

# MHSI May Predict Clinical Outcomes in Diabetic Foot Ulcers

Not only is this diagnostic technique noninvasive, it is nontouch. It quantifies tissue oxyhemoglobin and deoxyhemoglobin.

BY CONNI BERGMANN KOURY, EDITOR-IN-CHIEF

**M**edical hyperspectral imaging (MHSI) may detect differences between diabetic foot ulcers that heal and those that do not, therefore predicting clinical outcomes, according to a presentation at the American Diabetes Association's 66th Scientific Sessions in Washington, DC.

Lead author Aristidis Veves, MD, MSc, said, "We believe that the changes in both oxyhemoglobin and deoxyhemoglobin indicate variations in oxygen delivery and oxygen extraction. Therefore, this technique may detect microvascular abnormalities." Dr. Veves is research director of the Microcirculation Lab and Joslin-Beth Israel Deaconess Foot Center, and associate professor, Harvard Medical School.

Dr. Veves' unit teamed up with the small start-up company HyperMed (Waltham, Mass), that developed a camera-based MHSI technique that can measure oxy- and deoxyhemoglobin in the skin and provide information regarding tissue oxygenation. The main aim of the group's study, therefore, was to test MHSI for its efficacy and its ability to predict wound healing. The phase 1 study was performed under the auspices of a Small Business Technology Transfer Grant from the National Institutes of Health.

## STUDY DESIGN

Type 1 diabetic patients with a foot ulceration, aged an average of 70 years, were included in the study. Dr. Veves said the investigators excluded patients with standard problems or serious conditions that can affect wound healing such as peripheral arterial disease (PAD), edema, heart failure or cancer, as well as treatment with medications that could affect wound healing.

"We studied 10 patients with type 1 diabetes and foot ulceration, and we also included 13 patients with type 1

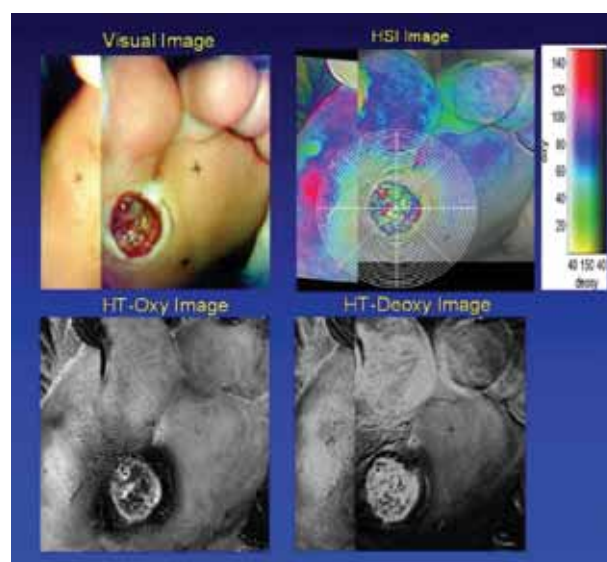


Figure 1. The figure shows a photo of a diabetic foot ulcer and MHSI images of the same wound.

diabetes and no ulceration and 15 control subjects." Dr. Veves said. The demographics among the groups were more or less the same, he said, except for blood pressure, which was lower in the control group.

"The clinical exam, as you would expect, showed that the patients with ulcers had more severe neuropathy compared with the controls and the group with no ulceration. But the ankle brachial index was the same in all three groups, which was not surprising because we excluded patients with [PAD]," he said.

## CLINICAL PARAMETERS

Patients with foot ulcers were examined four times

over 6 months. The investigators used MHSI to measure oxy- and deoxyhemoglobin, and oxygen saturation, an artificial product derived by dividing oxyhemoglobin by the sum of oxy- and deoxyhemoglobin. “We believe oxyhemoglobin indicates blood supply to the skin, and deoxyhemoglobin is probably related to the extraction of oxygen in the tissue,” Dr. Veves said.

