

Early diagnostic value of spectral domain-optical coherence tomography for retrograde optic nerve changes in sellar-occupied patients

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Research article

Keywords: Spectral domain-optical coherence tomography, Optic nerve injury, Papillary retinal nerve fiber layer, Macular ganglion cell complex

Posted Date: November 11th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-51871/v2>

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Abstract

Background: The comparison of the diagnostic value of peripapillary retinal nerve fiber layer (pRNFL) and macular ganglion cell complex (mGCC) for optic nerve injury has not been reported. The aim of this study was to investigate the value of spectral domain-optical coherence tomography (SD-OCT) in the early diagnosis of optic nerve injury in patients with occupying lesion in sellar region.

Methods: A prospective case-control study was conducted for patients who were diagnosed with the occupying lesion in sellar region in the Department of Ophthalmology. The general routine examination and visual field examination were performed. A total of 22 patients (44 eyes) with no abnormalities were selected, and 22 healthy controls (44 eyes) were enrolled (age ≥ 18 years). SD-OCT was used to detect the average thickness of peripapillary retinal nerve fiber layer (pRNFL) and the thickness of four quadrants and the thickness of each layer of macular ganglion cell complex (mGCC). The results were compared to evaluate the damage of the optic nerve. The area under the receiver operating characteristic (ROC) curve (AUC) was evaluated by SD-OCT to detect the diagnostic efficacy of pRNFL and mGCC for sellar-occupying optic nerve damage.

Results: The average thickness of pRNFL was significantly thinner than that of healthy controls ($P < 0.01$). The mean thickness of mGCC, macular retinal nerve fiber layer (mRNFL) and GCL+ were significantly thinner than those of healthy controls ($P < 0.05$). The AUC values of pRNFL, mGCC, ganglion cell layer (GCL) + and mGCC were 0.757, 0.643, 0.702 and 0.688, respectively. The diagnostic value was pRNFL > GCL+ > mGCC > mRNFL.

Conclusion: The thickness of pRNFL and mGCC detected by SD-OCT has clinical value in the diagnosis of optic nerve injury in early patients with occupying lesion in sellar region. The change of pRNFL thickness is more effective than mGCC thickness in the early retrograde optic nerve changes, which has potential clinical use value for the diagnosis of retrograde optic nerve changes.

Background

Common space-occupying lesions in the sellar region include pituitary tumors, sellar meningioma, and craniopharyngioma [1]. Because the structure of the sellar region is closely related to the optic nerve and optic chiasm, the tumor in the sellar region will be directly compressed from different directions or “stealing blood” and optic nerve, leading to optic nerve block and blood supply disorders [2]. At present, visual field examination is usually used for assessing the degree of visual impairment of patients, but its detection results are greatly affected by subjective factors of patients, and it is difficult to accurately assess the visual function of patients.

Spectral domain-optical coherence tomography (SD-OCT) is an image diagnosis technology developed rapidly in ophthalmology in recent years [3, 4]. It has the characteristics of non-contact, high resolution, high reproducibility, fast image acquisition, and it can objectively quantitatively detect the thickness of each layer of the retina and monitor the occurrence, development and outcome of optic nerve fiber damage [5, 6]. The previous study showed that for patients with sellar region occupying defects, the thickness of the peripapillary retinal nerve fiber layer (pRNFL) was correlated with visual field damage and can be used to quantitatively assess visual impairment [7]. The quantitative detection of macular ganglion cell complex (mGCC) can be used as a reference for early diagnosis of glaucoma [8].

It has been found that the pRNFL thickness has become thinner than the normal control and the mGCC volume is reduced when the visual acuity, fundus and visual field of the sellar region do not change abnormally [9, 10]. The comparison of the diagnostic value of pRNFL and mGCC for optic nerve injury has not been reported. The main purpose of this study is to compare the diagnostic efficacy of pRNFL and mGCC, and to explore the sensitivity of both to the assessment of retrograde optic nerve changes using receiver operating characteristic curve .

Methods

General information

This prospective study enrolled 22 patients (case groups) who were diagnosed as sellar region and attended ophthalmology consultations in the Department of Neurosurgery, Shanxi Provincial People's Hospital from July 2014 to December 2018. Inclusion criteria: general routine examination and visual field examination without abnormalities, no family history of glaucoma and other eye diseases, no diabetes or other systemic diseases affecting the eyes and optic nerve. All patients with a definite visual field defect, defined as vertically demarcated temporal field loss in either eye on the pattern deviation map or any intraocular surgery history were excluded.

