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Prognostic value of retinal nerve fiber layer thickness for postoperative peripheral visual field recovery in optic chiasm compression

Clinical article

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Object. The authors' objective was to evaluate the predictive value of preoperative axonal loss for peripheral visual field recovery after surgery for optic chiasm compression.

Methods. Consecutive patients with optic chiasm compression in the period from October 2010 through August 2012 were retrospectively studied. Time-domain optical coherence tomography (OCT) had been performed before surgery. Kinetic automated perimetry had been performed before and after surgical decompression. The area of the peripheral isopter (square degrees [deg^2]) was assessed. Postoperative improvement was defined as an increase of 25 deg^2 or more.

Results. Sixty-eight eyes in 34 patients were included in the analysis. In 44 eyes the visual field improved after surgery, and in 24 eyes it was unchanged or worse. Nasal retinal nerve fiber layer (RNFL) thickness was a good prognostic factor for peripheral visual field recovery (OR 1.56 per 15 μm, p = 0.041).

Conclusions. Peripheral visual field recovery after surgery for optic chiasm compression is predicted by nasal RNFL thickness, which is in accordance with the retinotopy of retinal ganglion cells, as nasal axons decussate at the optic chiasm.

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Key Words • **tomography** • **optical coherence** • **retinal ganglion cells** • **visual field** • **optic chiasm** • **surgery**

The postoperative visual outcome in patients undergoing a surgical procedure for chiasmal compression remains uncertain when severe visual field impairment is present preoperatively. Knowledge of prognostic factors enables the surgeon to provide the patient with information on postoperative recovery, especially in cases at risk for visual impairment. Visual prognosis following chiasmal decompression surgery depends on patient age, duration of compression, nature and size of the lesion, preoperative visual field, visual acuity at the time of surgery, and the presence of optic disc atrophy.[1,4–6,8] However, none of these factors enables the surgeon to evaluate the postoperative outcome for each case. In particular, the preoperative visual field examination provides information only on visual dysfunction, not on whether the impairment is associated with permanent axonal loss.

Optical coherence tomography (OCT) is an important tool for objective quantification of axonal loss indirectly evaluated by retinal nerve fiber layer (RNFL) thickness.[11] In a previous study, RNFL thickness proved to be a prognostic factor for postoperative visual field recovery following surgical decompression of parachiasmal lesions,[2] with central visual field recovery evaluated using static perimetry. However, chiasmal compression is predominantly associated with peripheral visual field changes assessed via Goldmann kinetic perimetry, with implications for visual impairment, especially as it affects a patient's driving ability. The present study was designed to evaluate the prognostic value of RNFL thickness for peripheral visual field outcome after decompressive surgery for parachiasmal lesions.

Methods

In this single-center retrospective study, consecu-

This article contains some figures that are displayed in color online but in black-and-white in the print edition.

Abbreviations used in this paper: OCT = optical coherence tomography; RNFL = retinal nerve fiber layer.

tive patients with lesions compressing the optic chiasm who were treated at Reims University Hospital during the period from October 1, 2010, to August 31, 2012, were initially eligible for inclusion. Other criteria for inclusion consisted of a lesion demonstrated on MRI and data from both preoperative and postoperative examinations, including a complete ophthalmological examination. The following parameters were noted both prospectively and retrospectively: mode of presentation of the parachiasmal lesion, comorbidities (cardiovascular risk factors, alcohol consumption), treatment, functional symptoms (headache, decreased visual acuity, visual field defects, and/or symptoms of hormonal dysfunction), best-corrected visual acuity data, intraocular pressure measurement, and ophthalmoscopic appearance of the optic disc. Optic disc pallor, swelling, or a normal appearance was noted.

Kinetic automated perimetry (Ophthalmology Monitor, Metrovision) had been performed both preoperatively and postoperatively. Three peripheral isopters and the blind spot had been tested. Only the peripheral isopter (III4d) was considered for analysis. The total area resulting from the sum of the areas of the 4 quadrants—temporal superior, temporal inferior, nasal superior, and nasal inferior—was expressed in square degrees (deg^2). The area of the temporal and nasal hemifield was also considered for analysis. The mean test-retest variability in healthy subjects in kinetic perimetry is 25 deg^2.[3] A change of 25 deg^2 or more between the initial preoperative evaluation and the postoperative evaluation was therefore considered to be significant. Driving ability was evaluated on the basis of visual acuity and visual field examination.

