Plantar Forces in Flexor Hallucis Longus vs. Flexor Digitorum Longus Transfer in Adult Acquired Flatfoot Deformity

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INTRODUCTION:

Flexor hallucis longus (FHL) and flexor digitorum longus (FDL) tendon transfers are frequently used to restore the function of a deficient posterior tibial tendon (PTT) in flexible stage II adult acquired flatfoot deformity (AAFD). [1] Increasingly, the FHL has been chosen as the preferred donor as prior anatomic analysis has shown the physiologic cross-sectional area (PCS A) of the FHL to be twice that of the FDL, though biomechanical data demonstrating that this equates to better PTT augmentation is not yet conclusive. [1-3]

The decision to tenodese the cut end of the transferred FDL or FHL tendon remains controversial. Prior clinical studies have demonstrated loss of flexion force in the toes of the transferred tendon but have not determined if this loss is clinically significant. [4,5] The need for tenodesis has been thus far been questioned because of the increased risk to the surrounding neurovascular structures in the arch of the foot. [6]

Thus, the aim of this study was to quantify changes in plantar force in the great and lesser toes before and after tendon transfer and with or without tenodesis in order to assess the ability of a tenodesis to restore lost toe flexion force. Additionally, through comparisons of mediolateral x-rays following tendon transfer with and without tenodesis, the effects on arch height in an AAFD cadaveric model were investigated.

METHODS:

Using a previously developed loading frame, 10 matched pairs of cadaveric lower extremities, disarticulated at the knee, were statically loaded under a 100lb axial force applied through the tibial plateau. [7] Soft-tissue activation was approximated through a 100lb Achilles force applied at the level of the calcaneus through braided cable and custom tendon clamps, as well as 10lb and 6lb tensile loads applied to the FHL and FDL tendons, respectively. Specimens were loaded with both the FHL and FDL intact, with only one of the two transferred based on the testing group, and finally with the transfer and distal tenodesis.

For each testing state, plantar force distribution in each of 5 distinct regions of the foot were assessed using a plantar pressures mat (Tekscan Inc., South Boston, MA) as has been done previously. [7] Specifically, these regions were the great toe (1), the lesser toes (2), the distal 1st metatarsal (3), the distal 2nd metatarsal (4), and metatarsal heads 3-5 (5). Additionally, mediolateral x-rays using fiduciary pins in the navicular tuberosity were taken during each trial to assess changes in arch height for each level of repair, as has been done previously. [8] Figure 1

RESULTS:

Transfer of the FHL and FDL showed a significant decrease in flexion force from intact for the great toe (Region 1) (p<0.01) and lesser toes (Region 2) (p<0.001), respectively. Tenodesis demonstrated an ability to increase flexion force in the great (p>0.05) and lesser (p>0.01) toes over transfer alone for FHL and FDL, respectively. For the FHL transfer and tenodesed state, the great toe flexion force was not significantly less than intact (p>0.7). (Figure 2) Additionally, FHL transfer resulted in an increase in all regions of forefoot loading (p<0.05). This increase was disporportionately distributed to the medial forefoot as compared to the lateral forefoot. Following transfer of the FHL tendon, 1st metatarsal force (Region 3) increased by 22.4% over intact; 2nd metatarsal force (Region 4) increased 18.4% over intact, and lateral metatarsal force (Region 5) increased by 8.6%. (Figure 3)

DISCUSSION:

As expected, both FHL and FDL transfer resulted in a significant reduction in flexion force of the great and lesser toes, respectively. Likewise, tenodesis of the transferred tendon stump significantly restored this associated toe flexion force in both the FHL and FDL groups. However, toe flexion force was restored closer to intact for the FHL transfer group than for the FDL group. This suggests that toe morbidity may be better addressed through FHL transfer and tenodesis than through FDL transfer and tenodesis.

The larger increase in medial forefoot versus lateral forefoot force after FHL transfer may suggest that the use of either tendon transfer for PTT dysfunction may mitigate the increased loading of the lateral column of the foot associated with other corrective flatfoot procedures, namely medializing calcaneal osteotomy. [8] In this cadaveric model, the loss in arch height may be attributed to loss of static support tissues of the arch, namely fibers of the spring ligament and PTT insertion, due to the placement of the osseous tunnel through the navicular. Therefore, this observation is contrary to the understanding of the tendon transfer as a means of restoring arch height.

SIGNIFICANCE:

This study quantifies the toe flexion morbidity associated with FHL and FDL tendon transfer in a cadaveric model, as well as the restoration of flexion force following distal tenodesis. Thus, this work can help provide surgeons with additional understanding of the biomechanics associated with tenodesis following tendon transfer with the goal of creating better outcomes for AAFD surgical patients.

REFERENCES: