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Tuberculum sellae meningiomas Complications avoidance strategy in 75 patients Serie

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Abstract:
Aim: our retrospective study aims to highlight the improvement of trans cranial and transsphenoidal surgical related morbidity and complications avoidance strategy in in every step of the surgical procedure in our centre over the past 10 years with the overall management of tuberculum sellae meningiomas. Patients and methods: *we present our Serie of 75 patients presenting with tuberculum sellae meningiomas operated in the department of neurosurgery at EHS (6) Cherchell Hospital and the department of neurosurgery at EHS Ali Ait Idir Hospital (7) over the period of 10 years (2009 to 2018). We reviewed all our cases in a retrospective descriptive study. Results: Majority of our patients presented with frontal headaches (95%) associated with the main symptom of visual impairment found in 95% ranging from slight unilateral visual loss to severe bilateral deterioration. A variety of approaches were used in our study including transcranial approaches (pterional Approach was performed in 56.3%, subfrontal unilateral approach in 15.8%, lateral supraorbital approach in 13.2%, Bifrontal in 9.4%) and endoscopic transsphenoidal approach was performed in 4 cases. Involvement of one side of the optic canal was found in 15 patients. Consequently, the clinoid process was drilled intradurally in 12 cases. The overall improvement on the vision was found in 55%, unchanged in 30 %, and worsened in 15%. Gross total resection (GTR) was achieved in 72%, near total resection (NTR) in 18% in subtotal resection (STR) in 10 %. Conclusion: TSM are still considered as a challenging lesion in neurosurgery that dictates a deep understanding of the local anatomy of the tumors in order to accurately plan an ideally chosen approach for each patient by preventing and limiting related surgery complications despite the lake of agreed consensus about the approach's decision making.*

Keywords: *optic nerve, optic canal, transcranial approach, transsphenoidal approach, Tuberculum sellae meningiomas.*

Abbreviations*: TSM: tuberculum sellae meningiomas, GTR: Gross total resection, NTR: Near total resection. STR: Subtotal resection, ON: optic nerve, OC: optic canal, CH: chiasm, TC: transcranial approach, TS: Transsphenoidal approach, DSA: Digital subtraction angiography CSF: cerebrospinal fluid, MRI: magnetic resonance imaging, ICA: internal carotid artery, ACA: anterior cerebral artery, ACOA: anterior communicating artery*

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I. Introduction

TSM are considered as a particular anatomical entity among other intra cranial localizations of meningiomas considering its complex anatomical localization near vascular structures (internal carotid artery ICA) and also important neuronal structures (optic nerve ON, infundibulum, hypothalamus and pituitary gland). In addition to this complex localization in the skull base, the tumors can be seen to encase and envelope the ICA, extend toward the optic canal anteriorly and even posteriorly to the hypothalamus and the infundibulum as it is observed in particularly large tumors. these attributes make the tumors removal with the lowest rate of morbidity a significant challenge [1,2].

TSM's account for 3% to 10 % of all intra cranial meningiomas [1,5,6] and arise from the tuberculum sellae, chiasm sulcus and the limbus sphenoidale making the TSM to appear centered on the tuberculum sellae displacing the optic nerves outward and upward whereas planum sphenoidale meningiomas as well as olfactory groove meningiomas displace the optic apparatus posteriorly[1,2]. the benign nature of the neoplasm dictates that the main goal remains the decompression of the optic nerves and prevention of further recurrence or worsening. That goal is ideally achieved with a total removal of the tumors, excision the dural attachment and the hyperostosis. [1,2,3]

A considerable amount of progress in the recent years has been achieved on the post-operative improvement of vision with lesser morbidity and mortality rates with the help of advanced technological equipment [3,4]. As it has been seen in the past few decades, the introduction of the concept of minimally

invasive neurosurgery and the progress made by endoscopic transsphenoidal surgery seem to open the door to new approaches challenging the classical trans cranial approaches in the management of TSM according to their recorded results. However, the debate has risen to choose the ideally approach for each patient [1,5].

