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Thermal changes during healing of distal radius fractures—Preliminary findings

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ABSTRACT

Introduction: The bone healing process is very complex. In simple terms, bone healing comprises three basic steps, the inflammation phase, the repair phase and the remodelling phase. The increase in blood flow around the fracture during the healing process increases the temperature of the surrounding tissue. Infrared thermography is a method of measuring body temperature that can detect temperature changes during bone healing. Studies on the application of thermography in traumatology are scarce, and there are no studies of thermal changes during normal bone healing. The authors have tried to determine the dynamics of thermal changes during bone healing.
Material and methods: The Flir ThermaCam B2 (FLIR Systems, Inc., Oregon, USA) was used for all measurements. Thermographic recordings were made one, three, five, 11 and 23 weeks after fracture. The contralateral, healthy, forearm was used for comparison.
Results: A total of 25 patients of mean age 65.9 ± 10.4 years (range 50–80 years) with fracture of the distal radius were examined in this study. The mean temperature difference between healthy and fractured distal forearm one week after fracture was 1.20 ± 0.48 °C, three weeks after fracture was 1.42 ± 0.54 °C, five weeks after fracture was 1.04 ± 0.53 °C, 11 weeks after fracture was 0.50 ± 0.30 °C, and 23 weeks after fracture was 0.22 ± 0.25 °C.
Conclusion: Preliminary findings during this research showed significant temperature changes during healing of distal radius fractures. Infrared thermography is a simple and reliable method in clinical practice that could be used as a good follow-up method in traumatology, but further investigations on more patients are needed.

Introduction

The bone healing process is very complex. In simple terms, bone healing comprises three basic steps, the inflammation phase, the repair phase and the remodelling phase. The increase in blood flow around the fracture during the healing process increases the temperature of the surrounding tissue. As the bone heals, the temperature around the fracture site should start to decrease [1–5]. These temperature changes can be detected by infrared thermography, which is a non-invasive and harmless method of measuring body temperature [6–8]. Technical standards have been established for thermographic imaging of individual body parts and of the whole human body [9,10]. Studies in healthy volunteers have been conducted to establish the normal patterns of temperature of certain parts of the body [11,12]. Infrared thermography has been applied in medicine [13–18]; however, studies on the application of thermography in traumatology are scarce [19–26], and there have been no studies of thermal changes during normal bone healing.

Distal radius fractures are common fractures; they comprise one-sixth of all fractures in the emergency department [27–30]. Stable distal radius fractures are treated conservatively with plaster immobilisation in the majority of cases. Unstable fractures are treated operatively [27,30]. Comparison of X-ray images is a standard way to control the position of bone fragments and to

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assess callus formation, which enables decisions to be made about further treatment [30].

In the current study, the authors have tried to determine the temperature difference between healthy and fractured forearms and the dynamics of thermal changes during bone healing.

Materials and methods

All patients aged 50 to 80 years with distal radius fracture who reported to the traumatology clinic for further treatment were included in the study. Each patient had previously been treated at the emergency department of our institution, where the fracture was confirmed on X-ray by an independent on-call radiologist. The injured distal forearm was immobilised with a plaster splint. If there was a clinically significant dislocation of fragments, closed reduction of bone fragments was performed before the forearm was immobilised.

Patients were excluded from the study if they were aged more than 80 years or less than 50 years, had already undergone surgery for the fracture, or were suffering from complex regional pain syndrome, Raynaud syndrome, vasculitis, infection of the hands or injuries to both hands.

The study was approved by the Hospital and University of Zagreb, School of Medicine Ethics Committees. All patients signed informed consent before the examinations.

The thermographic camera, Flir ThermaCam B2 (FLIR Systems, Inc., Oregon, USA) was used for all thermographic measurements. This infrared system has a 320 × 240 pixel image presentation and thermal sensitivity of <0.10 °C at 25 °C, with 0.96 emissivity. The thermographic camera was calibrated according to the manufacturer's instructions. Analysis was performed with Flir ThermaCam QuickView 2.0 and Flir QuickReport 1.2 software.

Before thermographic imaging, patients spent 30 min in an air conditioned room (22–24 °C); thermographic imaging was then conducted in another air conditioned room with the same temperature. Room temperature was measured and controlled by ETHG 880 thermo-hygrometer (IDT International, San Jose, CA, USA).

During image taking, patients put both hands on a Styrofoam plate and the camera was positioned 100 cm from the forearms. One image was taken in forearm supination position and the other in pronation position. Each image contained both forearms from the fingers to below the elbow.

