Effect of Flexor Tendon Hallucis Longus Tendon Transfer on Joint kinematics during Simulated Gait

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INTRODUCTION: Medial longitudinal collapse is one of the key clinical and radiographic features of progressive collapsing foot deformity (PCFD) and can occur within any of the joints of the medial column.[1] While a medial column osteotomy or arthrodesis can be performed to address this instability, these procedures can stiffen the medial column and result in instability in adjacent joints. Clinicians have begun to use soft tissue transfers to address medial column instability to maintain stability and flexibility. A recently developed procedure which involves transfer of the flexor hallucis longus tendon to the base of the 1st metatarsal has shown promise postoperative restoration of the medial arch.[2] However, it is unclear what effect this transfer would have in a dynamic loading environment, such as level walking. Therefore, the objective of this study is to examine the effect of medial column stabilization using a transfer of the FHL tendon on the kinematics of the foot and ankle during stance phase of level walking. We hypothesized that the FHL transfer would increase plantarflexion and inversion in the joints of the medial column during stance phase.

METHODS: Twelve mid-tibia cadaveric specimen (6 male; Age 48 ± 16 years) were used in this study with approval from the hospital's institutional review board. A validated six-degree of freedom robot[3] was used to simulate stance phase by rotating a force platform around a stationary foot to recreate in-vivo ground reaction forces. Reflective markers were attached to seven bones of the foot and ankle by intracortical bone pins: tibia, talus, calcaneus, navicular, medial cuneiform, and 1st metatarsal. An eight-camera motion capture system (Vicon Motion Systems Ltd, Oxford, UK) was used to track the motion of the markers throughout gait. Three conditions were collected for each condition: prior to creating a PCFD deformity (Intact), after creating a PCFD deformity (sPCFD)[4], and after performing a FHL tendon transfer (FHL). The FHL transfer was performed by harvesting the FHL tendon at its distal insertion and fixing it in the 1st metatarsal with a biotenodesis screw (Figure 1A). Outcome measures included joint rotations of the talonavicular, 1st TMT, and 1st NC joints, which were calculated relative to a simulated standing pose collected at the end of every testing condition. Statistical analysis was conducted to determine the kinematic differences between the FHL and sPCFD conditions. Bias corrected 95% confidence intervals of the difference between the two conditions were constructed, where statistical differences are determined in periods of stance in which the confidence interval does not cross zero.

RESULTS: The FHL condition demonstrated significant changes ($p<0.05$) in the kinematics of the medial column relative to the sPCFD condition (Figure 1B). Talonavicular eversion was decreased during early and late stance, while adduction was increased during mid-stance. Increased plantarflexion, eversion, and abduction were noted in the 1st NC joint during early stance. Additionally, in the 1st TMT joint was more plantarflexed during early and late stance, and more everted during early and mid-stance.

DISCUSSION:
The results of this study demonstrate that the FHL transfer increases plantarflexion and eversion in the distal joints of the medial column. These results indicate that the FHL transfers assists in preventing medial arch collapsed during stance phase, aligning with the results of previous static clinical studies.[2] Additionally, changes in talonavicular eversion and abduction indicated that correction in the forefoot can indirectly contribute to multiplanar correction in the hindfoot during stance phase. These results demonstrate that the FHL transfer is effective in augmenting the multiple levels of instability in the medial column during surgical reconstruction of PCFD.

SIGNIFICANCE/CLINICAL RELEVANCE: The results of this study provide insight into the effects of a new surgical procedure to address forefoot instability in Progressive Collapsing Foot Deformity (PCFD). In turn, clinicians will be able be able to make more effective and informed decisions in how to address the surgical reconstruction of a PCFD deformity.

REFERENCES: 1. Kadaika et al, 2017; 2. Kim et al., FAI 2021; 3. Baxter et al., JOR, 2016; 4. Henry et al, FAI, 2022

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B

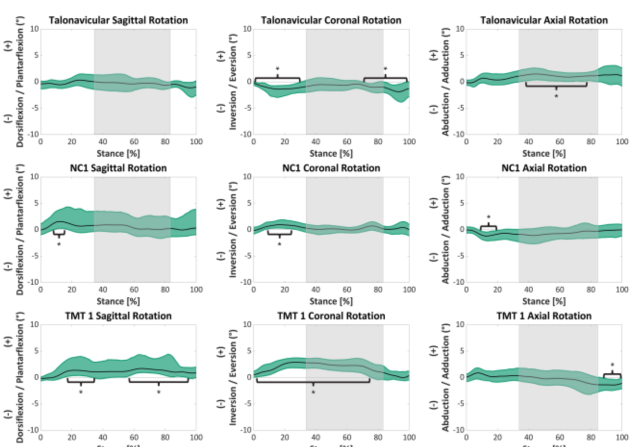

Figure 1: (A) The FHL tendon was harvested at the distal insertion and secure to the proximal 1st metatarsal with a biotenodesis screw. (B) Ninety-five percent confidence intervals of the difference in talonavicular, NC1, and TMT1 joint kinematics from the sPCFD condition. The gray shaded region is the portion of stance in which the FHL is active during stance phase {*} denotes significant differences from the sPCFD condition