Thus the good results published of the TS approach does not seem to convince the neurosurgical community due to the fact that they have been achieved in highly specialized centers which cannot be necessarily reproduced easily sooner and require highly skilled endoscopic neurosurgeons to perform safe tumors dissection and removal as well as the reconstruction of the skull base [3,6] The vascularized Flap revolutionized the reconstruction of the skull base and allows to overcome the post-operative fistulas which is considered as the main complication of the extended endoscopic approach [1,3,7] the high risk of fistulae after endoscopic TS approach seem to be greater than their counterpart that are operated via transcranial approach [1]. The lateral supra orbital approach seems to represent a reasonable alternative for Small sized TSM but this has to be achieved with Full control of the tumors and stress the most cosmetic concerns for surgeons [1,2]

Many authors have pointed the need to clarify what are the characters of TSM that are best operated on by LSO approach, transcranial approach or TS approach. From our point of view as it was highlighted by Michael W. McDermott, MD the neurosurgical community need to come to an agreement about the potential grading system of TSM in order to choose the Ideal Approach and to achieve the best results for each category [1,5] The Goal of this study is to review the main technical surgical features then to relate them retrospectively with the complication rate in our Serie.

II. Methods

We report our retrospective and descriptive study of 75 patients operated of TSM over the period of 10 years in two centers: from 2009 – 2017, 41 patients were operated at Ali Ait Idir Specialized hospital in Algiers, and 34 patients were operated at Cherchell Specialized hospital. Our patients were operated by skilled neurosurgeons in both microsurgery and endoscopy and were directed by our senior author.

We included every patient operated of TSM confirmed by MRI and assessed by an ophthalmological examination of visual acuity and vision field. The endocrine evaluation of pituitary gland was performed in all patients. The operative decision-making was taken after a case by case analysis and considering every aspect of clinical symptoms and MRI Imaging findings. The extent of tumors removal is appreciated by the surgeon and the finding is integrated with post-operative MRI measurements of any residual tumor which has been represented by a percentage. GTR is referred to more than 99% of tumour removal, NTR for more than 94% and STR for less than 94% [5,2]

Post-operative symptoms evaluation was recorded from ophthalmologists and endocrine specialized reports over the post-operative period as well as their evolution. Complications were specifically analyzed in order to match them with the size of the tumors, its extension to the optic canal and the encasement of ICA.

III. Results

In our Serie the demographic symptoms presentation shows an age range from 22 to 72yo with the mean age of 48yo. The majority of our patients were particularly women represented with Sex ratio of 4 Women for 1 man. The onset symptoms were found to be related to vision persistent disturbances that account for 95% visual field cut in 5%. Unilateral visual loss was the most frequent in our Serie represented with 55%, Bilateral visual impairment was found in 45%. Foerster Kennedy syndrome was found in 8%. Unilateral optic atrophy represented 15%. The second most frequent symptom was found to be retro orbital headaches that 70% of our patients complained from. This symptom was found to be the unique symptom at the time of diagnosis in 7% of our patients. endocrine disturbances were represented with 10 % of our patient who have diabetes insipidus with 2 patients suffering from Ante hypophyseal hormonal deficit. The duration of symptoms prior to operation ranged from 2 to 18 months.

The pterional approach was the most used in our Serie with the rate of 56% followed by the subfrontal unilateral approach with 15.8% while the lateral supra orbital approach was adopted in 13.2%. bifrontal approach in 9.4%. 4 cases were operated via extended endoscopic transsphenoidal transplanum approach.

3.1 outcome data

Gross total resection was achieved in 72% of our patients and it is referred to more than 99 % of tumors resection. Near total resection (NTR) which reflects 95-99 % of tumour removal was achieved in 18 % of cases. Subtotal resection (STR) was achieved in 10 % of our patients. we have recorded 55% of visual improvement rate and 30% of unchanged visual status. The worsening of vision appeared immediately after surgery in 5% and delayed in 10 % after 5 days postoperatively. Transitory diabetes insipidus was found in 5 patients after surgery which improved after 5 days, this complication was found in large tumours >3cm with an important posterior extension and involvement of sellar diaphragm. 3 patients were found to have additional corticotrope and thyroid hormonal deficit

CSF leakage appeared in 2 patients operated by Bifrontal approach that improved after 4 days after surgery. Basal Frontal lobe hemorrhagic infarction was diagnosed in the first day in one patient and resolved in the 10th day after surgery associated with post-operative seizures. 02 cases of per operative carotid artery injury causing death (the mortality figures occurred in the first year of our study).

