Acute Charcot Neuroarthropathy: A Novel Use for a Daily Remote Temperature Monitoring Mat

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Introduction

Charcot neuroarthropathy is an uncommon but potentially devastating progression of neuropathy, most frequently affecting patients with diabetes. The first stage of Charcot is acute and is characterized by erythema, edema, and calor. Radiographic evidence of bony fragmentation can be seen with joint dislocation and soft tissue swelling, most commonly at the tarsometatarsal, calcaneocuboid, and talonavicular joints. The second stage, coalescence, is characterized by decreased erythema, edema, and calor with bony healing seen on x-ray. The third, or chronic, stage is characterized by resolution of erythema, edema, and calor with bony healing, typically resulting in a new deformity.

Previous research [1, 2] supports the use of foot temperature monitoring for diagnosing and tracking the resolution of Charcot episodes. To date, these studies have been conducted in-clinic with infrequent assessment of foot temperatures. As might be expected, the affected foot has been shown to be significantly warmer than the unaffected foot in a patient with acute Charcot. One study [1] showed a contralateral temperature difference of 4.8 +/- 1.3°C at enrollment, decreasing to approximately 0°C on average over the year reading frame as the Charcot episodes resolved. This same study also notes that 44% of the study cohort presented with a DFU while in treatment for a Charcot episode.

A thermometric telemedicine smart mat* has been developed to detect the temperature changes due to plantar inflammation [3]. Previously, this technology has been used for monitoring high risk patients for the early detection and prevention of diabetic foot ulcers (DFU). While temperature assessment for Charcot neuroarthropathy is widely practiced, there is no consensus on what thermometric criteria should be used. Furthermore, given that Charcot may increase a patient's risk for developing DFU, daily thermometric monitoring may be helpful for preventing complications of Charcot as well monitoring its progression.

This case series details two patients with diagnosed acute Charcot neuroarthropathy. The patients live remote to clinic, 240 and 75 miles, and are unable to travel to clinic regularly for application of total contact cast (TCC) or frequent in-clinic temperature assessment. The objective of this investigation is to present remote temperature monitoring (RTM) as a viable tool for tracking the resolution of acute Charcot neuroarthropathy and recommending offloading treatment between clinic visits.

Methods

Two high-risk veterans followed in the PAVE clinic were given mats for remote temperature monitoring. Veterans were trained to use the device, which requires standing on it daily for 20 seconds. The thermometric data are securely transmitted and accessed. Clinical staff can access de-identified thermograms through an online physician portal for triage.

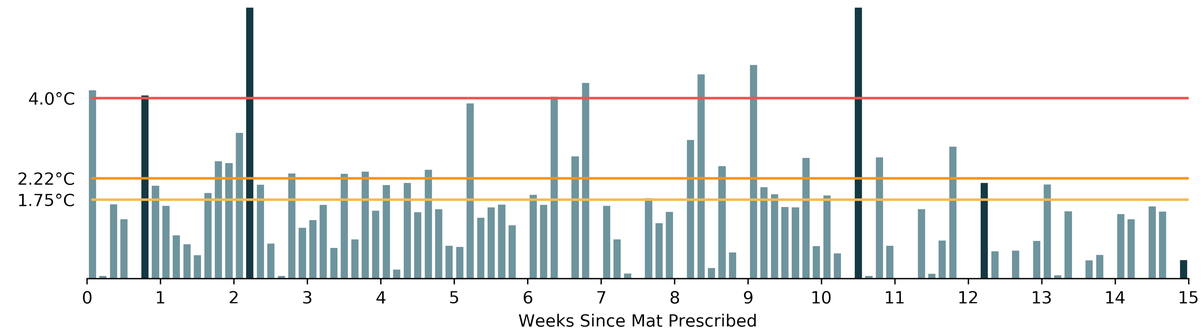
The temperature data collected by the mat are automatically analyzed for temperature differences, or asymmetry, between the left and right feet at six locations consistent with the most commonly described approach [3].

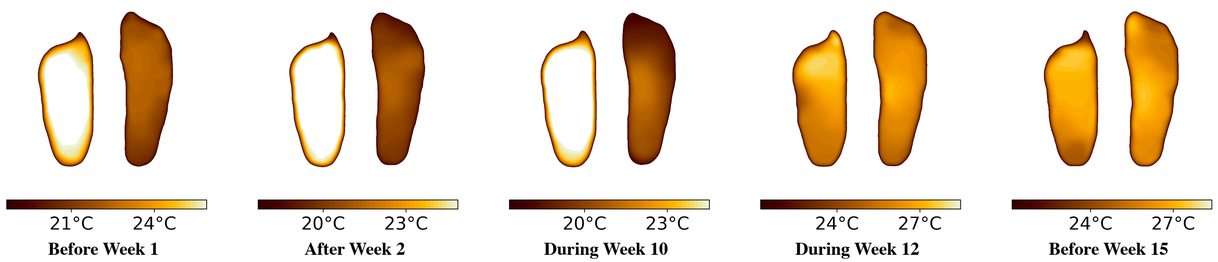
A veteran with temperature asymmetry exceeding 1.75°C over two or more consecutive uses at the same location triggers a notification to the clinical staff, after which the veteran is considered "in episode" and is more aggressively monitored for the following two weeks. A phone call is made to the veteran to encourage offloading and visual exam at home.

