Thermographic findings in a case of type 2 diabetes with foot ulcer and osteomyelitis

Using thermography, skin temperature was evaluated in a 76-year-old patient with type II diabetes mellitus, presenting with diabetic foot ulceration on the right hallux and a corn on the left fourth toe. Increased skin temperature was observed in both the right hallux and the left fourth toe, though there were no visible clinical signs of infection. Unexpectedly, the high temperature area was seen to extend from the left fourth toe to the ankle. The patient was later diagnosed with osteomyelitis, due to the presence of a high-intensity area on T2-weighted magnetic resonance imaging, suggesting the elevated skin temperature was due to osteomyelitis. Based on these observations, thermography could prove useful for screening for foot ulcers with osteomyelitis.

diabetic foot ulcers; osteomyelitis; thermography

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Diabetic foot ulceration (DFU) severely affects a patient's physical condition, long-term prognosis and quality of life.[1–4] Furthermore, diabetic patients with neuropathy cannot recognise an injury until ulceration and/or infection occurs,[5] therefore, an effective, objective assessment method for identifying developing or progressing DFU is important.

One possible tool for detecting the risk of ulceration in patients with diabetes mellitus is thermography. A number of studies have previously highlighted the usefulness of thermometry in monitoring skin temperature to reduce the risk of ulceration.[6–8] However, compared with conventional devices for measuring skin temperature at local points, such as contact infrared skin thermometers (TempTouch; Xilas Medical, Inc.),[6–8] thermography has the advantage that it can visualise morphological patterns of temperature distribution.[9,10] In a cross-sectional study of patients with foot calluses, latent inflammation was detected by thermography in 10% of patients with diabetes,[11] suggesting the versatility of thermography as a screening tool for the potential risk of DFU.

One of the most serious complications of DFU is osteomyelitis, as its diagnosis and treatment (surgery and/or long-term antibiotics) have been long-standing controversies.[12–14] Therefore, early detection of osteomyelitis is important. Although magnetic resonance imaging (MRI) is the gold standard for diagnosing osteomyelitis,[12–14] it has disadvantages, such as high cost and non real-time diagnosis. Temperature assessment using non-invasive and easy-to-use thermography could be one consideration in helping identify the presence of osteomyelitis. However, to date, there have been no reports on thermography of DFU with osteomyelitis. Here, we report a case study of patient with both DFU and osteomyelitis, detailing the thermographic findings.

This research was approved by the Ethics Committee at National Centre for Global Health and Medicine Hospital. The patient gave his written informed consent.

Case report

A 76-year-old man with type 2 diabetes mellitus (disease duration 28 years) was admitted to the Department of Dermatology, National Centre for Global Health and Medicine (NCGM) Hospital, Tokyo, Japan, with DFU located on the right hallux. He had neuropathy (decrease in sensation for 5.07 monofilament) and angiopathy (ankle brachial pressure index=0.63 [right] and 1.09 [left]).

Table 1. Skin temperature at days 106 and 196

		Day 106		Day 196	
		Skin temp (°C)	ΔTemp* (°C)	Skin temp (°C)	ΔTemp* (°C)
Right	Hallux	34.2	0.7	32.8	–0.1
	Dorsum	33.8	0.3	31.3	–1.6
	Ankle	33.8	0.3	31.9	–1.6
	Knee	33.5	—	32.9	—
Left	Fourth toe	35.3	1.2	33.4	0.3
	Dorsum	35.2	1.1	33.3	0.2
	Ankle	35.2	1.1	33.5	0.4
	Knee	34.1	—	33.1	—

*Temperature difference (ΔTemp = temperature of local skin–knee skin temperature) was adopted as the secondary outcome in this study for the parameter of increasing skin temperature, as toe skin temperature is not typically higher than knee skin temperature. Positive values for temperature difference could indicate inflammatory temperature increase at each site

