

Tuberculum sellae meningioma: Is there an ideal approach?

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BACKGROUND: Tuberculum sellae meningiomas is a serious challenge for neurosurgeons. It accounts for up to 10% of all intracranial meningiomas. The difficulty in surgically excising a Tuberculum sellae meningioma comes from its anatomical relationship to the optic nerves and chiasm and to the anterior cerebral and internal carotid arteries and their perforators. The authors discuss the main approaches and the complications based on their experience in comparison to previously reported data.

METHODS: We report our personal case series of 38 patients with Tuberculum sellae meningiomas; 36 patients underwent craniotomy for tumor resection (12 bifrontal, 12 pterional, 6 supraciliary, 4 unilateral frontals, and 2 fronto-orbito-zygomatic); in two patients, the excision was performed through an endoscopic endonasal approach. The Simpson grade of meningioma resection as well as the non-visual morbidity and the mortality rates were analyzed.

RESULTS: Thirty-one patients had Simpson grades 1 and 2 excisions, while seven had Simpson grade 4 excisions. The overall rate of non-visual morbidity was 13.15% (5 of 38 patients) and mortality was 5.3% (2 of 38).

CONCLUSION: The primary symptom leading to the diagnosis of a Tuberculum sellae meningioma is visual compromise and the main goal of surgery is to achieve improvement of vision. Favorable outcomes were achieved with appropriate selection of surgical approach. More studies are necessary to define the prognostic factors for patients in this scenario.

KEYWORDS: Tuberculum Sellae, Meningiomas, Skull Base, Clinoid Process, Optic Nerve.

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INTRODUCTION

Meningiomas are benign and slow growing tumors that usually take years to produce clinical symptoms. But the tuberculum sellae meningioma (TSM) is a challenge for neurosurgeons. Due to the complex anatomy of the tuberculum sellae region, decision making is very difficult. When choosing an approach, neurosurgeons must carefully analyze which is the best alternative for each case, because

these are among the most challenging surgeries in the neurosurgical field.^{1,2} These meningiomas appear from the limbus sphenoidale, chiasmatic sulcus, and tuberculum, and comprise approximately 3%–10% of all intracranial meningiomas.³ The tumor may fill the sellar and suprasellar area, with dural attachment generally at the tuberculum sellae. As the tumor grows it will displace, stretch, or even encase vital structures; thus, the optic nerves may be displaced superiorly, the internal carotid arteries may shift laterally, and the pituitary stalk may be pushed posteriorly if the tumor extends backwards.

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The tuberculum sellae is an osseous protuberance that constitutes the anterosuperior limit of the pituitary fossa. The diaphragm of the sellae creates a roof to the pituitary fossa stretching from the tuberculum over the sella turcica to the posterior clinoid processes and covers the pituitary gland, except for the pituitary stalk. The limbus sphenoidale is identified as a small borderline separating the planum sphenoidale and chiasmatic sulcus. Vital structures and important anatomic landmarks bound the tuberculum sellae. Laterally we find the clinoid processes, the internal carotid and the posterior communicating arteries; posteriorly we identify the pituitary stalk, infundibulum, and the Lillequist membrane; superiorly, we have the optic chiasm, the lamina terminalis, and the anterior cerebral artery complex.⁴ The space is quite small, (mean length 8mm, mean width 11mm), and the path of least resistance for tumor growth tends to be over the planum sphenoidale (anteriorly), the optic nerves into the optic canals (laterally), above the chiasma, displacing it superiorly, or down over the tuberculum and sellae (inferiorly) as shown in Figure 1.