Preoperative global and sectorial thickness measurements (inferior, temporal, superior, and nasal) of the RNFL were performed using time-domain OCT (Stratus, Carl Zeiss Meditec) as provided by the manufacturer; that is, we did not modify the instrument. All resected lesions were analyzed in the Department of Pathology at Reims University Hospital.

For descriptive analysis, variables were expressed as mean values with standard deviation. According to the sample size, either Student t-tests or Mann-Whitney U-tests were used to compare quantitative variables. A chi-square test was used to compare qualitative variables. For bivariate and multivariate analysis, logistic regression modeling was performed to test the link between outcome and explanatory variables (age, sex, nasal and temporal peripapillary RNFL thickness); the results were expressed with odds ratios within a 95% confidence interval. For all statistical analyses, the significant threshold was fixed at 0.05. We used SPSS software 12.0 (SPSS, Inc.) for the statistical analysis.

Based on univariate analysis, a paired-samples t-test was performed to evaluate intra-pair differences between the two eyes of the same patient.

Results

Patient Characteristics and Symptoms

Sixty-eight eyes in 34 patients, 18 females and 16 males with a mean age of 53 ± 16 years, were included in our analysis. No signs of excessive alcohol consumption were encountered. The average duration of symptoms before the first consultation for symptoms was 31 ± 49 months. Parachiasmal lesions were revealed by 3 different types of symptoms: 1) visual signs, 2 patients with disorders of the visual field and 11 with decreased visual acuity; 2) endocrine symptoms, 12 patients (4 cases of acromegaly and 2 cases of Cushing's syndrome); and 3) signs of increased intracranial pressure, most often headaches, 9 patients.

Preoperative Ophthalmological Examination

The mean preoperative best-corrected visual acuity was 0.22 ± 0.3 logMAR (log of the minimum angle of resolution). The slit-lamp examination revealed a cataract in 15 of 68 eyes. Intraocular pressure was 15 ± 3.04 mm Hg. The ophthalmoscopic examination of the optic disc showed a normal appearance for 55 eyes and pallor in 13 eyes. No optic disc swelling was encountered.

The visual field defect had the appearance of a superior temporal quadrantanopia in 17 patients and a bitemporal hemianopia in the other 17 patients. The mean total area of the peripheral isopter was 8313 ± 2562 deg^2 (Fig. 1).

The mean preoperative global RNFL thickness was 93.86 ± 16.09 μm. It was 120.88 ± 26.01 μm in the inferior quadrant, 117.07 ± 20.31 μm in the superior quadrant, 73.40 ± 22.88 μm in the nasal quadrant, and 64.12 ± 16.98 μm in the temporal quadrant.

Surgical and Perioperative Data

Preoperative endocrinological assessment revealed that 20 patients had pituitary blood disorders, and thus they received a specific preoperative medical treatment. Ten patients received corticosteroids preoperatively.

The surgical approach was transsphenoidal in 33 patients and transeyebrow in 1 patient.

Pathological examination revealed 26 pituitary adenomas (12 nonsecreting, 5 somatotropic, 4 gonadotropic, 3 prolactinomas, 1 thyrotropic, and 1 corticotropic), 5 craniopharyngiomas, 2 cysts, and 1 meningioma.

Clinical Outcome

The mean postoperative follow-up was 19 weeks. The mean visual acuity was 0.1 ± 0.22 logMAR. In 44 eyes the visual field improved after surgery, and in 24 eyes it was unchanged or worse. The mean total area of the peripheral isopter was 9074 ± 2147 deg^2. The mean variation in the peripheral isopter was +761 ± 2159 deg^2, with a maximum improvement of +8801 deg^2 and a maximum loss of −6612 deg^2.

Based on univariate analysis, a paired-samples t-test was performed to evaluate each pair of eyes separately and revealed no intereye difference. Therefore the analysis showed that we could examine each eye individually in a paired test, enabling us to compare two groups: one with visual field improvement (44 eyes in 22 patients) and the other without visual field improvement (24 eyes in 12 patients). When visual field improvement was noted, it occurred between 2 and 58 weeks postoperatively. Among