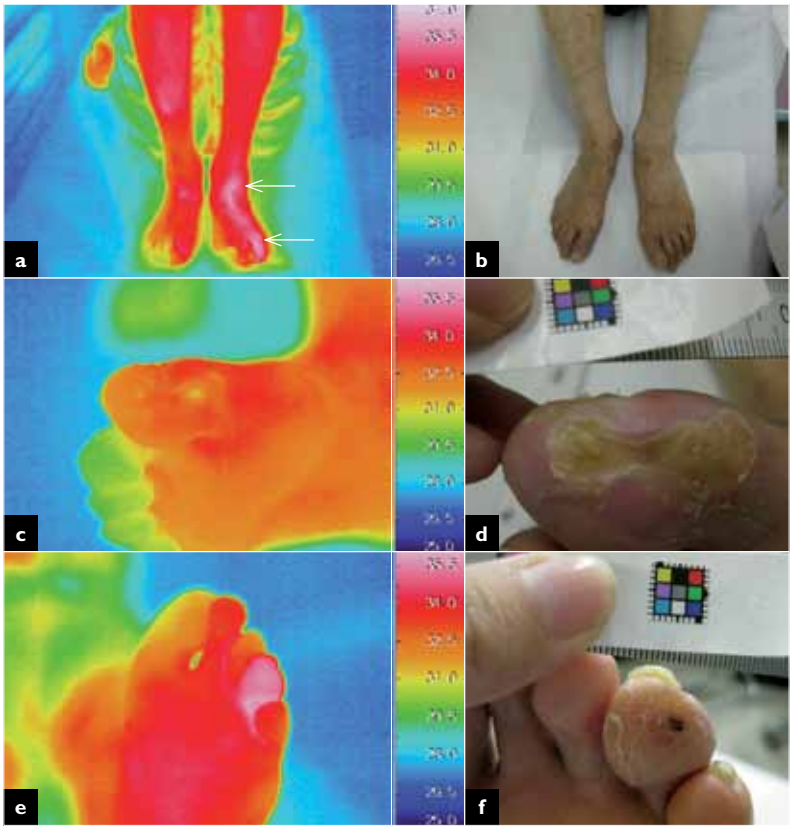

Fig 1. Thermal and visual images at day 106 of both legs, (a, b), the ulcer on the right hallux, (c, d), and corn on the left fourth toe, (e, f). Increased skin temperature was observed in both the right hallux and the left fourth toe with corn, though the infection was not observed by visual image, (f). Notably, the area of increasing skin temperature extended to the ankle (arrows)

On admission, he was diagnosed with osteomyelitis in his right hallux, due to a high intensity area on T2-weighted MRI, and was treated by systemic antibiotics (ampicillin and gentamicin) and topical silver sulphadiazine cream. The ulcer was not offloaded due to the patient's non-concordance, although the necessity of offloading was explained. Cleansing of the wound, and dressing change, were conducted once a day, and necrotic tissue was debrided, if necessary. His HbA1c level was 8.7%, and he was treated by subcutaneous insulin infusion. Wound size gradually decreased.

On day 106, a thermographic image of both his feet was taken using a Thermotracer TH7800N (NEC Avio Co. Ltd.); it was the first time that thermography was applied to a patient with DFU, in this setting. Thermographic images, after 15min of equilibration[9,11] were used to evaluate skin temperature. The temperature difference between the knee and each site was also evaluated, as foot skin temperature is not typically higher than knee skin temperature.

Thermography on day 106 confirmed that skin temperature was still increased in the right hallux. Unexpectedly, a greater increase in temperature was thermographically detected in the left fourth toe with a corn, although no macroscopic signs of infection were observed (Fig 1).

Notably, the area of increased skin temperature extended from the fourth toe to the ankle (arrows in Fig 1a, and Table 1), implying that latent inflammation could be associated with the corn.[11] On day 121, the patient was diagnosed with osteomyelitis in the left fourth toe by MRI (Fig 2), suggesting that the elevated skin temperature from the fourth toe to the ankle was due to osteomyelitis. Following diagnosis, systemic antibiotic therapy was restarted. No macroscopic signs of infection of the corn on the left fourth toe were observed following therapy. On day 106, the corn was treated through debridement, revealing a small ulcer underneath.

By day 195, the high intensity area on the right hallux was no longer visible on MRI; however, it was still observed on the left fourth toe (Fig 3). Increased skin temperature again extended from the left fourth toe to the ankle (arrows in Fig 4a); however, only a minimal increase in skin temperature was observed in the right hallux (Fig 4, Table 1).

These data might suggest that thermographic findings can reflect the time course of the osteomyelitis identified by MRI. The osteomyelitis could have been mostly healed in the right hallux, whereas it was clearly prolonged in the left fourth toe, even without visual inflammatory symptoms.

Discussion

To our knowledge, this is the first report of thermography in a DFU patient with osteomyelitis. Notably, the area of increased skin temperature was seen

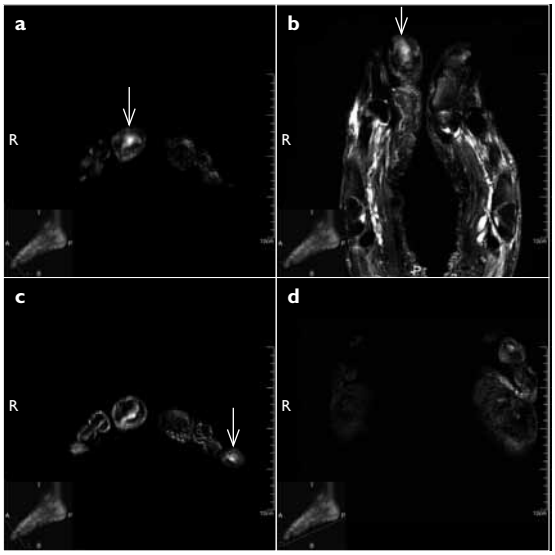

Fig 2. MRI on day 121 revealed a corresponding focus of increased T2 signal in the left fourth toe, (a, b), and right hallux, (c, d) (arrows)

