate fiber paths to account for the broad origin, using four control points to define each fiber path. The variant muscle was modeled by a single cubic spline path defined by three control points. The control points were manually positioned to yield 3D cubic spline paths, as shown in Figure 2, analogous to those observed in cadaver specimens, and their positions were iteratively refined to avoid intersections with bone throughout the range of motion of the 5th proximal phalanx (Figure 3). In some cases in the normal model, virtual control points were utilized to avoid intersection of the paths with the bones.

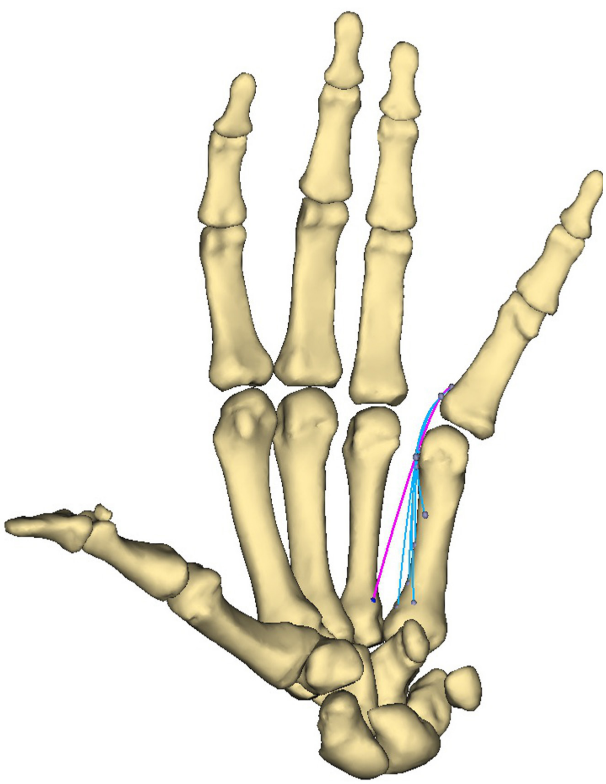

Figure 2. Screenshot of palmar view of the muscle-tendon path models in the simulation.

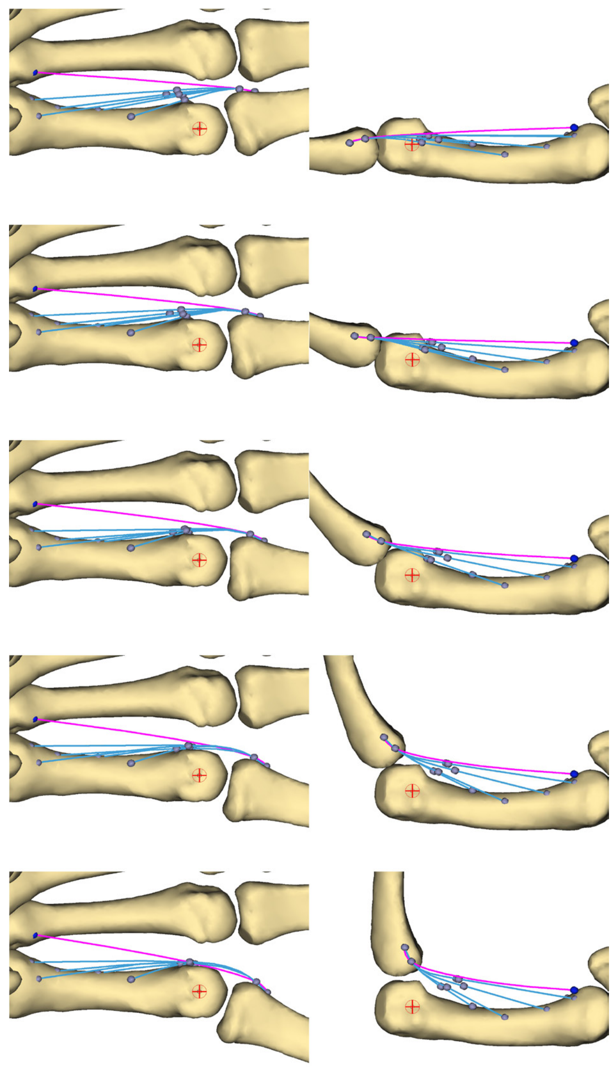

Figure 3. Simulation screenshot of a left hand showing 3rd palmar interosseous muscle-tendon path models in abduction-adduction (left column, palmar perspective) and flexion-extension (right column, radial perspective, intervening bones not shown).

