

Tensile Strength of the Medial Collateral Ligament of the Hallux

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Statement of Purpose

Augmenting or replacing the MCL utilizing suture material attached to bone anchors on either side of the first MPJ can enhance correction of hallux valgus with immediate intraoperative results. However, testing and quantification of this ligament's tensile strength are necessary to understand the innate anatomic qualities that must be replicated by any artificial replacement construct. This value is what we believe to be the necessary strength that must be matched or exceeded.

Level of Study

Level IV Study

Introduction

Hallux valgus is a foot disorder characterized by lateral deviation of the first metatarsophalangeal joint, and medial deviation of the first metatarsal. The precise etiology leading to the development of hallux valgus deformity remains unclear and may be multifactorial. One of the most notable causes can be due to failure of the soft tissues at the first metatarsophalangeal joint as the deformity has been observed to increase after surgical release of the medial collateral ligament (MCL) or after acute rupture of this ligament. The MCL of the hallux is essential for maintaining biomechanical functional alignment and position of the hallux at the joint. Thus failure of this tissue structure, whether through attenuation, trauma, or surgical release, is associated with hallux valgus.

There has been no uniform technique for the repair or reconstruction of the MCL described in previous literature, however a novel approach uses a bone anchors and non absorbable high strength suture to recreate the ligament. Bone anchors are inserted in the medial head of the metatarsal and the medial base of the proximal phalanx (as seen in Illustration 1) and cinched closer together with the suture. The pullout force of the anchors and mechanical strength of the Force Fiber suture are well documented, but the tensile strength of the the native MCL has never been studied.

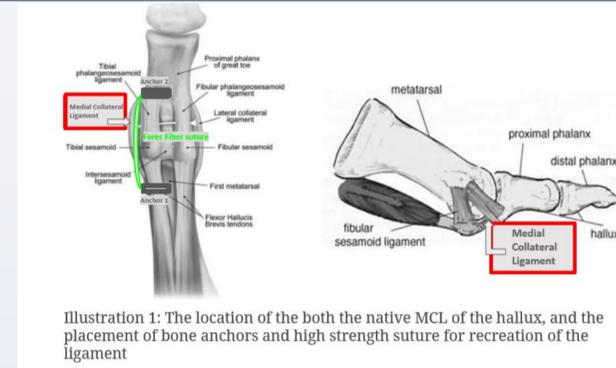


Illustration 1: The location of the both the native MCL of the hallux, and the placement of bone anchors and high strength suture for recreation of the ligament

Methods

A total of three different cadaveric specimens were made available for use within a travel lab. The three limbs were anchored to the equipment via a drill hole through the head of the metatarsal and the proximal phalanx with it attached to a carabiner. The carabiner was then attached to a mechanical force gauge. Dissection of the three specimens was accomplished at the metatarsophalangeal joint following proper podiatric technique through the superficial and deep fascial layers. A L-shaped capsulotomy was performed at the level of the first metatarsal phalangeal joint. The dissection included the preservation of and sectioning of all soft tissue elements leaving the MCL as the only attachment structure between the head of the first metatarsal and the base of the proximal phalanx of the hallux. The in situ testing on the models involved axial tensile loading, with peak load at the failure point of the ligament being documented upon failure from the mechanical force gauge

Results

The MCL was found to fail at 50lbs (22.7kg) of axial force in specimen one, 42lbs (19.1kg) in specimen 2, and 52lbs (23.6kg) in specimen 3. This would represent the peak strength of the ligament along its longitudinal axis.

Discussion

These measurements provide new baseline data for the design and selection of a MCL replacement in order to reproduce normal hallux kinematics. To this point, the strength of the ligament has not been well documented or observed. The choice of bone anchors and connecting suture material must match or exceed this value for proper anatomical repair to be accomplished. Prior anchors have been documented to have a load to failure in procedures involving the hip and rotator cuff of at least 103.9 N. Their endurance was also tested to show a mean displacement of only 8.4 mm after repetitive stressors under tension at 50 cycles. (5). Traditional anchors may have slightly higher load to failures; however, the anchors chosen are readily available, cheaper, and sufficient for procedures in the lower extremity. The wedge anchors permit reapplication where as those such as barbs have a destructive removal process limiting the surgeon. Bunion recurrence rates have been studied and range from 2.7% to 16.0% across multiple studies.

While the number of specimens was fairly limited in this study, having a general target value to exceed with any artificial construct aids in the fine tuning of this type of procedure. By augmenting this structure in hallux valgus procedures, increased correction can be attained with a lower likelihood of recurrence of deformity.

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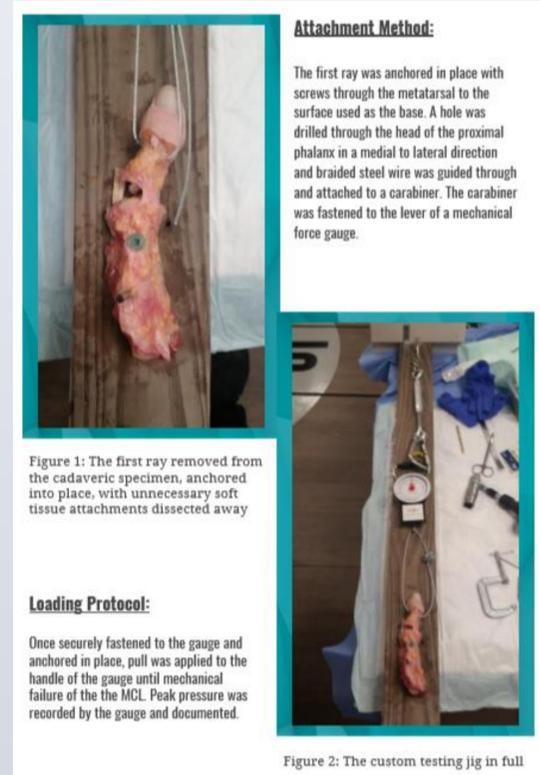


Figure 1: The first ray removed from the cadaveric specimen, anchored into place, with unnecessary soft tissue attachments dissected away

Loading Protocol:

Once securely fastened to the gauge and anchored in place, pull was applied to the handle of the gauge until mechanical failure of the MCL. Peak pressure was recorded by the gauge and documented.

Attachment Method:

The first ray was anchored in place with screws through the metatarsal to the surface used as the base. A hole was drilled through the head of the proximal phalanx in a medial to lateral direction and braided steel wire was guided through and attached to a carabiner. The carabiner was fastened to the lever of a mechanical force gauge.

Figure 2: The custom testing jig in full