COMPARISON OF DIFFUSION KURTOSIS IMAGING, DYNAMIC SUSCEPTIBILITY WEIGHTED IMAGING AND SHORT ECHO TIME CHEMICAL SHIFT IMAGING FOR GRADING GLIOMAS

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Target audience: Neuroradiologists and MR scientists with an interest in advanced MR techniques and their practical implementation to address problems encountered in routine clinical practice.

Purpose: Adequate grading of gliomas presents many difficulties in clinical practice but is of capital importance because treatment regimens and prognosis depend on the malignancy grade. Currently, a biopsy is warranted in order to obtain a definitive diagnosis. An imaging-based method for determining glioma grade is appealing due to its non-invasiveness. Several studies, using advanced MR techniques to grade gliomas have been published, although most of the reported results were demonstrated on a group level. In order to find acceptance in clinical practice, prospective grading of gliomas should be performed on an individual patient level with sufficient accuracy. Moreover, combining different modalities has the potential to increase diagnostic accuracy, as the different advanced MR techniques yield complementary information. In this study, it was our aim to assess the separate diagnostic performances of diffusion kurtosis imaging (DKI) [1], dynamic susceptibility-weighted MR imaging (DSC-MRI) and short echo time chemical shift imaging (CSI) for grading gliomas, and to examine if a multimodal approach could be used to improve these results.

Material and methods: Thirty-five patients with cerebral gliomas (12F/23M; age range: 22-78 years, median age: 55 years) underwent DKI, DSC and CSI on a 3T MR scanner, implementing previous published protocols [2-4]. Diffusion parameters - mean diffusivity (MD), fractional anisotropy (FA), mean kurtosis (MK) - perfusion parameters – mean relative regional cerebral blood volume (mean rCBV), mean relative regional cerebral blood flow (mean rCBF), mean transit time (MTT) and relative decrease ratio (rDR), and twelve CSI metabolite ratios- were compared between 22 high grade gliomas and 14 low grade gliomas (Mann Whitney-U, p<0.05, Bonferroni correction). The classification accuracy, sensitivity, specificity, negative predictive value and positive predictive value were determined with a linear discriminant analysis. To combine the DKI, DSC-MRI and CSI information, we propose a decision-tree rule. The receiver operating characteristic (ROC) curve was used to determine for each statistically significant parameter a low-confidence interval. We made a first attempt to join the discriminatory capabilities of each modality to present a decision tree using the parameters with the highest combined added value. If at any of the decision-tree levels the parameter value is outside the previously mentioned low-confidence interval, we can accurately predict the tumor grade and a further level is not needed.

Results: MK, MD, mean rCBV, mean rCBF, rDR, Lips/Cho, Lips/Cr, Myo/sum and Cre/sum showed statistically significant differences among tumor grades, with mean rCBF as the best discriminative parameter of the perfusion parameters and MK as the best discriminative parameter of the diffusion parameters. The classification accuracy, sensitivity, specificity, negative predictive value and positive predictive value of DKI, DSC and CSI datasets for differentiating low from high grade glioma are shown in Table 1. When considering the statistical significant DSC parameters, the performance reached 83%. Based on the DKI and CSI data the accuracy is overall lower. For the current dataset, the combination of mean rCBF, MK and Myo/sum to grade gliomas could even show a diagnostic accuracy of 100%. Based on the ROC analysis, the mean rCBF low-grade glioma and high-grade glioma. In order to find acceptance in clinical practice, prospective grading of gliomas should be performed on an individual patient level with sufficient accuracy. Moreover, combining different modalities has the potential to increase diagnostic accuracy, as the different advanced MR techniques yield complementary information. In this study, it was our aim to assess the separate diagnostic performances of diffusion kurtosis imaging (DKI) [1], dynamic susceptibility-weighted MR imaging (DSC-MRI) and short echo time chemical shift imaging (CSI) for grading gliomas, and to examine if a multimodal approach could be used to improve these results.

Conclusion: The most accurate parameters for determination of glioma grade were MK and mean rCBF. However, a combination between calculated parameters could still provide a better differentiation between high- and low-grade glioma in this data set; this should be further explored in a larger study population.


Table 1: Linear discriminant analysis performance in the separation between high and low grade glioma. The mean accuracy, sensitivity, specificity, negative predictive value and positive predictive value over 100 runs are reported.