Prognostic Utility of Optical Coherence Tomography for Visual Outcome After Extended Endoscopic Endonasal Surgery for Adult Craniopharyngiomas

Ning Qiao

Beijing Tiantan Hospital, Capital Medical University

Chuzhong Li

Beijing Tiantan Hospital, Capital Medical University

Jing Xu

Beijing Tiantan Hospital, Capital Medical University

Guofo Ma

Beijing Tiantan Hospital, Capital Medical University

Jie Kang

Beijing Tiantan Hospital, Capital Medical University

Lu Jin

Beijing Tiantan Hospital, Capital Medical University

Lei Cao

Beijing Tiantan Hospital, Capital Medical University

Chunhui Liu

Beijing Tiantan Hospital, Capital Medical University

Yazhuo Zhang

Beijing Tiantan Hospital, Capital Medical University

Song-Bai Gui (✉ guisongbai@yeah.net)

Beijing Tiantan Hospital, Capital Medical University <https://orcid.org/0000-0002-3638-2018>

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Abstract

Optical coherence tomography (OCT) serving as a novel high resolution imaging technique can assess the retinal morphology. At present, a few studies are reported with limited evidence on the predictive value of OCT for visual outcome after optic nerve decompression. This study aims to utilize the largest series of adult craniopharyngiomas to evaluate the association between OCT parameters and visual outcome following the extended endoscopic endonasal surgery (EEES). From October 2018 to October 2020, one hundred and seventy eyes in 88 adult patients with craniopharyngiomas were retrospectively reviewed. Gross total resection was performed in 82 (93.2%) patients. The median follow-up time was 10.9 months. Our study showed that increased temporal circumpapillary retinal nerve fiber layer (cpRNFL) thickness was associated with higher odds of visual acuity (VA) improvement and maintenance (OR=1.070; P=0.035), and greater inferior cpRNFL thickness was significantly associated with visual field (VF) improvement and maintenance (OR=1.034; P=0.046). Tight adhesion was demonstrated as an independent adverse factor for either postoperative VA or VF (P=0.048, P=0.030, respectively). Receiver operating characteristic (ROC) analysis further verified the robustness of the prediction model either in VA (AUC=0.842; P<0.001) or VF (AUC=0.849; P<0.001). Preoperative OCT can effectively predict visual outcome after EEES for adult craniopharyngiomas. It can also serve as a reliable alternative to evaluate preoperative visual field defects, especially for patients with lower compliance. Tight adhesion was confirmed as an independent risk factor for postoperative visual outcome. The OCT-based multivariable prediction models developed in present study may contribute to patient counseling on visual prognosis.

Introduction

Craniopharyngiomas are rare brain tumors originating from any point along the pituitary–hypothalamic axis, accounting for 1.2–4.6% of all intracranial tumors[25]. By reason of the close vicinity of optic chiasma, visual deterioration is known as a common complication following surgery for craniopharyngiomas[6,34,29,4,20]. Prognostic factors related to postoperative visual outcome, including age[2,14,8], symptoms duration[5], tumor size and volume[15], preoperative visual function[14], and optic atrophy[17], have been studied extensively, but results are not consistent.

Retrograde axonal degeneration caused by chronic optic nerves compression secondary to craniopharyngiomas often leads to thinner circumpapillary retinal nerve fiber layer (cpRNFL) and macular ganglion cell complex (mGCC) , thus leading to irreversible visual dysfunction[28]. Hence, visual recovery largely relies on timely removal of optic nerves compression and the amount of viable axons[28,13]. Optical coherence tomography (OCT) can serve as a noninvasive in vivo method to quantitatively and objectively measure cpRNFL thickness and mGCC parameters[33,28]. The clinical efficiency of OCT as a predictor of visual recovery after surgery for pituitary adenomas, meningioma or pediatric craniopharyngiomas has already been verified[28,11,17,10,33,24,22,3]. Differing from pituitary tumors and meningioma, craniopharyngiomas often directly adhere to optic nerves, with a higher risk of postoperative visual deterioration. Compared with pediatric craniopharyngiomas, adult craniopharyngiomas more frequently cause visual impairment prior to surgery[25]. Therefore,

investigating reliable predictive indicators of postoperative visual outcome may be beneficial for patients counseling on visual prognosis. However, there is limited evidence on the prognostic utility of OCT for visual outcome after surgery for adult craniopharyngiomas [33,10].

