# DWI and DTI of the Post-Mortem Brain: Imaging, Autopsy and Histopathologic Findings

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**Introduction:** Increasingly, radiological methods are used for forensic evaluation, especially computed tomography and magnetic resonance imaging (MRI)[1]. We currently use a combination of CT and MRI to investigate post-mortem findings. The intention of this study was to determine whether DWI and DTI findings of the post-mortem brain correlate with autopsy and histoneuropathological results, and to primarily evaluate these imaging methods for their routine use in forensic medicine.

**Material and Methods:** 29 cadavers (20 male, 9 female, aged 3 to 94; 14 cases were post-traumatic head injuries following gunshot incidents, falls from great height, motor vehicle accidents or homicidal blunt force trauma, 15 had deceased from cardiac arrest, suicidal hanging, diving accidents, medical maltreatment or hypothermia) and 4 healthy volunteers were examined. Post-mortem MR imaging of the whole brain was performed on a 1.5 T clinical scanner (GE Signa) at a mean of 20 hours after death. For DWI, a multi-slice line-scan sequence was used with the following parameters: b values of 5 and 1000 s/mm2, 6 diffusion directions, field of view: 24 x 18 cm, 5 mm thick axial slices; TR: 3424 ms, TE: 92 ms. In 21 cases the brain was scanned in the axial plane and in 8 cases of suspected brainstem injury, the brainstem was additionally scanned in the sagittal plane (maximum b-value of 1500 s/mm2, TE 100ms, TR 2600 ms, 4 acquisitions). Maps of the apparent diffusion coefficient (ADC) were calculated on a pixel-by-pixel basis. 22 images were obtained covering the whole brain with the line-scan sequence. Fractional anisotropy maps were generated. Additionally, axial T1 and T2-weighted images were acquired. For ADC measurements, forty regions of interest were defined on the ADC maps in each case and average ADC values were determined. FA was evaluated in 18 regions of interest on the Fractional Anisotropy maps. In 8 cadavers and 3 living cases, the trajectories of the brain stem nerve fibers were delineated using the XPhase software. In all deceased, standard forensic autopsy was carried out, and neurohistopathological correlation (H&E staining and APP-immunohistology) was obtained.

**Results**: DWI showed regions of traumatically injured brain tissue (contusions, shearing injuries and intracerebral hemorrhages (n= 11) and secondary changes following brain trauma (e.g., brain stem hemorrhage, infarction; n=5) in a good correlation to the autopsy and histoneuropathologic results. In 6 bodies grey-white matter differentiation could not be seen on the diffusion images or the ADC maps. In the cadavers, we found the brains to be diffusely hyperintense ("white brain") on the diffusion images with maximum b value. The ADC values were markedly reduced and ranged between 0.18 and 0.26x10-5 cm2/s (mean: 0.22x10-5 cm2/s) without and between 0.29 and 0.41x10-5 cm2/s (mean: 0.34x10-5 cm2/s) with approximate temperature correction of 2%/degree. ADC values in the living volunteers were between 0.67 and 0.84x10-5 cm2/s (Figure 1). FA measurements depicted no significant differences between the cadavers and the living volunteers. Diffusion tractography of the brain stem showed slight, wavy, "regular" fiber disorientation in all post-mortem cases which was not reflected histologically. In one case with brain stem contusion, a disruption of the nerve fibers at the contusion site could be clearly demonstrated, which was also seen on the corresponding FA maps (Figure 2).

**Figure 1**

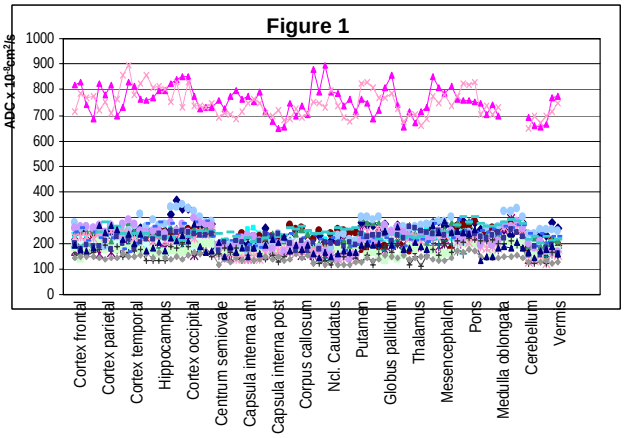
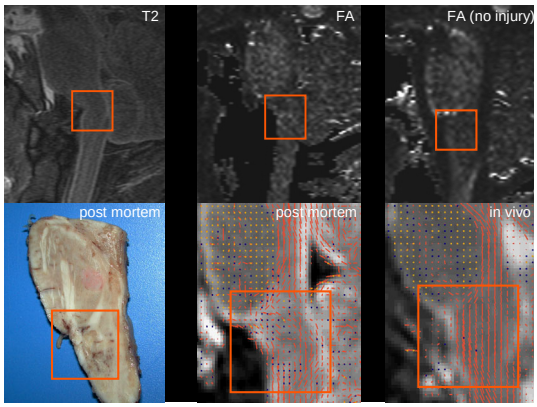



**Figure 2**




**Discussion:** DWI shows diffuse hyperintensity and reduced ADC values in the cadaver brain. This reflects changes following profound cerebral ischemia, occurring upon cessation of the cerebral circulation. The changes are more profound than the T2-shine-through phenomena might explain and also more marked than the expected reduction of diffusion due to the decreased temperature after death, making this a specific finding for this state. Concerning traumatic injuries, the DW images were sensitive to post-traumatic injury and hemorrhage as well as secondary changes following brain trauma. The FA measurements showed that the overall microstructural fiber-orientation of the brain post-mortem is not rapidly altered within hours after death, thus allowing radiological diagnostics using MRI. The slight fiber disorientation on the DT-images in the cadavers which was not reflected in the histologic examination is probably a sign of edematous changes following hypoxia at the time of death. One major future application of DTI could be the direct in vivo demonstration of post-traumatic fiber ruptures following major head injury. In conclusion, diffusion MR methods such as DTI and ADC mapping seem to be of great value in the assessment of post-traumatic brain tissue damage and will have a place not only in clinical radiology, but also in the routine radiological assessment of forensic cases where they can provide additional information which cannot be obtained when routine autopsy methods are used.

**References:** 1. Thali MJ, Yen K, Schweitzer W, Vock P, Boesch C, Ozdoba C, Schroth G, Ith M, Sonnenschein M, Doernhoefer T, Scheurer E, Plattner T, Dirnhofer R. Virtopsy, a new imaging horizon in forensic pathology: virtual autopsy by postmortem multislice computed tomography (MSCT) and magnetic resonance imaging (MRI)--a feasibility study. J Forensic Sci. 2003 Mar;48(2):386-403.