A total of 22 healthy workers (44 eyes) from family members of the patients and healthy workers in our hospital were used as normal group. All tests and results analysis were performed by an experienced ophthalmologist. The case group included 10 male patients (45.6%), 12 female patients (54.6%), aged 28 to 75 years, mean (44.3 ± 11.8) years old; the normal group included 10 male patients (45.6%), 12 patients Female patients (54.6%), aged 28 to 75 years, mean (44.4 ± 11.7) years old. The study was conducted following the principles of the Declaration of Helsinki. The study was approved by the Ethics Committee of Shanxi Provincial People's Hospital and written informed consent was obtained from each subject.

Visual field inspection

Using the US SYNEMED EP-930 vision machine, the central 30 field of view was performed using the full threshold procedure, and the visual field stimulation point was 59.

SD-OCT inspection method

The pRNFL scan mode and the mGCC scan mode of the Topcon 3D OCT-2000 are applied (Figure 1). The pRNFL scan is centered on the optic papilla with a resolution of 512 x 128 and a scan length of 6 x 6 mm. The mGCC scan is centered on the fovea of the macula with a resolution of 512 x 128 and a scan length of 7 mm. The eyes of all subjects were scanned by the same examiner to save the image. The mGCC is the sum of thicknesses of macular retinal nerve fiber layer (mRNFL), macular ganglion cell layer (mGCL), and macular internal plexiform layer (mIPL). GCL+ is the sum of the thicknesses of mIPL and mGCL.

pRNFL and mGCC measurement

The computer image analysis system automatically performs measurement and analysis of pRNFL thickness and mGCC thickness according to the formula provided by the manufacturer. The abnormal grids are marked

with yellow ($P < 0.05$) or red ($P < 0.01$) on the deviation map. The damage grid area of each OCT parameter can be obtained from these abnormalities.

Statistical analysis

All data were tested for normality using SPSS 17.0 statistical analysis software. Two sample comparisons were performed using an independent sample t test and a paired t test. An independent grouped two-level study design was used to compare the thickness of mGCC (GCL+, GCL++, mRNFL) and the thickness of pRNFL (N, T, S, I) between the case group and the control group. The area under the receiver operating characteristic (ROC) curve (AUC) was used to evaluate the specificity and sensitivity of SD-OCT, with $AUC \geq 0.9$ for high diagnostic efficiency, $0.7 \leq AUC < 0.9$ for medium diagnostic efficiency, $0.5 \leq AUC < 0.7$ for low diagnostic performance according to previous study [11], and the test level was $\alpha = 0.05$. $p < 0.05$ was considered statistically significant.

Sensitivity = Number of true positives / number of true positives + number of true negatives

Specificity = Number of true negatives / number of true positives + number of true negatives

Results

Average thickness of pRNFL between case and control groups

The average thickness of pRNFL in the case group was significantly thinner than that in the control group ($t = 4.785$, $P < 0.01$), and the average thickness of the four quadrants (N, T, S, I) of the case group was smaller than that of the control group, with statistical significance ($t = 4.000, 3.751, 3.683, 3.679$, $P < 0.01$) (Table 1).

Table 1. Comparison of pRNFL thickness in the eyes of the two groups

Groups	N	T	S	I	pRNFL average
Control	90.36±14.03	85.68±10.92	127.91±10.83	134.41±12.56	109.59±7.79
Case	75.45±20.35	74.11±17.3	116.02±18.47	119.18±24.41	96.19±16.86
t	4.000	3.751	3.683	3.679	4.785
P	<0.001	<0.001	<0.001	<0.001	<0.001

Comparison of thickness of GCC layers in the macular area of the two groups

The average thickness of the GCC layers in the case group was significantly thinner than that in the control group ($t = 3.557$, $P < 0.01$). The average thickness of mRNFL and GCL+ in GCC was lower than that in the control group ($t = 2.894$ and 3.478 , $P < 0.01$) (Table 2).

Table 2. Comparison of the thickness of GCC each layer in the macular area of the two groups

Groups	mRNFL	GCL average	GCC average
Control	36.3±2.76	75.84±5.59	112.05±7.03
Case	33.93±4.66	70.89±7.64	104.86±11.4
t	2.894	3.473	3.557
P	0.005	0.001	0.001

Diagnostic performance

The AUC of pRNFL average, mRNFL average, GCL+ average, GCC average for sellar region occupancy were 0.757, 0.643, 0.702, and 0.688, respectively. The diagnostic value was followed by pRNFL average > GCL + average > GCC average > mRNFL average (Figure 2).

