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REVIEW ARTICLE

Advances in magnetic resonance imaging of musculoskeletal tumours

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Summary Functional magnetic resonance imaging (MRI) improves tissue characterisation and staging of bone and soft-tissue tumours compared to the information usually supplied by structural imaging. Perfusion MRI, diffusion MRI, and in-phase/opposed-phase MRI can be performed in everyday practice. Nuclear magnetic resonance (NMR) spectroscopic imaging is a challenging technique that is available only in specialised centres. Tumour characterisation can benefit from perfusion MRI with dynamic gadolinium injection and enhancement time-intensity curve analysis or from diffusion MRI. Highly cellular malignant tumours restrict diffusion and consequently decrease the apparent diffusion coefficient (ADC). With some tumours, tissue heterogeneity or the presence of a myxoid component can hinder this evaluation. Chronic hematoma can be distinguished from haemorrhagic sarcoma. Perfusion and diffusion MRI contribute to the evaluation of tumour spread, in particular by differentiating oedema from tumour tissue. Another advantage of perfusion MRI and ADC mapping is the early identification of good responders to chemotherapy. The use of NMR spectroscopy remains limited. Evaluation of the choline peak can help to differentiate benign and malignant tumours. All available functional MRI techniques have limitations and leave some overlap between benign and malignant tumours. Functional MRI can be used only as an adjunctive imaging modality to complement morphological imaging.

Introduction

Magnetic resonance imaging (MRI) is now indispensable for the preoperative workup and therapeutic follow-up of patients with musculoskeletal tumours [1,2]. Standard MRI uses structural criteria to assess tumour spread to the bone or soft tissues but makes only a limited contribution to the differentiation of benign and malignant tumours and to the characterisation of the tumour tissue [2,3]. Among other imaging tools, the most specific for determining that the lesion is neoplastic is radiography, which determines whether MRI is in order [1]. In many patients, standard MRI cannot determine the exact extent of tumour necrosis or the presence of viable tumour cells, two criteria used to evaluate the treatment response and predict the outcome [2,4]. Patients in this situation can benefit from the latest

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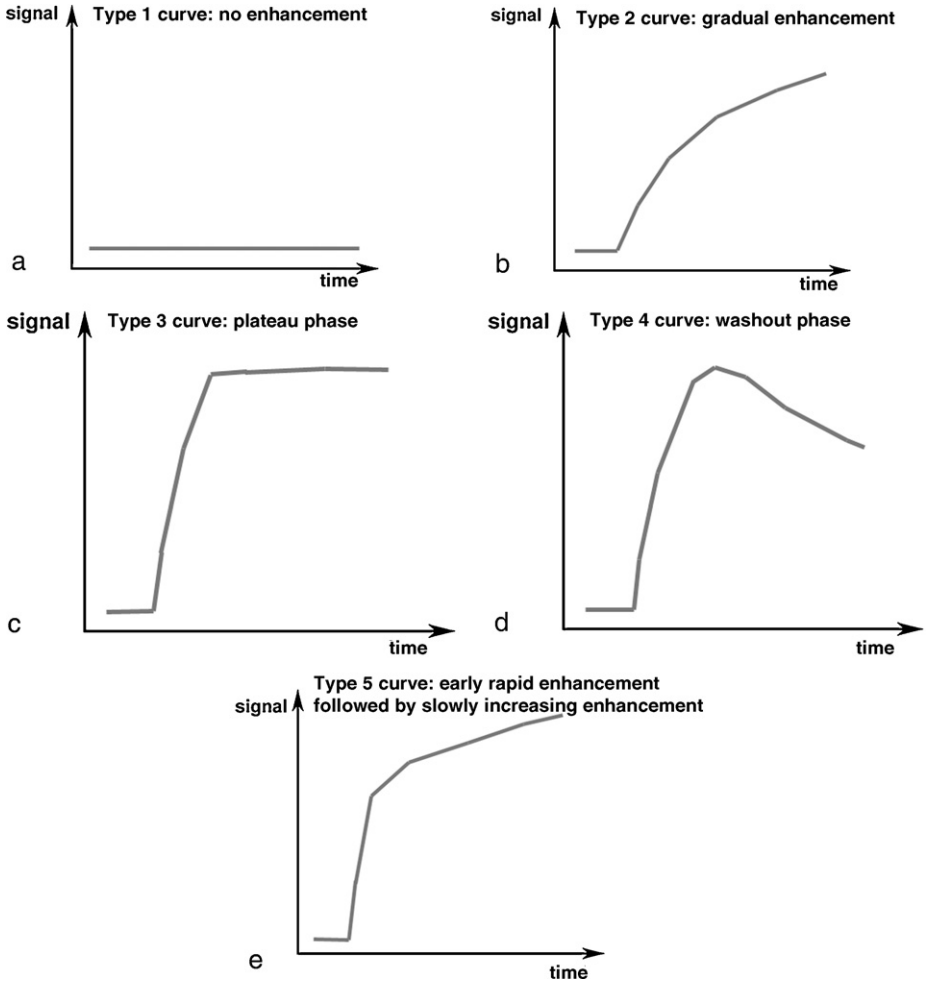

Figure 1 The various types of MRI enhancement time-intensity curves after gadolinium injection.

advances in MRI such as perfusion imaging, proton nuclear magnetic resonance (NMR) spectroscopy, diffusion imaging, and in-phase/opposed-phase imaging [2].

Perfusion imaging by dynamic contrast-agent injection

Dynamic perfusion MRI is a functional imaging technique in which early enhancement of the tumour is monitored after an intravenous gadolinium bolus injection [5]. This technique provides information on vascularisation and perfusion, capillary permeability, and interstitial compartment volume [1,5]. It is often used to evaluate musculoskeletal tumours [6—8]. The main contributions of dynamic perfusion MRI are identification of viable tumour sites to guide the biopsy, monitoring of preoperative chemotherapy, and differentiation of residual tumour from scarring. The injection is monitored for about 5 minutes within a region of interest (ROI) appropriate for the size of the tumour.

To evaluate perfusion, three ROIs of identical size are positioned at a site of marked early tumour enhancement, in an artery, and in healthy muscle, respectively [2]. The time-intensity curves indicate the time from bolus arrival to tumour enhancement, maximal enhancement, and the enhancement slope [5]. The curves can be classified into five types (Fig. 1):

- type 1, no enhancement (e.g., lipoma or haematoma);
- type 2, faint and gradual enhancement (e.g., benign tumours or schwannoma);
- type 3, rapid early enhancement followed by a plateau (limited specificity for tumour characterisation: benign vascular tumours, desmoid tumours, abscesses, some malignant tumours);
- type 4, rapid early enhancement followed by a washout phase (highly vascular tumours with a small interstitial compartment including several malignant tumours [malignant histiocytofibroma, synovial cell sarcoma, and leiomyosarcoma] and several benign tumours [e.g., giant-cell tumour and osteoid osteoma nidus]);
- type 5, rapid early enhancement followed by slow gradual enhancement (e.g., tumours after radiotherapy or chemotherapy and tumours with large interstitial compartments such as myxoid tumours). A colour map of enhancement parameters can be produced.