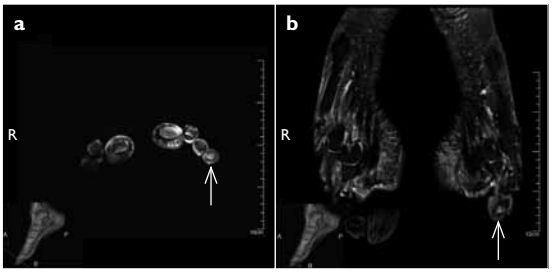

Fig 3. MRI at day 195 revealed a corresponding focus of increased T2 signal in the left fourth toe (a, b; arrows); prolonged osteomyelitis is suspected

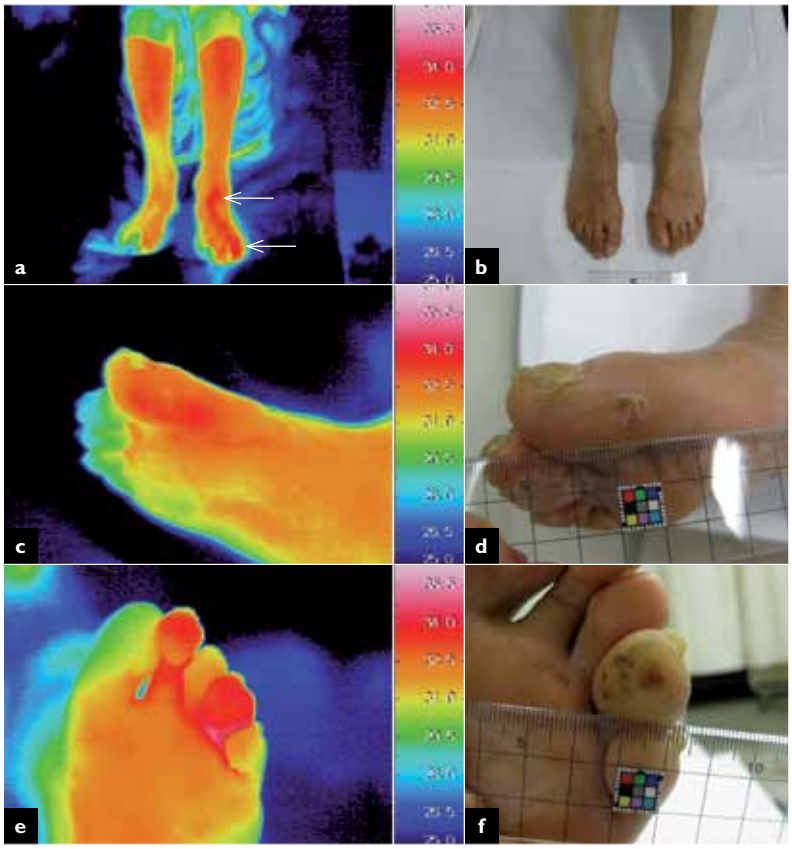

Fig 4. Thermal and visual images at day 196 of both legs, (a, b), the ulcer on the right hallux, (c, d), and corn on the left fourth toe, (e, f). Increased skin temperature was observed in the left fourth toe, and the area of increasing skin temperature was still extended to the ankle (a). On the other hand, increasing skin temperature in the right hallux was hardly observed. Note the absence of visual inflammatory signs in the left fourth toe, (f)

to extend to the ankle, in a diabetic patient presenting with, previously undiagnosed, osteomyelitis of the left fourth toe.

In this case, increased skin temperature was observed exceeding the affected area of osteomyelitis. Swelling and/or the redness is sure to be macroscopically observed, if it is due to phlebitis or cellulitis, therefore, this result might suggest that fever of osteomyelitis can extend beyond the infected bone. More detailed analyses will be needed to confirm whether extension of increased skin temperature is a specific sign of osteomyelitis.

It is also of note that the corn without inflammatory signs was associated with prolonged osteomyelitis. It is reported that inflammatory subcutaneous changes are occasionally found underneath asymptomatic, seemingly dry, corns or calluses in patients with diabetes mellitus.[11,15,16] Such minimal skin changes should not be underestimated in the diabetic population.

While the importance of thermometry for lower extremities has been emphasised as a method for detecting risk of DFU,[16,17] only the local skin temperatures were measured in most of the previous reports. Here, thermography was used to visualise temperature distribution as the primary outcome, with the thermographic area of increased skin temperature found to extend to the ankle in this patient with osteomyelitis. This type of temperature evaluation may only be possible with thermography. Therefore, thermography could be a useful screening tool for DFU with osteomyelitis.

Conclusion

Using thermography, skin temperature was evaluated in a patient with DFU. A high temperature area was observed, not only in the wounds, but also in the ankles. The patient was later diagnosed with osteomyelitis, due to the presence of a high-intensity area on MRI. Moreover, the high temperature was not observed in the wound after osteomyelitis had resolved. Based on these findings, thermography could prove useful for screening for DFU with osteomyelitis. ■

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