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CASE REPORT AND LITERATURE REVIEW

Visual Prognostic Factors in Surgery of Tubercule Sellae Meningiomas

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Abstract

Background: Meningiomas of the tuberculum sellae account for 8% of all meningiomas operated on in our department. Visual acuity deterioration is the primary symptom, and the surgical goal is the removal of the meningioma while preserving or improving visual acuity. The objective of this study is to evaluate the factors influencing the postoperative visual prognosis of tuberculum sellae meningiomas operated on via the lateral supraorbital approach.

Methods: This is a retrospective study of patients operated on for TS meningioma, conducted in the Department of Neurosurgery at Dr. Benbadis University Hospital in Constantine, Algeria. All patients were evaluated by an ophthalmologist before and after surgery. MRI is used to study tumor size, tumor extension and tumor relationships with vessels of the anterior part of the polygon of Willis. It also provides postoperative evaluation of the quality of resection and follow-up of tumor residue. The different factors we will be studying are duration of visual impairment, degree of visual loss at time of diagnosis, funduscopic examination and existence of optic atrophy, tumor size, intraoperative optic nerve appearance, tumor extension into the optic canal and tumor resection quality.

Results: We report a retrospective study of 16 patients operated on for TS Meningioma during the period from September 2019 until May 2023. The findings highlighted several factors, particularly preoperative ones: Visual acuity impairment was observed in 93.75% of patients at the time of diagnosis. The average duration of visual acuity decline was 31.5 months. Tumor size was between 20 and 40 mm in 75% of cases, and larger than 40 mm in 18.75% of cases. Postoperatively: Visual acuity improved in 62.5% of patients. Total tumor resection was achieved in 75% of cases. In one patient, subtotal resection was performed due to tumor infiltration of the A1 segment of the anterior cerebral artery, which was completely involved by the tumor.

Conclusion: The prognostic factors for visual outcome in TSM surgery remain controversial. The aim of surgery is to achieve improvement of vision. The key to preserving visual function is to minimize direct manipulation of the optic nerves and avoid injury to the blood supply to the optic apparatus.

Keywords

Visual acuity, LSO, Improvement of vision, Blood supply

Abbreviations

TSM: Tuberculum Sellae Meningioma; LSO: Lateral Supraorbital Approach; ICA: Internal Carotid Artery; ACA: Anterior Cerebral Artery

Introduction

Tubercule sellae meningiomas (TSM) represent 5 to 10% of all intracranial meningiomas [1-3]. They insert on the tubercule sellae and grow into the interoptic space, laterally displacing the optic nerves and with the possibility of extension into the optic canal. It is in intimate contact with the internal carotid arteries, the anterior cerebral artery and the anterior communicating artery. These anatomical relationships explain its visual clinical symptomatology and surgical difficulties. Various surgical approaches have been described, including uni or bilateral subfrontal, lateral supraorbital, fronto-pterional and endoscopic endonasal approaches.

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We performed surgery for 24 patients with TS meningioma using the LSO appraoch. We examine preoperative and intraoperative prognostic factors that may influence postoperative visual function outcomes.

Materials

We report a retrospective study of 16 patients operated on for a TS Meningioma during the period from September 2019 until May 2023, at the neurosurgery department of Dr Benbadis university hospital in Constantine, Algeria.

All patients were evaluated by an ophthalmologist before and after surgery. The optic nerve examination consists of an assessment of visual acuity, a visual field, and a funduscopic examination.

MRI is used to study tumour size, tumor extension and tumor relationships with vessels of the anterior part of the polygon of Willis, it also provides postoperative evaluation of the quality of resection and follow-up of tumor residue. A brain CT scan was performed immediately after surgery to eliminate possible complications.

