POLARIMETRIC MEASUREMENT OF THE RETINAL NERVE FIBRE LAYER

PhD Thesis

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I. INTRODUCTION

Glaucoma is a progressive optic neuropathy and one of the most frequent causes of irreversible blindness. Projections made in the early 1990s for the year 2000 estimated the number of people suffering from primary glaucoma at 66.8 million; one tenth of them would get bilateral blindness due to glaucoma, and a further 6 million people would suffer from secondary glaucoma.

Glaucoma cannot be cured but it can be effectively managed, if diagnosed early and treated in a way that prevents functionally significant visual impairment. In addition to the conventional diagnostic techniques (applanation tonometry, funduscopy, photo documentation, central corneal thickness measurement, diurnal intraocular pressure curve) detailed evaluation of visual function (automated perimetry) as well as assessment of the retinal nerve fibre layer thickness (scanning laser polarimetry, SLP) are important in the modern glaucoma diagnosis and long-term care.

Scanning laser polarimetry (GDx family of devices) has been developed in the last decade and offers the advantage of objectively and non-invasively assessing the primary target of the glaucomatous process, i.e. the retinal ganglion cell layer. The technique has been established as a diagnostic aid and a potential method for patient follow-up. However, polarimetry is considerably influenced by retardation of non retinal nerve fibre layer origin, and the relationship between polarimetric retinal nerve fibre layer thickness and the corresponding visual functions has not been established yet. The goal of the studies performed in the frame of my PhD research was to clarify some of these issues.
II. AIMS

1. To investigate the influence of LASIK on scanning laser polarimetric measurement of the retinal nerve fibre layer with fixed angle (SLP-F) and customised (SLP-C) corneal polarisation compensation.

2. To investigate possible alterations in the polarimetry-determined retinal nerve fiber layer thickness (RNFLT) after the third postoperative month in LASIK-treated patients as measured with SLP-F.

3. To examine the effect of subfoveal choroidal neovascularisation (CNV) on macular imaging with scanning laser polarimetry.

4. To compare measurements of the retinal nerve fibre layer with customised and fixed corneal polarisation compensation and to compare the relation of values determined with each compensation technique to the visual field indices in glaucoma patients and healthy subjects.

5. To investigate the potential differences in structure-function relationship between polarimetric retinal nerve fibre layer thickness and retinal sensitivity determined with frequency-doubling technology (FDT) perimetry and standard automatic perimetry (SAP).
III. METHODS

The research protocols were approved by the Institutional Review Board of the Semmelweis University and written consent was acquired from all participants.

1. In study 1 the influence of LASIK on polarimetric retinal nerve fiber layer thickness measurements was studied. The GDx-Access scanning laser polarimeter was used both with fixed and customised corneal polarisation compensation. We examined 15 consecutive healthy subjects with no eye disease who underwent LASIK. The SLP measurements were performed preoperatively, then on day 1 and day 6 after LASIK.

2. In study 2 we used the classic GDx Nerve Fiber Analyzer to investigate alterations in the polarimetry-determined RNFLT in LASIK-treated patients after the third postoperative month. Thirteen consecutive healthy adults with no eye disease were scanned preoperatively, then at 3 and 12 months after LASIK.

3. In study 3 the influence of CNV on macular imaging with scanning laser polarimetry with the GDx Nerve Fiber Analyzer was studied. Twenty-two consecutive patients with angiographically verified CNV and 23 healthy control subjects were imaged. The GDx parameter values and the frequency of the regular “bow-tie” polarisation pattern were analysed, and the ratio of mean retardation values along two perpendicular axes was used to calculate “macular ratio”.
4. In study 4 measurements of the retinal nerve fibre layer obtained with the GDx-Access device with customised and fixed corneal polarisation compensation were compared. Thirty-seven consecutive chronic open-angle glaucoma patients and 14 healthy control subjects were included. Values of GDx parameters were analysed and their correlation with the Octopus 101 full-threshold perimetry indices was determined.

5. In study 5 we used the GDx device both with customised and fixed corneal compensation, as well as FDT perimetry and Octopus 101 full-threshold perimetry to investigate the structure-function relationship between the retinal nerve fibre layer thickness and the retinal sensitivity. Twenty-four consecutive chronic open-angle glaucoma patients and 17 healthy control participants were evaluated. Correlation between the SLP parameters and the retinal sensitivity values determined with the different perimetry tests was investigated.
IV. RESULTS

1. In study 1 it was found that SLP parameters representing the RNFLT at the superior and inferior poles of the optic nerve head remained unchanged after LASIK when SLP-C was used, but decreased or tended to decrease when SLP-F was used. The parameter showing the probability of having glaucoma (The Number) remained unchanged with both types of corneal compensation. The results suggest that the virtual decrease of the polarimetric RNFLT after LASIK is avoided with customised corneal compensation.

