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EDITORIAL

Diffusion-weighted MRI in head and neck cancer

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Abstract

Diffusion-weighted magnetic resonance imaging (MRI) is an imaging technique showing molecular diffusion. Cell size, density and integrity influence the signal intensity seen on diffusion-weighted images. This technique is a helpful complementary tool to distinguish tumoral from non-tumoral tissue, and has several interesting applications in the evaluation of head and neck cancer.

Keywords: *Diffusion-weighted magnetic resonance imaging; head and neck cancer.*

Computed tomography (CT) and magnetic resonance imaging (MRI) are well established methods in the initial diagnostic evaluation of head and neck malignancy, and are also widely used for treatment monitoring and follow-up. As in other areas of the body, the results obtained with these anatomy-based imaging methods are not always optimal, due to difficulties in identifying early disease or small volume lesions, as well as differentiating tumour from inflammation and/or scar tissue.

Although diffusion-weighted MRI (DWI) has been used for some time for brain evaluation[1], its potential utility for evaluating extracranial neoplastic disease has only recently been recognized. DWI is able to characterize tissue based on differences in water mobility. Diffusion-weighted images are obtained by applying pairs of opposing magnetic field gradients around the refocusing pulse of a T2(*)-weighted sequence. Water molecules will be dephased by the first gradient and rephased by the second gradient. If the water molecules are stationary, no net dephasing is expected. Movement of the tissue water molecules between the two opposing gradients will result in dephasing, depicted as signal loss on the diffusion-weighted images[2]. This signal loss will be proportional to the amount of water molecule movement and the strength of the gradients (*b*-value). By repeating the sequence with different *b*-values, the observed signal loss can be quantified using the apparent diffusion coefficient (ADC).

Hypercellular tissue, such as occurring within malignant tumours, will show low ADC values. Non-tumoral tissue changes such as oedema, inflammation, fibrosis, and necrosis are expected to show low cellularity, in strong contrast with viable tumour. This results in a high ADC. An inverse correlation between the ADC value and tumour cellularity in experimental models has been shown, and this has been clinically validated[3,4].

In the head and neck region, DWI may have several possible applications. The localisation and extent of primary squamous cell cancer, one of the most common types of malignant disease in this region, is usually well defined by CT or conventional MRI. However, the characterisation of neck lymph nodes remains a difficult issue with anatomy-based imaging methods, and DWI may be of particular value in this regard. Differentiation of treatment-induced tissue changes, especially after (chemo)radiotherapy, and persistent or recurrent cancer, is another area in which DWI may be very helpful. As DWI allows differentiation between inflammatory tissue and neoplastic tissue, another possible application could be the monitoring of tumour response during radiotherapy: this could have prognostic importance and possibly influence the management of the patient. Furthermore, DWI can also be used as a whole body imaging sequence, to exclude or confirm metastatic disease or a second primary tumour[5].

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For several of these possible applications of DWI in head and neck cancer, currently fluorodeoxyglucose (FDG)-positron emission tomography (PET) is being used or advocated. However, FDG is not an entirely specific cancer tracer, and false positive finding are not uncommon. Also, PET suffers from a low spatial resolution, leading to false negative findings in small volume disease. DWI could be an interesting alternative, as direct correlation with anatomical magnetic resonance (MR) images acquired during the same study is possible, allowing precise anatomical localisation of the observed abnormalities. DWI also appears to offer a better discrimination between neoplastic disease and inflammatory changes than PET. DWI is a method that can be performed at a lower cost than PET, without the need for an external tracer, and without exposing the patient to ionising radiation.

The few studies that have already been published on the diagnostic accuracy of DWI in head and neck cancer, confirm the great potential for this technique, by complementing anatomical MR imaging. For staging neck lymph nodes in squamous cell cancer, high sensitivities and specificities were reported, better than what is obtainable by CT or conventional MRI[6,7]. If these results are confirmed, the improved pretherapeutic nodal characterisation may result in a closer conformity of the radiation target volume to the anatomical tumour extent. This may reduce side effects of treatment when intensity modality radiotherapy is applied.

DWI was also reported to discriminate treatment-induced tissue changes from tumour recurrence after (chemo)radiotherapy with a sensitivity and specificity of about 95%, and in several cases, DWI appeared more reliable than PET[8,9]. Studies investigating the role of DWI as a prognostic tool during, and very early after treatment, are ongoing; if successful, tailoring treatment according to the individual response as seen on DWI may become feasible.

The interpretation of DWI in such a complex area as the head and neck is not straightforward, requiring training and experience. Reproducing these promising results on a broad scale will be a challenge, and technique standardisation is desirable. For example, the results obtained are very dependent on the selection of the *b*-values. Also other technical issues, such as magnetic field inhomogeneity or suboptimal placement of receiver coils, have a strong negative effect on image quality.

More research is needed to precisely determine under what circumstances DWI will be helpful. Notwithstanding the excellent results that are being reported in evaluation of head and neck squamous cell cancer, DWI is not a panacea for all diagnostic problems. For example, a substantial overlap in ADC values has been reported between benign and malignant parotid tumours[10–12]. Nevertheless, judicious use of DWI likely will be very helpful in tackling a number of diagnostic issues not solved by anatomical imaging methods.

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