This is first study to systematically evaluates the association between OCT parameters and visual outcome after the extended endoscopic endonasal surgery (EEES) for adult craniopharyngiomas.

Materials And Methods

Patient Population

From October 2018 to October 2020, a total of 118 adult patients underwent EEES for primary craniopharyngiomas at Beijing Tiantan Hospital of Capital Medical University. Inclusion criteria were as follows: (1) adult patients aged ≥ 18 years, (2) newly confirmed diagnosis of craniopharyngioma, (3) computed tomography (CT), magnetic resonance imaging (MRI) and ophthalmologic tests before and after surgery. The exclusion criteria were: (1) past medical history of treatment including radiotherapy and surgery, (2) any ophthalmic condition other than compressive optic neuropathy caused by craniopharyngiomas, (3) any medical illness (including glaucoma, diabetes mellitus) known to affect optic apparatus, (4) ineligible OCT parameters, (5) unreliable visual field (VF) and best corrected visual acuity (BCVA) testing (fixation losses more than 20%, false-negative error more than 20%, and false-positive error more than 20%), (6) myopia greater than -6.00 diopters, (7) and papilledema on fundoscopy. Consequently, 88 (74.6%) of 118 patients with primary craniopharyngiomas were retrospectively analyzed in this study. The flow chart for study inclusion and exclusion was described in Figure 1. All participants signed an informed consent form. The study was approved by the ethics committee of Beijing Tiantan Hospital of Capital Medical University.

Radiological Evaluations

The MRI examinations were performed preoperatively and at 3 and 9 months after surgery. Subsequent MRI scans were executed annually. Gross total removal (GTR) was defined as the resection without visual residual enhancing tumor according to postoperative MRI[20]. Tumor recurrence during follow-up was defined as the development of a pathological lesion on MRI that had not previously been observed or the regrowth of tumor residuals[20]. Tumor volume was calculated by using the following formula[21]: $\text{volume} = 4/3\pi (a/2 \times b/2 \times c/2)$ (where a, b and c represent the diameters in the three dimensions).

Visual Evaluation and Definition

The ophthalmologic tests were performed preoperatively and at least 3 months after surgery. The BCVA was evaluated using logarithmic visual acuity chart , and then converted to the logarithm of the minimum angle of resolution (logMAR) for analysis. The VF examinations, including mean deviation (MD), pattern standard deviation (PSD) and visual field index (VFI), were performed using the Humphrey Field Analyzer (24-2 SITA-fast program, Carl Zeiss Meditec, Dublin, California, USA). OCT measurements, including

cpRNFL thickness and mGCC parameters, were conducted using spectral-domain OCT (Optovue, Fremont CA, USA). OCT parameters were also analyzed based on decade of age: £ 20 years, 21-30 years, 31-40 years, 41-50 years, 51-60 years, and 61-70 years[16,12]. For the analysis, improvement or worsening in BCVA (normal $\pm$ 1.0) was defined as a change of greater than 0.1 in LogMAR visual acuity[19]. The VF improvement or worsening was defined as a change of MD (normal $\pm$ 2 decibels (dB)) greater than -3dB[26].

Spectral-Domain Optical Coherence Tomography

Subjects underwent SD-OCT scanning without pupillary dilation using Avanti RTVue-XR (Optovue, Fremont, California, USA) by experienced examiners on the same day as the ophthalmic evaluation. This equipment with an axial scan speed of 100 KHz using an 840 nm wavelength laser has the resolution of 5.3 mm axially and 18 mm laterally. Three consecutive scans were performed on each eye. The scanning protocol for peripapillary RNFL thickness was acquired using the optic nerve head map, with a scanning range covering centered on the optic disc and covered a circle 3.45 mm in diameter. The GCC thickness was obtained using the GCC scanning protocol, which generates the data though the scans of a square grid (7mm´7mm) on the central macula centered 1 mm temporal to the fovea and covered. Criteria for acceptable images included signal intensity level greater than 7 of 10, signal strength index $\geq$ 40. The normal RNFL and GCC thickness was defined as within the 95% percentile of age-, sex-, and race-matched normative values obtained from the manufacturer's database.