Discussion

The tumor in the sellar region accounts for about 30% of intracranial tumors, often causing optic nerve, optic chiasm and optic tract to be compressed, causing vision loss and visual field defects [12]. Long-term follow-up observations show that early release of oppression of the optic chiasm can prevent further damage to visual function. Therefore, the early diagnosis of optic nerve damage has a positive significance for protecting patients' visual function [13]. The visual field change caused by the sellar region occupancy is an important indicator to evaluate the visual function damage of the disease, but its examination is subjective, the variability is large, and the early reports lack consistency, and the results will affect the objective judgement of the disease and prognosis. SD-OCT can objectively and quantitatively measure the thickness of the optic disc and retina. It has been found that the visual field defect of the sellar region has a good correlation with the thickness of pRNFL and the thickness of mGCC [14]. It has been reported in the literature that the optic disc fibers and optic ganglion cell complexes in the sellar region patients with no visual field changes have shrunk and thinned [15]. The thickness of pRNFL and mGCC in the sellar region patients who did not have visual field changes were detected by SD-OCT to determine the occurrence, development and outcome of optic nerve fiber damage, and to compare the diagnostic value of the two, to provide more objective and accurate information for the early diagnosis and condition monitoring of optic nerve injury in the sellar region occupying patients, and provide a theoretical basis for its treatment.

In the sellar region patients, whose the visual acuity, fundus and visual field did not change significantly, the average peripapillary RNFL of the optic disc was thinner than the normal control, and the average GCC of the macula was thinner than normal. The early mechanical compression of the tumor in the sellar region or the cross-over of the blood vessel or the blood-stasis damage could be caused by the optic chiasm [16]. SD-OCT showed thinning of pRNFL and mGCC thickness.

At the same time, this study found that the AUC of the average optic disc RNFL thickness measured by SD-OCT was 0.757, the diagnostic efficiency was medium and the AUC value of the average GCC thickness measured by SD-OCT in the macular area was 0.688, and the diagnostic efficiency was low. The diagnostic efficiency of pRNFL in this study was higher than that of mGCC. It can be presumed that the early influence of oppression on

the visual pathway is mainly the change of optic nerve fibers. There is still a period of pause between optic nerve injury and optic neuron degeneration. At this time, the oppressive factors are removed and the patient's visual function can be restored or improvement, so the thickness of the optic disc RNFL is a sensitive and objective indicator in the assessment of optic nerve damage in the sellar region. The GCC concept comes from the study of glaucoma, which contains dendrites of axons, cell bodies, and ganglion cells, respectively [14]. Inspired by glaucoma diagnostic studies, we used SD-OCT to measure changes in GCC thickness in patients with pituitary tumors. The average mRNFL, GCL+, and GCC average GCC under the GCC examination were 0.643, 0.702, and 0.688, respectively. The GCL+ has moderate diagnostic performance, and the mGCC and mRNFL has less diagnostic performance. The reason was that GCC was not the simple addition of mRNFL and GCL+, which continues to oppress the optic chiasm with the development of sellar-occupying lesions. We assumed that when GCL+ is in the early atrophy stage, mRNFL is in a stage of severe swelling, and the superposition of the two produces neutralization and makes the GCC thickness normal.

The main limitation of this study was that the pathology was not specified. Further study with more strict design was needed. The radiological features of the patients with sellar tumors were not recorded.

Conclusion

In conclusion, the use of SD-OCT to detect changes in thickness of pRNFL and mGCC has clinical value in the diagnosis of optic nerve injury in early patients with occupying lesion in sellar region. The diagnostic effect of pRNFL thickness on the early sellar-occupying optic nerve injury is higher than that of mGCC. In addition, the sellar region oppression optic chiasm will not only cause optic ganglion cell degeneration, but also cause lateral geniculate optic neuron and visual cortical neuron degeneration [16]. Its influence on pRNFL and mGCC remains to be studied. The characteristics of directional projection, SD-OCT examination for the location diagnosis of the sellar region needs further investigation.

List Of Abbreviations

spectral domain-optical coherence tomography (SD-OCT)

peripapillary retinal nerve fiber layer (pRNFL)

macular ganglion cell complex (mGCC)

receiver operating characteristic (ROC)

curve (AUC)

ganglion cell layer (GCL)

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Shanxi Provincial People's Hospital and informed consent was obtained from each subject.

