

The Plantar-Palmar Index with Near Infrared Spectroscopy Replaces the Ankle-Brachial Index for Noninvasive Evaluation of Vascular Perfusion and Peripheral Arterial Disease

Jonathan A. Niezgoda, OMS 2 / Francis Derk, DPM / Debarpan Das, MSc / Najratun N Pinky, PhD / Sandeep Gopalakrishnan, PhD / Jeffrey A. Niezgoda, MD

INTRODUCTION

The Ankle Brachial Index (ABI) is a widely used diagnostic technique for peripheral artery disease (PAD), which involves measuring the ratio of systolic blood pressure (SBP) in the ankle to the SBP in the arm. The ABI procedure can be time-consuming, labor intensive, technically challenging, and uncomfortable for patients. As a screening technique the ABI has poor sensitivity and can be unreliable in diabetic patients^{1,2}. These limitations have spurred the development of novel imaging techniques for PAD screening.

METHODS

Study subjects were recruited on a voluntary basis from the clinical practice of one of the authors. Subjects included normal-healthy, patients with history of prior foot ulcers, patients with known PAD and patients with prior amputations due to complications of PAD. The ABIs and pulse volume recordings (PVRs) were accomplished and recorded in all subjects using a standardized device (MESI mTABLET ABI Diagnostic System, MESI, Ltd., Slovenia, EU). Near infrared spectroscopy (NIRS) (SnapshotNIR, Kent Imaging LLC, Calgary, Canada) is an imaging device that can measure the levels of oxygenated and de-oxygenated hemoglobin in tissues to calculate and create an image of tissue oxygen saturation³. NIRS is non-invasive and has demonstrated efficacy to assess tissue perfusion quickly at the bedside in patients with PAD⁴.

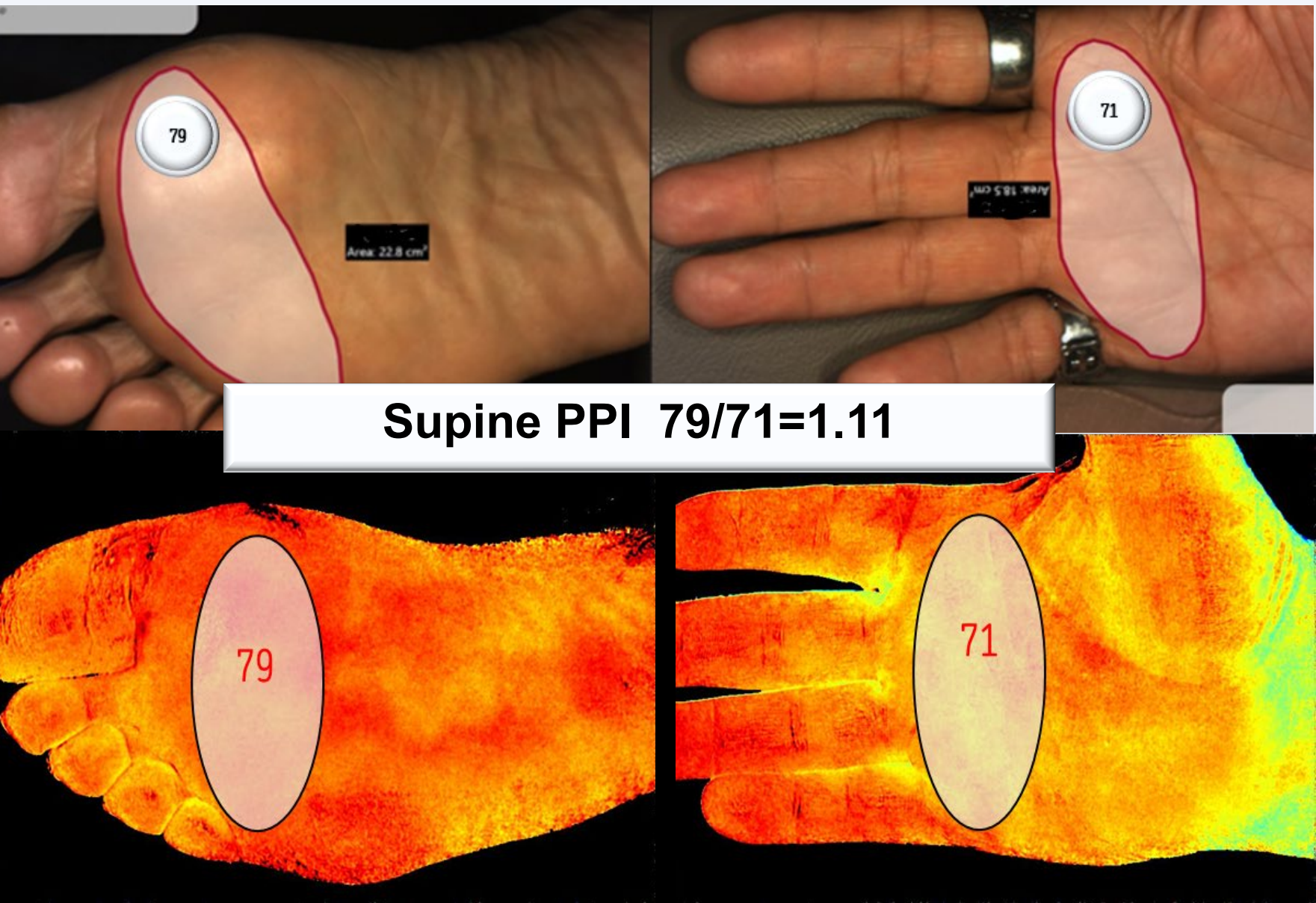
NIRS images were obtained of the palmar surface of the hand and the plantar foot with all subjects lying in the supine position. The NIRS images were centered on the regions of interest (ROI), the metatarsals and metacarpals respectively and an average tissue oxygen saturation (STO₂) data obtained from the NIRS device by circumscribing the ROI. The Plantar-Palmar Index (PPI) is a calculation similar to the ABI ratio (Plantar STO₂ divided by Palmar STO₂).

