Exploring the Retina as a Window to the Brain

Some major neurological disorders that are difficult to diagnose and assess by MRI in their earliest stages, produce certain indications in the eye. This provides diagnostic opportunities for special- ists. One important example is multiple sclerosis (MS). Optical coherence tomography (OCT) can be used to assess the retinal damage caused by MS as a marker for the wider neurodegenerative process that occurs inside the whole brain in MS. Neurologist and MS expert, Professor Bart Van Wijmeersch, leads the University MS Centre in Pelt, Belgium. He explained to VISIONS how OCT imaging can help in determining MS-prognosis, treatment options and follow-up.

Multiple sclerosis (MS) is a lifelong autoimmune condition that affects the central nervous system. At the start of the disease, some lesions are produced inside the brain and can cause an initial symptom. This is categorized as a clinically isolated syndrome. When it repeats itself, it becomes known as relapsing-remitting MS, and later on, it can progress into other forms, such as progressive-MS. On a cellular level, MS develops through a combination of inflammatory lesions, and simultaneous axonal loss and demyelation, which cause neurodegeneration and brain atrophy.

Optical coherence tomography (OCT) is a fast and noninvasive imaging technique that is used to map the layers of the retina. This technology is used in many medical specialties beyond ophthalmology, such as cardiology and research.

A challenge to diagnose

MS can progress below a clinical thresh- old for many years without the patient noticing and prove difficult to diagnose. While it can be used to detect lesions over time, MRI is not always 100% reliable in detecting all lesions inside the brain.

Canon Medical Eye Care

Alongside its reputation as a leader in MRI, CT and Ultrasound technology, Canon Medical is becoming increasingly recognized in ophthalmology for its range of high-quality eye care imaging systems. Canon's ophthalmic diagnostic equipment includes digital retinal imaging systems, OCT systems, and other ophthalmic measurement instruments, as well as associated intuitive advanced ophthalmic software to enhance patient workflow and diagnostic reporting.

"Cortical grey matter lesions, in particular, do not show up well on MRI," remarked Prof. Van Wijmeersch. "Even though double inversion recovery (DIR) is already somewhat better, around 80% of these cortical lesions are not seen."

First indications

The optic nerve is one of the three key areas most often initially affected by MS, alongside the brain and spinal cord, and optical neuritis can be one of the first indicators of the disease. Optical coherence tomography (OCT) is used to image and measure the different layers of the human retina and can provide detail on any retinal damage caused by MS.

"Around 80% of MS patients have atrophy in the retinal nerve fiber layer and ganglion cell layer of the retina and 40% of patients have problems with the inner nuclear layers of the retina," explained Prof. Van Wijmeersch. "With OCT there is the possibility to examine these layers in detail, in real life."

Important assessment tool

OCT can be used in MS assessment in three ways: diagnosis, prognosis and follow-up of treatment.

"Using OCT in a diagnostic way for MS is not so surprising, because one of the first symptoms of the condition is optic neuritis, but it can also be used on a prognostic level, and in follow-up of treatments or follow-up of these patients over time," said Prof. Van Wijmeersch.

"I think this is the most promising contribution that OCT makes in MS assessment, and I believe that it can have a very big impact in clinical practice."

"What happens on the retina mirrors what happens inside the brain in MS," he continued. "Studies have shown that atrophy in the brain over time due to MS correlates very much with loss of retinal nerve fiber layer thickness over time. So, the smaller that is, the more atrophy there is."

Longer term monitoring

Detecting progression of MS and neurodegeneration before the patient is affected by it can offer the possibility for treatment that can slow the loss of neurons and even restore some of the damage caused by the disease.

"The prognostic relevance of retinal fiber layer thinning is particularly important. A very low retinal nerve fiber layer means that the patient already has a lot of brain damage and has less brain reserve, which leads to a worse prognosis in MS," said Prof. Van Wijmeersch. "When patients who present initially with a retinal fiber layer that is thinner than 87 or 88

Prof. Bart Van Wijmeersch is a Neurologist specialized in Multiple Sclerosis (MS). He is the Medical Director of the University MS center in Pelt, Belgium, where he leads a multidisciplinary MS-team. He is also an Associate Professor of Neurology at the University of Hasselt, also in Belgium, where he's involved in pre-clinical, as well as clinical research on MS. He has a supporting role in all the immunological research on blood- and CSF samples of people with MS and in EAE-animal models, as well as in the clinical rehabilitation research (BIOMED & REVAL). Immunological, Biomarker, MRI, Electrophysiological and Rehabilitation research in MS come together in this way. He has an educational role in the Faculty of Medicine and Physiotherapy at the University.

Prof. Van Wijmeersch is a member of the Belgian Study Group of Multiple Sclerosis and a member of advisory boards of different pharmaceutical companies with interest in MS. He was co-founder and the first President of the ParadigMS Foundation - an organization dedicated to education on MS to improve the everyday clinical care of people with MS. As an acknowledgment of his scientific work, he received an honorary award from the Flemish Government in 2019.

"OCT is a real tool for the future."

Professor Bart Van Wijmeersch, Medical Director of the University MS center in Pelt, Belgium.

