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Endonasal surgical management of tuberculum sellae meningiomas. Our experience

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Purpose: to evaluate the results of endonasal interventions in patients with meningioma of the TS, to determine the criteria for selecting patients for endonasal approach, to establish indications and contraindications, to analyze the radicalism of operations, their technical features and complications associated with this approach.

Materials and methods. the indications and contraindications for endonasal surgery of meningioma of the TS, which were performed in Romodanov Neurosurgery Institute from 2014 to 2022. The study includes 32 patients with a diagnosis confirmed by instrumental examinations: meningioma of the TS, who underwent endonasal tumour removal. The results of interventions were evaluated based on the postoperative ophthalmological (with optical coherence tomography - OCT), endocrinological (laboratory), instrumental (CT and MRI) and rhinoscopic follow-up of patients.

Results. Performance of endonasal surgery for TS meningioma, method of bony defect plastic surgery, which significantly reduces the percentage of CSF leak was described in our article. Thus, it was confirmed that our percentage of CSF leak (9.4%) was significantly lower compared to other authors.

We also assessed radicality of endonasal removal of TS meningioma of the TS. Simpson I was achieved in 87.5%.

In 26 patients (81.2%) in the early postoperative period improvement of visual acuity and expansion of visual fields has been noted, which was confirmed by an ophthalmologist's examination and optical coherence tomography. In 4 patients (12.5%) no dynamic of visual disturbances was noted, in 2 patients (6.25%) a slight decrease of visual acuity was noted. Intra- and postoperative complications in patients with TS meningiomas were analyzed. There were no mortality, hemorrhagic complications and postoperative meningitis. Five (15.6%) patients had postoperative hypopituitarism. Two (6.25%) patients had a syndrome of inadequate secretion of antidiuretic hormone, manifested by hyponatremia. Among postoperative complications there were 3 cases of CSF leak (9.38%). One case of CSF leak required reoperation (3.13%). We also observed an overpacking with a fat graft (1 case), which led to decreased visual acuity in the early postoperative period and required reoperation (3.13%). In 6 (18.7%) cases in the postoperative period, anosmia occurred due to the extended approach and traumatization of the nasal mucous membrane.

Conclusions. The main complications of endonasal interventions are: intraoperative damage of neurovascular structures, CSF leak, meningitis, necrosis of the nasoseptal flap, hemorrhages in the tumour bed, overpacking with a fat graft which leads to decreased vision in the early postoperative period and anosmia. The rate of major complications described in this article is low and quite acceptable. Critical issues such as meningitis and hemorrhagic complications are completely absent in this study.

Key words: *TS meningioma; sellar region; transnasal endoscopic approach; CSF leak*

Introduction

Percentage of TS meningiomas is about 25% of the total number of the anterior cranial fossa

meningiomas [1]. The removing of these tumours is complicated due to their location near critical neurovascular structures (internal carotid artery

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(ICA), anterior cerebral artery, anterior communicating artery, visual structures, infundibulum) [2]. Control of these structures and the possibility of early bony decompression of the optic canals (if necessary), is provided by anterolateral basal approaches using microsurgical techniques which in recent decades have been preferred for the removal of these tumours. The radicality of basal meningioma removal is ensured not only by removal of the main tumour volume but also by excision or coagulation of the invaded dura mater (DM) which is the original growth zone of meningioma ("matrix"). The presence of severe hyperostosis in the area of initial tumour growth in most cases changes the configuration of the anterior cranial fossa, require the removal of pathologically altered bone tissue and may limit the radicality of transcranial interventions. The desire of reducing trauma in meningiomas of the tubercle and diaphragm of the sella turcica has led to an increase of using endoscopic assisted transcranial interventions and the development of endoscopic "keyhole" surgery. At the same time the rapid progress of endonasal neurosurgery has led to more frequent use of transnasal endoscopic intervention for certain types of basal meningiomas as more effective and less traumatic approach. The first publications about the usage of endoscopic transnasal technique in the TS meningiomas surgery appeared in the early 2000s. The main problem remains the high rate of postoperative CSF leak. According to the Pittsburg Group considered to be the pioneers of this technique the incidence of postoperative CSF leak during endonasal removal of basal meningiomas is 10% [3].

The article describes our experience of using transnasal endoscopic approach for the tuberculum sellae meningiomas, substantiates the advantages and defines indications and contraindications for its use, and analyzes the ophthalmological and endocrinological outcomes of surgical treatment.

