METATARSAL AND TOE LOADING PATTERNS IN DIABETIC PATIENTS: POSSIBLE ROLE IN THE ETIOLOGY OF CHARCOT FOOT COMPLICATIONS.

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INTRODUCTION

Charcot foot deformities are a complication for diabetic patients with neuropathy. The etiology is poorly understood, though many patients report minor trauma preceding the collapse of their foot. Under normal foot conditions there is a balance[1] in bending stresses applied to the first metatarsal (Figure 1). For this study, it was hypothesized that patients at risk for Charcot complications would exhibit higher imbalances in these loading profiles.

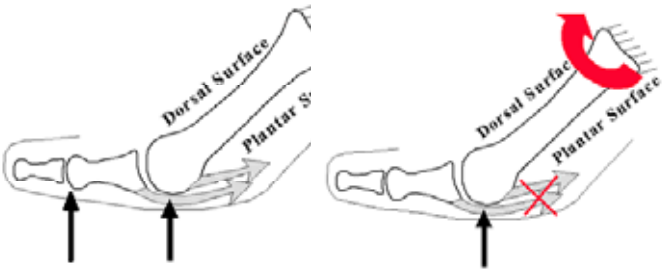

Figure 1. With normal foot conditions, the dorsiflexing forces under the metatarsal heads (vertical black arrow) are balanced by intrinsic muscle contractions (grey arrows). If intrinsic plantar flexor muscle forces are reduced (either through a surgical release or because of pathological changes) the metatarsals will experience greater bending moments.

METHODS

Twelve subjects (five control patients, mean age 58.8 ± 7.89, and seven diabetic patients, mean age 57.33 ± 7.42) were assessed. All diabetic subjects had plantar structural deformities related to Charcot foot disease. The subjects were not age matched, however age has not been found to be a significant factor in plantar pressure distribution. Written informed consent was obtained from all volunteers before data collection, in accordance with Institutional Review Board policies.

For all subjects, recordings of toe and metatarsal head forces were obtained during gait using an EMED pressure measurement system. Three trials were completed for each foot. Pressure masks were designed using Novel Multimask Evaluation software to divide the plantar footprint into anatomical regions, specifically, hallux, second toe, 1st metatarsal head (MTH) and 2nd MTH. Measurements of the arch index[2] for were obtained, with an increased arch index representing a flattened arch.

In terms of statistical analyses, a regression approach was used to relate the ratio of toe and MTH loading to arch index. Finally, ANOVA techniques were used to compare diabetic and control groups (level of significance was 0.05).

RESULTS AND DISCUSSION

Control subjects exhibited a balance between toe and metatarsal loading, whereas diabetic patients had significantly reduced toe loads (Figure 2). The ratio of toe to metatarsal loading was significantly related to arch index (Figure 3).

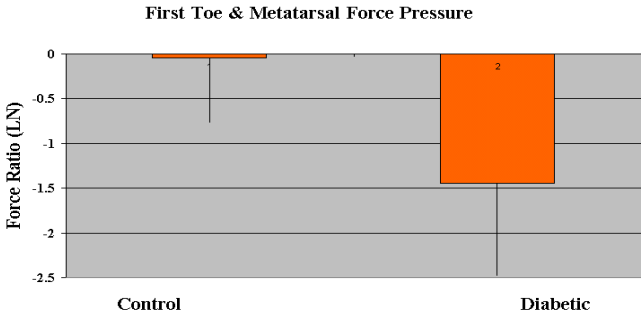

Figure 2: The relationship between forces of the first toe and metatarsal for each experimental group. In control subjects, there is a balance between toe and metatarsal loading, as evidenced by the logarithm being close to zero.

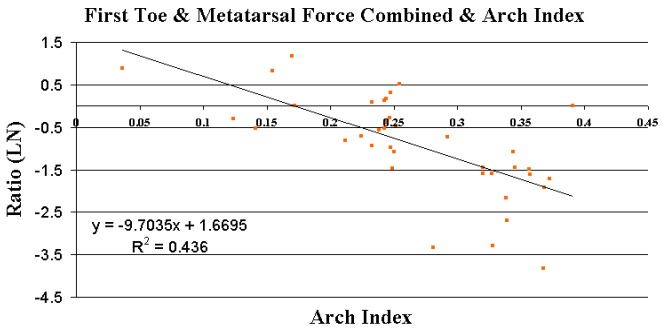

Figure 3. The ratio of toe loading to metatarsal loading was related to arch index ($p<0.05$), with the relationship given by: Log(loading ratio) = 1.67 - 9.7(arch Index)

CONCLUSIONS

The fact that diabetic patients with signs of Charcot foot had (i) smaller forces in the first toe compared with non-diabetic patients, and (ii) increased values for their arch index, supports the hypothesis that diminished plantar muscle forces may increase the likelihood of Charcot foot problems.

REFERENCES

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2. Cavanagh PR and Rodgers MM (1987). The arch index: a useful measure from footprints. J.Biomech. 20: 547-551

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