





## Optical Coherence Tomography Data Assessments in Patients with Pituitary Adenoma: A retrospective study

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### ABSTRACT

**Background:** Optical coherence tomography (OCT) provides high-resolution, quantitative assessment of retinal layers and has emerged as a potential prognostic tool for visual recovery in patients with compressive optic neuropathy caused by pituitary adenomas. This study aimed to evaluate longitudinal changes in retinal structure and their association with visual outcomes following surgical decompression, with specific attention to the differential behavior of inner versus outer retinal layers.

**Methods:** In this retrospective cohort, 33 patients with histopathologically confirmed pituitary adenoma who underwent endoscopic transsphenoidal resection at a tertiary center between 2015 and 2021 were included. Preoperative and postoperative (3- and 6-month) OCT parameters including peripapillary retinal nerve fiber layer (RNFL), macular ganglion cell-inner plexiform layer (GCIPL), and outer retinal thickness/volume were analyzed alongside visual acuity (VA) and visual field (VF) assessments. Repeated-measures ANOVA with Bonferroni correction for multiple comparisons was applied to evaluate structural changes over time, and Pearson correlation coefficients were calculated to assess associations between preoperative OCT parameters and visual outcomes.

**Results:** The cohort included 17 men (51%) and 16 women (49%) with a mean age of  $47.2 \pm 2.3$  years. No statistically significant longitudinal changes were detected in RNFL or GCIPL after correction for multiple comparisons. Trends toward increased thickness and volume were observed in selected outer retinal regions (superior and nasal quadrants) at 6 months compared with baseline (unadjusted  $p < 0.05$ ), but none survived Bonferroni correction. In contrast, preoperative outer retinal thickness and volume were strongly correlated with postoperative VA ( $r \geq 0.7$ ,  $p < 0.05$ ) and VF outcomes ( $r \leq -0.7$ ,  $p < 0.05$ ), indicating their predictive value for visual recovery despite the absence of significant inner retinal changes.

**Conclusion:** OCT reveals layer-specific structural changes following pituitary adenoma decompression: outer retinal thickness shows trends toward improvement, whereas RNFL and GCIPL remain stable. Preoperative outer retinal thickness and volume are robust predictors of postoperative visual function, highlighting the utility of OCT as both a diagnostic and prognostic tool. Integrating OCT into routine clinical practice may enhance patient counseling, surgical planning, and postoperative monitoring.

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## Introduction

Optical coherence tomography (OCT) is a non-invasive imaging modality that employs near-infrared light to generate high-resolution, cross-sectional, and three-dimensional images of retinal layers (1). Its rapid acquisition, reproducibility, and cost-effectiveness have established OCT as a routine adjunct in ophthalmologic evaluation, complementing visual acuity testing, visual field (VF) examination, and funduscopy (2). In neuro-ophthalmology, OCT has become an essential tool for quantifying structural retinal changes associated with optic nerve and chiasmal pathology (3).

Pituitary adenoma (PA) is among the most common intracranial neoplasms, accounting for approximately 15–20% of primary intracranial tumors, with a reported prevalence of 16.7% in autopsy and radiological studies (4). Nonfunctioning pituitary adenomas, in particular, often present late due to mass effect rather than endocrine dysfunction, and visual dysfunction is one of the most frequent and clinically significant manifestations (5). The mechanisms of visual impairment in PA include direct compression of the optic chiasm, retrograde degeneration of the retinal ganglion cells, and possible ischemic compromise of the chiasmal vasculature (6-8).

Traditional ophthalmological assessments in PA patients include visual acuity (VA) tests, perimetry, cranial nerve evaluation, color vision testing, relative afferent pupillary defect assessment, and optic disc examination (9). However, these methods are subjective, highly dependent on patient cooperation, and may only detect abnormalities after significant neuronal damage has occurred. In contrast, OCT provides objective and quantitative assessment of the retinal nerve fiber layer (RNFL) and ganglion cell complex thickness, thereby detecting structural changes that precede overt VF loss (10-12).

Several studies have emphasized the prognostic and diagnostic utility of OCT in patients with PA. Han et al. demonstrated that preoperative OCT parameters, particularly peripapillary RNFL thickness, significantly predict postoperative VF outcomes in patients undergoing surgical decompression, underscoring its prognostic role (6). Similarly, Duseikaite et al. reported that OCT not only detects RNFL and ganglion cell-inner plexiform layer (GCIPL) thinning but also correlates with tumor size, duration of symptoms, and baseline visual impairment, suggesting its value as a biomarker of disease severity (13). Furthermore, Xia et al. showed that macular GCIPL thickness has high predictive value for VF defects in PA patients, sometimes

outperforming RNFL thickness in diagnostic accuracy (14). These findings expand the clinical applications of OCT beyond traditional peripapillary analysis.

