RELATIONSHIP BETWEEN SOFT TISSUE DEFORMATION AND APPLIED PRESSURE ALONG THE SECOND RAY OF THE PLANTAR NEUROPATHIC FOOT

[1]Donovan J. Lott, [2]Paul K. Commean, [2]Kirk E. Smith, [1]Michael J. Mueller
[1]Program in Physical Therapy and [2]Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, MO
E-mail: djlott@artsci.wustl.edu

INTRODUCTION

Neuropathic foot ulcers are one of the most common lower extremity complications for people with diabetes mellitus (DM) and peripheral neuropathy (PN). High plantar pressures commonly seen in people with DM and PN compress and damage soft tissue of the foot contributing to the occurrence of these ulcers. The aim of this study was to determine the relationship between soft tissue deformation and applied pressure along the second ray of feet of individuals with DM, PN, and a history of a plantar ulcer.

METHODS

Ten subjects (6 males/4 females, mean age 58.0 $\pm$ 10.3 years, mean BMI 32.6 $\pm$ 9.5 kg/m^2) with DM (2 Type 1/8 Type 2, mean duration of DM 16.5 $\pm$ 10.0 years), PN, and a history of a plantar ulcer participated.

Plantar pressure data were recorded using the FSCAN system (Tekscan, South Boston, MA, USA) during spiral X-ray computed tomography (SXCT). SXCT scans of the subjects' feet were performed as described in detail elsewhere [1]. The subject applied a load of $\leq$ 45 N (10 lbs.) for the first "preload" scan. For the second "loaded" scan, the subject applied a load of approximately 50% of his/her body weight. The alignment of the anatomical data from the SXCT scans with the pressure data from the FSCAN system was performed as described in detail elsewhere [2]. The second ray was determined in a similar manner by aligning the pressure data with the second metatarsal and second proximal phalanx. All testing was done with the subjects barefoot.

Soft tissue thickness was determined by measuring the distance from the most inferior aspect of the bone to the surface of the skin. Soft tissue deformation (STD) (strain) was defined as: ({[soft tissue thickness from preload scan]–[soft tissue thickness from loaded scan]} / {soft tissue thickness from preload scan})*100. Soft tissue thickness measurements were taken from 11 sensor pixels (5.08 mm spacing) proximal to the metatarsal head to five sensor pixels distal to the metatarsal head (for a total of 17 measurements per condition over 86.36 mm [3.4 inches]).

A Pearson correlation coefficient was performed for statistical analyses to determine the relationship between the STD and the applied pressure along the second ray.

RESULTS AND DISCUSSION

Figure 1 shows the average STD and the pressure difference between the two scans along the second ray. At the location of the second metatarsal head (MTH), the mean STD was 19.5 $\pm$ 6.1%, and the mean pressure difference was 287.3 $\pm$ 145.5 kPa. The mean correlation coefficient for the ten subjects demonstrates a strong relationship between soft tissue deformation and applied pressure along the second ray (r = 0.93 for the 17 points of data).

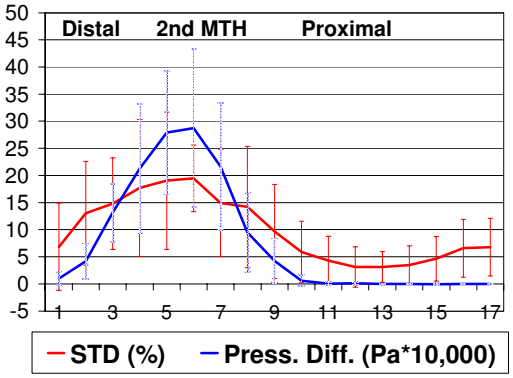

Figure 1: Mean Soft Tissue Deformation (in percentage) and Pressure Difference between loaded and preload conditions (in Pa x 10^4) along the second ray.

SUMMARY

This is the first study that has examined STD at several points along a ray of the plantar foot in patients with DM and PN. Our data suggest that the deformation that occurs along the second ray in patients with DM and PN is strongly correlated with the applied pressure at these same points. Our results at the MTH are generally consistent with those of others. Cavanagh found an average STD of 45.7% at the second MTH with a load of full body weight [3] while we found an average STD of 19.5% with a load of approximately 50% body weight. Future research can build upon these findings by analyzing how the use of footwear and orthotic devices affect the pressure distribution and STD along the second ray of the plantar foot for optimal footwear prescription for people with DM and PN.

REFERENCES

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