The different factors we will be studying are:

- Duration of visual impairment
- Degree of visual loss at time of diagnosis
- Funduscopic examination and existence of optic atrophy
- Tumor size
- Intraoperative optic nerve appearance
- Tumor extension into the optic canal

All our patients were operated via the lateral supraorbital approach (LSO). The patient was placed in a supine position. The patient's head was rotated to the contralateral side at a 10- to 20-degree angle. We operate on the side with the most severe vision loss. A slight extension of the head was performed to allow the frontal lobe to move away from the frontal base, which will decrease the retraction of the brain during surgery. Only the upper anterior part of the temporalis muscle was split and retracted (Figure 1). A burr hole was placed just posterior to the anterior temporal line and a craniotomy of 3 × 4 cm was performed. The lateral border of the frontal sinus had to be considered during craniotomy. The inner edge of the supraorbital bone was drilled to facilitate frontal lobe retraction (Figure 1B). The dura was opened under the operating microscope, and the frontal lobe was retracted slightly. At this point, the olfactory nerve was dissected and left free. After that the carotid cistern was located and opening the arachnoid at this level allows the flow of CSL. Gradually CSF aspiration achieves brain decompression. The identification of optic nerve depends on the tumor volume. Two situations are possible: Firstly, optic nerve is visible, displaced laterally by the tumor (Figure 2A). In the second situation, the optic nerve is challenging to identify (Figure 2B). When the optic nerve cannot be identified, the optic canal is opened with a section of the falciform ligament. This maneuver facilitates the identification and mobilization of the optic nerve, exposure of the carotid artery, and allows for the resection of the intracanalicular extension of the meningioma. Tumor resection involves alternating between intratumoral debulking and capsule dissection. The small perforator arteries to the optic structures (Figure 3) and pituitary stalk must be preserved.

Results

Epidemiological characteristics

During the period from September 2019 until May 2023, 200 meningiomas were surgically treated, of which 16 (8%) were TS meningiomas. The mean patient age was 54 years (range 39-74 years). The sex ratio was 4.33 (13w/3m). The mean duration of symptoms was 12 months (range from 3 to 36 months).

Clinical manifestations

Clinical symptomatology was dominated by visual acuity deterioration in 15 cases (93.75 %): It was

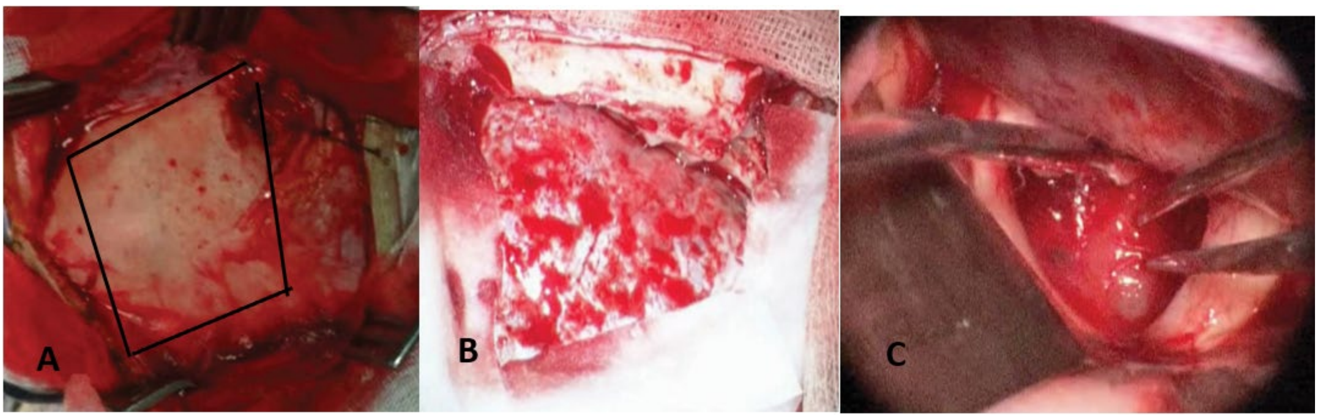

Figure 1: The lateral supraorbital approach on the right side: (A) Demonstrates the detachment of the temporal muscle limited to the external orbital rim and approximately one centimeter of the superior temporal line; (B) The bone flap is outlined to closely follow the roof of the orbit; (C) Highlights the angle of exposure of the tuberculum sellae region at the end of surgery.