Consent for publication

The study was approved by the Ethics Committee of Shanxi Provincial People's Hospital and informed consent was obtained from each subject.

Availability of data and materials

The authors agree to share the data and materials of this paper.

Competing interests

The authors declare that they have no conflicts of interest to report regarding the present study.

Funding

Research Project Supported by Shanxi Scholarship Council of China, 2014-081.

Authors' contributions

We declare that all the listed authors have participated actively in the study and all meet the requirements of the authorship. LZ designed the study and wrote the protocol, XY performed research, WZ contributed important reagents, MH managed the literature searches and analyses, WZ undertook the statistical analysis, XL wrote the first draft of the manuscript. All authors have read and approved the manuscript.

Acknowledgements

None.

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Figures

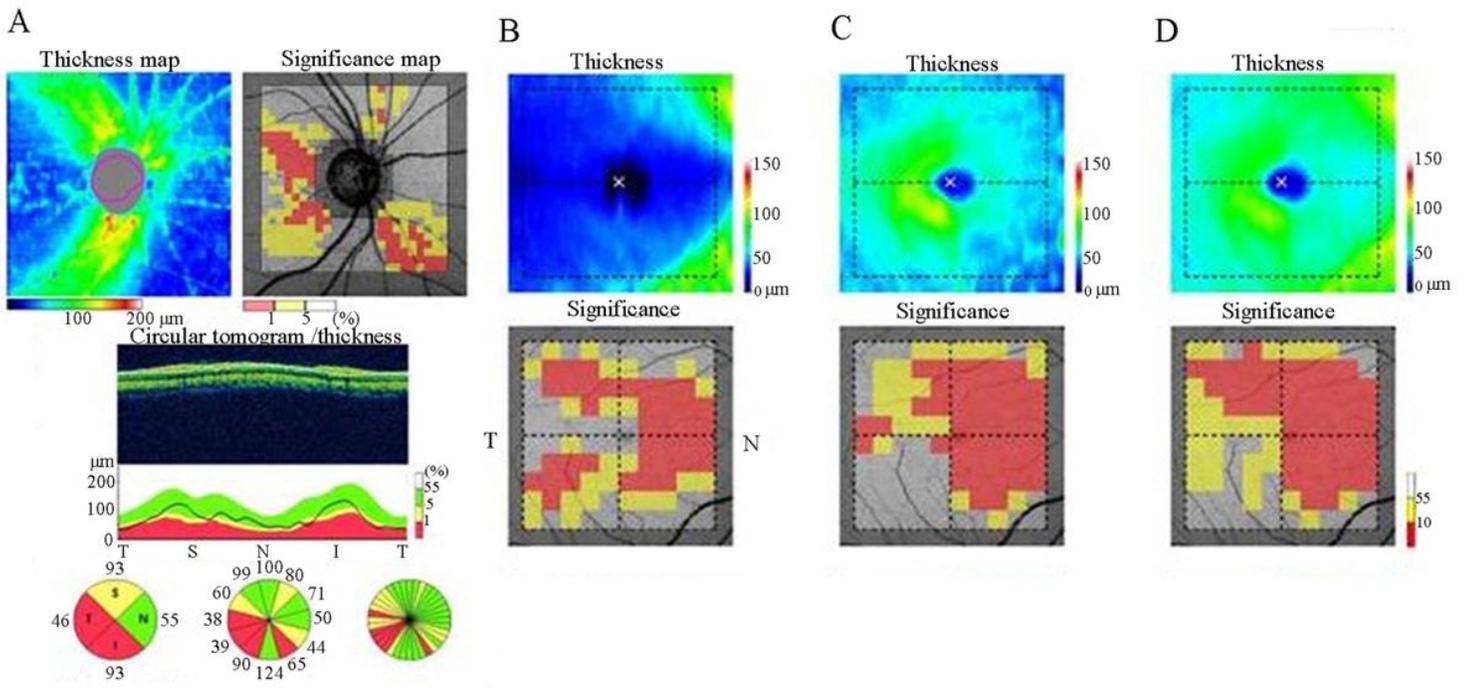


Figure 1

A typical case of SD-OCT measurement of saddle area occupancy. The SD-OCT provides color coded thickness deviation plots for pRNFL (A), mRNFL (B), GCL+(C), and GCL++(D) thicknesses. A grid with a normal thickness range is indicated in green, a grid with a thickness of 5% less than the normal distribution of the standard database is indicated in yellow, and a grid thickness at $P \leq 1\%$ is indicated in red. It is worth noting that in GCL+ and GCL++ measurements, the anomalous mesh is clearly along the vertical meridian through the fovea, which corresponds to the humeral hemacy caused by cross-compression.