The investigators also measured transcutaneous partial pressure of oxygen (TCPO<sub>2</sub>) and laser Doppler flowometry in all these patients.

MHSI incorporates a camera that takes pictures of the oxy- and deoxyhemoglobin wavelengths — which are different. A computerized process superimposes the images to show the spatial distribution of oxy- and deoxyhemoglobin, as well as tissue oxygenation and the location of the ulcer (Figure 1 and 2). These measurements can be taken in the ulcer and in the skin surrounding the ulcer.

“We can compare measurements from the ulcer, the periphery and the contralateral foot or the skin of the control patient who did not have foot ulcers. But we also have measurements inside the ulcer itself,” Dr. Veves explained.

### EXAMPLES

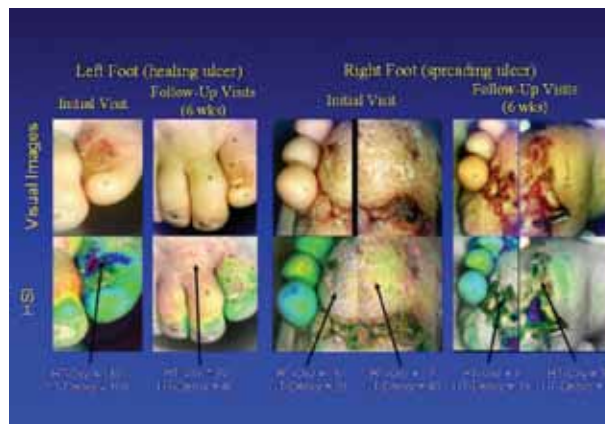
Dr. Veves showed an example of a patient with ulcers in both feet. In one foot, the patient had an ulcer near the toe that went on to heal. MHSI revealed that the ulcer had high measurements of both oxy- and deoxyhemoglobin. “It is of interest that, in the other foot, the measurements of oxy- and deoxyhemoglobin were low. The ulcer progressively deteriorated, and as a result, the patient had an amputation.”

With regard to the study results, Dr. Veves said in the 10 patients with 17 ulcers, eight healed and nine did not. The investigators compared these patients with the patients with no ulcers and the control measurements at the same level of the foot. “The oxyhemoglobin was higher in the patients who healed compared to other groups. But please note that laser Doppler flowometry — without any stimulation was similar in all groups — this is in agreement with previous studies in our unit.”

### COMMENTS

Dr. Veves’ group also measured the oxy- and deoxyhemoglobin for the ulcer side and the contralateral foot to have a control of the same patient. The ulcers that failed to heal had lower oxyhemoglobin compared with those that healed. The same area on the other foot had lower deoxyhemoglobin, and the oxygen saturation was similar, he said.

Taking these measurements in an ulcer is difficult, Dr.



**Figure 2.** This figure shows a photograph of a healing ulcer (left) and a spreading ulcer (right) and MHSI images of each.

Veves added, because if the ulcer is healing, you do not know where exactly to measure. Overall, patients who had nonhealing ulcers had indications of less oxygen perfusion. “PCPO<sub>2</sub> and laser Doppler flowometry did not help us in identifying patients who were not going to heal or were going to heal — there were no differences among them,” he said.

### COMPARES WITH EXISTING TECHNIQUES

When Dr. Veves’ group plotted the ulcers that healed and those that did not against oxyhemoglobin measurements and assigned a cutoff point of 45, they found that most of the ulcers that healed were above this point, and those that did not were below this point. “A quick statistical analysis shows that MHSI had a sensitivity and a specificity of 86%, which is quite satisfactory if you compare with existing techniques,” Dr. Veves said.

He concluded, that, while this was a preliminary phase 1 study designed to show proof of concept, it found that MHSI can detect differences between ulcers that heal and those that do not. “We believe that the changes in both oxy- and deoxyhemoglobin indicate changes in oxygen delivery and oxygen extraction. Therefore, this technique might detect microvascular abnormalities. Further studies will be required to confirm these results, and the phase 2 trial is underway.” ■

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