Classification of Adhesion

Compared to pituitary adenomas, craniopharyngiomas posed challenges mainly owing to their tendency to adhere to vital neurovascular structures, such as optic nerves and optic chiasma[30], with a higher risk of postoperative visual deterioration. Adhesion strength between optic apparatus and tumor was classified into two categories according to intraoperative findings by the surgeon: (1) no or loose adhesion if the tumor can be easily separated from the optic apparatus by gentle blunt dissection using dissectors; or (2) tight adhesion if the separation of the tumor required sharp dissection using scissors (Fig.2).

Statistical Analysis

We performed all statistical analyses with SPSS statistics software version 23 (IBM Corp). The data were presented as the mean $\pm$ standard deviation (SD) or median (with interquartile range (IQR)) for normally distributed and nonnormally distributed samples, respectively. Differences between the pre- and post-operative visual outcomes were assessed by using the Wilcoxon signed rank test. Spearman's rank correlation coefficients were used to evaluate the relationship between OCT and VF parameters. The prognostic factors for visual outcome were analyzed by binary logistic regression. Receiver operating characteristic (ROC) curves were used to determine the performance of the prediction model. Area under the curve (AUC) with 95% confidence interval (CI) and the associated P-value were calculated. P < 0.05 was considered statistically significant.

Results

Patient Characteristics

The present cohort included 37 (42.0%) male patients, and the mean age was 44.0 years old (range, 19-68 years). The most common preoperative symptom was visual impairment (78 patients; 88.6%) and the mean duration of such symptom was 6.2 months (range, 1-24 months). The median tumor volume was 6.5 cm³ (IQR, 3.4-14.0 cm³). The clinicoradiological data of 88 patients was showed in Table 1.

Preoperative Visual Function

One hundred and twenty-three eyes (72.4%) had VA impairment preoperatively. The median BCVA was 0.2 logMAR (IQR, 0 to 0.5). VF defects occurred in one hundred and forty-nine eyes (87.6%). MD, PSD, VFI on VF testing was -9.3 (IQR, -14.8 to -4.9), 7.7 (IQR, 3.5 -11.4), 77.5 (IQR, 56.5-90), respectively. The mean global RNFL thickness was 97.05 ± 13.17 mm. It was 121.72 ± 19.36 mm in the inferior quadrant, 124.66 ± 20.24 mm in the superior quadrant, 70.53 ± 13.96 mm in the nasal quadrant, and 70.28 ± 12.42 mm in the temporal quadrant, respectively. Inner average, superior and inferior mGCC thickness was 91.68 ± 9.15 mm, 91.00 ± 9.34 mm and 92.36 ± 9.49 mm, respectively (Table 1). The associations between the mGCC parameters, cpRNFL thickness parameters and VF parameters in the 170 eyes were showed in Table 2. mGCC parameters significantly correlated with MD, PSD and VFI. All cpRNFL thickness parameters were significantly associated with MD except for the superior quadrant, PSD except for the nasal quadrant and VFI except for the inferior and nasal quadrant, respectively.

Overall Surgical Results

GTR was achieved in 82 (93.2%) patients. Of the six cases with residual tumors, three were observed without further treatment, and three received gamma knife radiosurgeries postoperatively without causing new visual defects. Tight adhesion was observed in 31 (35.2%) patients. Adamantinomatous craniopharyngiomas were confirmed in 67 (76.1%) patients. After a median follow-up duration of 10.9 months, recurrence occurred in 2 (2.3%) patients. Of these patients, one did radiotherapy, and the other was observed without adjuvant therapy. There was no new visual impairment occurred in these two patients.