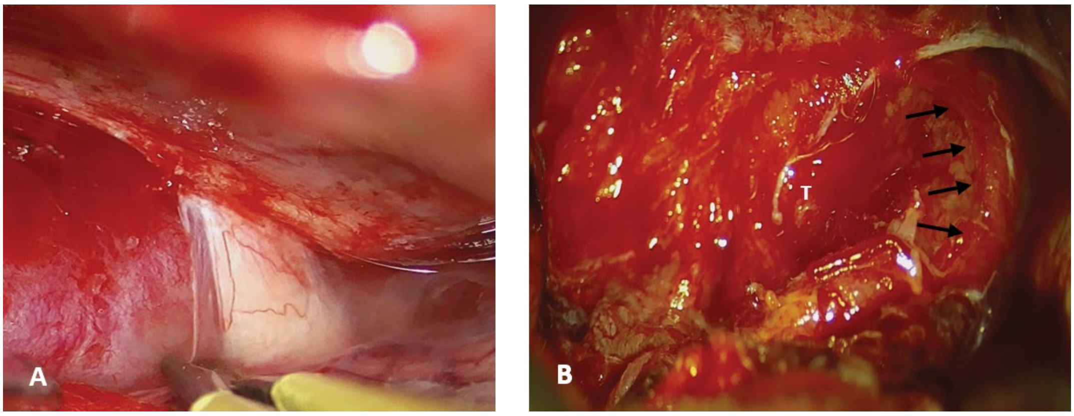

Figure 2: Meningioma of the tuberculum sellae operated via the lateral supraorbital approach: Intraoperative view of the optic nerve during tumor exposure. (A) The optic nerve was displaced outward by the tumor but remains easily identifiable; (B) The nerve appears laminated and pale, difficult to identify.

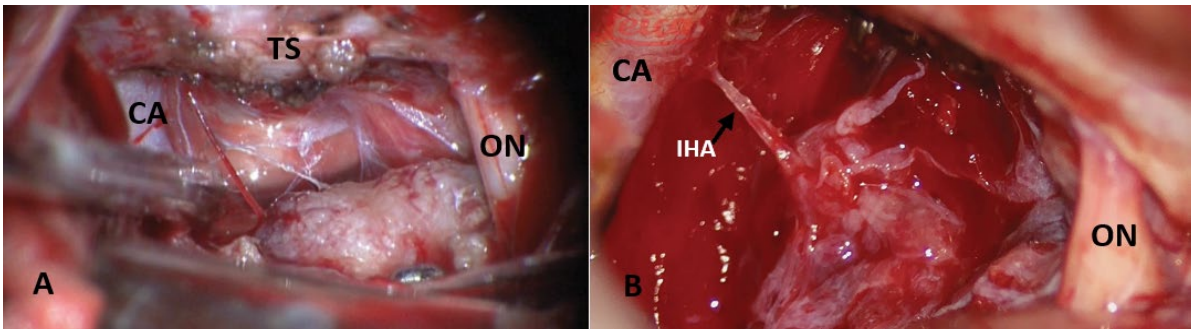

Figure 3: Meningiomas of the tuberculum sellae operated via the lateral supraorbital approach. **In Figure A**, the preservation of the pial vasculature supplying the optic apparatus is demonstrated, which is crucial to maintain. **In Figure B**, the preservation of the inferior hypophyseal artery, a branch of the internal carotid artery that also contributes to the vascularization of the optic apparatus, is shown.

TS: Tuberculum Sellae; CA: Carotid Artery; ON: Optic Nerve; IAH: Inferior Hypophyseal Artery

unilateral in 05 cases (31.25%) and bilateral in 10 cases (62.5%). Unilateral blindness was present in 4 patients. At the time of diagnosis, 06 patients (37.5%) had optic atrophy and 03 (18.5%) had Fooster kennedy syndrome.

The average duration of preoperative visual deficit was 31.5 months (range from 3 to 60 months).

Visual field defects were present in 10 patients; 06 of patients have bitemporal hemianopia and 04 have quadrianopia. No patient was presented with endocrine disorders preoperatively.

Imaging

Magnetic resonance imaging (MRI) was performed on all patients. MRI is performed to study tumor size and intra-orbital extension. Tumor size was classified according to the Hernesniemi classification [4] in Small Tumor < 2 cm: 01 cases, Medium Tumor 2-4 cm: 12 cases and large tumor > 4 cm: 03 cases.

The vascular sequence studies the tumor's relationship with the internal carotid arteries, A1 segments and the anterior communicating artery. In 15 cases, the internal carotid artery (ICA) is classically displaced laterally and the 2 A1 segments of the anterior cerebral artery (ACA) superiorly. We encountered a single case of vascular involvement.