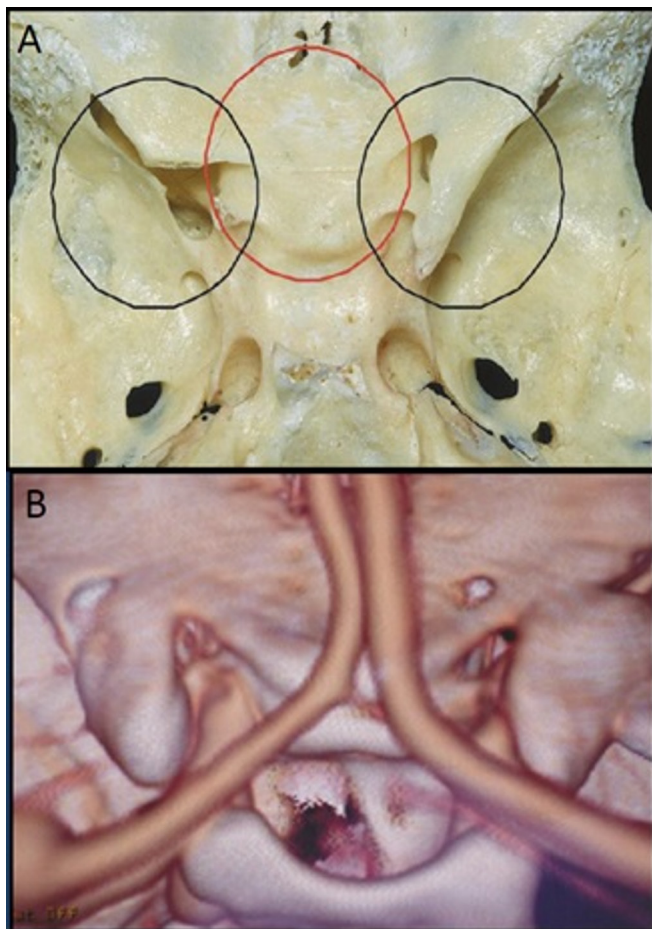


Figure 1 - Anatomy of tuberculum sellae. A - The region of the tuberculum sellae comprises the space belonging to the sphenoid bone between the two anterior clinoids (red circle), limited posteriorly by the dorsum sellae, before the planum sphenoidale. The optical column and the optic canal on each side form the posterior lateral limit (black circles). B - CT angiography with 3D reconstruction shows the relationship between the arteries and the tuberculum sellae.

The intimate relationship between tubercular sellae meningiomas and the optic apparatus characterizes their main clinical interaction. Compromise of the optic apparatus is an important feature for decision making.⁵ In cases of visual loss, surgical treatment seems to be the best alternative. It is mandatory to relieve the mass effect upon the optic apparatus. The proximity of these tumors to the optic apparatus usually eliminates radiosurgery as a treatment option for these tumors.^{1,6} Fortunately, a layer of arachnoid is always present between tumor and surrounding brain structures, and this provides a plane for dissection to aid the surgeon.⁷

Several surgical approaches such as subfrontal, bifrontal, unilateral frontal, supraorbital keyhole, pterional have been proposed for the resection of TSM, and more recently the neurosurgical endoscopic techniques have been introduced as a visualization option during removal of skull base tumors, both transcranially and endonasally.⁴ The aim of this paper is to report our case series, with special emphasis on different surgical approaches for TSM and their advantages and complications.

■ CASE SERIES AND METHODS

A total of 38 patients with TSM underwent surgery by our group during the period from 1995 to 2014, among a total of 201 skull base meningiomas. All patients underwent evaluation by CT scan and MRI. The radiological parameters included tumor size, brain-tumor interface, perilesional edema, arterial encasement, optic canal extension, and hyperostosis. The size of the tumors was calculated based on measurements obtained from MRI. Ophthalmologic evaluation was obtained from all patients before and after surgical procedure. The surgical approaches included bifrontal, unilateral frontal, pterional, supraciliary, fronto-orbito-zygomatic (FTOZ), and endoscopic endonasal. The extent of tumor resection was based on Simpson grading. Follow-up examinations were scheduled at 1, 3, 6, and 12 months postoperatively and annually thereafter.

■ RESULTS

This patient series includes 30 women and 8 men, whose age ranged from 19 to 82 years, with a mean of 52 years. Figures 2 and 3 illustrate some cases.

Visual impairment was present in 25 patients. The overall visual preservation (improvement + stable visual deficit) was 88% (23 patients). Among these, 40% (10 patients), had vision impairment recovery just after surgery, 12% (3 patients) recovered after 6 months, and 40% (10 patients) did not recover after 12 months. Vision deterioration occurred in 8% (2 patients – 1 who underwent supraciliary craniotomy and 1 who underwent fronto-orbito-zygomatic craniotomy).