Postoperative Visual Outcome

The follow-up time was 10.9 (IQR, 7.2-16.2) months. Among 123 eyes with preoperative VA impairment, VA improved in 78.0% but worsened in 4.9% postoperatively. Five (10.6%) of the 47 eyes with normal preoperative VA had postoperative VA deterioration. Of the 149 eyes with preoperative VF impairment, 83 (55.7%) experienced improved or normalized VF, with no change in 58 (38.9%), and 8 (5.4%) experienced deterioration after surgery. Eighteen (85.7%) of 21 eyes with normal preoperative VF showed no change and 2 (9.5%) experienced worsening. The median BCVA after surgery was 0.1 logMAR (IQR, 0 to 0.2), which was significantly lower than the preoperative 0.2 logMAR (IQR, 0 to 0.5) (P <0.001). The MD (IQR)

showed a significant improvement from -9.3 (IQR, -14.8 to -4.9) preoperatively to -5.3 (IQR, -9.9 to -2.5) postoperatively ($P < 0.001$).

Prognostic Factors for Visual Prognosis

Univariate logistic regression analysis for visual improvement and maintenance by OCT parameters were summarized in Table 3, and increased temporal ($P=0.001$) and inferior cpRNFL thickness ($P=0.004$) proved to be independent prognostic factors. Clinicoradiological factors were also assessed, and the univariate analysis results revealed that tight adhesion and gender were associated significantly with postoperative visual outcome. In the multivariate analysis, increased temporal (OR, 1.070; 95% confidence interval [CI], 1.005-1.140; $P=0.035$) and inferior cpRNFL thickness (OR, 1.034; 95% CI, 1.001-1.068; $P=0.046$) proved to be independent favorable factors for VA (Fig. 3A and 4) and VF (Fig. 3B and 5) improvement and maintenance after surgery, respectively. Moreover, tight adhesion was confirmed as an independent risk factor for VA (OR, 0.188; 95% CI, 0.036-0.986; $P=0.048$) or VF (OR, 0.162; 95% CI, 0.032-0.836; $P=0.030$) after surgery for craniopharyngiomas. Multivariable prediction models developed for postoperative VA and VF recovery and maintenance, including age, gender, cpRNFL thickness and adhesion strength, showed AUC of 0.842 (95% CI, 0.730-0.954; $P < 0.001$) and 0.849 (95% CI, 0.741-0.958; $P < 0.001$), respectively (Fig. 6).

Discussion

Retrograde axonal degeneration resulting from chronic compression of optic chiasma can result in cpRNFL and mGCC thinning, consequently leading to irreversible visual impairment[28]. OCT allows quick, non-invasive, in vivo cross-sectional imaging of the retinal layers and it can serve as an important tool for objective quantification of cpRNFL and mGCC[10]. There are growing evidences that preoperative OCT parameters are prognostic indicators of visual recovery after surgery for optic nerves decompression [35,18,28,27,10]. Danesh-Meyer et al[10]. first suggested RNFL thickness as a predictive factor following surgery for parachiasmal lesions. Park et al[28]. reported RNFL thickness was significantly associated with visual outcome following surgery for parachiasmal meningiomas. Mediero et al[24]. described that OCT may be a valid substitute when children were unable to perform perimetry and it can also predict visual outcome after surgery for pediatric craniopharyngiomas. Lee et al[22]. pointed out that the changes in retinal structure were closely related to peripapillary RNFL thinning and functional outcomes following surgery for pediatric craniopharyngiomas. Wang and his colleagues[33] demonstrated the predictive value of OCT parameters for visual outcome after pituitary tumor surgery. As far as we know, this is the first study to systematically analyze the prognostic utility of OCT parameters for visual outcome after extended endoscopic endonasal surgery for adult craniopharyngiomas.

