Diagnosis of Burn Wounds Using Terahertz Time-Domain Spectroscopy

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Abstract—We present experimental results from the application of terahertz time-domain spectroscopy in diagnosis of scald burns in a standardized porcine model in a clinical Operating Room setting. Superficial, deep partial-thickness and full-thickness burns were differentiated according to the spectral information between 0.2 and 0.8 THz. The severity of wounds were quantified based to the depth of the burned skin, using histological analysis of the biopsy sections, as the gold standard. Our results indicate that terahertz spectroscopy can be used to discriminate accurately between burns of varying severity.

I. INTRODUCTION

The American Burn Association has reported that each year approximately 450,000 burn injuries received medical care in the U.S. The clinical course of treatment for a given burn hinges on the results of the initial diagnosis. Clinical grading of burn injuries, which is traditionally based on visual and tactile inspection of the wound by experienced surgeons, attempts to estimate the depth of the burn; a key parameter that stratifies the wound into 4 categories: epidermal, superficial partial-thickness, deep partial-thickness and full-thickness. Full-thickness wounds cannot heal without skin grafting procedures, whereas for partial-thickness burns, the treatment consists of wound care and infection prevention over 2-3 weeks after injury [1-2]. During this period, superficial partial-thickness burns will naturally heal, while deeper ones will eventually desiccate further to a full-thickness state necessitating surgical interventions. The error rates in discrimination of partial- and full-thickness burns, however, have long remained near 35% [1-2].

THz spectroscopy has been proposed as a noninvasive modality for burn diagnosis, based on its sensitivity to water content of the tissue and scattering by discrete skin structures, in rodent models [3-4]. In this paper, we will discuss miniaturization of the system for application in a sterile OR. We will show results from porcine burn models, which are clinically more accurate, because the skin regeneration in swine better represents the wound healing process in humans. Finally, we will comment on instrumentation considerations for obtaining FDA approval to conduct the first clinical trial of this technology for burn diagnosis.

II. RESULTS

The following experiments were performed in accordance with the guidelines set forth by the NIH, based on an experimental protocol approved by the Institutional Animal Care and Use Committee. After induction of anesthesia, scald burns (n = 9) were created on three Landrace Yorkshire cross pigs, following a standardized induction protocol. The scald burn induction device is a “hot water bottle” with the glass bottom removed and replaced with plastic wrap (fastened with heat resistant tape). The bottle is filled with 300 ml of deionized water heated to 92°C. Compared to metal contact burn protocols, here the plastic wrap conforms to the anatomical contours, resulting in an even surface contact. Each burn site received 10, 15, or 20 seconds exposure to 92°C, respectively creating superficial partial-thickness, deep partial-thickness, and full-thickness burns. We used the well-established Vimentin immunohistochemistry (IHC) assay to quantify the burn depth. The terahertz spectroscopy results are shown in Figure 1. It can be noted that the terahertz reflectivity between 0.2 and 0.5 THz and the roll-off in the spectral slopes after the peak reflectivity, can be used to differentiate between different burns. Significantly, we can also see that the spectral slopes decrease from negative to near zero as the severity of the burns increases, which is consistent with the results observed previously in the rat studies [3].

III. SUMMARY

We will show successful customization and utilization of a compact, portable, and fiber-coupled THz-TDS system for highly accurate diagnosis of burn injuries inside an OR.

REFERENCES