The Anatomical Location of the Flexor Hallucis Brevis as It Pertains to Implant Arthroplasty

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Background: Hallux limitus/rigidus is a painful arthritic condition affecting the first metatarsophalangeal joint that can be treated by implant arthroplasty, which, ultimately, may cause loss of the anatomical insertion points of the flexor hallucis brevis muscle. Preparation of the base involves resection of bone, thus compromising the insertion of the flexor hallucis brevis muscle.

Methods: We dissected 54 fresh-frozen cadaveric specimens and quantitatively measured the distalmost insertion point of the medial and lateral heads of the flexor hallucis brevis muscle. These measurements were performed for both heads. The measurements were performed three times by three separate examiners. In addition, taking into consideration the anatomical construct of the articular surface of the base of the proximal phalanx of the hallux, another measurement was performed to note the concavity using 44 of the specimens. Again, these measurements were performed three times by three separate investigators.

Results: The mean length from the base of the proximal phalanx to the distalmost insertion of the medial and lateral heads of the flexor hallucis brevis muscle was found to be 7 mm.

Conclusions: This study provides precise anatomical data that can be used by foot and ankle surgeons when considering the use of implant arthroplasty for the treatment of hallux limitus/rigidus and the ability to maintain the insertion point of the flexor hallucis brevis muscle. (J Am Podiatr Med Assoc 102(1): 1-4, 2012)
of the base of the proximal phalanx, the fibular sesamoid, and the lateral aspect of the plantar pad of the hallux. The literature does not demonstrate an exact insertion point of the flexor hallucis brevis tendon. The purpose of this study was to quantitatively measure the distalmost insertion point of the flexor hallucis brevis tendon medially and laterally on the base of the proximal phalanx.

Materials and Methods

Fifty-four fresh-frozen cadaveric specimens were dissected with care to maintain the soft-tissue attachments to the base of the proximal phalanx plantarly (Fig. 1). The flexor hallucis brevis muscle and sesamoid complex along with any remaining soft tissues were then dissected from the plantar surface of the proximal phalanx of the hallux.

Once all of the specimens were fully dissected, digital calipers were used to measure the exact distance from the osseous base of the proximal phalanx to the distalmost insertion of the flexor hallucis brevis muscle (Figs. 2 and 3). These measurements were performed for the medial and lateral heads of the flexor hallucis brevis muscle. The measurements were performed three times by three separate examiners and then were averaged on each specimen to ensure accuracy.

In addition, taking into consideration the anatomical construct of the articular surface of the base of the proximal phalanx of the hallux, another measurement was performed to note the concavity using 44 of the specimens. This measurement was made from the deepest point of the concavity of the articular surface of the base of the proximal phalanx to the edge of the proximal aspect of the base of the proximal phalanx. This measurement was made possible by holding a string across the base of the proximal phalanx and inserting a perpendicular bisector into the concavity (Fig. 4). A mark was made at the level where the bisector crossed the string, and this distance was then measured using the digital calipers. Again, the measurements were performed three times by three separate investigators and were averaged to ensure accuracy.

The mean and standard deviation were calculated for all of the measurements taken. The differences between the measurements of the medial and lateral heads of the flexor hallucis brevis muscle were...
statistically analyzed with the two-tailed Student t test. Significance was defined as $P < .05$.

**Results**

The mean ± SD measurement for the medial head was $7.09 \pm 1.61$ mm and for the lateral head was $7.15 \pm 1.36$ mm. We found no significant differences in the mean measurements of the medial and lateral heads from the base of the proximal phalanx ($P = .835$). The mean ± SD concavity of the articular surface of the base of the proximal phalanx of the hallux was $2.13 \pm 0.94$ mm. When considering the medial and lateral measurements together, $1.85\%$ of all of the specimens were found to have a measurement less than $5.00$ mm, $21.30\%$ had a measurement of $5.00$ to $5.99$ mm, $27.78\%$ of $6.00$ to $6.99$ mm, $22.22\%$ of $7.00$ to $7.99$ mm, $15.74\%$ of $8.00$ to $8.99$ mm, $4.63\%$ of $9.00$ to $9.99$ mm, and $6.48\%$ of $10.00$ mm or greater. Thus, most of the samples ranged from $5$ to $8$ mm ($71.30\%$). The mode was $6.00$ mm; therefore, a resection greater than $6.00$ mm suggests a possible compromise of the flexor hallucis brevis tendon.

**Discussion**

We found no difference in the average measurement from the base of the proximal phalanx to the distal-most insertion of the flexor hallucis brevis tendon as it pertains to the flexor hallucis brevis muscle medial and lateral heads. When considering the medial and lateral measurements together, most of the samples ranged from $5$ to $8$ mm ($71.30\%$). The mode was $6.00$ mm; therefore, a resection greater than $6.00$ mm suggests a possible compromise of the flexor hallucis brevis tendon.

The concavity is also taken into consideration when performing a neutral cut during the hemi-implant procedure. The neutral cut is made to provide a planar surface. If excessive concavity is present, greater amounts of bone need to be resected to establish a surface to receive the implant, thus further decreasing the likelihood of maintaining the insertion points for the flexor hallucis brevis muscle.

The values obtained in this study were compared with those from different suggested surgical techniques for implant arthroplasty, and a significant potential problem was discovered. The present study found the mean length from the base of the proximal phalanx to the distalmost insertion of the flexor hallucis brevis muscle to be approximately $7$ mm for the medial and lateral heads. In addition, although certain implant devices may require a cut slightly smaller than the $7$-mm mean resulting from this study, the distal fibers remaining would not prove useful in maintaining the function of the flexor hallucis brevis tendon.

A key limitation of this study is the lack of information on the specimens regarding sex, age, and medical history. Thus, the simultaneous presence of different diseases, ie, arthritis, gout, etc, that affect the shape of the first metatarsophalangeal joint and the articular surface could affect the measurement results. Human error also plays a part in limiting the study; the investigators performed the measurements numerous times to minimize this limitation. Ultimately, measurement inaccuracies made during execution of the study would limit the accuracy of the results.

**Conclusions**

The present findings indicate that resection of bone greater than $7$ mm thick from the base of the proximal phalanx will lead to loss of insertion of the flexor hallucis brevis muscle. This is important to remember when performing an implant arthroplasty procedure for the treatment of hallux limitus/rigidus because functional loss of the flexor hallucis brevis muscle may lead to increased complications not originally considered.
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References