In accordance with the results reported in previous studies[35,18,28,27,10], our research showed that preoperative OCT parameters can effectively predict postoperative visual outcome following optical nerves decompression. Notably, increased inferior cpRNFL thickness was significantly associated with higher odds of VF recovery and maintenance ($P=0.046$) in present study, which was consistent with the

results reported in the earlier literature [33,23]. In addition, greater temporal cpRNFL thickness was confirmed as a significant favorable factor for VA recovery and maintenance ($P=0.035$) in our study, which was similar to the findings by Kawaguchi and colleagues[19]. Furthermore, in our findings, the superonasal quadrant mGCL thicknesses ($P=0.091$) and focal loss volume (FLV) ($P=0.087$) showed statistical tendencies for visual recovery and maintenance. These tendencies were in line with the findings declared in previous studies[35,27], although these tendencies were not significant. In our study, advancing age and gender failed to be predictors of visual outcome, in contrast to the results of previous studies[2,17,9]. However, in consideration of age-related changes and sexual difference in OCT parameters, age and gender still needed to be considered in multivariate analysis when using cpRNFL thickness to make clinical prediction models[12,16,1,32]. Moreover, the present study demonstrated that tight adhesion between craniopharyngioma and optic nerves was an independent risk factor for postoperative visual outcome, which was similar to our previous results[31]. Perhaps it was because tight adherence can predispose the optical nerves to mechanical and ischemic injury during the tumor resection. Overall, clinical prediction models established in the present study, incorporating age, gender, cpRNFL thickness and adhesion strength, suggested moderate discriminative abilities of VA ($AUC=0.842$) and VF ($AUC=0.849$) recovery and maintenance. It may be helpful to patient counseling on visual prognosis.

Operative trauma can be a confounder to postoperative visual outcome[28]. Compared with transcranial approaches[20], the extended endoscopic endonasal approach can provide a close-up view with better visualization of optic nerves and facilitate a lower visual deterioration after surgery[6,29,34], probably because there was less surgical trauma. Besides, this potential limitation was overcome by using the data of only one neurosurgeon (Songbai Gui). In addition, in our series, the mean follow-up time was 12.0 months (range, 3-28 months), which is longer than the period reported in Danesh-Meyer's series that the majority of visual recovery was inclined to happen within the first 6–10 weeks[11]. Considering the biological characteristic of craniopharyngiomas, the degree of the adhesion strength between optic nerves and tumor was evaluated according to intraoperative findings and included in multivariate analysis, which made it possible to control the possible confounding effect.

Our study demonstrated a statistically significant association between OCT parameters and MD/ PSD/ VFI, which is similar to the findings reported in Ohkubo's series[27] and Chung's series[7]. Therefore, OCT parameters can serve as an excellent alternative to assess preoperative visual field defects resulting from chronic chiasmal compression, particularly for patients with lower compliance.

Limitation

The single-centre setting and a retrospective study design have the potential to introduce selection bias, and our results required external validation in the future. In addition, detailed comparison between patients with normal and thin RNFL thickness about the extent of long-term visual recovery after surgery was limited by the present follow-up time, and serial ophthalmologic examinations should continue to be timely performed after surgery.

Conclusion

Preoperative OCT proved to have an independent predictive value in visual outcome after extended endoscopic endonasal surgery for adult craniopharyngiomas. It can also serve as a reliable alternative to evaluate preoperative visual field defects, especially for patient with lower compliance. Tight adhesion was also a strong predictor of postoperative visual outcome. The OCT-based multivariable prediction model developed in the current study may be beneficial to patient counseling on visual prognosis.

Declarations

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Conflicts of interest/Competing interests: The authors declare that there is no conflict of interest.

Availability of data and material: Not applicable.

Code availability: Not applicable.

Ethics approval: The present study was approved by the Ethics Committee of Beijing Tiantan Hospital affiliated to Capital Medical University (Beijing, China).

Consent to participate: All patients were informed of the purpose of this study and signed a written consent form.

Consent for publication: The manuscript has not been published before and the manuscript is approved by all authors for publication.

Authors' contributions: All authors take responsibility for the integrity and the accuracy of this manuscript. Study concept and design: Qiao and Gui ; draft of the manuscript: Qiao, Li and Xu; acquisition of data: Qiao, Li, Ma, Xu, Kang and Jin ; statistical analysis: Qiao and Cao ; edit: Qiao; supervision: Liu and Zhang; revised: Qiao and Gui.