Intraoperative findings

The intraoperative appearance of the optic nerve can vary (Figure 2). In 12 cases the optic nerve was displaced outward by the tumor but remains easily identifiable (Figure 2A). In 04 cases, the nerve appears laminated and pale, difficult to identify (Figure 2B). In this situation, the optic canal is opened with a section of the falciform ligament.

Surgical resection was total (GTR) in 12 cases (75%), near total (NTR) in 03 cases (18.75%), and subtotal in 01 case (6.25%). Resection was subtotal in 01 patient due to vascular involvement, specifically tumor encasement of carotid artery and both A1 segment of the anterior cerebral arteries (Figure 4).

The pituitary stalk is always separated from the tumor by an arachnoid plane and is never encompassed by the tumor in all our cases.

Postoperative visual outcome (Table 1)

Visual acuity: Visual acuity was improved in 10 patients, remained unchanged in 04 patients, and

Table 1: Outcome of visual function shown as postoperative development of the Visual Impairment Score in relation to the duration and quality of preoperative visual symptoms, and tumor size.

Patient	Sex	Age	Duration of symptoms, Month	Preoperative visual deficit	Size mm	Quality of resection	Outcome
B.S	W	54y	03	L 3/10, R 5/10	< 20	GTR	Improved
A.H	m	39y	12	L < 1/10, R 10/10	20-40	GTR	Improved
K.M	W	71y	18	L 3/10, R < 1/10	20-40	GTR	Improved
M.D	W	55y	24	L 5/10, R 10/10	20-40	GRT	Improved
K.M	w	40y	08	L 3/10, R 2/10	> 40	GRT	Improved
M.R	w	74y	12	L < 1/10, R 0/10	20-40	GRT	Improved
R.L.O	M	40y	06	L < 10/10, R 1/10	20-40	GRT	Improved
T.N	w	51y	10	L < 10/10, R < 1/10	> 40	GRT	Unchanged
B.F	w	55y	04	L < 1/10, R 5/10	20-40	GTR	Improved
A.H	m	61y	60	L < 1/10, R 3/10	20-40	GTR	Unchanged
B.S	w	44m	24	L < 1/10, R 0/10	20-40	GTR	Worsened
B.A	w	51y	12	L 1/10, R 1/10	20-40	GTR	Improved
B.Y	w	47y	36	L 1/10, R 1/10	> 40	STR	Worsened
S.DJ	W	40	18	L 3/10, R 1/10	20-40	GTR	Unchanged
K.W	W	42	10	L 1/10, R 7/10	20-40	GTR	Improved
B.S	W	35	14	L 1/10, R 1/10	20-40	GTR	Unchanged

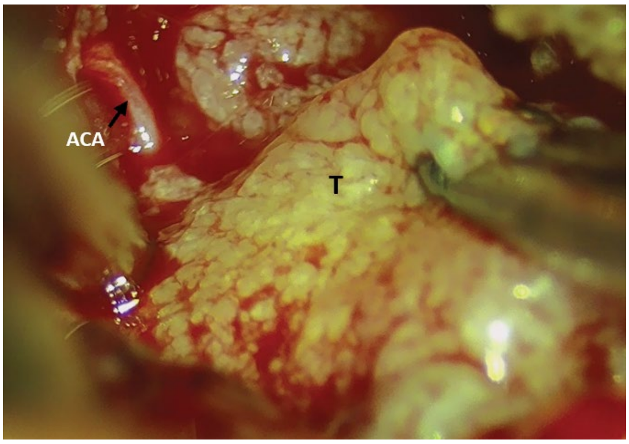

Figure 4: Meningiomas of the tuberculum sellae operated via the lateral supraorbital approach. Involvement of the A1 segment of the anterior cerebral artery by the tumor.

ACA: A1 segment of the anterior cerebral artery; T: Tumor

worsened in 02 patients. Among the 10 patients with preoperative visual field deficits, 7 showed postoperative improvement, 2 remained unchanged, and 1 experienced worsening of the visual field deficit.

Duration of preoperative visual deficit: In 09 patients with a short duration of symptoms less than 12 months, visual function improved in all cases. In 07 patients with a preoperative symptom duration of more than 12 months, in 03 patients' visual acuity remained unchanged, in 02 patient, visual acuity worsened and in 02 patients was improved.