TABLE 1: *Preoperative clinical findings of our 75 patients operated on TSM*

Clinical data	Number of cases
Age(yrs)	
Range 22 – 72	75
Mean 48	
Sex	
Females	67
Males	8
Symptoms	
Visual impairment	
Acuity loss	72
Field cut	73
Unilateral	42
Bilateral	33
Forsterkennedy Syndrome	6
	62
Headaches	1
Endocrine Dysfunction	2
Diabetes insipidus	1
Pituitary involvement	1

The rate of recurrence was 0 % for GTR without any increase in the size of residual tumor related to the Near total resection group.10 % for the subtotal resection STR group with less than 1cm of residual tumor volume that has been assessed after the mean follow up duration of 38 months were referred to adjuvant treatment by radiosurgery. None of our patients presenting any form of recurrence (increase in size after the mean follow up of 38 weeks after surgery or those who had a similar residue compared to recent post-operative status) was re-operated

IV. Preoperative evaluation and planning

Patients presenting with diabetes insipidus and any other endocrine deficit were assessed and substituted by endocrinologist prior to surgery. Those presenting with seizures were put under medication preoperatively by neurologist. our patients underwent a variety of transcranial approaches that were discussed in our team according mainly to the tumor size and the local anatomy of the tumor as it is analyzed from gadolinium enhanced MRI data with a deep and accurate planning for each case in order to appreciate the relationship of the tumor to optic nerves laterally, detect a prefixed chiasm, the degree of encasement of ICA or any anterior Willis polygon vascular structures by the tumor [1,5,9]. the relationship to the infundibulum and hypothalamus posteriorly is always evaluated. the extent of dural attachment or the involvement of the optic canal can be assessed to plan clinoid process drill [1,2]. Computed tomography (CT) was performed and analyzed in three dimensional reconstructions in patients suspected to have hyperostosis of the skull base centred on the tuberculum sellae and for those prone to be operated by Endoscopic endonasal transtuberculum transplanum approach in order to tailor the bony opening and to predict any difficulty related to osteodural defect reconstruction techniques [3]. calculation of the suprasellar notch angle is important and defined by the intersection of two lines the first pass through the tuberculum sellae and perpendicular to the plan of the cribriform plate and the second joins the midpoint of the limbus sphenoidale and the mid of tuberculum sellae. Type I with angle <118° is particularly difficult to reconstruct the skull base defect after transtuberlum sellae trans planum endoscopic approach [1,3]. Magnetic resonance imaging (MRI) with gadolinium enhancement is the diagnostic study of choice that can distinguish precisely TSM with high degree of accuracy among other suprasellar tumors.

Accordingly, MRI provides valuable information about TSM by showing the dural attachment, upward displacement of both anterior cerebral arteries and ICA laterally as well as the relationship with neuroendocrine structures. Digital subtraction angiography (DSA) was not performed in our Serie considering the typical

vascularization type of meningiomas as it might be seen on DSA. Consequently, we do not advocate the need for Embolization in this type of meningiomas. (2,14)

V. Approach selection

TSM can be approached through many transcranial openings. The pterional approach was the most used approach in our Serie with 59% of cases as it offers after a generous removal of the sphenoid ridge and a wide dissection of the sylvian fissure. A short access to the whole supra sellar region is then obtained with less brain retraction. This approach avoids the breach of the frontal sinus; thus, it does not subject the patient to complications related to the opening of the frontal sinus (Infection, CSF Rhinorrhea) as well as an additional risk of olfactory nerve injury. We usually approach the tumor from the monodominant hemisphere side. In some particular cases however, we choose the amblyopic side when one eye is blind. That allows better decompression of the less involved optic nerve. When the tumor presents an eccentric unilateral predominant extension toward one side of ON and ICA, the same side is preferably chosen to approach the tumor [8]. Some authors argue that the main drawback of the pterional approach is the less control of the tumor extension toward the under surface of the ON and chiasm which best avoided by the ideal choice of approach tailored according mainly to the size of the tumor and the interface of tumor with the neuro vascular structures in particularly cases of local complex anatomy [8,14]

The subfrontal approach was chosen in 15.8 % of our surgeons' team as it provides a good exposure of sellar region with an adequate control of the undersurface of both optic nerves and the chiasm. [2,8,14]