CLINICAL CORRELATION

The Snapshot devices provide touch screen interface that allows the clinician to obtain StO₂ measurements at selected sites. These values can be in either wound or periwound regions of interest. This feature was used to select sites correlating tissue StO₂. The StO₂ values were then averaged and compared.



NIRS Plantar-Palmar Index Technique



Plantar Palmar Index

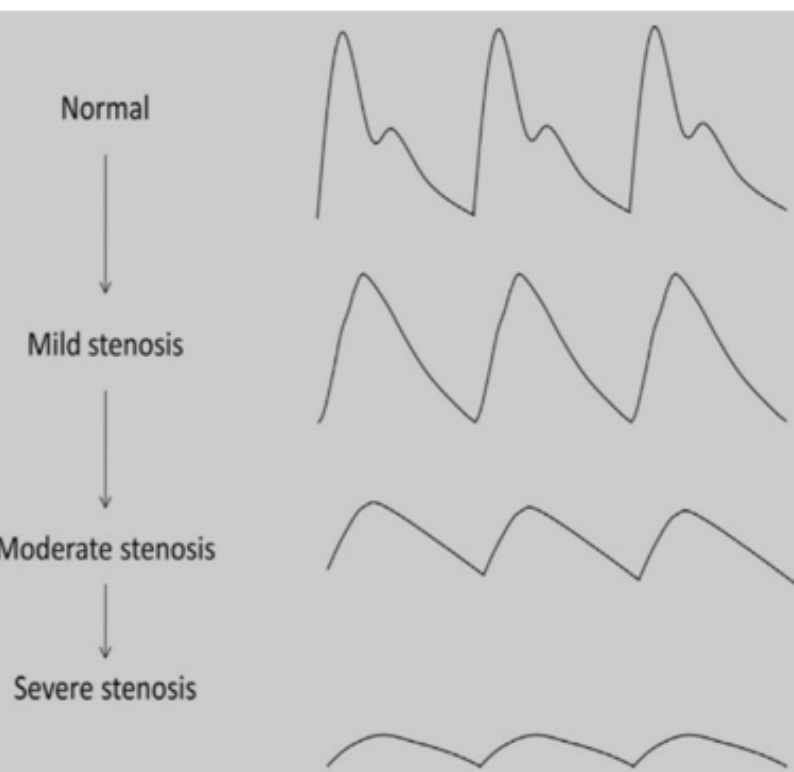
Plantar NIRS STO₂

Palmar NIRS STO₂

Calculated by dividing the NIRS STO₂ average obtained over the plantar metatarsal phalangeal joint (MTPs) region by the NIRS STO₂ average obtained over the palmar metacarpal joint region (MCPs).