Thermographic recordings were taken one week after fracture, and then three, five, 11 and 23 weeks after fracture. The contralateral, healthy, forearm was used for comparison throughout the thermographic recordings. During the first two recordings, temperature measurements were made at the level of the fingers, which were not covered with plaster, to see the difference in temperature. At each subsequent recording, temperature changes were measured at wrist level. If there were radiological signs of healing and there was no pain during pressure at the fracture site, plaster immobilisation was removed five weeks after fracture. X-ray examination was performed on the same day as the thermographic recording at one, three and five weeks after fracture.

Results

A total of 25 patients of mean age 65.9 ± 10.4 years (range 50–80 years) with fracture of the distal radius were examined in this study. During the first recording one week after fracture, the mean temperature of all healthy arms was 32.84 ± 1.58 °C, and that of the arms with fractured distal radius was 33.89 ± 1.45 °C. Two weeks later, during the second recording three weeks after fracture, the mean temperature of all healthy arms was 32.96 ± 1.27 °C, and that of the fractured arms was 34.21 ± 1.43 °C. During the third recording five weeks after fracture, the mean temperature of healthy arms was 32.58 ± 1.16 °C, and that of the fractured arms was 33.62 ± 1.26 °C. The fourth recording was made 11 weeks after fracture and the mean temperature of all healthy arms was 32.48 ± 2.05 °C, and that of the fractured arms was 33.00 ± 2.02 °C. The fifth and final recording was made 23 weeks after fracture when the mean temperature of all healthy arms was 31.96 ± 1.38 °C, and that of the fractured arms was 32.16 ± 1.37 °C. The mean temperature difference between the healthy arm and the arm with fractured distal radius one week after fracture was 1.20 ± 0.48 °C, three weeks after fracture was 1.42 ± 0.54 °C, five weeks after fracture was 1.04 ± 0.53 °C, 11 weeks after fracture was 0.50 ± 0.30 °C, and 23 weeks after fracture was 0.22 ± 0.25 °C (Fig. 1). These findings indicate significant temperature changes during different stages of bone healing (Fig. 2).

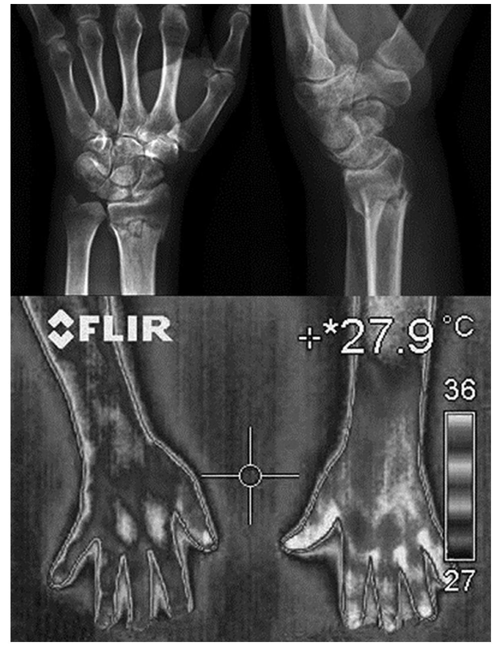

Fig. 1. Infrared thermography and X-ray image of the patient with fracture of left distal radius 5 weeks after fracture.

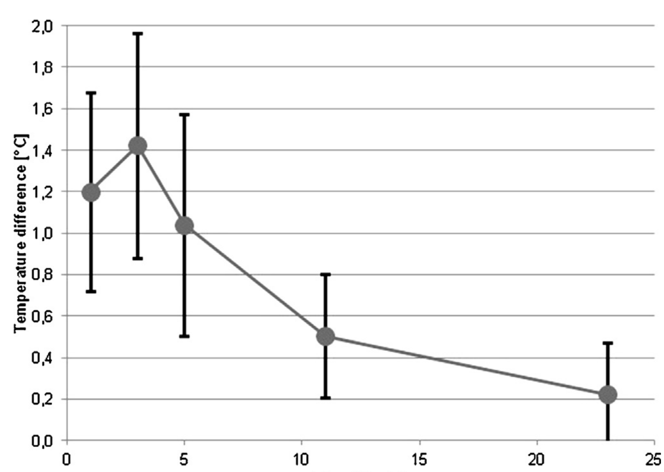

Fig. 2. Temperature difference between healthy arms and arms with fractured distal radius.