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Tables

Table 1. Clinicoradiological Characteristics of the Enrolled 88 Patients

Parameters	Values, n (%)
Total number	88
Sex	
Male	37 (42)
Female	51 (58)
Age, y	44.0 ± 13.1
Preoperative manifestations	
Visual disturbance	78 (89)
Menstrual disorder / impaired sexual function	70 (80)
Headache	58 (66)
Fatigue	43 (49)
Polyuria/polydipsia	33 (38)
Preoperative visual acuity	
Normal	23 (26)
Abnormal	65 (74)
Preoperative visual field	
No defect	10 (11)
Defect	78 (89)
Size of tumor	
Volume (cm)	6.5 (IQR,3.4-14.0)
Characteristics of tumor	
Solid	12 (14)
Cystic	31 (35)
Solid and cystic	
Cystic component >50%	29 (33)
Solid component >50%	16 (18)
With hydrocephalus	33 (37.5)
With calcification	49 (55.7)
Preoperative cpRNFL parameters (mm)	

Average thickness	97.05 ± 13.17
Superior quadrant	124.66 ± 20.24
Inferior quadrant	121.72 ± 19.36
Nasal quadrant	70.53 ± 13.96
Temporal quadrant	70.28 ± 12.42
Preoperative mGCC parameters (mm)	
Inner Average	91.68 ± 9.15
Superior	91.00 ± 9.34
Inferior	92.36 ± 9.49
GCC FLV (%)	3.19 ± 2.94
GCC GLV (%)	6.49 ± 5.88

Values are presented as number (%), mean ± standard deviation, or median (with interquartile range (IQR)). cpRNFL=circumpapillary retinal nerve fiber layer; mGCL=macular ganglion cell layer; GLV=Global loss volume; FLV=Focal loss volume

Table 2. Relationship between GCC parameters, RNFL thickness parameters and visual field parameters

	MD		PSD		VFI	
Variable	r	P value	r	P value	r	P value
cpRNFL parameters						
Average thickness	0.226	0.003*	-0.342	<0.001*	0.245	0.001*
Superior quadrant	0.266	<0.001*	-0.347	<0.001*	0.288	<0.001*
Inferior quadrant	0.140	0.069	-0.225	0.003*	0.124	0.106
Nasal quadrant	-0.039	0.611	-0.086	0.266	0.003	0.971
Temporal quadrant	0.327	<0.001*	-0.356	<0.001*	0.325	<0.001*
mGCC parameters						
Inner Average	0.264	0.001*	-0.293	<0.001*	0.239	0.020*
Superior	0.288	<0.001*	-0.318	<0.001*	0.267	<0.001*
Inferior	0.235	0.002*	-0.259	<0.001*	0.203	0.008*
Focal loss volume	-0.342	<0.001*	0.367	<0.001*	-0.356	<0.001*
Global loss volume	-0.332	<0.001*	0.334	<0.001*	-0.317	<0.001*

cpRNFL=circumpapillary retinal nerve fiber layer; mGCL=macular ganglion cell layer; MD=mean deviation; VFI= visual field index; PSD=pattern standard deviation; The asterisk indicates statistical significance, P<0.05

Table 3. Univariate logistic regression for visual improvement and maintenance by OCT parameters

	VA improvement and maintenance		VF improvement and maintenance	
Variable	OR (95% CI)	P value	OR (95% CI)	P value
cpRNFL thickness (mm)				
Average	1.036 (0.990-1.083)	0.127	1.012 (0.965-1.061)	0.630
Superior	1.012 (0.982-1.043)	0.440	0.990 (0.960-1.021)	0.509
Inferior	1.019 (0.989-1.051)	0.216	1.049 (1.016-1.083)	0.004*
Nasal	1.020 (0.976-1.066)	0.375	1.018 (0.972-1.066)	0.444
Temporal	1.104 (1.041-1.172)	0.001*	1.027 (0.975-1.082)	0.313
mGCC parameters (mm)				
Inner Average	1.056 (0.988-1.128)	0.109	1.049 (0.979-1.124)	0.175
Superior	1.056 (0.991-1.126)	0.091	1.041 (0.974-1.112)	0.235
Inferior	1.046 (0.983-1.113)	0.152	1.049 (0.983-1.119)	0.146
GCC FLV (%)	0.860 (0.723-1.022)	0.087	0.958 (0.781-1.175)	0.681
GCC GLV (%)	0.933 (0.855-1.019)	0.122	0.950 (0.865-1.044)	0.290