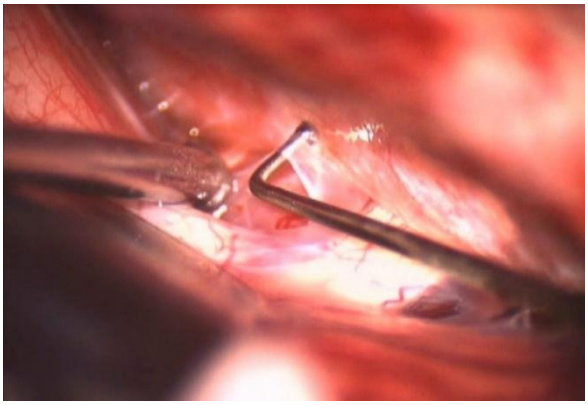
Bifrontal Approach provides a better visualization of both ON, better control lateral to ICA, good visualization of the suprasellar cistern, best approach for drilling of the tuberculum sellae, excision and reconstruction of the dura. [2,8,6] We consider that this approach is preferable for large tumors with important superior and lateral extension to justify the longer operating time for surgery and reconstruction of dural attachment as well as the need of the dissection of the olfactory apparatus that risks anosmia alongside with potential complications related to the frontal sinus opening [2,6,8]

Transshpenoidal transtuberculum transplanum approach as it was introduced around two decades ago is being proved to be efficient and effective in dealing with TSM as it offers an early devascularization of tumor, removal of the involved bone without brain retraction, allows dissection of the tumor from the optic nerves and chiasm with possibility of the medial opening of the optic canal [3,7]. TS approach is found to be particularly useful in pre-fixed chiasm situations due to the limitation of the inter optic triangle space which limits sufficient tumor removal via transcranial approaches. The choice of the TS should take into account the lack of significant lateral extent of the tumor, an encasement of the ICA, ACA, ACOA, and a suprasellar notch angle < 118° that contradicts the use of this approach. [1,3,7]

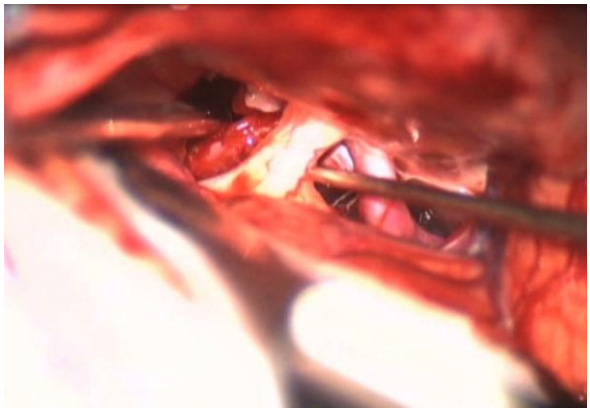
We used the lateral supra orbital approach in 13.2% of our cases as it allows a good control of the more anterior planum extension of the tumour without any extension below the chiasm level. [1,3] The LSO approach can be achieved for TSM with lateral extension toward optic nerves and supraclinoid carotid artery. This approach allows decompression of the optic canal superiorly [2].

Table2: *Surgical features of 75 operated TSM* cases

Features	Percentage
Surgical approaches	
Pterional	56.3%
Subfrontal Unilateral	15.8%
Lateral supraorbital (LSO)	13.2%
Bifrontal	9.4%
Endoscopic Transsphenoidal	5.3%
Optic canal involvement	
Unilateral	20%
Bilateral	5.3%
Clinoid process drilling	
Intradurally	16.2%
Extent of resection	
GTR	72%
NTR	18%
STR	10%