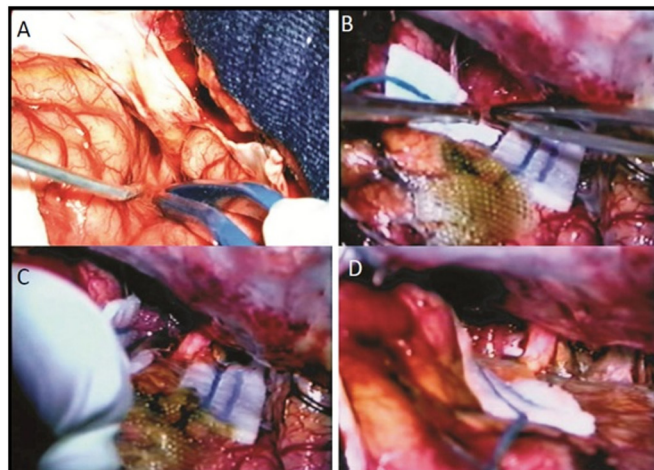


Figure 2 - A - Microsurgical vision of the frontotemporal approach of Tuberculoma Sellae Meningioma by subfrontal access through the transylvian fissure. B - Microsurgical vision, showing the tumor compressing the optic chiasm. C - Microscopic view of the dissection into the space between the optical nerve and the tumor using pterional access. D - Microscopic view shows the complete removal with preservation of the optic nerve and pituitary stalk.

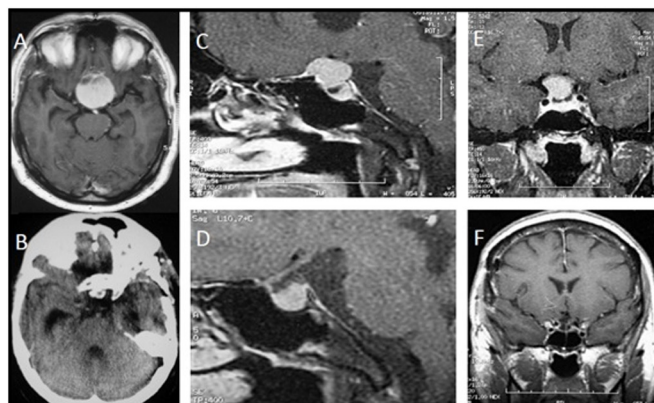


Figure 3 - Three cases (CASE 1: panels A and B; CASE 2: - panels C and D; CASE 3 - panels E and F) of Tuberculoma Sellae Meningioma operated in our neurosurgery service. Panel A: MRI of a 63-year-old male patient showing a tuberculoma sellae meningioma after contrast. Panel B: same patient, CT scan, showing complete resection of tumor associated to an increase of ventricular dilation. Panel C: MRI T1 of a 62-year old female patient, complaining of preoperative visual impairment, showing (in sagittal section) an injury in tuberculoma sellae and diaphragm with sellar invasion after contrast. Panel D: same patient, postoperative MRI T1 in sagittal section shows complete resection, with residual intrasellar component. Panel E: preoperative MRI T1 in coronal section, with contrast, showing a tumor with suprasellar extension. Panel F: postoperative MRI in coronal section, showing the radical resection.

Table 1 shows the distribution of tumor size and levels of recovery of the 25 patients with visual impairment. Best recovery rates of visual impairment were among patients with tumor size of 1-2 cm (75%), followed by tumor size 3-4 cm (40%); for tumor size 4-5 cm only 1 patient recovered (14%). The two larger size tumor groups (5-6 cm and > 6 cm) included only two patients each. We found no significant influence of tumor size on the visual outcome; however, due to the anatomy of region (shown in Figures 1 and 2), we did observe that the extension of the optic canal and the degree of arterial encasement by the tumor did relate to visual outcome.

Table 1 - Tumor size of the patients with visual impairment.

Tumor Size	Visually impaired patients	Recovery number (5)
< 2 cm	4	3 (75%)
3 - 4 cm	10	4 (40%)
4 - 5 cm	7	1 (14%)
5 - 6 cm	2	1 (50%)
> 6 cm	2	0 (0%)
Total	25	

Thirty-six patients underwent craniotomy for tumor resection: 12 bifrontal, 12 pterional, 6 supraciliary, 4 unilateral frontals, 2 fronto-orbito-zygomatic Figures 2 and 4 illustrate the techniques employed in the surgical act; two patients underwent an endoscopic endonasal approach. No patients were considered for radiosurgery due to the proximity of the tumor with the optic apparatus.

