This point is singled out on the ROC plot with estimated 95% confidence intervals in both TPF 0.81, 0.98 and FPF 0.07, 0.27.

2 Discussion

The ability to accurately and reproducibly assess burn injuries is critical in the early post-burn period. The importance stems from the shift in burn management from more traditional nonsurgical treatments to the current standard of early excision and grafting of deep dermal and full-thickness burns. Earlier studies demonstrated statistical associations between NIRS and grafting of deep dermal and full-thickness injuries. This represents a major development in burn care, particularly with the increased use of NIRS in clinical settings. NIRS allows for the non-invasive and continuous monitoring of tissue oxygenation and blood volume, which are critical parameters in the management of burn injuries.

In this study, NIRS assessments of burn injuries were demonstrated to be able to distinguish between shallow injuries, superficial and intermediate partial-thickness injuries, and deep burns, deep partial-thickness injuries. The upper shaded area of the ROC plot corresponds to probabilities 0.5 that the injury was deep, while the lower shaded region corresponds to predicted probability of 0.5 that the injury was deep. Using 0.5 probability as the boundary between the two classes, the model sensitivity to separate deep from shallow burns was 0.90 while model specificity was 0.83, leading to an overall accuracy of 86.7% color online only.

A number of instrumental methods, many photonics-based, have been adapted to examine burn injuries. Most of these methods are highly complementary to NIRS. For example, optical coherence tomography and high-frequency ultrasound scans probe the various layers of the skin and can detect structural derangements of these layers due to the burn injury. Perfusion imaging techniques such as indocyanine green fluorescence or noninvasive methods such as laser Doppler or speckle provide measures of blood flow at the wound. Similar to these perfusion-based methods, NIRS provides information on the local hemodynamics, blood volume, and oxygenation of the wound. However, like optical coherence tomography, NIRS is also sensitive to changes in the optical scattering properties of the underlying tissue. Thus, in addition to being able to infer structural alterations by detecting changes in the scattering of tissue, NIRS is also sensitive to the local hemodynamics. These features are latent in the NIR reflectance spectrum and, as
demonstrated here, have the potential to be used to predict the likelihood that the injury is deep and requiring surgery.

The technical simplicity of fiber optic-based diffuse reflectance NIRS measurements makes the technique clinically practical. The ability of the technique to provide a measure of tissue water content, blood volume, and tissue oxygenation at the site of the injury along with structure changes that can be inferred from how the light scattering properties of the injured tissue change, renders clinical relevance to the technique in the assessment and monitoring of burn injuries. The approach taken in this report takes a different track. By using the inherent differences in the spectral signature from skin subject to a shallow burn injury compared to skin with a deep injury an individual-level classification of burn severity is developed based on these differences in spectral signature. This method does not explicitly attempt to extract concentration estimates of constituents in the tissue, and thereby does not rely on having reliable estimates of the optical pathlength and by inference the optical scattering and absorption coefficients of the tissue. The probabilistic output of the classifier indicates the likelihood that the burn injury is severe and requires early excision and grafting. The classification approach does not preclude extracting concentration estimates of water and hemoglobin from the tissue spectra and providing hemodynamic indices of the burn. The diagnostic information from the classifier along with the hemodynamic indices also available from NIRS measurements provides unprecedented insight into the biochemical, physiological, and structural changes occurring at the wound site, which should be a significant aid to the burn specialist in managing these injuries.

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References