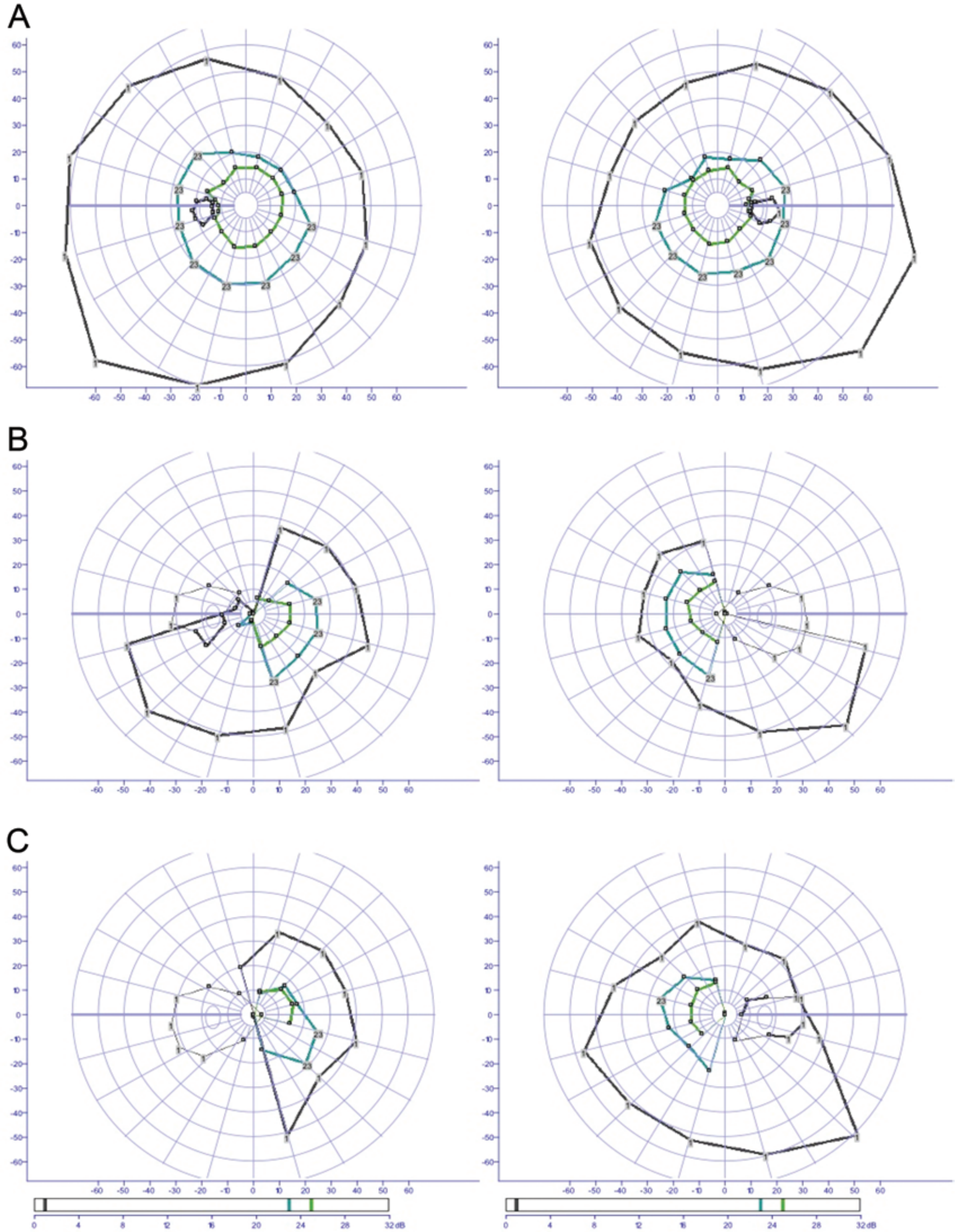

Fig. 1. Visual fields. **A:** Normal: peripheral isopter area left eye (LE): 10628 deg^2; right eye (RE): 10203 deg^2. **B:** Quadrantanopia: peripheral isopter area LE: 3864 deg^2; RE: 3366 deg^2. **C:** Bitemporal hemianopia: peripheral isopter area LE: 1854 deg^2; RE: 5821 deg^2.

the 22 patients with visual field improvement, 5 had been unable to drive preoperatively, but 4 of them recovered their driving ability after surgery. Among the 12 patients with stable or worse visual fields, 5 had been unable to drive preoperatively and remained so postoperatively.

Comparing the mean RNFL thickness values between the group of eyes with improvement and the group without improvement, we found no significant difference (p = 0.720) when applying a Student t-test (Table 1). However, the RNFL thickness in the temporal and nasal quadrants was associated with a $p < 0.20$ and could therefore be used in a logistic regression analysis. A significant correlation between the nasal RNFL thickness and visual field recovery was found: OR 1.03 per µm. An increase in thickness of 15 µm (minimal resolution of time-domain OCT) was associated with an OR of 1.56 (Table 2).