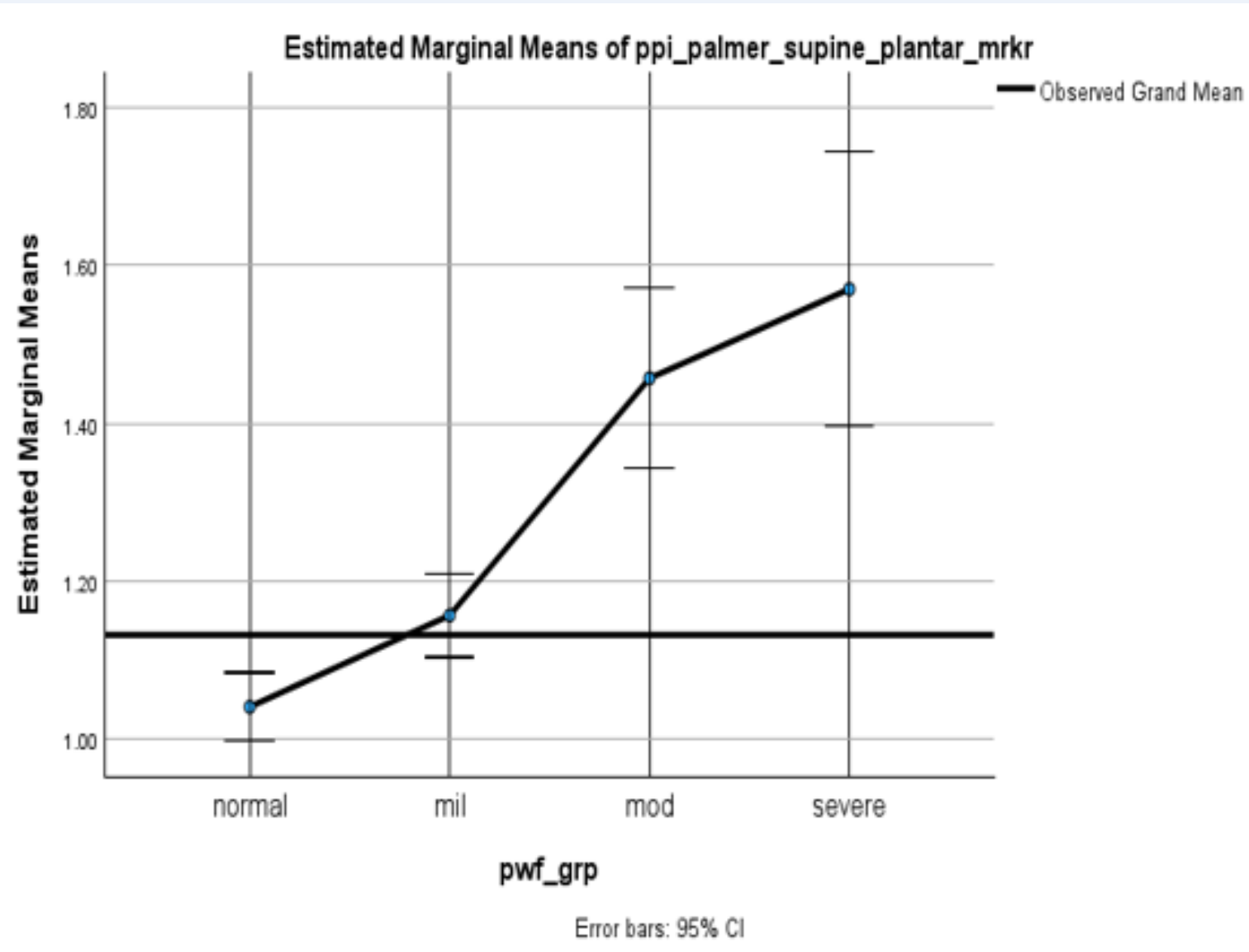
RESULTS

A series of 90 limbs (48 subjects) were studied. The cohort included healthy subjects as well as patients with various degrees of PAD. ABIs and PVRs were obtained, and NIRS imaging PPI ratios were calculated for all limbs. PVRs were interpreted and classified as Normal (n=48), Mild (n=32), Moderate (n=7) and Severe (n=3).



Pulse Volume Recordings

The Estimated Margin Means of the PPI in reference to the PVR were calculated; Normal 1.041, Mild 1.148, Moderate 1.457, Severe 1.570 with 95% CI's Normal (0.998, 1.084), Mild (1.095, 1.201), Moderate (1.345, 1.589) and Severe (1.399, 1.741). ANOVA results across all 4 groups yielded p<0.001. Pairwise comparison showed significance of Normal-Mild p<0.005, Normal-Moderate p<0.001 and Normal-Severe p<0.001.



DISCUSSION

While the ABI remains deeply entrenched in clinical assessment of PAD, the challenges and limitations associated with this test have been well recognized. As evidence, a recent proposed LCD (L35041) originally stated “An ankle-brachial index (ABI) should be taken for patients with a questionable pulse deficit...” Based on clinician input his language was modified to read “Vascular evaluation is also vital for all patients... to demonstrate adequate perfusion for wound healing. Palpation of pulses... is not a reliable indicator of sufficient perfusion in those with diabetes. An objective, non-invasive measure of perfusion/oxygenation to determine if there is adequate flow for wound healing is helpful in predicting ulcer healing and/or the need for vascular intervention.”⁵ The positive correlation of NIRS PPI with ABI has been previously reported.⁶ This study suggests that NIRS-PPI also correlates well with PVR evaluations and could replace the ABI/PVR as the method for assessing both the presence and severity of PAD in patients by providing a more accurate evaluation. Further research and clinical trials will be essential to validate these methods and establish standardized protocols for their implementation in routine clinical practice.

CONCLUSIONS

*NIRS imaging can measure changes in tissue StO₂ in patients with peripheral arterial disease. The PPI is comparable to the PVRs obtained in the supine position.
*NIRS can be used as an alternative to ABI/PVR screening and evaluation of patients with PAD.
*Additional work is required to correlate NIRS imaging data with the physiological changes that are observed in patients with moderate-severe disease.
*NIRS when used for PAD screening and evaluation provides faster, more efficient and less invasive testing for patients in this population.

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SnapShot Device provided courtesy of Kent Imaging, Inc, Calgary Canada
Protocol Design and Academic Affiliation: Sandeep Gopalakrishnan PhD, University of Wisconsin
Corresponding Author; Jeffrey Niezgoda, MD
Jeffrey@KentImaging.com