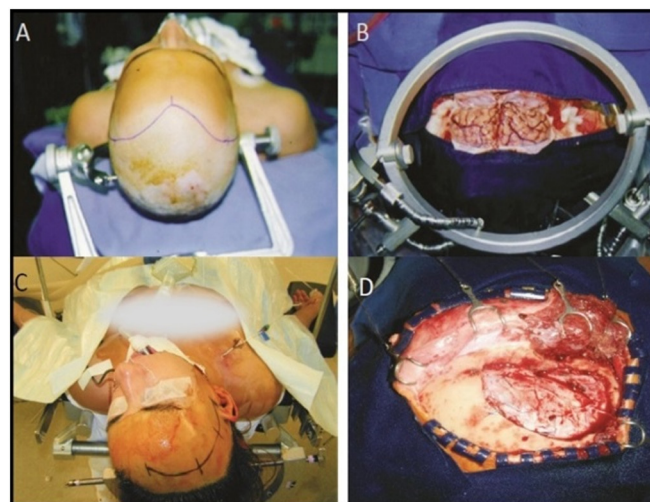


Figure 4: Techniques in surgical approach of TSM. A - Patient positioned with bicoronal marked incision to perform bifrontal craniotomy. B - Inter-hemispheric access for tuberculoma sellae meningioma approach. C - Patient positioning for frontotemporal approach. D - Pterional craniotomy.

Thirty-one patients (81%) had Simpson grades 1 + 2 excisions, while seven (19%) had Simpson grade 4 excisions, owing to fact that their tumors were located around the vessels or the optic nerve.

Postoperatively, the observed complications were (a) cerebrospinal fluid fistulae in three patients (1 from endoscopic endonasal and 2 from bifrontal craniotomy); (b) operative site hematoma in two patients, with transient deficits. Two patients (5.3%) died: one patient with a fistula developed ventriculitis; the other death occurred with a patient who developed pulmonary thromboembolism. The overall rate of nonvisual morbidity was 13.15% (5 of 38 patients).

■ DISCUSSION

Different surgical routes can be used for Tuberculoma Sellae Meningiomas; each has its advantages and disadvantages and this allows the neurosurgeon to make decisions concerning route preference, tactics and strategies. To correctly select the surgical approach, it is necessary to understand the advantages and disadvantages of each procedure and some factors must be considered by the neurosurgeon in making the right decision.

In the case of TSM, the factors that should receive due attention are: (1) the anatomical characteristics of the tumor, such as size, consistency and its relationship with neurovascular areas (optic device, ICASs, cavernous sinuses, pituitary, among others); (2) patient condition and symptoms presented; (3) the experience of the neurosurgeon, a decisive factor in the choice of the approach.

The most frequent primary symptom leading to the diagnosis of a TSM is visual compromise.⁸ Therefore, the aim of surgery is to achieve improvement of vision. In previous reports, visual acuity improved in 28% to 80% of patients, remained unchanged in 9% to 64%, and deteriorated in 7% to 33%.³ In our series, vision improved in 52% of the patients, remained unchanged in 40%, and deteriorated in 8%. The key to preserving visual function is to minimize direct manipulation or trauma to the optic nerves and avoid injury to the blood supply of the optic apparatus.

There are various transcranial approaches used to resect these meningiomas: (1) bicoronal subfrontal, (2) unilateral subfrontal, (3) pterional transsylvian, (4) anterior interhemispheric, (5) extended bifrontal, (6) skull base technique, and (7) Fronto-Temporal-Orbito-Zygomatic. Regarding the choice of the ideal approach aiming at the best prognosis, the following points are relevant: (i) tumor size and location, (ii) anterior cerebral artery encasement, (iii) optic canal involvement, (iv) arachnoid membrane intactness, (v) age of patient, (vi) duration of symptoms (vii) preoperative visual function. Table 2 shows that small and well localized tumors, with little or no cerebral artery encasement or optic canal involvement offer good prognosis. Prognosis is also better in younger patients with a short history of symptoms and good preoperative visual function.^{3,9-25}

