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Editorial

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What Should Ophthalmology Expect from MRI

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Editorial

The number of visual impairment related problems affecting children and very young people increased during the last decades. Together with the existing blindness and visual impairment related problems in adult and elderly people, these represent a major socioeconomic issue. Most of them can be avoided, prevented or treated through appropriate programs [1], such as, for example, MRI techniques implemented in Ophthalmology. MRI presents many advantages: safer imaging technique, no need of a special path condition through the eye during image acquisition, whole globe coverage in a slice-by-slice manner in scanning times of a few minutes, complex chemico-physico-geometrical quantitative information (Figure 1) on the qualitative anatomical biophysiology of the eye [2].

A summary of the bio-anatomical qualitative and chemico-phyisico-geometrical quantitative information that can be achieved clinically at present is described.

The qualitative MRI information consists in visualization of the main eye structures, while more recently three layers in the retina/choroid complex (RCC) region have been visualized. Physicochemically, the inner and outer MRI layers correspond to the cellular retinal layers, while de mid layer corresponds to the retinal blood supply [3]. Apart from this, very complex quantitative information on the chemico-physico-geometrical biophysiology of each anatomical eye region mentioned in Figure 1 can also be achieved using MRI as presented in Table 1. Thickness measurements performed in the RCC region present on MRI images of normal human eyes acquired at 3 T showed an increase from 0.71 mm (location: 2 mm distance from the optic nerve head, along the RCC length) [4] to 2.20 mm (location: approximately 26 mm from the ciliary body towards the optic nerve, along the RCC length), followed by a decrease to approximately 1.69 mm in the vicinity of the ciliary body. RCC layer thicknesses of the normal human eye range from 0.48 mm to 0.84 mm [3]. Physicochemical properties of the eye can also be accessed through the T1 and T2 relaxation times. These were measured at 1 [5]/1.5 [6]/3 [3]/7 [7] T in all ocular regions visualized using MRI and range from 25 ms (T2 at 1.5 T: lens nucleus) [6] to 5,155 ms (T1 at 7 T: anterior chamber) [7].

Ocular diffusion, magnetization transfer and magnetic susceptibility can very easily be implemented clinically, using the hardware and software developments to date. Only MRI flow quantification remains a main challenge for the eye. A method for its quantitative analysis has been proposed very recently [8]. This method can be applied very easily on the clinical MRI eye images acquired using the hardware capabilities to date, combined with offline image post processing Matlab codes for flow quantification. Implementation of this method in clinical ocular MRI will fill the gap of the quantitative information that can be achieved using MRI without contrast agents. While the protocol for clinical ocular MRI can be set up using the information and developments to date, there is still need for the definition of the reference intervals of each of the quantitative parameter presented

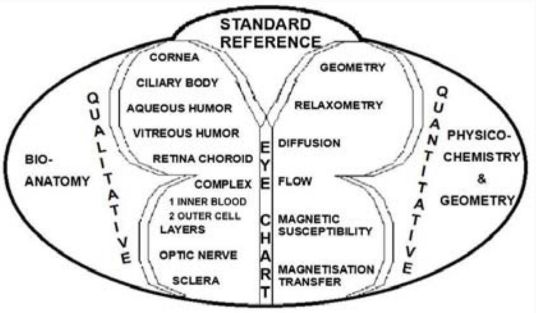

Figure 1: Standard reference chart of the normal human eye.

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Table 1: Details on the quantitative information achieved using MRI. For each qualitative bio-anatomical information, six types of chemico-physico-geometrical quantitative information can be accessed through the parameters calculated and presented below.

Quantitative information	Parameters	
	Name	**Unit**
Geometry	Thicknesses	mm
	Areas	mm^2
	Volumes	mm^3
Relaxometry	T1 Relaxation time	ms
	T2 Relaxation time	ms
Diffusion	Diffusion coefficient(s)	mm^2/s
	Diffusing component(s) fractional volume	%
Flow	Blood volume	ml (blood) /100 g (tissue)
	Blood flow	ml/g/min
Magnetic susceptibility	Magnetic susceptibility	dimensionless
	Magnetic permeability	H/m
	Iron concentration	mmol/g
Magnetization transfer	Magnetisation transfer ratio	%
	Protein volume	mm^3
	Protein concentration	%

in Table 1. The reference intervals for the RCC thicknesses [3,4] and relaxation times [3,5-7] have already been established in pilot studies, but further statistical and more complex studies involving much more subjects still need to be performed. The complete eye chart can then be achieved and used for each ocular MRI investigation to offer more rapid, accurate, precise and sensitive diagnosis in Ophthalmology. The eye is a superficial organ consisting of very fine structures with very different physicochemical composition from very similar to water to very solid protein structures. The protocols assessed for ocular MRI can, therefore, represent a model for developing similar studies for any other organ in the human body, but also for fetal MRI. In Ophthalmology, sensitivity, accuracy, and precision of an eye reference scale developed can be assessed to test the scale for diagnosis and prediction of ocular disease, but also for the efficiency of therapies, surgical interventions, and development of new drugs. Further hardware and software developments of anatomically-shaped scanners will make the implementation of the MRI techniques in Ophthalmology more affordable, but also medical staff and patient friendlier. For example, push-button automat diagnosis will become possible through the implementation of these reference scales on the clinically available scanners. This will help Radiologists, but also Ophthalmologists and medical specialists decide on the diagnosis in a more precise, accurate, and scientific way.

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