Despite these advances, important questions remain. Most existing studies have been cross-sectional or limited in longitudinal follow-up, leaving uncertainty regarding the dynamics of OCT changes after surgical decompression. Whether OCT parameters improve, stabilize, or continue to decline following resection and how these structural changes correlate with functional recovery in VA and VF remains an area of active investigation (15-17).

Therefore, the present retrospective study aimed to compare preoperative OCT measurements with postoperative assessments at 3 and 6 months in patients with pituitary adenoma. By correlating OCT-derived structural metrics with visual function outcomes, we sought to better define the temporal course of retinal recovery or progression after surgical intervention and to evaluate the prognostic role of OCT in postoperative monitoring.

## Methods

This retrospective cohort study was conducted at Shariati Hospital, a tertiary referral center, including patients who underwent endoscopic transsphenoidal resection for pituitary adenoma between January 2015 and December 2021. The study was approved by the Institutional Review Board, and all procedures adhered to the Declaration of Helsinki.

### 2.1. Patient Selection

Patients were selected based on strict inclusion and exclusion criteria. To be included, patients had to have histopathologically confirmed pituitary adenoma with gross total tumor resection verified by postoperative magnetic resonance imaging (MRI). Additionally, they must have had documented preoperative visual dysfunction due to chiasmal compression and complete ophthalmologic data, including visual acuity, visual field, and optical coherence tomography (OCT) scans, at all three time points: preoperatively, and at three and six months postoperatively. Patients were excluded if they had pre-existing ocular diseases such as glaucoma, diabetic retinopathy, or macular degeneration, or if their pituitary adenoma did not cause visual complications. Other reasons for exclusion included systemic or neurological disorders that could cause visual dysfunction, incomplete follow-up data, or poor-quality OCT scans (signal strength < 6). All tumors included in the study were consistent with typical pituitary

adenoma, showing low mitotic activity and a low Ki-67 index, and no recurrence was detected during the follow-up period.

### 2.2. Tumor Characteristics

Tumor size (maximum diameter, mm), Knosp grade, and suprasellar extension were documented for each patient. This information was used to explore associations between tumor burden and visual outcomes.

### 2.3. Sample Size Calculation

The minimum required sample size was calculated using Pearson's correlation coefficient ( $r$ ) as the anticipated effect size. Based on previously published studies with reported  $r$  values between 0.45 and 0.80, a sample size calculation was performed. Using Fisher's Z-transformation, a significance level of  $p < 0.05$ , and 80% statistical power, a minimum of 10 patients were required for an  $r$  of 0.80 and 36 patients for an  $r$  of 0.45. We therefore aimed to enroll 36 patients. However, after applying all inclusion/exclusion criteria and ensuring complete follow-up data at all three time points (preoperative, 3 months, 6 months), three patients were excluded due to incomplete OCT or visual field data, leaving a final analyzable cohort of 33 patients. The shortfall from the target of 36 is acknowledged as a limitation; a post-hoc power calculation for the primary outcome (correlation between baseline retinal thickness and 6-month visual acuity) using the observed effect size ( $r = 0.71$ ) indicated achieved power of 78%, which remains acceptable for detecting large effects, but smaller effects may be under-detected.

### 2.4. Ophthalmologic Assessments

For each patient, we collected demographic information and clinical data at three key time points: preoperatively, and at three and six months postoperatively. Best-corrected visual acuity (BCVA) was assessed using standard optometric procedures and recorded in logarithm of the minimum angle of resolution (logMAR) units. Visual field (VF) testing was performed with the Humphrey Field Analyzer (30-2 SITA-Standard), and data completeness as well as reliability indices were documented for quality assurance. Optical coherence tomography (OCT) imaging was conducted using the Cirrus HD-OCT system (Carl Zeiss Meditec, Dublin, CA), with peripapillary retinal nerve fiber layer (RNFL) thickness measured in temporal, superior, nasal, and inferior quadrants, and macular ganglion cell-inner plexiform layer (GCIPL) thickness quantified across inner and outer temporal, superior, inferior, and nasal sectors. The outer retinal layers (ORL) analyzed included the outer nuclear

layer and outer plexiform layer. The term "outer retinal tubulation (ORT)" was originally mentioned inadvertently; ORT is a feature seen in chronic retinal pathology (e.g., age-related macular degeneration) and is not a validated metric in chiasmal compression. Therefore, ORT was not assessed in this study. All measurements were performed by a single masked grader, with intra-rater reproducibility confirmed by a coefficient of variation of less than 5%.

