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3. Jahrestagung der Deutschen Gesellschaft für Computer- und Roboterassistierte Chirurgie e.V.

Frühe Indentifizierung von Tumor-Infiltration in Faserbündeln der Weißen Substanz mit Diffusions-Tensor-Bildgebung

Early Stage Detection of Tumor Infiltration in White Matter Fiber Bundles Using Diffusion Tensor Imaging

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Purpose

We present a method for the visualization and quantification of white matter infiltration from brain tumors based on Diffusion Tensor Imaging (DTI). This approach can be used to utilize Corpus Callosum (CC) inflitration as a surrogate marker for contralateral tumor progress, which is important for intervention planning.

Material and Methods

Two tumor patients with a right hemispheric glioblastoma are considered. One (F, 65 y) with and one (M, 47 y) without CC infiltration. A healthy volunteer (M, 29 y) serves as a reference.
For the tumor patients one T1 weighted, one T2 weighted FLAIR and 10 DTI (6 gradient directions each) datasets are acquired on a Siemens 1.5T Symphony. For the healthy volunteer 10 DTI datasets (12 gradient directions each) are acquired on a Siemens 3T Allegra. Before diffusion tensor reconstruction, the 10 independent DTI datasets are resampled, registered and averaged in order to increase the SNR. The main diffusion directions and the complete diffusion tensors are visualized by color maps and ellipsoids, respectively (Fig. 1 and 2: tumor patient with (top) and tumor patient without (bottom) CC infiltration). The DTI color maps are fused with the T1 weighted anatomical images (Fig. 1). Potential tumor infiltration is quantified by the diffusion anisotropy along cross sections of the CC (Fig. 3) for the tumor patients and for the healthy volunteer. In order to get robust

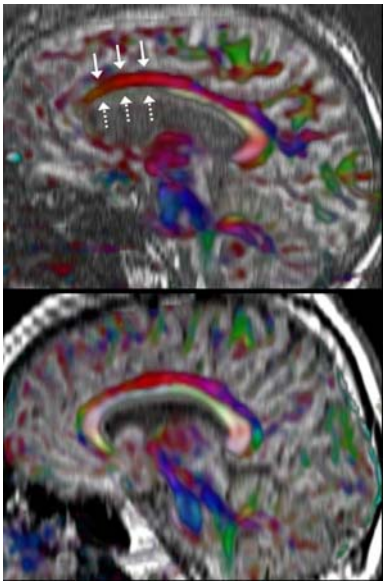
and reproducible quantification results, the diffusion features are automatically classified into CC, background and mixture tissue.

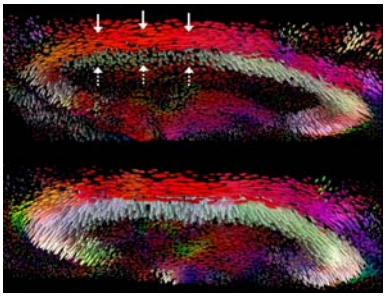
Results

Since destruction of fiber tissue leads to a decrease of diffusion anisotropy, CC tumor infiltration can be well detected on DTI data as demonstrated in the combined visualization of the anatomical and the adequately preprocessed DTI data (Fig. 1 and 2 dashed arrows). Furthermore the DTI data suggests, that the cingulum, located directly above the CC but with fiber orientation perpendicular to the fiber orientation of the CC, is still intact (Fig. 1 and 2 solid arrows). Thus, the DTI data demonstrates that brain tumors mainly infiltrate along fibers but not in perpendicular directions.
In correspondence with the visualization, the diffusion anisotropy along cross sections of the CC decreases significantly in the frontal part of the CC for the patient with CC infiltration (Fig. 3 dashed arrows), while for the patient without CC infiltration the diffusion anisotropy shows no abnormal behavior.

Conclusion

The introduced DTI based visualization of fiber tissue by color maps and diffusion ellipsoids permits the detection of white matter infiltration from brain tumors. It can also be demonstrated from the DTI data that brain tumors preferably infiltrate along fibers. A robust and reproducible method for the determination of the diffusion anisotropy leads to a quantification of the amount of white matter infiltration.
In comparison to conventional MR imaging, the introduced DTI based method allows for an early, direct, and sensitive detection of CC inflitration. Thus, DTI based assessment of white matter infiltration has the potential to support therapeutic decisions and intervention planning.





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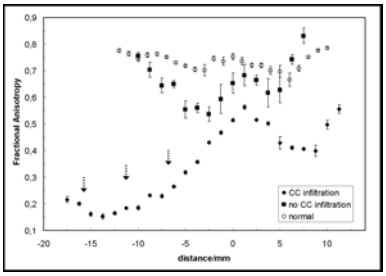
Fractional Anisotropy
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
-20
-15
-10
-5
0
5
10
distance/mm
CC infiltration
no CC infiltration
normal