

q-Space Imaging in Meningioma

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Commentary

It has always been a goal in the medical sciences to develop diagnostic and imaging strategies having a minimum or no invasiveness and/or obliterating need of further invasive investigations. The differentiation of benign versus malignant tumors on the basis of imaging findings has always been a diagnostic dilemma as there is always some degree of overlap of imaging characteristics in both the categories [1,2]. In superficial lesions or in some abdominal visceral lesions, excision biopsy or fine needle aspiration cytology are relatively easy to perform and are adopted before deciding the management strategy. This distinction, however, becomes more important when we talk of brain lesions and at the same time biopsy is not always easy to do. Meningioma is mostly benign, but its atypical and malignant counterparts are notorious for recurrences and metastases even after apparent complete surgical removals [3,4]. Although, the lesion has been described to have particular features that warn about its atypical nature such as loss of its marginal irregularity, cystic and necrotic changes etc., but still are not confirmatory [1,5,6]. For obvious reasons, in this situation, a modality that can give an additional hint about the histopathological characteristic of the meningioma would matter a lot.

Diffusion weighted imaging (DWI) which was initially implied for its diagnostic sensitivity of cerebral ischemia [5], was later on investigated for its further clinical applications one of which was histopathological differentiation of tumors. Malignant lesions were reported to have lower apparent diffusion coefficient (ADC) values as compared with benign ones [6,7]. Some researchers then further suggested the fact that DWI that can also give an insight to the tumor cellularity. The results of these studies showed that ADC values had a significant negative association with the cellularity or tumor cell count. The reason that was hypothesized for this finding is that dense cellular nature restricts extracellular diffusion of water thus decreasing the ADC values [8,9].

The concept of q-space imaging (QSI) was introduced by Callaghan [10]. This form of imaging based on diffusion characteristics of the tissue is different from the conventional DWI in that it involves imaging using multiple and much higher b values than required for conventional method [11]. DWI is obtained as a result of signal decay based on diffusion characteristics of the tissue assuming single, free, unrestricted diffusing component. NMR experiments on neuronal tissue using higher b values, however, show multi exponential signal decay representing multiple diffusion components diffusing at different rates. The q-space analysis allows us to acquire displacement probability profiles of such components without a need of making any assumption. Using higher b values in QSI makes it possible to acquire information about restricted diffusion component [11-13]. The QSI

provides us with a physical parameter; mean displacement (MDP) measurement while ADC is a coefficient obtained as a result of DWI [13].

In a study conducted by us [14] on 52 meningioma lesions QSI was performed using a MRI scanner of 1.5-T (Signa HD ver. 12, GE Healthcare, Milwaukee WI, USA) in addition to routine MR sequences and conventional DWI. Raw data were acquired using b values ranging from 0 to 12,000 s/mm² in 12 steps and then were subjected to post-processing on Interactive Data Language (IDL)-based diffusion analysis software (QSI Analyzer 2.4, Tokyo Metropolitan University, Tokyo, Japan), and MDP maps were obtained. The values of ADC and MDP correlated well with each other. The results of this study also confirmed the previous notion of negative association of diffusion parameters, both ADC and QSI determined by DWI and QSI respectively, with the cell count of the tumor, which was meningioma in this study. QSI provides information about tissue diffusion including the extracellular and intracellular components. The increased cell population as already mentioned creates a cell dense environment with a reduced extracellular as well as intracellular space also reducing the possibilities for molecular diffusion in both these compartments. This leads to concomitant decrease in the ADC and MDP values.

Results of one of the study about the clinical application of QSI in patients with stroke [12] suggested no association between ADC and MDP values in infarcts. In infarction the most hypothesized mechanism of explaining the decreased ADC values is the shift of extracellular water into the intracellular compartment resulting in decreased ADC values. This shift will cause reduction in ADC values. In each case of ischemia/infraction this exchange of diffusion component might vary depending upon the severity of causative factors. As QSI derived MDP values on the other hand represent both intracellular and extracellular diffusion components, these might not correlate with ADC.

Keeping in view the results of both these studies, it can be implied that QSI might have a potential to differentiate between the lesions depending upon the pathological changes in extracellular and intracellular diffusion components.

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