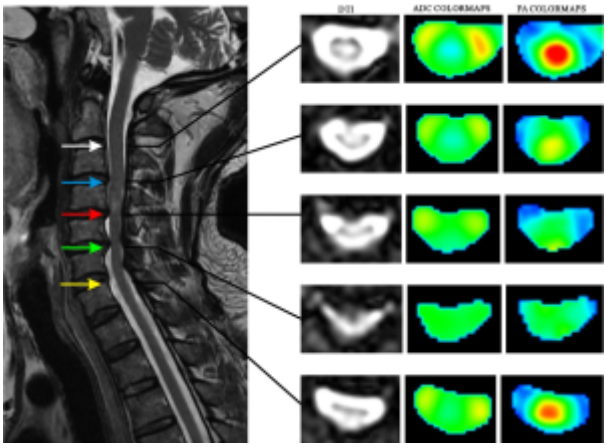
Diffusion tensor imaging for degenerative cervical myelopathy



Despite its invasiveness, computed tomography myelography (CTM) is still considered an important supplement to conventional magnetic resonance imaging (MRI) for preoperative evaluation of multilevel degenerative cervical myelopathy. Schöller et al., analyzed if diffusion tensor imaging (DTI) could be a less invasive alternative for this purpose.

In 20 patients with degenerative cervical myelopathy and an indication for decompression of at least one level, CTM was performed preoperatively to determine the extent of spinal canal/cerebrospinal fluid (CSF) space and cord compression (Naganawa score) for a decision on the number of levels to be decompressed. Fractional anisotropy (FA) and apparent diffusion coefficient (ADC) were correlated with these parameters and with MRI-based increased signal intensity (ISI). Receiver operating characteristic analysis was performed to determine the sensitivity to discriminate levels requiring decompression surgery. European Myelopathy Score (EMS) and neck/radicular visual analog scale (VAS-N/R) were used for clinical evaluation.

According to preoperative CTM, 20 levels of maximum and 16 levels of relevant additional stenosis were defined and decompressed. Preoperative FA and particularly ADC showed a significant correlation with the CTM Naganawa score but also with the ISI grade. Furthermore, both FA and ADC facilitated a good discrimination between stenotic and nonstenotic levels with cutoff values < 0.49 for FA and $> 1.15 \times 10\text{-}9$ m2/s for ADC. FA and especially ADC revealed a considerably higher sensitivity (79% and 82%, respectively) in discriminating levels requiring decompression surgery compared with ISI (55%). EMS and VAS-N/R were significantly improved at 14 months compared with preoperative values.

DTI parameters are highly sensitive at distinguishing surgical from nonsurgical levels in CSM patients and might therefore represent a less invasive alternative to CTM for surgical planning [1)].

A study population included 50 patients with symptoms of cervical myelopathy. The patients were evaluated based on symptoms using the European myelopathy scoring system and were divided into: Grade 1, including patients with mild symptoms; Grade 2, referring to patients with moderate symptoms and Grade 3, which included patients revealing severe symptoms. All the patients were investigated with a 1.5 T MRI unit acquiring DWI and DTI sequences. FA and ADC values from each

spinal segment were analyzed in terms of Frequency, Percentage, Mean, Standard Deviation and Confidence Intervals. The comparison of values was done by ANOVA and post hoc analysis by bonferroni test. Comparison of accuracy of FA, ADC and T2WI in recognizing myelopathic changes was done by t-test. Receiver Operating Characteristics (ROC) analysis was performed to obtain a cut off value of FA and ADC for each spinal level to identify myelopathic change in the spinal cord.

The study revealed a significant difference in the mean FA and ADC value of stenotic and Non-stenotic segments. T2WI was highly significant ($p = 0.000$) in recognizing myelopathy changes in patients falling under Grade 2(moderate) and Grade 3(severe) according to European Myelopathy scoring system. Regarding patients under Grade 1 (mild) FA and ADC values showed significant difference compared to T2WI. The collective sensitivity in the identification of myelopathic changes was highest with FA (79%) as compared to ADC (71%) and T2WI (50%). ROC analysis was done to determine the cut off values of FA and ADC at each cervical spine segments. The proposed cut off, for FA and ADC at the level of C1-C2 is 0.68 and 0.92, C2-C3 is 0.65 and 1.03, C3-C4 is 0.63 and 1.01, C4-C5 0.61 and 0.98, At C5-C6 0.57 and 1.04, At C6-C7 0.56 and 0.96 respectively.

FA and ADC values enhance the efficacy and accuracy of MRI in the diagnosis of cervical spondylotic myelopathy. Hence diffusion tensor imaging can be used as a non-invasive modality to recognize spondylotic myelopathy changes even in the early stages, which can be helpful in deciding on appropriate timing of decompression surgery before the irreversible chronic changes set in [2)].

A meta-analysis was conducted to assess alterations in measures of diffusion tensor imaging (DTI) in the patients of cervical spondylotic myelopathy (CSM), exploring the potential role of DTI as a diagnosis biomarker. A systematic search of all related studies written in English was conducted using PubMed, Web of Science, EMBASE, CINAHL, and Cochrane comparing CSM patients with healthy controls. Key details for each study regarding participants, imaging techniques, and results were extracted. DTI measurements, such as fractional anisotropy (FA), apparent diffusion coefficient (ADC), and mean diffusivity (MD) were pooled to calculate the effect size (ES) by fixed or random effects meta-analysis. 14 studies involving 479 CSM patients and 278 controls were identified. Meta-analysis of the most compressed levels (MCL) of CSM patients demonstrated that FA was significantly reduced (ES -1.52, 95% CI -1.87 to -1.16, $P < 0.001$) and ADC was significantly increased (ES 1.09, 95% CI 0.89 to 1.28, $P < 0.001$). In addition, a notable ES was found for lowered FA at C2-C3 for CSM vs. controls (ES -0.83, 95% CI -1.09 to -0.570, $P < 0.001$). Meta-regression analysis revealed that male ratio of CSM patients had a significant effect on reduction of FA at MCL ($P = 0.03$). The meta-analysis of DTI studies of CSM patients clearly demonstrated a significant FA reduction and ADC increase compared with healthy subjects. This result supports the use of DTI parameters in differentiating CSM patients from health subjects. Future researches are required to investigate the diagnosis performance of DTI in cervical spondylotic myelopathy [3)].

The measurement of DTI indexes within the spinal cord provides a quantitative assessment of neural damage in various spinal cord pathologies. DTI studies in animal models of spinal cord injury indicate that DTI is a reliable imaging technique with important histological and functional correlates.

DTI is a noninvasive marker of microstructural change within the spinal cord. In human studies, spinal cord DTI shows definite changes in subjects with acute and chronic spinal cord injury, as well as cervical spondylotic myelopathy. Interestingly, changes in DTI indexes are visualized in regions of the

cord, which appear normal on conventional magnetic resonance imaging and are remote from the site of cord compression. Spinal cord DTI provides data that can help us understand underlying microstructural changes within the cord and assist in prognostication and planning of therapies [4].

References

1)

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