Regarding the surgical act, independently of technique, the initial debulking of the tumor should start from its center, where no vital structures are present. The arachnoid plane is then delineated, starting at the contralateral optic nerve and working toward the undersurface of the optic chiasma and then along the ipsilateral nerve. During resection of the meningioma, small vessels observed in the stretched arachnoid layer should not be coagulated. By preserving these vessels, there is a better chance for visual function improvement. Although

the medial optic canal can be opened endonasally to address the meningioma through the sphenoid sinus, opening the medial optic canal in its length causes the closure of the dural defect to turn into a challenging task. According to the literature and to our experience, the presence of medial optic canal invasion contraindicates endonasal approaches.

In cases of TSM with a significant level of optic nerve compromise and with limited lateral extension, Gadjet et al.²² have shown that an endoscopic endonasal resection is an excellent option.

In another study, Ajlan et al.²³ noted that recent reviews comparing transcranial vs. endoscopic transnasal resections failed to show superiority of one approach over the other, as far as visual outcomes are concerned. The transnasal endoscopic access, in general, offers less complication from a statistical point of view, although tumor resection rates are less complete when compared to transcranial approaches.^{9,24,25} In our series the endonasal approach showed worse results compared to transcranial approaches with increased CSF leakage; however, our number of endonasal endoscopic approach is very low and cannot be compared to other approaches.

In our series of TSMs, it was possible to achieve a favorable outcome with a low incidence of morbidity and mortality. We strongly believe that these results were due to an appropriate selection of the surgical approach, including minimally invasive surgery by craniotomy and anterior clinoidectomy. Early CSF drainage, meticulous duroplasty and bony repair for skull base reconstruction were also found to be relevant. More studies are necessary to define the prognostic factors for patients with TSM after surgical intervention.

■ CONCLUSIONS

The most common primary symptom leading to the diagnosis of a TSM is visual compromise and the main goal of surgery is to achieve improvement of vision. Favorable outcomes were achieved with appropriate selection of surgical approach. More studies are necessary to define the prognostic factors for patients with TSM after surgical intervention.

■ CONFLICT OF INTEREST

Authors declare no conflict of interest concerning the materials discussed in this study.

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Table 2. Advantages, disadvantages and indications of techniques in surgical approach of TSM.

Techniques	Tumor Size	Advantages / Indications	Disadvantages
Bicoronal Subfrontal ^{9,16-19} (Figure 4A)	> 2,5 cm	<ul style="list-style-type: none"> • Presence of bioptic canal involvement; • Wide surgical field 	<ul style="list-style-type: none"> • Partial exposure of the tumor height; • The need of some degree of frontal lobe retraction for adequate tumor exposure;
Unilateral Subfrontal ^{9,16-19} (Figure 2)	< 2,5 cm	<ul style="list-style-type: none"> • Minimally invasive technique for suprasellar meningiomas 	<ul style="list-style-type: none"> • Limited surgical field; • Partial exposure of the tumor height.
Pterional Transsylvian ^{9,10,13,16,17,21} (Figures 4D)	Any size	<ul style="list-style-type: none"> • Early exposure of the ipsilateral supraclinoid carotid artery, optic nerve, and anterior cerebral artery; • Absence or decreased need of brain retraction; • Higher rates of gross total resection when compared with other techniques; • Presence of bioptic canal involvement 	<ul style="list-style-type: none"> • Inadequate visualization of optic nerve and carotid artery; • Higher rates of visual deterioration; • High degree of difficulty in cases of invasion of the optic canal and intrasellar extension of the tumor
	Any size	<ul style="list-style-type: none"> • Wide surgical field; • Full exposure of the entire tumor height; • Visualization of the entire optic apparatus and surrounding structures, including the tuberculum sellae; • Minimal or no frontal lobe retraction; 	<ul style="list-style-type: none"> • Long surgical duration; • Higher rates of anosmia and rhinoliqorrhea; • Inadequate access to cases with significant extension into the optic canal; • Very difficult to perform an early unrousing of the optic canal, which is known to improve visual outcome.
Anterior Interhemispheric ^{13,14,17,20,21} (Figure 4B)		<ul style="list-style-type: none"> • Preservation of the optic and olfactory nerves; • Significant surgical results (higher than 80% of visual improvement) associated to absence or low rates of postoperative visual deterioration; • Higher rate of total excision; • Preservation of the subdural space; • In cases of tumor debulking without bleeding this approach is the most reliable method to preserve the arachnoid plane and the small vessels supplying the optic apparatus. 	
Extended Bifrontal ^{9,16-19}	> 2,5 cm	<ul style="list-style-type: none"> • Wide surgical field; • Flexibility of surgical trajectories; • Avoidance of excessive brain retraction; 	<ul style="list-style-type: none"> • Requires some degree of frontal lobe retraction for adequate tumor exposure; • Significant potential loss of olfaction; • High risk of occlusion of superior sagittal sinus leading to venous infarction; • Difficulty in reaching the undersurface of the optic nerves or the intrasellar extension of the tumor.
		<ul style="list-style-type: none"> • Direct view of both optic nerves, internal carotid and anterior cerebral arteries. 	
Endonasal Approach ^{9,22-25}	-	<ul style="list-style-type: none"> • Minimally invasive technique for suprasellar meningiomas; • Lower rates of complications 	<ul style="list-style-type: none"> • This approach is contraindicated in the presence of medial optic canal invasion; • Limited lateral extensional; • Lower rates of complete resection of tumor;
FTOZ ¹⁷	Any size	<ul style="list-style-type: none"> • Presence of bioptic canal involvement; 	<ul style="list-style-type: none"> • Limited surgical field; • Partial exposure of the tumor height.