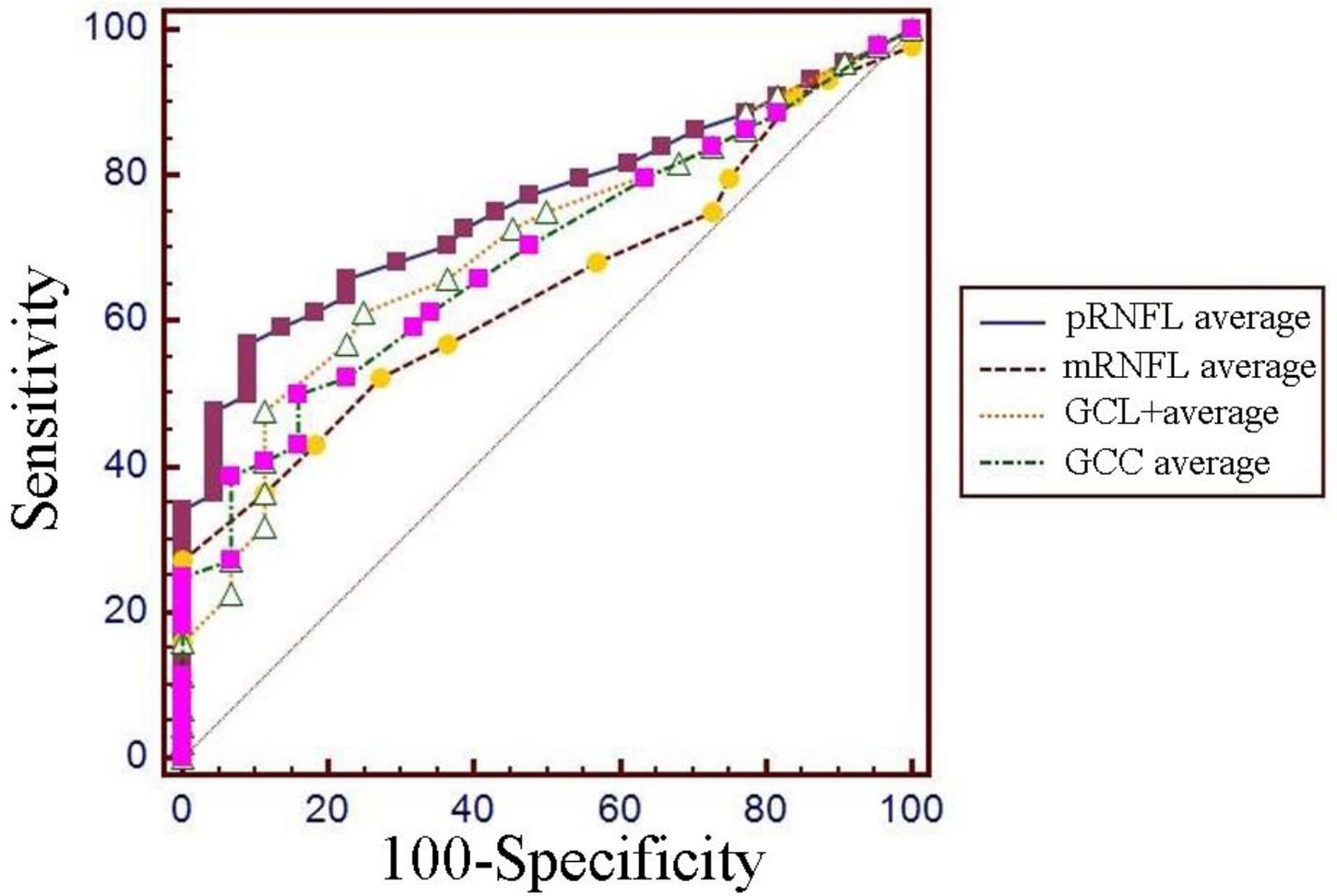


Figure 2

ROC analysis of the GCC thickness and the thickness of the optic disc RNFL in the control and case groups. pRNFL average > GCL + average > GCC average > mRNFL average.