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

Case 1

- 56-year-old male with IDDM2 (HbA1c 8.3%), neuropathy, CKD stage 3, HTN, HLD, anxiety, tobacco use, OA of knee, and obesity.
- Three months prior to receiving the mat, patient had a right navicular fracture on MRI and reported no pain or trauma.
- One month prior to receiving the mat, patient was admitted for suspected osteomyelitis of the right foot with increasing edema and erythema. He was ambulating in normal shoe gear. While admitted, osteomyelitis was ruled out and the diagnosis of active Charcot was made. X-rays show "2nd-5th Lisfranc and midfoot tarsal fractures."
- One week prior to receiving mat, patient was seen in clinic and instructed that offloading for anywhere between 6 and 12 months is the expected treatment. Patient was placed in CAM walker and instructed to be NWB with knee scooter, crutches, or wheelchair.
- During week 2, the mat alerted the care team to right foot asymmetry of 5.1°C. During a phone call prompted by the alert, patient reported a small superficial popped blister to the arch of his foot. He reported no erythema, edema, or calor. He was instructed to continue daily mat use and visual inspection and reminded of SOI.
- At the patient's next scheduled exam, the lesion was found to be resolved, possibly due to the early intervention prompted by the mat.
- During week 5, there was coalescing evident on x-ray. Despite this, patient showed diffuse thermal asymmetry averaging 2.7°C through week 12, with warmer right foot temperatures and a peak temperature difference of 6.7°C during week 10. Patient was instructed to continue NWB.
- From weeks 12 through 15, the patient's average temperature asymmetry reduced to below 1.5°C, potentially indicating reduced inflammation and calor consistent with most recent imaging.
- Patient continues to be monitored with daily thermal scans and clinic visits every other month with new x-rays.

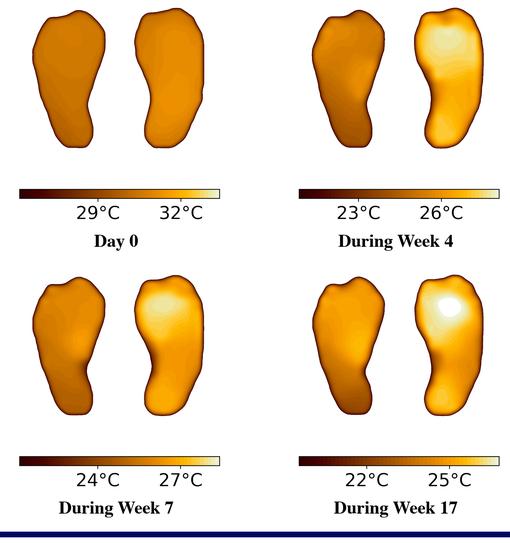




Case 2

- 67-year-old male with NIDDM2 (HbA1c 8.1%), neuropathy, HLD, aortic stenosis, varicose veins, HTN, obesity.
- 9 months prior to receipt of the mat, patient entered an episode of acute left Charcot. He was treated with CAM walker, decreased weightbearing, and bone stimulator for consolidation of fractures.
- Three weeks prior to receiving the mat, x-rays suggest consolidation.
- Patient had two episodes of low to moderate thermal asymmetry during weeks 4 and 5 with peak asymmetry of 2.2°C. Both episodes prompted a phone call to the patient to instruct offloading, and both resolved without further clinical intervention.
- Patient entered into a third episode in week 17 with low asymmetry to the left forefoot and remains in episode currently. This episode also prompted a reminder to the patient to continue offloading.
- During week 22, the bone stimulator was discontinued with no progression toward healing, but no further cortical erosion seen on x-ray in the past 6 months. Patient remains in asymmetry episode, with peak asymmetry of 2.5°C. Patient has been instructed to continue use of CAM walker with partial weightbearing.
- Patient continues to be monitored daily on thermograms and seen monthly in clinic with new x-rays.

Case 2 (continued)



Conclusion

Both patients in this series live remote to clinic. Thermometry was used to evaluate the progression of their Charcot on a daily basis between in-person evaluations monthly or every other month and monitor for other complications such as DFU. In both cases, alerts to emerging asymmetry allowed for targeted, brief, remote intervention.

Currently, we are aware of no studies on daily temperature monitoring for acute Charcot, but there are published data showing a decreasing thermal asymmetry trend over time as the patient progresses into the coalescence and chronic stages. There is need for additional study to protocolize the daily monitoring of patients with acute Charcot to guide therapy and prevent ulceration and severe deformity.

References

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[3] Frykberg RG, Gordon IL, Reyzelman AM, Cazzell SM, Fitzgerald RH, Rothenberg GM, Bloom JD, Petersen BJ, Linders DR, Nouvong A, Najafi B. Feasibility and Efficacy of a Smart Mat Technology to Predict Development of Diabetic Plantar Ulcers. Diabetes Care. 2017 Apr 29:dc162294.

Acknowledgements

The Southern Arizona VA Health Care System provided the facilities and support for this research. Dr. Jonathan Bloom, Dr. Gary Rothenberg, Brian Petersen, and Nicole Neff of Podimetrics Inc. assisted in poster layout, figures, and copy editing.