Magnetic Resonance Imaging and Spectroscopy of Pressure Ulcers
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Introduction

In the previous chapters of this book, we have seen that pressure ulcers (decubitus ulcers) are extremely common in patients who are bed or chair bound, e.g. during hospitalization or because of spinal cord injuries. The ulcers can range from mild coloration of the skin to deep non-healing wounds, which extend into organs or bone. This complex pathology and aetiology of pressure ulcers makes a clinical evaluation by physical examination alone very difficult, if not impossible. Therefore, there is a great need for diagnostic methods to evaluate the depth and extent of pressure ulcers.

With their ability to measure structural, functional and metabolic parameters in healthy and diseased tissue, magnetic resonance imaging (MRI) and spectroscopy (MRS) offer a variety of fast and non-invasive tools that can be used not only for diagnosis and suitable planning of treatment, but also for a better understanding of the mechanisms underlying the formation of pressure ulcers.

In this chapter the current MR literature on pressure ulcers is discussed and new techniques that can be used in research and clinical diagnosis are proposed. The outline of the chapter is as follows. First the present role of MR techniques in pressure ulcer research is reviewed. Subsequently, a brief description of the basic principles of MR is given, followed by an explanation of a number of MR modalities and their (possible) applications in relation to the investigation of pressure ulcers. We conclude with a summary and perspective.

Present Role of MR

Magnetic resonance imaging has proven an important non-invasive experimental tool in the detection and characterization of pathologies in the musculoskeletal system (see e.g. [1–7]). The technique offers excellent soft tissue contrast and high anatomical resolution. Therefore, it is rather surprising that there are only a few systematic MRI studies of pressure ulcers in humans and animal models, especially because MRI can provide the clues for a fast and accurate diagnosis, which might prove crucial for efficient medical or surgical treatment.
Human clinical studies have been conducted mainly on debilitated patients with spinal cord injuries, who often develop chronic pressure ulcers (see other chapters of this volume). In a study by Heneay et al. [8], 37 male spinal cord injury patients who had current or recent sacral, ischial or peritrochanteric pressure ulcers were examined with MRI. It was concluded that MRI could play an important role in the clinical evaluation of decubitus ulcers. The technique was able to detect the extent of soft tissue changes, adjacent fluid collection and the involvement of bone.

In contrast, Rubayi et al. [9] reported a case study of six spinal cord injury patients with iliopsoas abscess evaluated by MRI, computed tomography (CT), conventional radiography, and radionuclide scanning. Iliopsoas abscesses were best diagnosed and treated using CT. From this study it was concluded that CT was superior to MRI and other radiographic methods.

More recently Huang et al. [10] evaluated the clinical accuracy of MRI was in the diagnosis of osteomyelitis in the pelvis/hips of 44 paralysed patients and the utility of MR mapping of the disease extent as a guide to the extent of surgical resection. It was found that MRI is able to diagnose the associated findings in spinal cord-injured patients and can also guide the surgeons as to the anatomic extent, allowing accurate and limited treatment.

Ruan et al. [11] also evaluated the use of MRI in making clinical decisions when assessing non-healing pressure ulcers and non-healing myocutaneous flaps for the presence of abscesses, osteomyelitis, sinus tracts and fluid collections. This was done in 12 patients as part of their pre- and postoperative diagnostic evaluation. A number of case studies illustrated the complicated treatment and evaluation. It was concluded that MRI could be used to identify and evaluate the pressure ulcers in the preoperative period.

To our knowledge, there are only a few histological animal model studies on pressure ulcers [12–15], and only one that combines histology and MRI [16]. In the latter work decubitus ulcers were induced in the tibialis anterior muscle and overlying skin in the right hind limb of the rat by compression from an indenter over the tibia. MR images were obtained in vivo 24 h after load application, and subsequently tissues were processed for ex vivo histological examination. The amount and extent of the damage determined with MRI and from histology were in good agreement. It was concluded that MRI, as it is non-destructive, is a promising alternative for histology in research on pressure ulcer aetiology and, especially, in follow-up studies to evaluate the development of muscle damage over time and in clinical studies.

The studies above, although limited in number, have clearly shown that MRI can be a useful tool for the clinical assessment and in the research of the aetiology of pressure ulcers. However, apart from the use of MRI, to provide basic contrast and mainly anatomical information, there are a number of MRI modalities available nowadays that have found no application in pressure ulcer research yet. Tagging MRI, diffusion-weighted MRI and perfusion MRI offer the possibility to measure local muscle fibre de-