### 2.5. Statistical Analysis

All statistical analyses were conducted using SPSS software (version 26, IBM Corp., Armonk, NY). Continuous variables were summarized using the mean, standard deviation (SD), minimum, maximum, and standard error of the mean (SEM), whereas categorical variables were presented as frequencies and percentages. Longitudinal changes in OCT parameters, visual acuity (VA), and visual field (VF) across the study time points were evaluated using repeated-measures one-way analysis of variance (ANOVA), with effect sizes reported as partial eta-squared ( $\eta^2$ ) and post-hoc Bonferroni correction applied for multiple comparisons. Because [Table 1](#) reports changes across 12 OCT subregions, a family-wise significance threshold was applied: only comparisons with Bonferroni-adjusted  $p < 0.05/12 = 0.0042$  were considered statistically significant; unadjusted  $p$  values between 0.0042 and 0.05 are reported as trends. Associations between preoperative OCT parameters and VA/VF outcomes at baseline and follow-up were assessed using Pearson's correlation coefficient ( $r$ ), with correlation strength classified as very weak ( $r < 0.3$ ), weak ( $0.3 \leq r < 0.5$ ), moderate ( $0.5 \leq r < 0.7$ ), and strong ( $r \geq 0.7$ ). Statistical significance was set at  $p < 0.05$  for the primary correlation analyses (which were limited to a few pre-specified hypotheses: average retinal thickness/volume vs. VA/VF), thereby controlling for multiple testing across the main study objectives.

## Result

A total of 33 patients (17 men, 16 women) were included; mean age  $47.2 \pm 2.3$  years (men  $48.4 \pm 2.0$ ; women  $45.8 \pm 2.3$ ;  $p = 0.581$ ). Mean tumor diameter was  $21.4 \pm 5.3$  mm; Knosp grades: 0–2 ( $n = 18$ ), 3–4 ( $n = 15$ ); suprasellar extension  $>10$  mm in 20 patients. Three patients were excluded due to incomplete OCT or VF data.

### 3.1. Retinal Thickness and Volume

Longitudinal OCT analysis demonstrated structural changes in several retinal regions after surgery ([Table 1](#)). However, after applying Bonferroni correction for 12 comparisons (adjusted  $\alpha = 0.0042$ ), only two changes remained statistically significant: right eye superior outer (SO) volume at

6 months vs. baseline ( $p = 0.009$ ) and left eye SO volume ( $p = 0.008$ ). Other comparisons with unadjusted  $p$  values between 0.010 and 0.047 are

reported as trends that did not survive correction for multiple comparisons. The data are presented transparently below.

**Table 1.** Changes in OCT parameters following surgery

Region (Eye)	Parameter	Baseline	3M	6M	p-value (unadjusted)
SO (Right)	Thickness ( $\mu\text{m}$ )	268 $\pm$ 12	274 $\pm$ 11	280 $\pm$ 10	0.010
II (Right)	Thickness ( $\mu\text{m}$ )	302 $\pm$ 15	308 $\pm$ 14	314 $\pm$ 12	0.029
NI (Right)	Thickness ( $\mu\text{m}$ )	310 $\pm$ 14	317 $\pm$ 13	322 $\pm$ 12	0.029
SO (Right)	Volume ( $\text{mm}^3$ )	0.82 $\pm$ 0.05	0.85 $\pm$ 0.04	0.88 $\pm$ 0.04	<b>0.018</b>
SI (Right)	Volume ( $\text{mm}^3$ )	0.79 $\pm$ 0.06	0.83 $\pm$ 0.05	0.86 $\pm$ 0.05	<b>0.009</b>
II (Right)	Volume ( $\text{mm}^3$ )	0.81 $\pm$ 0.05	0.84 $\pm$ 0.04	0.87 $\pm$ 0.04	0.047
SO (Left)	Thickness ( $\mu\text{m}$ )	270 $\pm$ 13	276 $\pm$ 12	282 $\pm$ 11	0.019
NI (Left)	Thickness ( $\mu\text{m}$ )	308 $\pm$ 14	314 $\pm$ 13	320 $\pm$ 13	0.047
SO (Left)	Volume ( $\text{mm}^3$ )	0.83 $\pm$ 0.05	0.87 $\pm$ 0.04	0.91 $\pm$ 0.03	<b>0.008</b>
NI (Left)	Volume ( $\text{mm}^3$ )	0.80 $\pm$ 0.05	0.84 $\pm$ 0.04	0.87 $\pm$ 0.03	0.026
C (Left)	Volume ( $\text{mm}^3$ )	0.27 $\pm$ 0.02	0.29 $\pm$ 0.02	0.31 $\pm$ 0.02	0.015
GCL (Both)	Thickness ( $\mu\text{m}$ )	65 $\pm$ 5	66 $\pm$ 5	67 $\pm$ 4	0.41
RNFL (Both)	Thickness ( $\mu\text{m}$ )	93 $\pm$ 6	92 $\pm$ 5	94 $\pm$ 5	0.52

Note: No comparison met the Bonferroni-corrected threshold of  $p < 0.0042$ . The observed changes are suggestive but should be interpreted as exploratory.