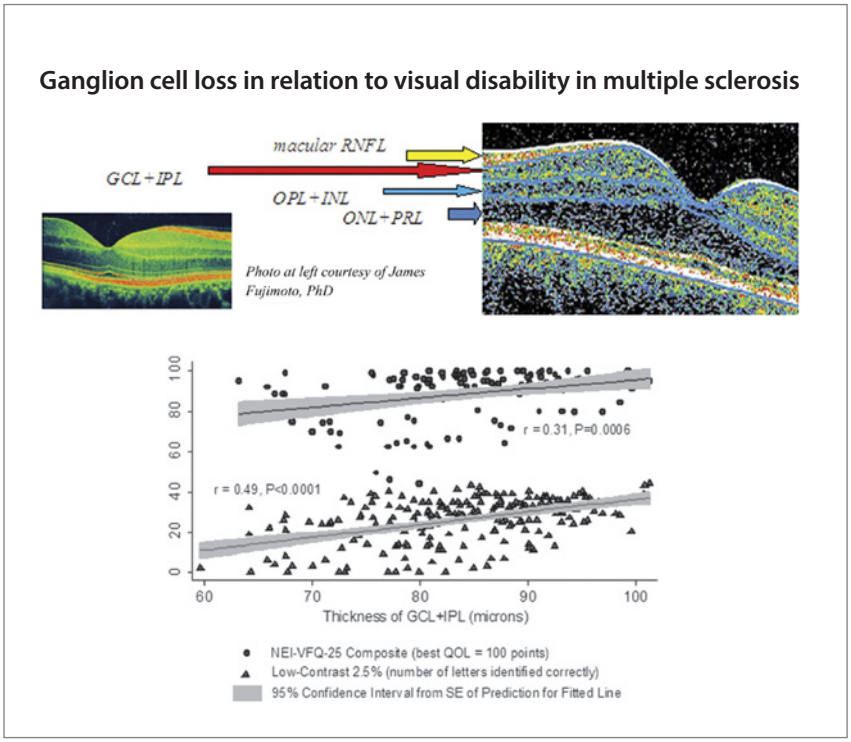

Figure 1: OCT and conventional MRI

microns are re-examined two-years later, there can be a doubled risk of having increased disability. Three to five years later, and that risk can be fourfold."

Tool for the future

Predicting the progression of MS, independent of relapses, is something that remains very hard to achieve, because there has been a lack of good biomarkers for neurodegeneration.

'Using OCT to map changes in the retinal nerve fiber and ganglion cell layer can help as a baseline for prognosis, in guiding your treatment choices, and also follow up on patient treatment responses in MS. I think it's a real tool for the future." said Prof. Van Wijmeersch.

Studies into the use of OCT in MS diagnosis and treatment continue to find out more about their scope in a clinical setting. //

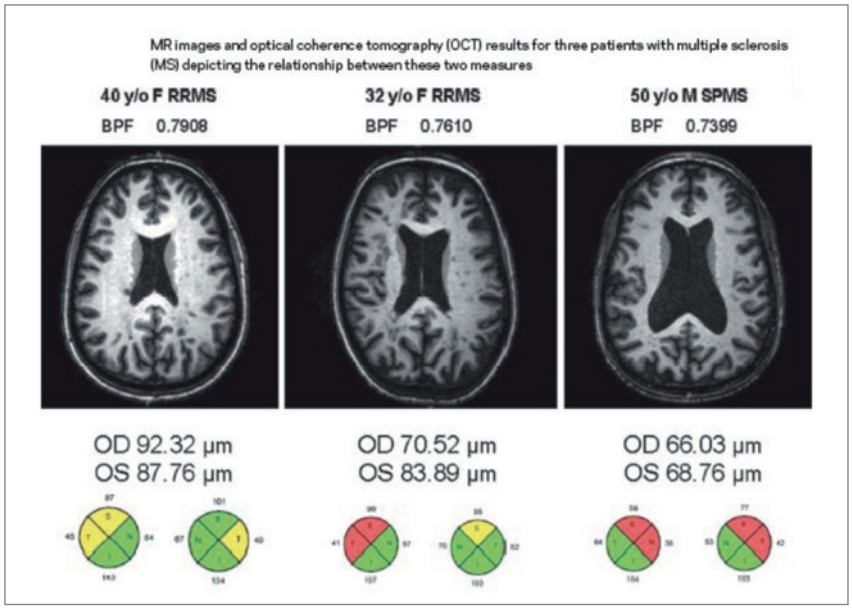

Figure 2: Retinal nerve fiber layer (RNFL) thickness

Canon Medical OCT

Canon Medical has recently developed and launched Xephilio - a new generation of OCT using AI empowered technology combining Japanese craftsmanship with latest Canon imaging solutions.

This is embodied in two new OCT systems:

Xephilio OCT-A1

A fully automated OCT with unsurpassed image resolution for fast and efficient eye examinations. SLO based technology the Xephilio OCT-A1 is allowing efficiency and patients' comfort during the few minutes' patient examination.

Xephilio OCT-S1

Xephilio OCT-S1 features Canon Medical's revolutionary swept source technology, which allows the user to capture in a single acquisition wide-field images of up to 23 mm with 5.3mm depth. Xephilio OCT-S1 fast acquisition up to 100,000 a-scan per seconds combined with a longer wavelength of 1,060 microns enables superior penetration of eye opacities and dense objects while providing outstanding tomographic and OCT Angiographic images.

Read more on studies carried out with OCT from Canon Medical:

Birkeldh et al. | Retinal nerve fiber layer thickness associates with cognitive impairment and physical disability in multiple sclerosis | Multiple Sclerosis and Related Disorders (2019)

Birkeldh et al. | The Temporal Retinal Nerve Fiber Layer Thickness Is the Most Important Optical Coherence Tomography Estimate in Multiple Sclerosis | Frontiers in Neurology (2017)