New Anatomical Landmark for Surgical Release of A1 Pulley in the Hand

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ABSTRACT
Anatomical landmark of A1 pulley is important especially in minimal invasive surgery. The lengths and landmarks of A1 pulleys were evaluated in 510 preserved cadaver digits. The cadavers were 25 females and 26 males aged at the time of death ranged from 48 to 89 years. Measurements of A1 pulley lengths were made and used to predict the landmarks of the proximal pulley margins, which are related to the knuckle via an imaginary perpendicular line to the palmar surface of the fingers and thumbs in an objective way. The average lengths of the A1 pulleys in each digit were as follows: thumb; 5.30 ± 0.53, index finger; 6.32 ± 0.17, middle finger; 6.58 ± 0.19, ring finger; 6.32 ± 0.19, and little finger 5.30 ± 0.49 mm. The average lengths of all fingers were 6.13 ± 0.57 mm. The margin from the proximal edge of the A1 pulleys on the perpendicular line from the knuckle to the palm was in the same line in 327 (64.1%) fingers and thumbs, while 464 (91.0%) fingers and thumbs were ≤ 1 mm and 509 (99.8%) were ≤ 2mm to the proximal edge of the A1 pulley of its finger or thumb. In conclusion, the tip of the knuckle line perpendicular to each digit was a new surface anatomical landmark that was useful for identifying the proximal part of A1 pulley during the operative procedure.
INTRODUCTION
Knowledge regarding surface landmarks of A1 pulleys is important to surgical treatment of trigger digit especially in minimal invasive and percutaneous techniques.\textsuperscript{1,2} One popular technique of percutaneous release of trigger digit was described by Jean Lorthioir who used the palmar crease as a landmark for localizing A1 pulleys.\textsuperscript{2} However, this technique can be inaccurate due to the variability of palmar creases or hand size.\textsuperscript{1,3,4} Wilhelmi et al. found that the distance from the palmar digital crease to the proximal interphalangeal crease corresponded to the distance of the proximal edge of the A1 pulley to the palmar digital crease.\textsuperscript{1,5} In addition, none of the several anatomic studies of the A1 pulley has been described the location of the A1 pulley in relation to the knuckle.\textsuperscript{6-11} The purpose of this study was to measure the length of the A1 pulley in each digit and revealed the landmark of the proximal edge of the A1 pulley with relation to knuckle line in perpendicular line to the palm of its finger and thumb.

MATERIALS AND METHODS
Five hundred and ten preserved cadaver digits were dissected with a 4X loupe for measurement of length and landmark of A1 pulley by using a caliper of 1 orthopedist. Measurements were also taken of the proximal A1 pulley margins relating the central tip of the knuckle which was lined perpendicular to the palm. The distance between the proximal edge of the A1 pulley and the perpendicular line from the knuckle to the palm of each digit was measured, by using a large reduction with point which one point was fixed to the center of the knuckle gripped over the palm and the other to the flexor tendon while the hand was placed over the table with both the shaft and the handle of reduction with point perpendicular to the palm. Each distance was measured twice.

![Fig.1](image)

Fig.1. Landmarks for measurements of proximal A1 pulley margins with relation to the central tip of knuckle which lined up perpendicular to palm. (A) And the distance from the proximal edge of the A1 pulley (B) to the perpendicular line from the knuckle to the palm of each fingers (left) and thumbs (right) was measured.
**RESULTS**

In the 510 cadaveric digit dissections, the margin from the proximal edge of the A1 pulley to the perpendicular line from the knuckle to the palm was in the same line in 327 digits (64.10%), was ≤ 1 mm in 464 (91.0%), and ≤ 2 mm in 509 (99.80%). The overall mean difference was 0.37 ± 0.55 mm. The margin from the proximal edge of the A1 pulleys of the thumb, index, middle, ring and little finger were 67 (65.70 %), 59 (57.80 %), 62 (60.80 %), 69 (67.60 %), 70 (68.60 %) digits respectively to the same line in the perpendicular line from the knuckle to the palm.

The margin from the proximal edge of the A1 pulleys of the thumb was 67 (65.70 %) digits as same line as in the perpendicular line from the knuckle to the palm.
The thumb, index, middle, ring and little finger were 95(93.10 %), 91(89.20 %), 90(88.20 %), 94(92.20 %), 94(92.20 %) digits respectively differences ≤ 1 mm to the line in the perpendicular line from the knuckle to the palm (Table 1).
The length of A1 pulley averaged 5.30 ± 0.53 mm for thumb, 6.32 ± 0.17 mm for index, 6.58 ± 0.19 mm for middle, 6.32 ± 0.19 mm for ring, and 5.30 ± 0.49 mm for small finger, whereas the A1 pulley of small fingers were not significantly shorter (p>0.05) than the length of the A1 pulley for the index, middle and ring fingers with a 95 percent confidence interval (Table 2).

DISCUSSION

A1 Pulley is fibrous band of variable length, thickness, and configuration lining the synovial sheaths.\textsuperscript{7,12,13} It’s function is to enable flexor tendon excursion of the fingers. The location of the A1 pulleys must be determined before treatment of various hand conditions and injuries, i.e. steroid injection or release of an A1 pulley for trigger digit or repairing flexor tendon at the digital level.\textsuperscript{1,4-23} Wilhelm and colleagues reported that the proximal edge of the C0 fibers or the distal part of A1 pulley is approximately 5 mm proximal to the palmar digital crease and C0 line can be used as a guide for trigger release.\textsuperscript{1,5} During the releasing procedure of A1 pulley, it is essential to avoid injury to the A2 pulley, because it is a critical pulley.\textsuperscript{4,6,11,25,26} Loss of this pulley can result in decreasing flexor tendon excursion and create bowstring effect.\textsuperscript{6} The flexor system will tolerate loss of 25% of the length of either the A2 or A4 pulley without flexion effect.\textsuperscript{27} Use of the distal A1 surface landmark line or the C0 pulley cruciate fibers as the guide for terminating pulley release can ensure preservation of the A2 pulley and optimal finger flexion.\textsuperscript{1,6} In our study, the average length of the A1 pulleys was 5.30 ± 0.53 mm for the thumb, 6.32 ± 0.17 mm for the index finger, 6.58 ± 0.19 mm for the middle finger, 6.32 ± 0.19 mm for the ring finger, and 5.30 ± 0.49 mm for the small finger. These A1 pulley lengths can serve as an important guide for the location for termination of A1 pulley release. Wilhelm and colleague found that the distance from the palmar digital crease to the proximal interphalangeal crease corresponded to the distance of the proximal edge of A1 pulley to the palmar digital crease in absolute differences of ≤ 2 mm in 89.8% of their digits.\textsuperscript{1} Doyle described the A1 pulley system as spanning the volar plate of the metacarpophalangeal joint and base of the proximal phalanx.\textsuperscript{5,9,10} Strauch and De Moura found that the annular proximal pulley starts 2 mm proximal to the metacarpophalangeal joint.\textsuperscript{7} Gau-Tyan Lin found that the joint centers intersected the center line of adjacent phalanges and the axis of motion of the metacarpophalangeal joint was in the metacarpal head.\textsuperscript{8}

Traditionally, trigger digits have been operated via formal skin incisions. Minimally invasive and percutaneous techniques have gained popularity recently.\textsuperscript{14-22} Knowledge from our study about length and proximal edge of the A1 pulley is useful for accuracy and adequacy of surgical procedure and also avoids complication from injury to the A2 pulley.

In conclusion, this study demonstrated that the tip of the knuckle line perpendicular to the palm can be used as surface landmark for surgical release of A1 pulley.
REFERENCES