2. In study 2 it was found that with the classic GDx Nerve Fiber Analyser, inferior, temporal and nasal average thickness as well as ellipse average thickness and average thickness showed no difference between pre-LASIK values and post-LASIK values at months 3 and 12. Superior average thickness was significantly smaller both at three months and twelve months than before LASIK. The three- and twelve-month values were not significantly different. Our results show that the polarimetric RNFLT values become stable by the third post-LASIK month, and show no further change until the end of the first year. Baseline polarimetric RNFLT values for follow-up can be obtained from the third post-LASIK month.

3. In study 3, CNV patients had significantly higher "Macular ratio" than healthy subjects. Ellipse modulation did not differ between the groups, but ellipse average was higher in the CNV group. The variance for each of these two parameters was significantly higher for the CNV group. The typical "bow-tie" polarisation pattern was seen in 23 of the 23 control eyes but only in 7 of the 22 CNV eyes. Therefore,
measurements with SLP may be disturbed for eyes with CNV when the customised corneal compensation method, which makes use of the macular retardation image, is employed.

4. In study 4 it was found that almost all SLP-C and SLP-F parameters were able to discriminate between the glaucoma and control group, the only exception being the ellipse modulation with SLP-F. When SLP-C and SLP-F values were compared, inferior maximum thickness and ellipse standard deviation were significantly lower with SLP-C both in the glaucoma and the control group. Superior maximum thickness was significantly lower in glaucoma with SLP-C than with SLP-F and tended to be lower with SLP-C than with SLP-F in the control group. In the glaucoma group it was only with SLP-C that a significant (positive) correlation between the superior maximum thickness and the inferior hemifield mean sensitivity (MS), and between the inferior maximum thickness and the superior hemifield MS was found. The other global and sectoral SLP parameters showed significant correlation with the corresponding visual field parameters with both techniques. Our study indicates that, compared to SLP-F, measurements with SLP-C produce more valid results.

5. In study 5 it was found that for the total study population the quadrant SLP parameters superior average, inferior average, superior maximum and normalized superior and inferior areas correlated positively with the MS of the opposite hemifield with both FDT and SAP. All the global SLP parameters correlated positively with FDT-MS, SAP-MS and FDT mean deviation (FDT-MD), and negatively with SAP-MD (in Octopus perimetry MD is positive in case of sensitivity
loss). No correlation was found between RNFLT parameters and indices of localized sensitivity depression (FDT-PSD and SAP-CLV). In contrast, the Nerve Fiber Indicator (NFI) correlated also with FDT-PSD and SAP-CLV. Our results show that a similar structure-function relationship exists between polarimetric RNFLT determined with SLP-C and retinal sensitivity measured with SAP and FDT.
V. NEW RESULTS and CONCLUSIONS

1. Alterations of corneal retardation caused by LASIK can be considered stable after the third post-LASIK month when SLP with fixed corneal compensation is used. When SLP is performed with variable corneal compensation the LASIK-induced effects are significantly reduced. These results of studies 1 and 2 suggest that SLP-C is superior to SLP-F, but both methods can provide clinically useful information after LASIK if their limitations are considered.

2. As shown in study 3, SLP-C measurements may be disturbed in eyes with CNV due to the CNV-induced artifacts of the macular retardation image. To reduce these artifacts the use of SLP with fixed compensation or new software versions of SLP-C are recommended.

3. Studies 4 and 5 show that the measurement results with SLP-C correlate better with the visual functions than those with SLP with fixed compensation. The results also show that a similar structure-function relationship exists between polarimetric RNFLT determined with SLP-C and retinal sensitivity as measured with a non-selective test (SAP) or an M-cell selective test (FDT). This information may be especially useful in long-term clinical research, when detection of disease progression or stability is studied in glaucoma.
VI. PUBLICATIONS IN THE TOPIC OF THE Ph.D. RESEARCH

Articles published in peer-reviewed scientific journals


Citable abstracts


VI. PRESENTATIONS IN THE TOPIC OF THE Ph.D. RESEARCH

Presentations at international scientific meetings and congresses


Presentations at national scientific meetings and congresses