Once the muscle-tendon paths were defined, the simulation generated moment arm curves throughout the range of motion in flexion-extension and abduction-adduction. Figures 4 and 5 show the simulated moment arm curves for flexion-extension and abduction-adduction, respectively. The apparent "noise" in the graphs is due to the use of virtual control points for collision avoidance and is the result of the virtual point sliding across the uneven bone surface, which affects the length of the splined muscle-tendon path. The graph of the normal model's moment arm curve shows the mean and one standard deviation bounds for the five fiber paths spanning the broad origin.

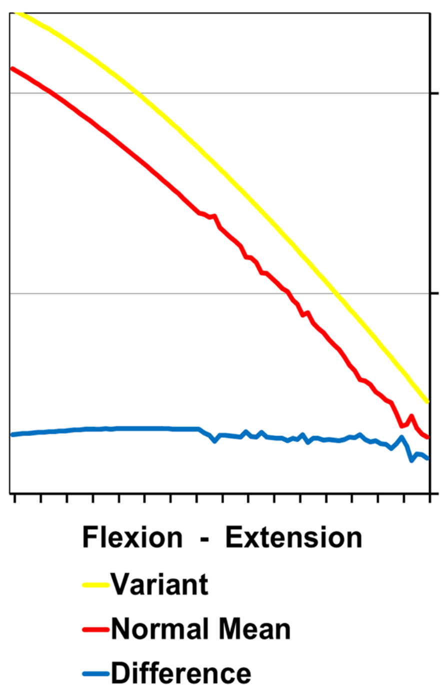

Figure 4. Simulated moment arm (millimeters) in flexion-extension (5 degree tick marks) for the normal and variant 3rd palmar interossei muscles.

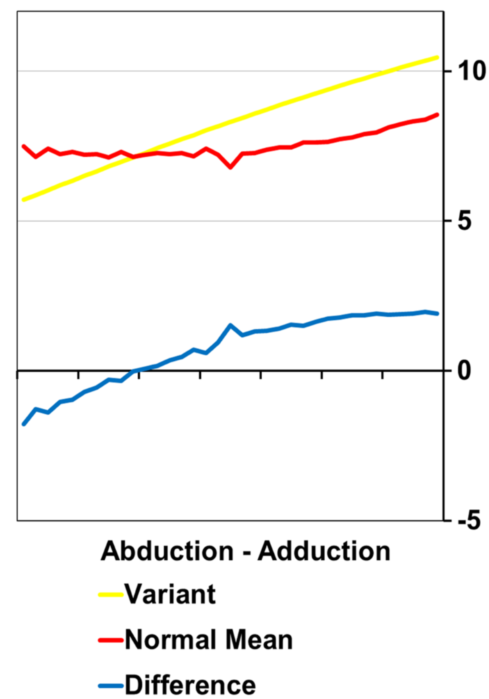

Figure 5. Simulated moment arm (millimeters) in abduction-adduction (5 degree tick marks) for the variant and normal 3rd palmar interossei muscles.

DISCUSSION

In flexion-extension, the variant origin yielded a near-constant increase in moment arm with respect to the mean normal moment arm of about 1.5 mm. As the normal moment arm varies almost linearly from 1.5 to 10.5 mm, the variant origin contributes additional moment arm of between approximately 15% at full flexion and 60% at full extension. Both the normal and variant paths exhibit a moment arm increase (bowstringing) with flexion at the MP joint.

In abduction-adduction, the comparison of variant with normal is more complex. The curves intersect at about a quarter of the way from full abduction. The normal moment arm does not vary significantly over the range of motion, beginning at near 7 mm at full abduction and remaining little changed for the first half of the range, then gradually increasing to about 8.5 mm at full adduction. The variant moment arm varies linearly over the same domain from about 6 mm to 10.5 mm. Relative to the normal moment arm, the variant contributes a decrease of nearly 25% at full abduction, transitioning to 0% in the first quarter of the range, then increasing through the remaining three quarters of the range to near 25% at full adduction.

CONCLUSIONS

In general, the described variant origin of the 3rd palmar interosseous muscle provides a potentially beneficial increase in moment arm in comparison with the normal origin. This is the case throughout flexion-extension, as well as most of the range in abduction-adduction, except near full abduction where the variant moment arm is less than normal. This variant would offer particularly improved mechanical advantage when performing flexion and adduction of the little finger, but some disadvantage at full abduction.

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