Sizing of the Lesser Toe Flexor Digitorum Longus Tendon and the Proximal Phalanx for Hammertoe Correction

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Disclosures

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Introduction

• The flexor to extensor transfer of the flexor digitorum longus (FDL) tendon through a drilled bone hole is a common operative procedure for the treatment of a flexible hammer toe deformity.

• A rare complication of the flexor to extensor transfer is iatrogenic fracture through the drill hole site for the tendon transfer.

• The structural integrity of the proximal phalanx is important since the average contact and toe off forces acting upon the MTP joint can reach 600 N in the 1st toe and gradually decrease in the lesser toes to approximately 100 N in the 5th toe.

• Little is known about the average measurements of the FDL tendon and the proximal phalanx, and the dimensions of each for the safe passage of the tendon through the bone.
Purpose

• The purpose of this study was to ascertain the average measurements of the diameter of the FDL tendon at the mid-diaphysis and the diameter of the metaphyseal-diaphyseal junction of the proximal phalanges so as to better understand the relationship of the tendon to the bone.

• Our aim is to provide the surgeon more clinically relevant information regarding the relationship of the bone and tendon in this area.

• In some individuals the proximal phalanx may be too small to accommodate the full diameter of the FDL tendon with the appropriate drill hole, thus the resulting bone-tendon construct is weakened to the extent that it may not withstand the normal mechanical stresses placed on it during gait.
Materials and Methods

• The proximal phalanx and FDL tendon of the 2nd - 4th toes of 14 cadavers were dissected; the digit was amputated at the MTP joint
• FDL tendon was measured with a tendon sizer
• Proximal phalanx was measured for diameter at the metaphyseal-diaphyseal junction using radiographs
• The area and volume of the bone and the dimensions of the drill hole necessary to pass the tendon through were calculated
• The following equations were used to find our volumes:
  • $V_{cylinder} = \{\pi \times (D_{bone} \div 2)^2 \times H\}$
  • $V_{drill hole} = \pi \times (D_{tendon} \div 2)^2 \times \{\sqrt{2 \times D_{bone2}}\}$
  • % $V_{bone}$ remaining = \{(V_{cylinder} - V_{drill hole}) \div V_{cylinder}\} \times 100
Diagram illustrating the pathology seen in Hammertoe Deformity
http://feetdoc.com/hammer_toes.htm
Arch City Foot & Ankle, 521 North Virginia Ave, Eureka, MO 63025

Amputated toe at the MTP joint with FDL tendon separated from the FDB tendon

FDL tendon being passed through the drill hole in the proximal phalanx
Arthrex.com 2007
http://arthromed.org/pdf/smalljoint/Flexor%20to%20Extensor%20Tendon%20Transfer
Results

- The average bone diameter decreased from the 2nd (7.49mm) to the 4th digit (6.26mm)
- The average tendon diameter decreased from the 2nd (3.75mm) to the 4th digit (3.39mm)
- The average amount of bone remaining on either side of the drill hole decreased from the 2nd (1.78mm) to the 4th digit (1.43mm)
- The average percentage of bone volume remaining after the drill hole was very similar in the 2nd (76%), 3rd (72%), and 4th (73%) toes.
- 3 toes had a remaining diameter of < 1mm on either side of the drill hole
Discussion

• As expected the size of both the bone and tendons decreased from the medial forefoot to lateral forefoot as normal mechanical forces load the medial forefoot more so than the lateral forefoot.

• The increase in bone and tendon diameter in the medial forefoot versus lateral forefoot is in response to increased mechanical stresses acting upon the medial foot during the different stages of the gait cycle.

• The diameter of bone that remains on either side of the drill hole after the drilling process and the volume of bone in the proximal phalanx area of interest are indicators of the structural integrity of the bone and its ability to withstand the mechanical forces that could be applied to it in the post-operative period.
Conclusions

- In pre-operative planning for a flexor tendon transfer, a radiograph of the digit allows the surgeon to analyze its dimensions and decide if the proximal phalanx is capable of withstanding a drill hole size that will accommodate the average flexor tendon while maintaining adequate osseous structural integrity.
- We found notable variation in the measurements of the 2nd, 3rd, and 4th toes.
- In most cases the orthopaedic surgeon can use these measurements in combination with pre-operative radiographs of the feet to plan which toes can safely be drilled through while still maintaining sufficient structural integrity to withstand a reduced level of stress without fracturing.
References


