



Preventing Foot Ulceration by Identification of Skin at Risk for Ulceration Utilizing Near Infrared Spectroscopy (NIRS) and Monitoring Off-Loading Utilizing NIRS

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BACKGROUND

- Foot deformities and/or altered foot biomechanics result in areas at risk for foot ulceration.
- Foot ulceration can lead to major complications including infections, sepsis, and minor/major amputations.
- Inflammation over bony prominences (e.g., hammer toes, bunions, bony prominences associated with Charcot foot) can lead to ulceration. Early detection of inflammation and proactive offloading can prevent ulceration and associated complications.
- Near-infrared spectroscopy (NIRS) imaging is a tool that can quickly measure superficial oxygenation. A focal increase in oxygenation is a surrogate marker for inflammation.
- We explored utilizing NIRS for identification of areas at-risk followed by focused offloading to prevent ulceration.

OBJECTIVE

To evaluate if point-of-care near-infrared spectroscopy (NIRS) can be used as an objective measure of tissue inflammation related to pressure followed by proactive offloading to prevent ulceration.

METHODS & RESULTS

- Patients with intact skin, but who had bony prominences due to deformities were imaged with NIRS in areas that were identified as high risk for ulcer development.
- If areas of significantly elevated tissue oxygen saturation (StO₂) were identified on the image, proactive offloading was provided to the patient.
- Patients were followed to determine if a wound developed in the area identified as high risk.

Within 7 patients, 10 areas of inflammation over bony prominences in feet were identified. Areas of bony prominences included as follows: 2 hammer toes, 3 hallux abducto valgus, 1 first metatarsal head, and 3 fifth metatarsal heads. Within the 10 areas of inflammation, there was significantly higher StO₂ ($79.6 \pm 10.5\%$) over the bony prominences compared to the StO₂ in the surrounding tissue ($55 \pm 6.6\%$; $P < 0.001$). On follow-up after proactive offloading was provided, 1 area developed ulceration while the 9 other areas did not.

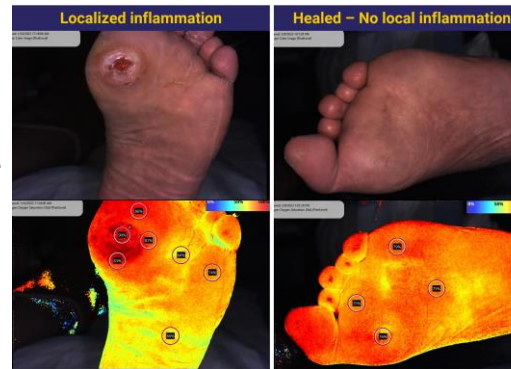


Figure 1. A male patient who was treated with a total contact cast and underwent a tenotomy. Offloading was continued until his wound was closed then patient was custom fitted for a diabetic shoe. The patient has a bony prominence but now they properly protect themselves from repeated pressure by proactively offloading

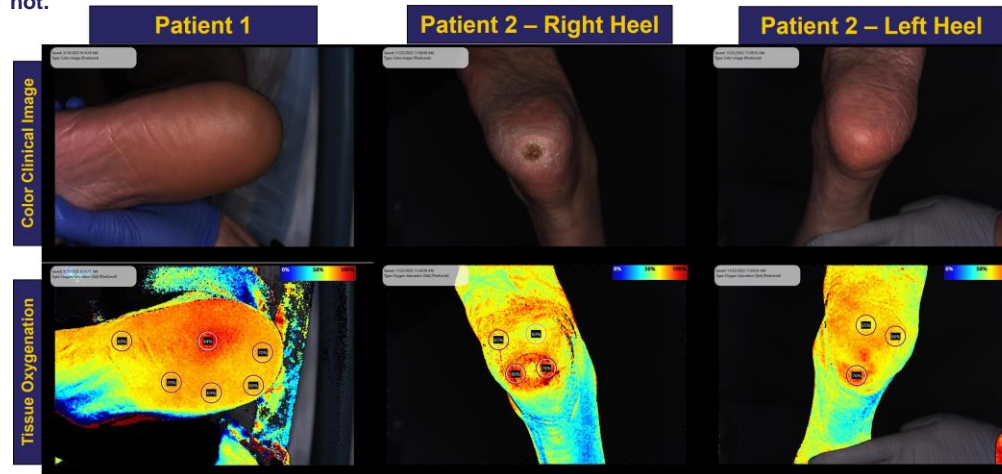


Figure 2. Clinical images (top) and tissue oxygen saturation (bottom) images of feet being screened for inflammation. Patient 1 had no visible erythema but showed an inflamed heel visible with NIRS. Patient 2 had an affected right heel and an unaffected left heel. Ulceration of the left heel was prevented with offloading.

DISCUSSION

- NIRS was able to identify areas of increased oxygenation (induced by inflammation) over bony prominences.
- Being able to identify the area of inflammation prior to ulceration facilitated a proactive approach of offloading to prevent ulceration.
- NIRS was also used in serial visits to track the effectiveness of offloading in reversing inflammation.
- This process of serial imaging and reviewing images with patients can be an excellent educational tool to reinforce the importance of offloading and thus potentially improving compliance.
- NIRS may be a fast, non-invasive, and valuable educational tool in preventing recurrent ulceration in patients and empowering patient autonomy.

CONCLUSION

These cases demonstrate the utility of using NIRS as a preventative screening measure for ulceration. With a fast and non-contact way to screen patients, ulceration rates and overall healthcare burden may be lessened with a focus on prevention and proactive responses.