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■ AUTHOR PARTICIPATION

Paulo Henrique Pires de Aguiar contributed to the conception of the project, revised the manuscript, approved the completed manuscript and participate of all steps of study; Iracema Araújo Estevão and Bruno Camporeze performed the bibliographical research, analyzed the data and wrote the draft manuscript; Giovanna Matricardi, Pedro da Silva Júnior, Daniel A. Gripp and Natally M. Santiago collected the clinical data of participants and contributed to the conception of the project.

■ MENINGIOMA DE TUBÉRCULO SELAR: HÁ UMA ABORDAGEM CIRÚRGICA IDEAL?

INTRODUÇÃO: Os meningiomas de tubérculo selar certamente representam um desafio para os neurocirurgiões no que se refere ao manejo cirúrgico. Estes tumores representam até 10% de todos os meningiomas intracranianos. A dificuldade em ressecar cirurgicamente estes meningiomas provém da sua relação com os nervos ópticos, com o quiasma óptico e com as artérias carótidas internas, cerebrais anteriores e suas perforantes. Discutimos as principais abordagens e as complicações com base em nossa série de pacientes e numa revisão da literatura.

CASUÍSTICA E MÉTODOS: Relatamos nossa série de casos pessoais de 38 pacientes com meningiomas de tubérculo selar. Trinta e seis pacientes foram submetidos a craniotomia para ressecção tumoral (12 bifrontal, 12 pterional, 6 supraciliar, 4 unilateral frontal e 2 fronto-orbito-zigomático) e 2 receberam abordagem endoscópica endonasal. A escala de Simpson, bem como as taxas de morbidade e mortalidade foram analisadas durante o período **pós-operatório**, em função das diferentes abordagens.

RESULTADOS: Trinta e um pacientes foram submetidos a excisões de grau I e II da escala de Simpson; os demais foram submetidos a excisão de grau IV da mesma escala. A taxa global de morbidade sem acometimento visual foi de 13,15% (5 de 38 pacientes), enquanto a mortalidade evidenciada foi de 5,3% (2 dentre 38 pacientes).

CONCLUSÃO: O principal sintoma que leva ao diagnóstico de meningioma de tubérculo selar é o comprometimento visual, de modo que o principal objetivo da cirurgia é alcançar a melhora da visão nestes pacientes. Os resultados alcançados foram favoráveis quando associados com a seleção apropriada da abordagem cirúrgica. Mais estudos são necessários para definir os fatores prognósticos para os pacientes com meningioma de tubérculo selar após intervenção cirúrgica.

Palavras-chave: Tubérculo selar; Meningiomas, Base do Crânio, Processo Clinóide, Nervo óptico

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