OCT=optical coherence tomography; VA=Visual acuity; VF=Visual field; BCVA= Best corrected visual acuity; MD=mean deviation; cpRNFL=circumpapillary retinal nerve fiber layer; mGCL=macular ganglion cell layer; GLV=Global loss volume; FLV=Focal loss volume; The asterisk indicates statistical significance, P<0.05

Figures

Figure 1

Flow chart demonstrating the inclusion/exclusion criteria used in the selection process. OCT=optical coherence tomography; VF=visual field.

Figure 2

Adhesion strength between craniopharyngioma and optic nerves was intraoperatively evaluated. K, L and M: No or loose adhesion. Contrast-enhanced T1-weighted MRI scans (A, F) showing an intrinsic third ventricular solid tumor compressing forward the optic chiasm. Intraoperative view (K) revealing that the proximal part of the pituitary stalk extending from the gland could be identified as intact and at a normal size before tumor resection. Preoperative MRI scans (B, C, G, H) showing a sellar-suprasellar /suprasellar cystic-solid tumor stretching upward the optic chiasm. Surgical view (L, M) showing the tumor can be easily separated from the optic nerves by dissector. N and O: Tight adhesion. Preoperative MRI scans (D, E, I, J) showing sellar-suprasellar cystic-solid tumors displacing the optic chiasm. Intraoperative video-captured photographs (N, O) showing tight adhesion between the tumor and the optic apparatus needing sharp dissection using scissors. OC=optic chiasma; ON=optic nerve; T= tumor; PG=pituitary gland; PS=pituitary stalk; SHA=superior hypophyseal artery; ACA= anterior cerebral artery; ACoA= anterior communicating artery.

Figure 3

Univariate and multivariate logistic regression analyses were used to evaluate the predictive factors for visual prognosis following surgery for craniopharyngiomas. The black squares indicate the OR values, error bars represent 95% CIs, and * $P < 0.05$. According to the analysis, increased temporal (A) and inferior (B) cpRNFL were favorable factors for postoperative visual acuity and visual field, respectively. Tight adhesion was an adverse factor for visual recovery. cpRNFL=circumpapillary retinal nerve fiber layer; BCVA=best corrected visual acuity; MD=mean deviation.

Figure 4

A 46-year-old female patient who underwent extended endoscopic endonasal surgery for craniopharyngiomas was evaluated before and three months after surgery. Preoperative MRI scans (A, B) reveals a suprasellar cystic-solid tumor involving the third ventricle compressing the optic chiasma. Preoperative visual field test showed mostly temporal visual field defects in both eyes. Preoperative OCT demonstrated decreased cpRNFL temporal thickness in right eye. Total removal of the tumor (C, D) led to the dramatic improvement of visual field and deterioration of visual acuity in both eyes confirmed by postoperative phthlalmologic examination. OCT=Optical coherence tomography; cpRNFL=circumpapillary retinal nerve fiber layer; BCVA=best corrected visual acuity; MD=mean deviation.

Figure 5

A 59-year-old male patient who underwent surgery for craniopharyngiomas was examined preoperatively and three months after surgery. Contrast-enhanced T1-weighted MRI scans (A, B) suggested a suprasellar cystic-solid lesion compressing downward the optic chiasma. Preoperative Humphrey visual field test showed mainly temporal visual field defects in both eyes. Preoperative OCT suggested normal cpRNFL thickness in both eyes. After total resection of the tumor (C, D), the optic nerves were sufficiently decompressed, the visual acuity and visual field in both eyes dramatically improved after surgery. OCT=Optical coherence tomography; cpRNFL=circumpapillary retinal nerve fiber layer; BCVA=best corrected visual acuity; MD=mean deviation.

Figure 6

Receiver operating characteristic (ROC) curves for the discriminative performance of the multivariable prediction models developed for visual prognosis.