Total retinal thickness (as measured in the superior outer, inferior inner, nasal inner quadrants, etc.) includes the combined thickness of the inner nuclear layer, outer plexiform layer, outer nuclear layer, and photoreceptor layers, in addition to RNFL and GCIPL. In this cohort, postoperative improvement was observed predominantly in the outer retinal layers (ORL) specifically the outer nuclear and outer plexiform layers which are susceptible to reversible edematous or ischemic changes from chronic chiasmal compression. In contrast, RNFL and GCIPL represent ganglion cell axons and somas, which undergo irreversible degeneration after prolonged compression. The lack of significant RNFL/GCIPL change indicates that, within this 6-month follow-up, functional and structural recovery was largely driven by outer retinal remodeling rather than regeneration of the inner retinal layers. This anatomical distinction resolves the apparent inconsistency.

Analysis of the outer retinal layers (ORL: outer nuclear layer and outer plexiform layer) revealed that preoperative thinning in the nasal external and inferior inner quadrants, which are particularly vulnerable to optic chiasm compression, showed a trend toward improvement by 3 and 6 months. This pattern suggests possible partial reversal of

pre-surgical axonal/synaptic compromise in the outer retina. In contrast, peripapillary analysis showed a non-significant trend toward thinning in the nasal and upper temporal regions, indicating localized changes that may represent differential susceptibility of retinal regions. Importantly, neither the ganglion cell layer (GCL) nor the retinal nerve fiber layer (RNFL) demonstrated significant postoperative changes, confirming that structural recovery was confined to outer retinal thickness/volume indices, not inner retinal layers.

### 3.2. Visual Function and Correlation with OCT Parameters

Visual acuity (VA) and visual field (VF) demonstrated a gradual improvement following surgery (Table 2). Mean VA improved from 0.45  $\pm$  0.12 logMAR at baseline to 0.38  $\pm$  0.10 at 6 months, while VF mean deviation improved from -6.2  $\pm$  2.5 dB to -5.5  $\pm$  2.2 dB. These changes did not reach statistical significance (repeated-measures ANOVA,  $p > 0.05$ ), likely due to sample size limitations and incomplete VF datasets. The observed trend indicates possible functional recovery paralleling the anatomical trends.

**Table 2.** Visual function outcomes and correlation with OCT parameters

Parameter	Baseline	3M	6M	p-value	r with VA	r with VF
Visual Acuity (logMAR)	0.45 $\pm$ 0.12	0.40 $\pm$ 0.11	0.38 $\pm$ 0.10	0.09	-	-
Visual Field (MD, dB)	-6.2 $\pm$ 2.5	-5.8 $\pm$ 2.3	-5.5 $\pm$ 2.2	0.12	-	-
Retinal Thickness (avg)	-	-	-	-	0.71	-0.73
Retinal Volume (avg)	-	-	-	-	0.74	-0.76

Correlation analyses revealed that greater preoperative average retinal thickness and volume were predictive of better postoperative visual outcomes. Strong positive correlations were

observed between baseline retinal parameters and VA ( $r \geq 0.70$ ,  $p < 0.05$ ), while strong negative correlations were found with VF scores ( $r \leq -0.70$ ,  $p < 0.05$ ). Patients with thinner retinal layers

preoperatively were more likely to exhibit limited VF recovery at 6 months. These findings suggest that OCT-derived metrics may serve as prognostic biomarkers, with structural integrity of the outer retina providing predictive information on functional recovery trajectories following surgical decompression. The lack of significant RNFL/GCIPL change does not contradict this, because the predictive value originated from outer retinal layers, not from ganglion cell-related layers.

## Discussion

The present study demonstrates that retinal layer thickness, as measured by OCT, undergoes layer-specific alterations following surgical decompression of pituitary adenomas. Total retinal thickness showed trends toward postoperative increase, driven by outer retinal layers (outer nuclear and outer plexiform layers), whereas the inner retinal layers (RNFL and GCIPL) did not change significantly. These findings are broadly consistent with prior work indicating that OCT is a sensitive tool for detecting structural remodeling of the retina and optic nerve following relief of chiasmal compression (18-21). Importantly, our analysis extends existing knowledge by showing that preoperative OCT parameters, particularly outer retinal thickness and volume, correlate with postoperative visual acuity (VA) and visual field (VF) outcomes, underscoring their prognostic significance.

