Effect of Peroneus Brevis Transfer on 1st Metatarsal Plantar Pressure in a Simulated Cadaveric Progressive Collapsing Foot Deformity Model

Jeffrey Hoffman, M.S., Matt Conti, M.D., Jaeyoung Kim, M.D., Joaquin Palma, M.D., Jonathan Deland, M.D., Brett Steineman, Ph.D.
Hospital for Special Surgery, New York, NY
hoffmanj@hss.edu

Disclosures: Jeffrey Hoffman (N), Matt Conti (9-AOFAS), Jaeyoung Kim (N), Joaquin Palma(N), Jonathan Deland (3C; Lima Corporate. 4; Wright Medical Technology. 7A; Arthrex, Zimmer Inc.), Brett Steineman (N)

INTRODUCTION: Although operative treatment of the flexible progressive collapsing foot deformity (PCFD) remains controversial, addressing forefoot varus and stabilization of the medial column are important components of PCFD reconstruction.[1] An opening wedge osteotomy or TMT joint arthrodesis is typically used to plantarflex and stabilize the 1st metatarsal. However, these procedures can lead to over stiffening of the medial column or plantar collapse in adjacent joints. Therefore, tendon transfers, such as a peroneus brevis (PB) to peroneus longus (PL) transfer has been proposed, as an alternative to provided stability and functionality to the first ray.[2] However, there is little data to support their use. Therefore, the aim of our study was to determine the effect of an isolated PB to PL transfer on plantar pressure in a simulated PCFD cadaveric model using a robotic gait simulator. We hypothesized that PB tendon transfer would result in increased pressure under the first metatarsal in comparison to the sPCFD condition.

METHODS: 10 mid-tibia cadaveric specimens (Age: 65.6 ± 14 years; 4 male) were used in this study with approval from the hospital's institutional review board. Simulations of level walking were performed by a validated six-degree of freedom robot[3], which recreates in-vivo ground reaction forces by rotating a force platform around a stationary tibia. Plantar pressure data was collected for each simulation through a 32x32 sensor array (novel technologies inc., St. Paul, MN) attached to the platform. Three conditions were tested for each specimen: prior to the creation of a deformity (Intact), after creation of a simulated PCFD deformity (sPCFD)[4], and after performing a PB to PL transfer on the specimen (PBT). The PB-to-PL transfer was performed by sectioning the PB tendon at its insertion and advancing the tendon 1 cm distally before insertion of the tendon in a longitudinal cut in the PL tendon, which was secured by sutures. An automated masking algorithm was used to apply masks to seven regions of the foot: hindfoot, midfoot, and 1st through 5th metatarsal.[5] The peak pressure, maximum force and average pressure were determined for each region during the period of stance in which the PB tendon is active. Outcome measures included the maximum force and peak pressure under the 1st metatarsal head, as well as, the lateral forefoot (3rd -5th metatarsal) to medial forefoot (1st-2nd metatarsal) average pressure ratio (LM Ratio). Statistical analysis was conducted using a one-way repeated measures ANOVA with a bonferroni post-hoc test to determine individual differences between groups.

RESULTS SECTION: Plantar pressure data under the 1st metatarsal head in the PBT condition. The maximum force under the 1st metatarsal increased by 21.9% in the PBT condition in comparison to the intact condition (p=0.027) and 22.0% (p=0.045) in comparison to the sPCFD condition (Figure 1A). Peak pressure under the 1st metatarsal in the PBT condition also increased by 36.3% (p=0.01) compared to the intact condition and 35.7% (p=0.038) in comparison to the sPCFD condition (Figure 1B). Additionally, the LM ratio in the PBT condition increased by 23.3% (p = 0.013) in comparison to the intact condition and 18.9% in comparison to the sPCFD condition, indicating a medial shift average forefoot plantar pressure during stance (Figure 1C).

DISCUSSION: Our study found that the addition of a PBT, as part of the surgical management of the flexible PCFD, increased pressure under the first ray during stance phase of gait when the PB tendon is active. This suggests that conducting a PBT during surgical reconstruction of PCFD assists in plantarflexing the first metatarsal, while also removing the deforming eversion force present in the first metatarsal. The addition of a PBT as an augmentation to a hindfoot osteotomy could help in providing additional stability to the medial column, which is important in preventing a post-operative collapse in one of the joints of the medial forefoot.

SIGNIFICANCE/CLINICAL RELEVANCE: This study provides biomechanical evidence for the use of a PBT, a current technique used in the reconstruction of PCFD. The data collected in the study can be used by clinicians to address medial column instability in PCFD patients.

REFERENCES: 1. Chadwick et al., 2015; 2. Sanhudo et al., 2018; 3. Baxter et al., 2016; 4. Henry et al., 2022; 5. Ellis et al., 2011

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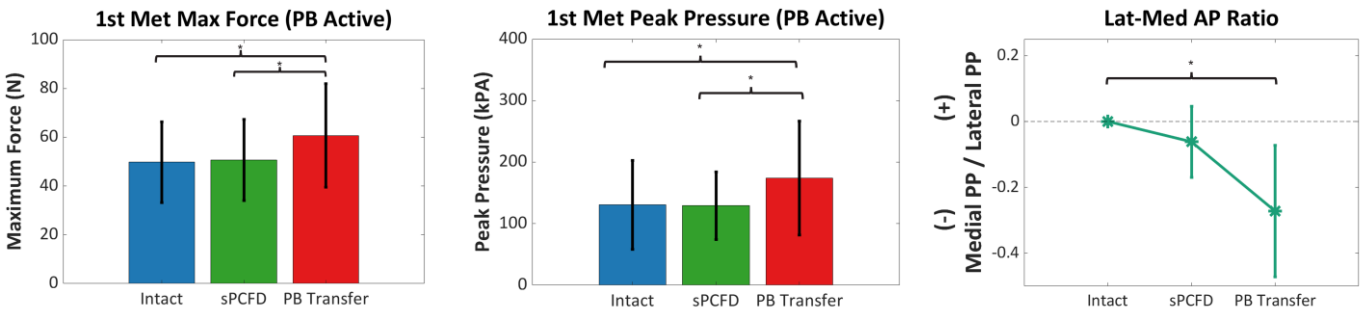

Figure 1: Plantar pressure measures during simulated gait on the robotic gait simulator. {*} denote significant (p<0.05) differences between conditions. (A) the maximum force under the first metatarsal during while the PB tendon is active during gait. (B) the peak pressure under the 1st metatarsal during the period that the PB tendon is active during gait (C) the lateral to medial average forefoot pressure ratio during stance phase.