Tumor size: In the patient with a tumor smaller than 2 cm, visual function significantly improved postoperatively. Among the 12 patients with tumors between 2 and 4 cm, visual function improved in 9 patients, remained unchanged in 3 patients. For the 3 patients with tumors larger than 4 cm, visual function worsened in 1 patient, while 2 patients showed no improvement.

Morbidity

The complications occurring in 05 patients were dominated by transient diabetes insipidus in 04 cases, which disappeared after 4 days, unilateral anosmia in 01 cases, and CSF leak in 01 cases, and seizure in 02 cases. There were no perioperative deaths.

Discussion

The prognostic factors for visual outcome in TSM surgery remain controversial. The aim of surgery is to achieve improvement of vision. Several factors have been studied:

Preoperative duration of visual symptom

The primary presenting symptom was a progressive visual loss (93.75% of cases) that was asymmetrical and had been progressive for 3 months to 26 months before the diagnosis.

Fahlbusch and Scott [5], in their study of 47 patients operated on for TS meningioma observed postoperative visual deterioration in patient with a history of symptoms lasting longer than 2 years (mean 5 years).

Prolonged compression of the optic nerve by the meningioma leads to ischemia, which can hinder favorable postoperative outcomes despite decompression. Zevgaridis, et al. [6], in their study

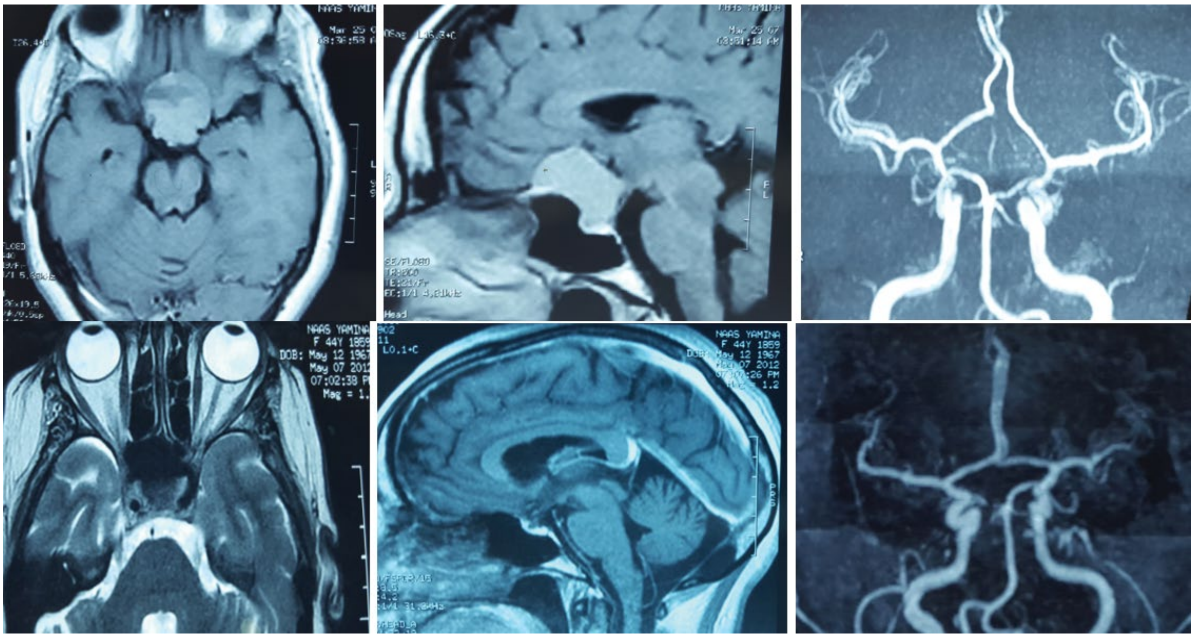

Figure 5: Pre and post-operative T1 weighted axial and coronal MRI scan with gadolinium enhancement showing a Great total resction of TSM operated via lateral supraorbital approach.

believe that ischemia is the primary cause of visual loss rather than simply optic nerve compression. Lee, et al. [7] said that the cause of preoperative optic nerve dysfunction is ischemia, or compression of the optic nerve. Compression of the nerve has been shown to lead to small vessel compromise and demyelination, especially in patients with a long history of visual impairment.