TABLE 1: Preoperative RNFL values as a function of recovery in the peripheral isopter*

Group & Recovery Status	No. of Eyes	Mean Thickness (µm)	p Value
global			0.720
yes	44	93.33 ± 17.70	
no	24	94.81 ± 12.90	
inferior quadrant			0.296
yes	44	118.43 ± 26.31	
no	24	125.38 ± 25.39	
superior quadrant			0.860
yes	44	116.75 ± 20.10	
no	24	117.67 ± 21.13	
nasal quadrant			0.061
yes	44	77.23 ± 23.50	
no	24	66.38 ± 24.42	
temporal quadrant			0.053
yes	44	61.18 ± 15.66	
no	24	69.50 ± 18.29	

* The average RNFL thickness was not significantly different between eyes with visual field recovery versus eyes with no recovery. However, the thickness in the temporal and nasal quadrants was associated with a $p < 0.20$ and could therefore be used in a logistic regression analysis.

The receiver operating characteristic curve, separating groups with improved and unimproved visual fields, demonstrated a nasal RNFL threshold of 68.50 µm ($p = 0.135$) with an optimal sensitivity (61%) and specificity (50%), indicating a high probability of visual field recovery.

Discussion

In the present study we demonstrated that peripheral visual field outcome after decompressive surgery for parachiasmal lesions is associated with the degree of preoperative retinal axonal loss evaluated using OCT. The principal prognostic factor is the nasal quadrant thickness, which is correlated with the postoperative shift in the peripheral isopter area.

Danesh-Meyer et al. showed that the global RNFL thickness assessed with OCT is a prognostic factor for the central visual field after surgery.[2] A mean thickness of 85 µm was considered the threshold for improvement.

Jacob et al. found that global RNFL thinning was associated with a poor prognosis for recovery of the central visual field. A temporal quadrant thickness below the 5th percentile was also considered a factor for a poor prognosis.[7]

In the present study, the nasal quadrant RNFL thickness appears to be the best parameter to estimate peripheral visual field recovery as evaluated with kinetic perimetry. This finding is in accordance with the ganglion cell retinotopy. Retinotopy also accounts for the correlation between the nasal RNFL thickness and the global area of the peripheral isopter, as the majority of retinal ganglion cells originate from the nasal rim of the optic disc. In addition, the spatial density of retinal ganglion cells is higher in the nasal quadrant than in other quadrants at a comparable degree of eccentricity. Thus, ganglion cells of the nasal retina encode a larger area than those of the temporal retina.[10]

Although the nasal retinal fiber layer thickness appeared to be a good predictor of peripheral visual field outcome, no cutoff value could be determined: the best threshold value of 68.50 µm nearly reached statistical significance in the present series. The retrospective design of the study could explain this lack of significance, as the timing of the postoperative evaluation varied. Thus, the present results must be confirmed in further prospective studies.

Optic disc pallor in patients with optic chiasm compression is known to predominate in the nasal and temporal quadrants, which is confirmed by RNFL measurements (“band atrophy” or “bow-tie atrophy”).[9] This pattern of RNFL loss is attributable to retrograde degeneration or the “dying back” of retinal ganglion cells.

In the present study, relative preservation of the nasal contingent of the RNFL appears to have been a reliable prognostic factor for peripheral visual field recovery.

Retinal ganglion cells in the nasal field of each retina emit axons that decussate the optic chiasm, whereas the axons located in the temporal retina remain ipsilateral. At the optic chiasm, the axons originating from the nasal quadrant of the optic disc represent the majority of decussating fibers. The more ganglion cells decussating at the chiasm are preserved, the better the recovery of the peripheral visual field, which accords with results in the present study.

Conclusions

Preoperative RNFL thickness correlates with the recovery of the peripheral visual field after surgery. The

TABLE 2: Multivariate analysis

Parameter	p Value	OR	95% CI Lower	95% CI Upper
age	0.387	1.015	0.981	1.051
sex	0.884	0.920	0.300	2.822
nasal OCT	0.041	1.557*	1.015	2.363
temporal OCT	0.086	0.624	0.364	1.062

* Nasal quadrant RNFL thickness is statistically correlated with a better recovery of the visual field.

thickness of the nasal RNFL is the best prognostic factor in our series. Thus, the quota of preserved decussating axons is associated with a better recovery of the peripheral visual field.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Garcia, Litré, Rousseaux, Arndt. Acquisition of data: Garcia. Analysis and interpretation of data: Garcia, Delemer, Arndt. Drafting the article: Garcia, Arndt. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Garcia. Statistical analysis: Sanchez. Administrative/technical/material support: Garcia, Litré. Study supervision: Arndt.

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