Remote Temperature Monitoring in Diabetic Foot Ulcer Detection

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Introduction
Diabetic foot ulcers (DFUs) are associated with increased morbidity, mortality, and resource utilization [1-3]. Thermometry has been found effective for the early detection and, when used to prompt timely non-invasive intervention such as pressure offloading, prevention of recurrent DFU [5-7]. A thermometric smart foot mat for the home* is available for remote monitoring of plantar foot temperatures. A recent investigation suggests that this smart foot mat may detect the inflammation preceding a DFU on average 5 weeks prior to clinical presentation [4].

This case series details 3 veterans with h/o DFU, elevated 9Hlc, and peripheral neuropathy who were followed in the Podiatry PAVE (Preventing Amputations for Veterans Everywhere) Clinic. These veterans were prescribed the smart mat for remote thermometric monitoring of their feet as an adjunct to standard preventative foot care.

Methods
Veterans followed at the PAVE Clinic are issued a mat if meeting at least 3 of the following: h/o DFU, peripheral neuropathy, h/o amputation, foot deformity, or impaired vascular status. Veterans are instructed to use the mat daily and to continue standard preventative foot care.

The thermometric data collected by the mat are referred to as scans and are securely transmitted and accessed. Clinical staff can access de-identified foot temperature maps, or thermograms, derived from the scans through an online physician portal for triage.

The temperature data collected by the mat are automatically analyzed for temperature differences, or asymmetry, between the left and right feet at six locations consistent with the approach most common in the literature [5-7]. A veteran with temperature asymmetry exceeding 1.75°C over two or more consecutive uses at the same location triggers a notification to the clinical staff, after which the veteran is considered “in episode.” A phone call is made to the veteran to encourage proper offloading, decreased walking, elevation of feet, and visual exam at home.

Case 1
- 67 year old male veteran with IDDM2 (HbA1c 8.5%), neuropathy, gout, hypertension, hyperlipidemia, osteoarthritis, and coronary artery disease.
- Veteran has extensive DFU history, including several wounds to left distal 3rd digit, with most recent healing 2 years prior to veteran receiving mat, and a wound to the right distal 2nd digit for which a digital amputation was performed, secondary to osteomyelitis, one year prior to veteran receiving mat.
- Veteran has h/o DFU at right plantar TMA stump, most recently healed three weeks prior to receipt of mat.
- Patient entered asymmetry episode on day 1. Patient in episode for following two weeks and presented to clinic with DFU. Veteran denied prior knowledge of wound.
- Continued offloading and wound care resulted in closure approximately 9 months after receiving the mat.
- The episode’s evolution suggests DFU may have been developing prior to day 0. The DFU recurved despite normal physical exam by the care team only weeks prior, and was identified by the mat prior to the patient or care team becoming aware of pathology.

Week 11
- Veteran has h/o DFU at right plantar TMA stump, most recently healed three weeks prior to receiving mat.

Week 18
- Veteran enters episode with temperature asymmetry of 4.1°C at the right hallux. During a call prompted by the notification, veteran denied any plantar lesions. Upon clinical exam a week later, no wounds found. Plastizome accommodative orthotics were given.
- A second phone call was made during week 16 for continued elevated asymmetry of 2.1°C at the right hallux. The veteran was seen in clinic five days later without DFU. A call to the distal left 3rd digit was pared without incident.
- Despite a history of multiple wounds and literature suggesting that 50% of patients who heal from a DFU suffer recurrence within two years [4], veteran has remained DFU free in the 34 days since receiving the mat.

Week 3
- Veteran has h/o DFU at right plantar TMA stump, most recently healed three weeks prior to receipt of mat.

Week 6
- Veteran presented to clinic at the end of week 11 wearing sandals with no offloading. A pre-ulcerative callus to the area of concern was noted. Upon debridement, the plantar medial hallux wound which healed 9 months prior to receipt of mat.

Week 20
- Veteran has h/o DFU at right plantar TMA stump, most recently healed three weeks prior to receiving mat.

Conclusion
Three high-risk patients with h/o DFU, poorly-controlled diabetes, and peripheral neuropathy were followed with a remote temperature monitoring mat. In all three cases, use of the mat resulted in early identification inflammation and prompted clinical evaluation and intervention. This practice observation is consistent with previous literature suggesting daily foot temperature monitoring may prevent as many as 70% of developing DFU [5-7]. Importantly, both reductions in DFU incidence or days may impact on morbidity, mortality, and resource utilization.

References

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*Podometrics RTM System, Podometrics, Inc., Somerville, MA