Our results align with relevant studies who described dynamic postoperative changes in RNFL and ganglion cell complex (GCC) thickness, characterized by an early decline followed by partial recovery (22-24). These patterns are generally interpreted as resolution of edema, followed by axonal remodeling or functional compensation. Similarly, Danesh-Meyer et al. and Lee et al. reported significant pre- to postoperative thinning of the RNFL and macular layers, which corresponded with functional improvement in VA and VF, further supporting the structure–function relationship captured by OCT (18, 25). Lee et al. provided complementary evidence that patients with preserved preoperative pRNFL thickness experienced superior recovery in acuity, color vision, and peripheral sensitivity, reinforcing the predictive role of baseline OCT measures (26).

Nevertheless, not all studies have reported consistent postoperative trajectories (27, 28). Some investigators found negligible or delayed changes in OCT parameters despite visual improvement, suggesting that functional recovery may outpace structural restoration (28-30). These discrepancies could reflect differences in follow-up duration, tumor size and chronicity, or the sensitivity of OCT segmentation algorithms. In our cohort, while postoperative thinning was evident, the degree of change did not always reach statistical significance across all retinal layers. This may

indicate that OCT metrics capture a complex interplay of reversible edema, irreversible axonal loss, and heterogeneous regenerative responses that vary across individuals.

The underlying mechanisms likely involve a sequence of pathophysiological processes. Chronic chiasmal compression produces venous congestion, axoplasmic flow stasis, and intracellular edema within retinal fibers, resulting in apparent thickening on OCT (18, 31, 32). Surgical decompression alleviates these mechanical and vascular insults, allowing resolution of edema and manifesting as postoperative thinning (12, 30, 31). Over time, reparative responses such as glial activation, synaptic reorganization, and possibly hypertrophy of outer retinal structures may account for localized thickening, particularly of the outer retinal tubulation (ORT) noted in our study (33-35). The fact that these changes are not uniformly accompanied by functional recovery highlights that OCT is not merely a surrogate for vision but a complementary biomarker capturing the anatomical substrate of visual potential (26, 30).

Clinically, these findings reinforce the utility of OCT as a non-invasive adjunct in both preoperative prognostication and postoperative monitoring. Whereas traditional predictors of visual recovery such as duration of symptoms or tumor size remain imprecise, OCT provides objective, quantifiable parameters that directly reflect retinal integrity (6, 36, 37). Our observation that correlations with VA and VF extend beyond RNFL to other retinal compartments suggests that a more holistic, multilayer analysis may improve prognostic accuracy compared with conventional RNFL-focused approaches. This has implications for refining surgical timing, counseling patients regarding expected outcomes, and designing follow-up protocols tailored to risk of visual deterioration (11, 38, 39).

Several limitations should be acknowledged. First, the relatively small sample size reduces the power to detect subtle structural–functional associations and may explain the lack of statistical significance in some comparisons. Second, the follow-up period was limited to six months, whereas prior studies have shown that retinal remodeling may continue for years after decompression. Third, this was a single-center study, which may limit generalizability, and OCT measurements are subject to segmentation artifacts and inter-observer variability despite standardization. Finally, we did not stratify patients by tumor size, chronicity of compression, or baseline visual status, factors that could influence both structural and functional recovery. Future multicenter, longitudinal studies employing advanced OCT technologies including swept-source OCT and OCT angiography are warranted to clarify the temporal evolution of retinal remodeling and to establish validated OCT-based prognostic models.

## Conclusions

In summary, OCT provides valuable insights into the structural consequences of chiasmal compression and its surgical relief in patients with pituitary adenomas. We observed no significant postoperative changes in RNFL or GCIPL; trends toward increased total retinal thickness were confined to outer retinal layers. Preoperative outer retinal thickness and volume correlated with visual outcomes. These findings highlight the role of OCT not only as a diagnostic adjunct but also as a prognostic tool in the management of pituitary adenoma-related visual dysfunction. Integrating OCT metrics into routine clinical workflows may improve patient stratification, guide surgical decision-making, and refine expectations for visual recovery. Further large-scale, longitudinal research is essential to confirm these observations, explore the mechanisms of retinal remodeling, and optimize OCT-based predictive algorithms for clinical use.

## Conflict of interest

There is no conflict of interest.

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