Objective: to evaluate the results of endonasal interventions in patients with TS meningiomas, to determine patient selection criteria, to establish indications and contraindications for endonasal approach, to analyze the radicality of operations, technical features and complications associated with this approach.

Materials and methods

Study participants

The study group included 32 patients with the TS meningioma who underwent endoscopical tumour removal through a transnasal approach in the department of endonasal neurosurgery of the skull base of the Institute of Neurosurgery named after Acad. A.P. Romodanov, Ukraine in the period from 2014 to 2022.

Informed and voluntary written consent to participate in the study was obtained from all patients.

The study was approved by the Committee on Ethics and Bioethics of the Institute of Neurosurgery named after Acad. A.P. Romodanov, Ukraine (Protocol № 89, December, 14, 2021).

Characteristics of the group

There were 21 (65.5%) women, 11 (34.4%) men. The patients' age ranged from 20 to 68 years, the mean age was (55.7±10.1) years.

Criteria for inclusion in the study

Patients with the tuberculum sellae meningiomas, who required endonasal endoscopic surgery, had visual and/or endocrine disorders in the preoperative period and consented to the surgery.

Study design

The criteria for patient selection were defined, the radicality of surgeries, their technical features were analyzed. The data of neuroimaging, instrumental and laboratory studies were evaluated in dynamics. Based on the obtained data, indications and contraindications for endonasal endoscopic surgical intervention were established. The most optimal method of endoscopic intervention is described, basing on the experience of other authors and our results of surgical interventions. Complications that occurred in patients as a result of endonasal interventions for the tuberculum sellae meningioma are analyzed, methods of prevention are described.

All patients underwent standard preoperative clinical and laboratory. Ophthalmological examination data (fundus examination and computer perimetry) in the preoperative and postoperative period were obtained. Endocrine status was assessed in all patients. Optical coherence tomography was performed in 78% of patients. Neuroimaging examinations (magnetic resonance imaging (MRI) with intravenous enhancement in 100% of patients, multispiral computed tomography (MSCT) of the skull base and paranasal sinuses in 90%, multispiral computer angiography (MSCT-AG) - 64%) were also performed (**Fig. 1**).

While planning interventions the tumour relation to the arteries of anterior semicircle, the stalk of the pituitary gland, the configuration and pneumatization of the tuberculum sellae, the presence of hyperostosis and optic canal invasion have been considered [4]. **Fig. 2** indicates that MRI without intravenous enhancement should also be assessed since meningioma may be isointensive to the pituitary gland. Transcranial approach with this tumour configuration may increase the risk of pituitary trauma which may lead to endocrine disorders.

Interventions were performed in the patient's supine position with a 15° head rotation to the right. The main surgeon performed manipulations in the operation field using two instruments, the assistant was positioned on the left and held the endoscope camera (**Fig. 3**) to provide an extended angle (0 and 30°) of instruments attack and better visualization of the operative field through the binostrial approach with formation of the nasoseptal flap at the beginning of surgery. Resection of the middle concha was performed in 12 operations. In all cases, resection of the rostral part of the nasal membrane was performed. The resection of anterior wall of the sphenoid sinus was performed using a high-speed bur while preserving the integrity of the sphenopalatine artery supplying the pedicle flap. Hyperostosis and basal

structures of the skull were sawn with bur. The bone plate was separated from the DM using rongeurs. During surgery, the clinoid (C5) and ophthalmic (C6) segments of the ICA with their branches were monitored using a Doppler probe (8 and 20 Hz), in particular through the bony structures and the communicating (C7) segment was visualized after tumour removal (Bouthillier classification). The bone flap had a trapezoidal shape, with its base turned towards the tuberculum sellae, or a pentagonal shape (**Fig. 4**) from the sella turcica to the sphenoid planum. The pentagonal shape provided better control of optic canals. The superior (anterior) cavernous sinus was transected and coagulated, which is the key point for transtuberular approach followed by safe control of the diaphragm of sella turcica and position of pituitary stalk. A T-shaped DM dissection was extended upward along the midline with visualization and coagulation of the tumour matrix. Biopsy and removal was performed on a devascularised tumour using a pituitary rongeur (1-2 mm), aspirators and microscissors. During the dissection, attention was paid to preserving the integrity of the following structures: pituitary gland, pituitary stalk, superior pituitary artery, optic nerves,

and chiasma. In the case of small size meningioma after arachnoid dissection was performed en-block resection (11 (34.4%) cases). With bigger meningioma sizes (>3 cm in the largest dimension), after devascularization of the matrix, the tumour was removed mainly by fragmentation and internal decompression, and then peripheral dissection was performed [5]. Hemostasis was performed using oxidized cellulose. In severe venous bleeding from the intercavernous sinus or from its inflow into the cavernous sinus, "Surgiflo™" was used (3 (9.38%) cases).