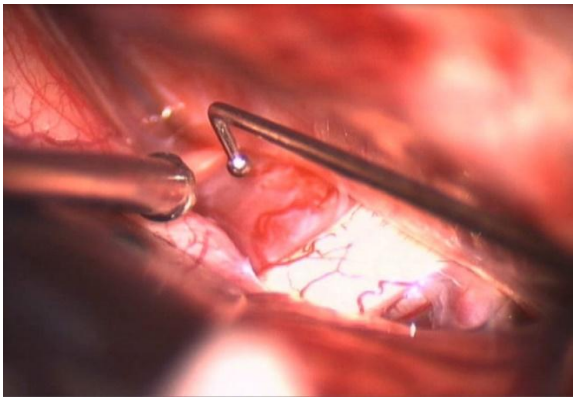
Picture 1: opening of arachnoid layer



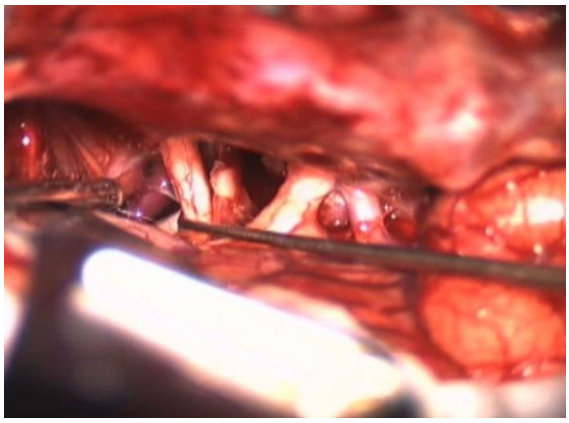
Picture3: dissection of the capsule from the right inter-optic-carotid triangle

TABLE3: *Outcome and Complications of 75 TSM Surgery*

Features	Percentage
Visual improvement	55%
Unchanged visual status	30%
Visual worsening	
Immediate	5.0%
Delayed	10%
Diabetes insipidus (transitory)	6.6%
Endocrine deficit	4.0%
CSF leakage	2.6%
Frontal infarction + seizures	1.3%
Arterial injury (Mortality)	2.6%
Recurrence*	
GTR	0%
NTR**	8%
STR	16%



Picture 2: early medial decompression



Picture4: total removal of TSM with full preservation of ON's

*Mean follow up of 38 months

** significant increase in tumor size

VI. Discussion

Surgery is performed under high power magnification for a clear identification of the arachnoid layer that should be preserved to achieve a safe microsurgical dissection of the capsule from Perforants. Microdissection is carried out to preserve the vascularization of the Optic nerve and blood vessels. [6,8] Arterial bleeding is managed with the use of Surgicel in our Serie avoiding potential thermal injury to the optic nerve [1,8]. In case of the optic canal involvement we proceed to intradural clinoid process drilling as it offers better visual control of the ON and ICA. [2]

Despite The proper understanding of the local microanatomy of the tumor and the relationship of the tumor with the optic nerve, the visual preservation is not possible in every case. Thus, there is a lack of understanding of the exact etiology of visual impairment [2] It can be understood that the onset of visual loss can be acute from direct trauma to the ON, but it was found that it is can be also delayed without any clear cause that can explain the delayed visual loss such as trauma, hematomas. According to that, the visual preservation remains the main goal of surgery of TSM and care should be focused on the preservation of ON's. [1,2] in addition to the gentle microsurgical dissection of the ON and the avoidance of thermal coagulation use.

We suggest an early opening of the optic canal intradurally under a good visual control which was found to reduce the risk of visual loss by reducing stress and tension on the ON during early debulking. An early safe decompression with gentle manipulation remains the main protective measure that should be integrated in the whole operative strategy while it is accounted for in the right operative timing which should be well defined in advance. [1,2] Other measures should be taken into account in the post-operative period to reduce the delayed visual loss with the maintain of an adequate arterial pressure during 48 hours post operatively to reduce the risk of any presumed delayed visual loss from a weak substantial perfusion of the ON that can result from local anatomical changes as swelling. [2,7]

Intra operative flash VEP (visual evoqued potentials) allows detection of optic pathways dysfunction from the retina to the visual cortex when combined with ERG monitoring. [2,7] Therefore, visual impairment could be avoided or minimized. This technique was proven to be possible in patients presenting with TSM under general anesthesia (using Propofol), but it was found that the Flash VEP per-operative monitoring is mainly low reproductible and difficult to record in patients having a serious preoperative visual impairment. It is suitable

that the flash VEP monitoring should be determined according to the preoperative visual function. In addition to that, other factors were found to affect a suitable VEP preoperative monitoring like body temperature, hypotension, hemodilution, variation in the partial pressure of the Carbone dioxide in the blood. Despite the theoretical feasibility of this technique. Technical constraints dictate that this method is not adequate in the surgery of TSM and should be discussed for better technological improvement and sensibility in the future. [11]