Hernesniemi [4], observed that improvement in the visual deficit was inversely related to the preoperative duration of the deficit: A preoperative visual deficit that had lasted for less than 6 months improved in 13 of 20 patients, a deficit lasting between 6 and 12 months improved in 7 of 11 patients, and a deficit lasting more than 12 months improved in only 2 of 11 patients.

Nakamura, et al. [3] concluded that visual improvement was dependent on the duration of preoperative visual symptoms, but not on preoperative visual acuity or tumor size.

Preoperative visual acuity

The primary symptom leading to the diagnosis of TS meningioma is visual deterioration. Therefore, the aim of surgery is to achieve improvement of vision. In our study, visual acuity was improved in 10 patients (83.33%), remained unchanged in 04 patients (33.33%), and deteriorated in 02 patients (16.66%). Hernesniemi [4], observed that 52% of patients with preoperative visual deficits showed improvement postoperatively, 17% experienced deterioration, and 2% developed new visual deficits.

Nakamura, et al. [3] in their study, observed that Postoperative visual function was assessed in relation to the preoperative visual acuity.

Tumor size

In our study, the tumor volume of the tuberculum sellae meningiomas operated on ranged from 20 mm to 60 mm. We observed that postoperative visual outcomes were dependent on tumor volume.

Rosenstein and Symon [8] found tumors smaller than 3 cm to be associated with better visual outcomes than tumors larger than 3 cm in diameter. Andrews and Wilson [9] described a tendency for visual outcomes to be worse when tumor size exceeded 6 cm. in contrast, Fahlbusch and Scott [5] observed that visual prognosis is not influenced by tumor size.

Nakamura, et al. [3] observed that there is no difference in postoperative visual acuity outcomes, as they are not dependent on tumor size. Thus, among the 31 tumors with a maximum diameter of less than 3 cm, they observed that visual impairment score (VIS) improved in 71%, remained the same in 19.4%, and worsened in 9.7%. In the case of tumor with the maximum diameter was 3 cm or more (25 cases), the VIS improved in 64% of patients, remained stable in 20%, and worsened in 16% of cases. This difference was not/Different surgical approaches have been preferred to resect meningiomas of the tuberculum sellae: Bifrontal approach, unifrontal approach, frontotemporal approach, interhemispheric approach, lateral supraorbital approach and extended transsphenoidal endoscopic approach. In reviewing the literature, it appears that the most frequent surgical approach to remove TSMs is the frontotemporal approach [3] this was first described by Dandy in 1938 (53.54) and later perfected and popularized by Yasargil [10], who reported the largest series of 112 TSMs treated via a pterional-transsylvian approach (Figure 5).

At the beginning of our experience, we used the frontotemporal approach. However, in later cases, patients with tuberculum sellae meningiomas were operated on using the lateral supraorbital approach described by Joha Hernesniemi [4]. We achieved similar outcomes to those obtained with the frontotemporal approach, but with fewer issues related to temporal muscle atrophy.

Hernesniemi [4], in his study of 45 tuberculum sellae meningiomas operated on via the supraorbital lateral approach between September 1997 and August 2010, concluded that regardless of the tumor volume, tuberculum sellae meningiomas can be safely resected using this approach with low morbidity and mortality. The results obtained with this approach are like those achieved with more complex approaches.

Nakamura, et al. [3] concluded that the highest rate of visual improvement, 77.8%, was achieved in patients who underwent the frontolateral approach for tumor removal, compared with 68.8% in patients who underwent a pterional approach and 46.2% of patients who were operated through the bifrontal approach.

The primary aim of surgery is, therefore, to achieve improvement or at least maintain visual function at the same preoperative level. Several factors may contribute to these outcomes. However, all authors agree that surgical manipulation is the most important factor in determining the prognostic of visual function [4,11,12].

The main cause of postoperative deterioration was related to ischemia caused by disruption of the vascular supply to the optic apparatus. The key to preserving visual function is to minimize direct manipulation of the optic nerves and avoid injury to the blood supply to the optic apparatus. During resection of the meningioma, small vessels observed in the stretched arachnoid layer should not be coagulated (Figure 3). By preserving these vessels, there is a better chance for visual function improvement.

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