Chapter 15
Clinical Applications:
Infrared Thermal Diagnosis of Orthopaedic Injuries in Childhood

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ABSTRACT

The study of the diagnostic accuracy of Infrared Thermal Imaging in the diagnosis of orthopaedic injuries in childhood has been motivated by the high incidence of these injuries throughout the world, being one of the most common reasons for urgent medical consultation. Diagnosis of musculoskeletal injuries usually involves radiography, but this exposes children without fractures to unnecessary ionising radiation. This chapter assesses whether infrared thermography could provide a viable alternative in cases of trauma. To evaluate the accuracy of this technique new thermographic variables have been added to those commonly analysed, such as the extent of the injury and the difference in the size of the area that is at an equal temperature or higher than the maximum temperature of the healthy area. Non-linear cataloguing methods (decision tree models) have also been applied. With the protocol presented, infrared thermal imaging had a sensitivity of 0.91, a specificity of 0.88 and a negative predictive value of 0.95 for diagnosing musculoskeletal injuries.

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INTRODUCTION

Musculoskeletal injuries (fractures, sprains, dislocations, contusions and compartment syndrome) are a leading cause of paediatric injuries in western countries (Collard, Verhagen, Van Mechelen, Heymans, & Chinapaw, 2011) and one of the main reasons why children visit paediatric emergency departments. At the hospital where the study was carried out, 65% of paediatric emergencies involved traumatological injuries. The diagnostic reaction towards these injuries is varied: while the case history and physical exploration constitute the first step in the clinical process, the interpretation of the diagnostic studies through imaging is essential, X-rays being the most commonly used means. Most paediatric fractures occur in the limbs and, although the effective radiation dose is very small, this procedure can be unnecessary for children without a bone fracture at the same time as exposing them to ionizing radiation (Schulze-Rath, Hammer, & Blettner, 2008; Mettler et al., 2009).

Moreover, the X-ray does not allow one to directly detect a relatively common type of traumatological injury such as epiphysiolysis type 1 (Salter-Harris fractures), as they involve fissures of the ligament and, therefore, require a complementary study.

Bone fractures usually trigger a local inflammatory response, evident through a set of signs and symptoms amongst which is a notable increase in skin temperature in the affected area. Infrared Thermal Imaging (ITI) is a useful addition to the diagnostic tools available to clinicians, as it can detect localized variations in temperature, such as those that occur when there is a fracture (Head & Elliott 2002; Pascoe, Mercer, & De Weerd, 2006; Arthur, Khan, & Barclay, 2011), as well as having the advantages of being easy to use and harmless (Awerbuch, 1991).The authors have, therefore, undertaken a systematic review looking into the diagnostic possibilities of infrared thermal imaging for musculoskeletal injuries (Sanchis-Sánchez et al., 2014), as very few studies on the use of infrared thermal imaging in children's limb injuries (Saxena & Willital, 2008; Silva et al., 2012) have been published.

The review found only three studies from the 1980s whose aim was to evaluate the diagnostic potential of infrared thermal imaging in stress fractures. Results from this systematic review showed high heterogeneity for sensitivity, negative likelihood ratio and diagnostic odds ratio, together with moderate combined values for specificity (0.69; 95% CI: 0.49–0.85) and low values for positive likelihood ratio (2.31; 95% CI: 0.63–8.47). These values limit the clinical use of thermal imaging.

However, in the studies consulted it was observed that, on the one hand, they did not consider several variables that could be of interest, such as the size of the injury, and, on the other hand, that the statistical treatment of the data provided by the thermographic images had been undertaken using conventional statistical tests such as Logistic Regressions, even though the type of variables considered would allow them to be analysed using other statistical tests, namely non-linear cataloguing, which would be more appropriate for dealing with complex clinical issues.

This chapter, therefore, presents a protocol for evaluating the thermographic images of traumatological injuries. A greater number of study variables and non-linear cataloguing methods are employed in the form of decision trees to discriminate between fractures and other musculoskeletal injuries (Breiman, Friedman, Olshen, & Stone, 1984). Using this protocol infrared thermal imaging had a sensitivity of 0.91, a specificity of 0.88 and a negative predictive value of 0.95 for diagnosing musculoskeletal injuries.