Thermal Imaging for Detection of Preclinical Diabetic Peripheral Neuropathy

M. Burge, MD1, P. Sollis2, PhD; Z. Jarry1, BS; C. Calder MD, PhD; N. Manivannan, PhD2
1Department of Internal Medicine/Endocrinology, University of Albuquerque, Albuquerque, NM, USA 87131.
2VisionQuest LLC, 2501 Yale Blvd, Suite 301, Albuquerque, NM 87109.
3Department of Neurology, University of New Mexico, Albuquerque, NM, USA 87131.

ABSTRACT
The objective of this study was to assess the clinical value of thermal imaging for detection of diabetic peripheral neuropathy (DPN). We showed that this non-invasive method complements our novel thermal tool is effective in detecting DPN. This study has demonstrated that there is a strong association between diabetic patients with impaired pain perception, as measured by thermal imaging, and nerve function. We further demonstrated that thermal imaging provides a measure for detecting signs of DPN in DM patients that are not yet diagnosed with clinical DPN.

METHOD

Our thermal imaging system was tested on 137 age-matched subjects: 44 diabetic controls, 46 diabetes patients without known DPN, and 32 patients with known DPN.

The goal of this study was to develop a DPN classification model by analyzing thermal imaging data from control and DPN subjects, and to subsequently apply the classifier to identify signs of DPN in a group of DM patients who may have undiagnosed DPN.

Table 1 shows the distribution of subjects by age group. All subjects received comprehensive neurological examinations. Table 1: Subject distribution in Phase I study.

Type of Features

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<th>Average</th>
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<tr>
<td>DPN</td>
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<td>15</td>
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To eliminate possible confounding factors, individuals who smoke, have consumed alcohol in the past 24 hours, have untreated hypertension, have ongoing, unhealed skin ulcers, or who have had amputations were excluded.

Imaging Protocol

Figure 4 shows a diagram of the steps in this Phase I study workflow. Figure 3 depicts the thermal imaging protocol.

Figure 3. Imaging protocol

1. Place the patient on a horizontal leg rest and foot movement was restricted by placing the feet on a tilted board with ankle-gaited shoes.
2. Thermal videos of the feet were taken before and after applying analgesic cream to the anterior tibial area and imaging, and were subsequently analyzed using a novel combination of spatial-temporal features.

Neuro Conduction Study (NCS)
NCS was performed on 14 males (6 Controls, 8 DPN, 3 DPN, DPN) and 23 females (5 Controls, 14 DPN, 6 DPN) using an electromyography (EMG) device (Naruto Fusion, Viking EEG) as the peripheral nerve of each leg, including the sural nerve.

Each subject was assigned a label of normal or neuropathy depending on the amplitudes and conduction velocity of each subject.

The Spearman correlation was calculated between the needle’s assigned labels and the output of our algorithm.

RESULTS

In the control of a subject with increased-spectral power in Figure 4 (P0.04), the pi-power is highly correlated in Table 5.

For 156 diabetic patients who clinically diagnosed DPN, Figure 5 indicates that there are a few DPN subjects that are categorized as DPN or by the thermal feature-based classifier.

CONCLUSIONS

We demonstrated that the thermal videos provide a means for detecting evidence of DPN in DM patients who were not otherwise clinically diagnosed with DPN.

We conclude that detection of DPN using thermal imaging is feasible and may prove to be a clinically useful tool for use in primary care clinics, where early detection of DPN is critically important at a time when preclinical and intervention are most likely to be effective.

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This study was approved by the University of New Mexico IRB, Study ID 15-194, and the Ethical and Independent Review Committee IRB, Study ID 15-159-4-11.

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