Inherent Foot Deformities Cause Increased Lateral Column Loading in Individuals with CMT

Tyce C. Marquez, Lauren Crowe, Jason Wilken, Bopha Chrea, Donald D. Anderson
University of Iowa, Iowa City, IA
tyce-marquez@uiowa.edu

Disclosures: Tyce C. Marquez (N), Lauren Crowe (N), Jason Wilken (N), Bopha Chrea (3B-Paragon 28, 8-JBJS,FAI, 9-AOFAS), Donald D. Anderson (8-J Orthop Res, 9-OARSI,OTA)

INTRODUCTION: Charcot-Marie-Tooth (CMT) disease is the most common inherited peripheral neuropathy, with an estimated prevalence of 1 in 2,500 individuals [1]. It is characterized by progressive motor and sensory dysfunction, often resulting in distal muscle weakness and characteristic foot deformities such as cavovarus [2]. These deformities contribute to altered gait mechanics, focal plantar pressures, and foot pain in individuals with CMT [3]. Additionally, cavovarus and forefoot adduction have been linked to increased lateral foot loading and a heightened risk of fifth metatarsal fractures [4]. The objective of this study was to evaluate regional dynamic plantar pressure patterns in individuals with CMT compared to healthy controls to better characterize lateral column overloading and associated injury risk.

METHODS: Fifty individuals with CMT (28M/22F, Age: 46.4±18.2 years, BMI: 28.9±7.5) and forty-four healthy controls (21M/23F, Age: 42.4±12.7 years, BMI: 28.5±4.9) were recruited to participate in this IRB-approved study. Each participant completed three walking trials per foot progressing over a Novel-EMED plantar sensor platform with the two-step method [5]. Plantar pressures were analyzed regionally using two masking techniques (Figure 1): a five-region mask based on foot size, and a two-region mask divided by the bisection of the long plantar angle. Peak pressure and pressure-time integral (PTI) values were extracted for each region. Due to data non-normality, five-region values were compared between groups using a Wilcoxon rank-sum test, while two-region peak pressure ratios were analyzed over the stance phase of gait using non-parametric two-sample t-tests with 1D statistical parametric mapping.

RESULTS: Individuals with CMT exhibited significantly increased loading along the lateral column in the rearfoot and lateral forefoot regions (Table 1), alongside significantly decreased loading in the medial midfoot. PTI in individuals with CMT was increased by 51% in the rearfoot and lateral forefoot, and by 40% in the lateral midfoot compared to controls. Notably, 16-40% of individuals with CMT showed increased lateral column PTI values across the three regions (rearfoot, lateral midfoot, lateral forefoot) that exceeded the normal range from controls. Throughout the stance phase of gait, altered plantar loading was observed, with longer heel contact and minimal toe-off associated with CMT. A more laterally biased peak pressure ratio, with significant differences from 4-8% and from 11-96% of stance was exhibited in individuals with CMT (Figure 2). The greatest difference in peak pressure ratio between individuals with CMT and control participants was observed at 73% of stance, corresponding to the terminal stance phase.

DISCUSSION: Regional masking demonstrated increased lateral column loading in individuals with CMT, elevating the risk of pain and fifth metatarsal fractures. Inherent CMT-related foot deformities most likely explain these changes in load transfer, with correlations between structural deformity and plantar loading offering important insight for targeted intervention strategies. A limitation of this study is the reduction of complex plantar loading patterns into discrete regional values. Future work will aim to assess 3D foot bony architecture in correlation to plantar loading and quantify lateral column overloading across the entire plantar surface during gait.

SIGNIFICANCE/CLINICAL RELEVANCE: Understanding differences in plantar loading between individuals with CMT and healthy controls can inform intervention strategies including surgical and non-surgical methods to reduce the potential injury risk.

REFERENCES: [1] Laura M, et al. Muscle Nerve. (2018), 57(2):225-29. [2] Tooth HH. *The peroneal type of progressive muscular atrophy*. 1886. [3] Burns J, et al. Neurology. (2010), 75(8):726-31. [4] Riegger M, et al. Foot Ankle Surg. (2022), 61:641-47. [5] McPoil TG, et al. J Am Podiatr Med Assoc. (1999), 89(10):495-501.

ACKNOWLEDGEMENTS: This research was supported by the National Institutes of Health (Award # U54 NS065712), CMT Association, and Paragon 28.

IMAGES AND TABLES:

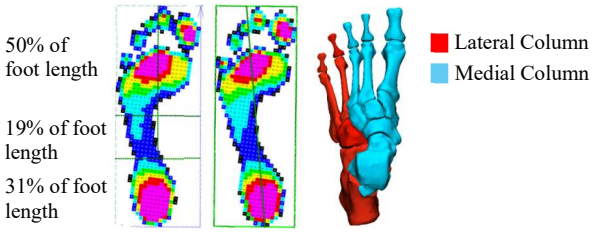

Figure 1. Five-region plantar pressure masking (left) separated by foot length and the plantar progression angle, two-region plantar pressure masking (middle) separated by the bisection of the long plantar angle, and medial-lateral foot column designation (right).

Table 1. Five-region average PTI values (kPa*s) with corresponding p-values (significance set at p<0.01)

Plantar Region	Control	CMT	p-value
Rearfoot	86.67	168.75	**$3.19x10^{-12}$**
Lateral Midfoot	28.92	71.89	0.787
Medial Midfoot	9.17	8.08	**0.0005**
Lateral Forefoot	178.50	347.60	**$4.36x10^{-8}$**
Medial Forefoot	210.03	288.92	0.039

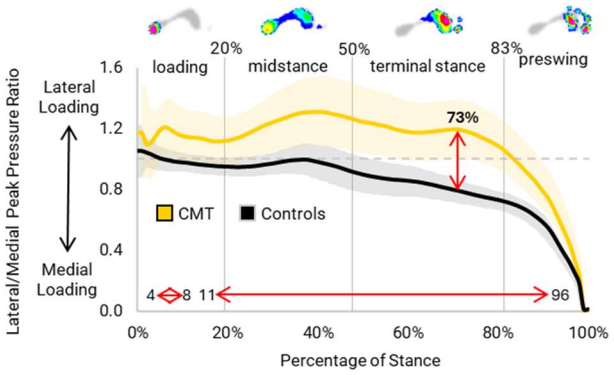

Figure 2. Lateral/medial peak pressure ratio across the stance phase of gait.