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STATE-OF-THE-ART

Diffusion Tensor Imaging (DTI) - A New Imaging Technique Applyed in Multiple Sclerosis

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Water molecules' motion or diffusion was found to be much faster along the white matter fibers than perpendicular to them. The difference between these two motions (parallel and perpendicular to the fibers, also termed diffusion anisotropy) is the basis of DTI (1-4).

Diffusion tensor imaging (DTI) has become one of the most popular MRI techniques in brain research, as well as in clinical practice. It is used to study the white matter architecture and integrity of the normal and diseased brains (multiple sclerosis, stroke, aging, tumors, dementia, schizophrenia, etc.) (5-8). ❑

PHYSICAL PRINCIPLES

Brownian motion is traditionally regarded as discovered by the botanist Robert Brown in 1827 while studying, under a microscope, pollen grains suspended in water.

The molecules of any substance in a continuous media have a random movement determined by their thermal energy. *The motion takes place over a distance in space which is determined by the diffusion coefficient (D), in accordance with Stokes-Einstein's law:*

D=kT/f,

- where **k** represents Boltzmann constant, and
- **f** depends on particle dimensions and fluid viscosity.

Diffusion Tensor Imaging (DTI) is a MRI-based technique, used for describing biologic tissues microstructures, that exploit quantification of water diffusion in tissues.

The **diffusion** can be either:

- **isotropic,** when there are no hinders to diffusion, being statistically the same in all directions in space, or (ex in CSF)

- **anisotropic:** when has barriers against diffusion for some directions (ex. white matter).

Diffusion parameters are fractional anizotropy (FA) and apparent diffusion coefficient (ADC).

- **FA (fractional anisotropy)** – that represents the degree of **directionality** of diffusion, the preference for a single direction of diffusion.

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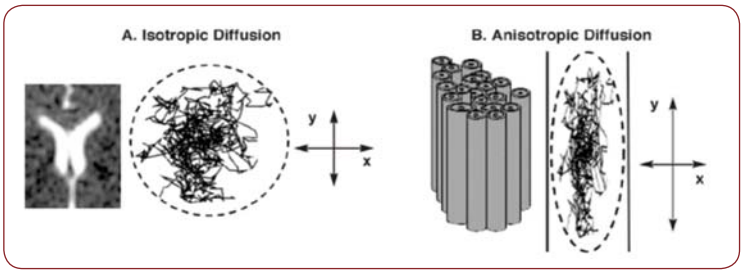

FIGURE 1. Isotropic and anisotropic diffusion.

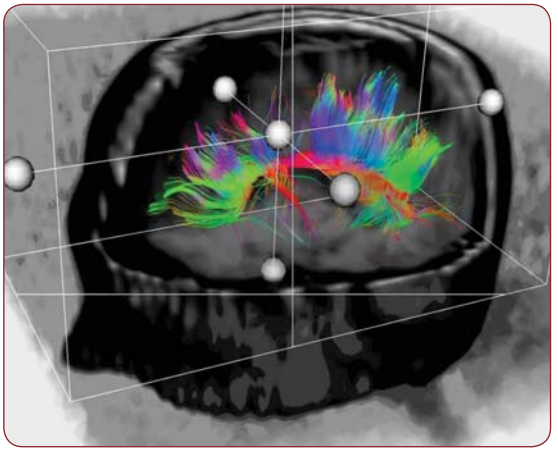

FIGURE 2. Normal subject – reconstruction of corpus calosus.

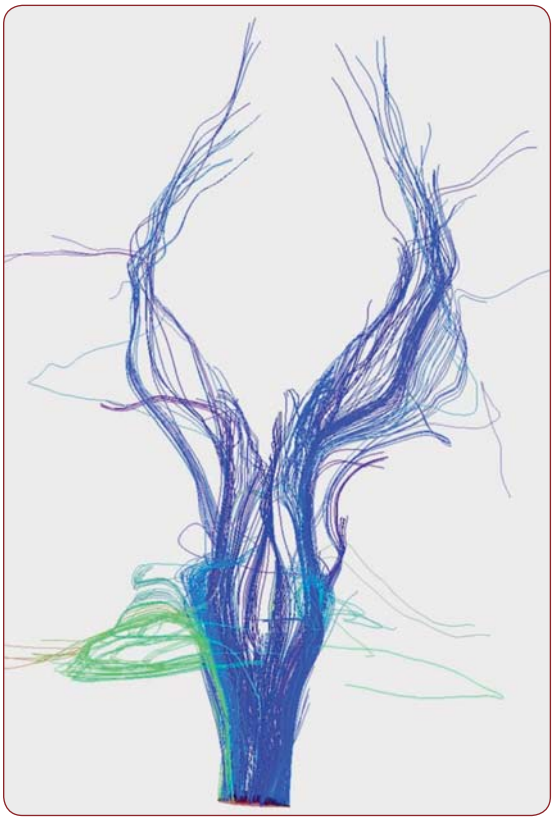

FIGURE 3. Normal subject – reconstruction of cortico-spinal tract.

