Implementation of a Remote Temperature Monitor for the Prevention of Diabetic Foot Ulcers
A Case Series of 5 Patients

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Introduction
Diabetic Foot Ulcers (DFU) are known to be preceded by clinical or sub-clinical inflammation, for which increased temperature is a surrogate marker. Once-diagnosis monitoring of plantar foot temperature has previously been demonstrated to be effective for preventing DFU when used to prompt timely, non-invasive interventions such as pressure off-loading of the affected region of the foot [1-3].

An in-home, telemedicine, thermometric mat (the Podometrics System) has recently been studied as part of a multi-center cohort trial to assess its usability and predictive accuracy [4-5]. The investigators found that the Podometrics System is capable of detecting up to 97% of non-acute plantar DFU approximately 5 weeks before clinical presentation, making it suitable for remote monitoring and real-time risk-stratification of patient risk. Although this implementation of this system in a veteran population as a tool for primary and secondary DFU prevention ideally requires a controlled clinical trial, our goal was to present an early demonstration of its potential as a valuable supplement to current diabetes care in a veteran population.

Objective
The objective of this study was to explore how the inflammation preceding and accompanying different pathologies in the diabetic foot present within plantar “thermograms,” which are two-dimensional temperature images captured automatically by the Podometrics System. We hypothesize that these thermograms, which are a novel aspect of the system, may provide helpful clinical context for evaluating patients at-risk for inflammatory foot diseases such as DFU.

Methods
We present a case series of five veterans, each of whom has been prescribed the Podometrics System and each of whom subsequently presented with a hotspot episode in early 2017. Each has history of diabetes mellitus and neuropathy.

Consistent with previous research [1-3], we assess patient risk by considering temperature differences between six contralaterally-matched locations on the left and right plantar foot surfaces: the hallux, first, third, and fifth metatarsal heads, arch, and heel. If the temperature difference at one or more location exceed 3.2 degrees Celsius (4 degrees Fahrenheit) over two or more consecutive scans, the veteran is deemed to have a “hotspot” and is instructed to reduce plantar temperature asymmetry across entirety of the right foot.

We have implemented this system in a veteran population as a tool for primary and secondary DFU prevention, and report the following observations.

Patient 1
- 64 y/o veteran with h/o diffuse b/l sub-hallux hyperkeratosis resulting in right foot DFU measuring 0.3 x 0.3 x 0.1 cm. Wound epithelialized 4 days prior to receiving Podometrics System.
- After approximately two weeks of using device (day 13), patient presents with hallux hotspot (T = 2.8°C) and localized inflammation visible on the thermogram. Veteran asked to offload and schedule appointment for clinical exam (next scheduled appointment > 2 months later). Veteran reported he was unaware of any changes in his feet.
- Diffuse hyperkeratosis noted on exam on day 25. Debridement revealed a superficial wound measuring 0.2cm x 0.3cm absent of malodor and drainage. Wound was dressed with Betadine.
- Wound epithelialized as of day 60, and patient has remained free of DFU and hotspots in the five months since initial resolution on day 50.

Patient 2
- 75 y/o veteran presented with DFU. Thrombogram suggests large inflammation (AT = 6°C) across the medial sub-MTPJ regions.
- Approximately three weeks later, veteran presented for hotspot at third metatarsal. Thrombogram suggests large inflammation (AT > 6°C) across the medial sub-MTPJ regions.
- Thick hyperkeratosis noted on exam at left sub-2nd MTPJ. Upon debridement, a 2cm x 2cm x 0.4 cm granular wound was noted with macerated edges free from infection and erythema.
- Superficial wound unhealed at veteran’s most recent exam. Patient instructed to use cam walker and reduce activity.

Patient 3
- 60 y/o veteran presented with DFU. After two weeks of use, the veteran presented with a hotspot and is called to offload and make an appointment. The hotspot had a maximum temperature asymmetry of 3.7°C at the hallux and is notable for diffuse asymmetry across entirety of the right foot.
- During exam seven days later, patient found to have paronychia on the lateral border of the right hallux, for which a nail avulsion was performed.
- Patient has remained free of hotspots since, and during the patient’s most recent visit more than a month after initial hotspot detected, the nail bed was found to be healed.

Patient 4
- 26 y/o veteran with h/o hyperkeratosis at left sub-2nd MTPJ subsequently prescribed Podometrics Mat.
- Debrided from the right forefoot.
- Patient seen in clinic on day 15 with recurrent hyperkeratosis at sub-2nd MTPJ requiring debridement.
- Patient’s large hotspot subsided over subsequent 10 days (AT < 2°C on average), although asymmetry has recently escalated just prior to preparation of this poster.

Patient 5
- 75 y/o veteran with h/o diffuse b/l sub-hallux hyperkeratosis resulting in right foot DFU measuring 0.3 x 0.3 x 0.1 cm. Wound epithelialized 4 days prior to receiving Podometrics System.
- After approximately two weeks of using device (day 13), patient presents with hallux hotspot (T = 2.8°C) and localized inflammation visible on the thermogram. Veteran asked to offload and schedule appointment for clinical exam (next scheduled appointment > 2 months later). Veteran reported he was unaware of any changes in his feet.
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- Wound epithelialized as of day 60, and patient has remained free of DFU and hotspots in the five months since initial resolution on day 50.

Conclusion
A series of five cases demonstrates the ways in which inflammation presents on thermograms captured by a novel thermometric system for primary and secondary prevention of DFU. Important observations include:

- The affected region may be colder than contralaterally-matched region (Case 4)
- Inflammation may present as diffuse across two adjacent regions (Case 3).
- Ulcers detected via thermometry often present as hyperkeratosis (Cases 2 and 5).
- Hotspots may resolve quickly in some cases due to offloading (Case 1) or debridement of pre-ulcerative lesions (Case 4), and as a result, thermometry may be used to remotely monitor the effectiveness of interventions.
- Day-to-day asymmetry may be volatile, even in cases where ulceration is imminent (Cases 4 and 5).

The availability of thermograms may provide useful clinical context to guide early preventative care and interventions for patients presenting with hotspots.

References