CSF leakage is a great concern and the main complications in the surgery of TSM via TS approach but it was found also with a lesser degree in the TC approaches. Skull base reconstruction after TSM removal via TS approach is particularly challenging giving the difficulty placing absorbable plates or bone under the edges of the bony defect near to the ON. [2] To reduce the risk of the ON compression fat should be compacted with sutures before placing in the tubercular defect. Furthermore, the pedicled Nasoseptal flap is a safe multi-layered conventional closure technique after the removal arachnoid layers of the tuberculum sellae region. [1,3] Meningitis is feared after CSF leakage and is considered as the major complication risk of CSF leakage after surgery. Antibiotics are then administered with the help of lumbar subarachnoid drainage. Patients who undergone surgery of MTS should avoid postures that increase abdominal pressure for up to 2 months with a high risk of failure of the skull base reconstruction in the first week after surgery. [2] In the TC approaches the avoidance of tension sutures and coagulation of the dura help achieving a better quality dural closure and consequently avoid CSF fistulae. The dural closure must be achieved in a water-tight fashion using the pericranium. [2,8]

As some complications are related to the choice of the adequate trans cranial approach, Mucocele are prone to form in the frontal sinus intentionally entered. The need to breach the frontal sinus should be assessed prior to surgery with a deep analysis of MRI imaging and CT scan. [2] Mucocele tend to form after the obstruction of the frontal sinus outflow in patients when the frontal sinus is insufficiently addressed during surgery. Reconstruction of the breached frontal sinus is best repaired with a vascularized pericranium placing the flap below the orbital osteotomy. Exenteration of the frontal sinus mucosa and obliteration of the Naso frontal duct is avoided as the pericranium patch is sufficient and adequate to prevent mucocele formation. The integrity of the Naso frontal duct must be verified. [2]

Diabetes insipidus tend to appear in patients presenting with large TSM with a posterior extension. The sharp microsurgical dissection by following the arachnoid layer is the only mean to avoid lesions of the pituitary stalk. Hormonal replacement is mandatory to avoid metabolic complication related to hormonal deficit [2,7,8]

Cosmetic prejudice should be addressed when 2 techniques can be performed in the surgery of similar sized TSM. Large dissection techniques should then be avoided with the condition that the surgeon have the entire confidence to achieve best surgical results with less invasive technique. [2] The preference of the surgeon's choice must be justified according to bad cosmetic results to be in favour of less invasive techniques. One rule should always be respected: the choice of less invasive technique should always be conditioned with full control of tumour removal beside best results in general. [2] Therefore, larger approaches should then be justified without neglecting the aspect of cosmetic prejudice for patients operated by large approaches (use of hydroxyapatite to fill gaps of the craniotomy cuts, thinning the outer bone table to rest titanium plates in the bifrontal craniotomy) [2]. The bi partite bone flap is preferred in the bifrontal craniotomy for a better and safer dissection of the venous sinus. As for the supraorbital approach, stress should be made on this approach as it require the most cosmetic concerns due to the need to the eyebrow incision. Good cosmetic outcome is conditioned by the precise planning during opening and beveling the bone to sit adequately during closure providing appealing results. [2,8]

The ideal Approach of TSM surgery with the minimal post-operative morbidity remains difficult to ascertain due to the multitude of trans cranial approaches, extended endoscopic approaches and also the recent minimally invasive techniques. The perfect approach which provides the best outcome for the patient remains a subject of debate between leading centres. Thus, many authors tried to set a grading system to classify TSM then to relate specific surgical results and morbidity for each subgroup [1]. It was found that there are many variables that a surgeon must consider before choosing the Ideal approach (tumour size, carotid artery encasement, optic canal involvement). The proposed grading system seem to be adequate for transcranial approaches as it showed an increase of resection rate from higher to low grades [1]. But it does not compare the different transcranial approaches used. TS Approaches seem to be suitable for lower grades. But it seems that those are not the only variables that the surgeon should consider. For instance, some leading skull base endoscopic centres are prone to approach complex TSM endoscopically with satisfactory results taking into account primarily the supra sellar notch angle [3]. In our center we advocate the TS Approach for the lower grade TSM (tumor size < 1.7 mm with no optic canal involvement and no carotid artery encasement when the Supra sellar notch angle is adequate). When it comes to the Transcranial approaches. We choose the adequate approach in a case by case study as it was illustrated above and justifying larger approaches with high grade TSM.

VII. Conclusion

The successful surgical management of TSM require experienced neurosurgeon with a wide practice in Microsurgical and Reconstructive endoscopic transsphenoidal techniques. In our experience we have achieved a significant decrease in the complication rate from the beginning of our experience until now as we are focusing to improve our surgical results with the minimum of morbidity (8 years mortality free). That goal can only be achieved with an accurate study while considering every variable in the process of the surgical management of TSM.

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