FA=0 (isotropic diffusion, equal in all space directions).

FA=1 (diffusion occurs only along one axis).

When axons or myelin are destructed ***FA decrease*** *(diffusion will not be restricted only to one direction).*

- **ADC (apparent diffusion coefficient),** estimates total diffusion for each voxel analyzed. We also determine the magnitude of axial (λ1) and radial diffusivity (λ3, λ2).

ADC increase if biological tissues are affected (no diffusion hinders) – due to increase in radial diffusion.

In nervous tissues (white matter), water diffuses preferentially along axons and nerve fiber bundles (λ1- axial difusivity).

On perpendicular direction diffusion process is hindered by axonal membranes and is modulated by myelin. (λ2 & 3 - radial difusivity) (9-11).

A diffusion tensor matrix can be generated for each voxel from aquired DWI diffusion weighted images.

RGB (red–green–blue) color-coded scheme attributes a color for each orientation of the fibers:

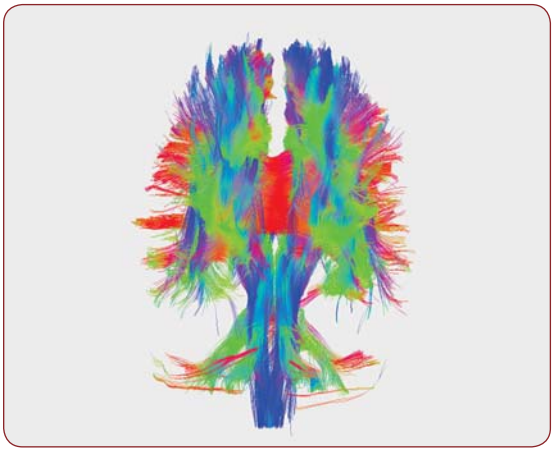

FIGURE 4. DTI recontruction of white matter tracts in normal subject.

- fibers crossing from left to right are visualized in red,
- fibers crossing anteriorly–posteriorly are visualized in green, and
- fibers crossing inferiorly–superiorly are visualized in blue.

At the Department of Neurology of Emergency University Hospital Bucharest and „Theodor Burghele" Hospital Bucharest, we take advantage of this neuroimaging technique to

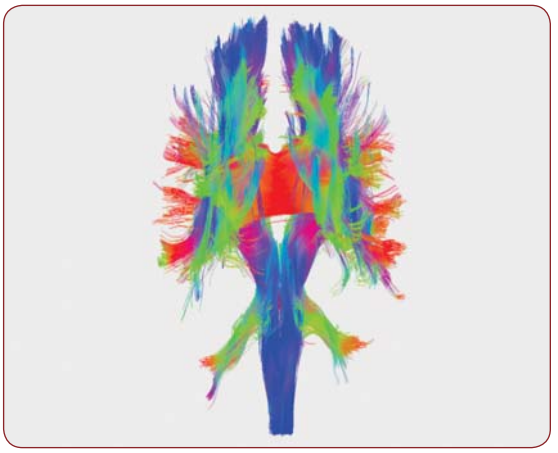

FIGURE 5. DTI recontruction of white matter tracts in MS patient.

study how neurological pathologies affect nervous fibers in multiple sclerosis patients (12-13).

Equipment used is GE Signa Excite **1.5 T** MRI equipment, with 6 or 25 gradients, with NEX 1-3, 128x128 matrix, b = 1000 s/mm^2.

As protocol, we start with a classic MRI exam which has a better spatial resolution, and then we apply **the pulsed gradients of DTI,** with exposure times that vary from 10 to 15 minutes.

After the acquisitions of DTI data we further process them using sophisticated **software** in terms of generating fibers and analyzing the parameters of the diffusion (12).

Multiple sclerosis is a demyelinating autoimmune inflammatory disease of central nervous system (CNS), affecting young patients.

Multiple sclerosis in its most typical form is characterized by relapses and remissions of CNS dysfunction. Disease and disability progression is variable.

In addition to simple MRI, other new neuroradiologic techniques and measurements offer a better estimation of disease status and amplitude of injures. MR Diffusion Tensor Imaging and Fiber Tracking Technique are the means for better understanding the cerebral white matter configuration and the different pathologies that could influence it.

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