Multi-layer plasty of the DM defect was performed in all cases [6], in case of a small defect, with a fat graft from the thigh, in case of large defects, with fat and a deep fascia of the thigh with additional fixation of the fascia with "TachoComb". The nasoseptal flap was always the outer layer of plasty. The flap was fixed with oxidized cellulose preparations and "Spongostan". We do not use mechanical fixation of the nasoseptal flap by inflating a Foley catheter in the sphenoid sinus because such a semi-blind manipulation may entail displacement of the underlying layers and ischemia of the flap itself.

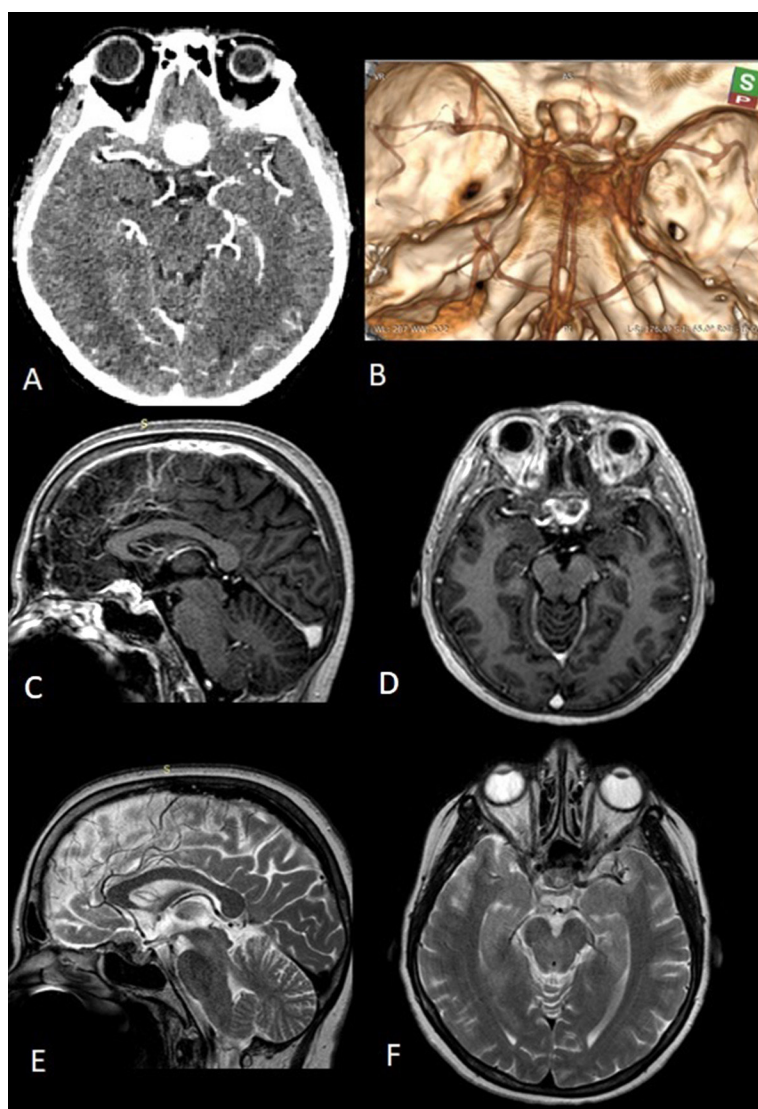


Fig. 1. Tuberculum sellae meningioma meeting the criteria for endonasal endoscopic intervention:
A, B – MSCT-AG before surgery: marked hyperostosis, location of the tuberculum sellae meningioma relative to vessels of anterior semicircle; C, D – MRI with intravenous enhancement before surgery; E, F – preoperative MRI in T2 mode

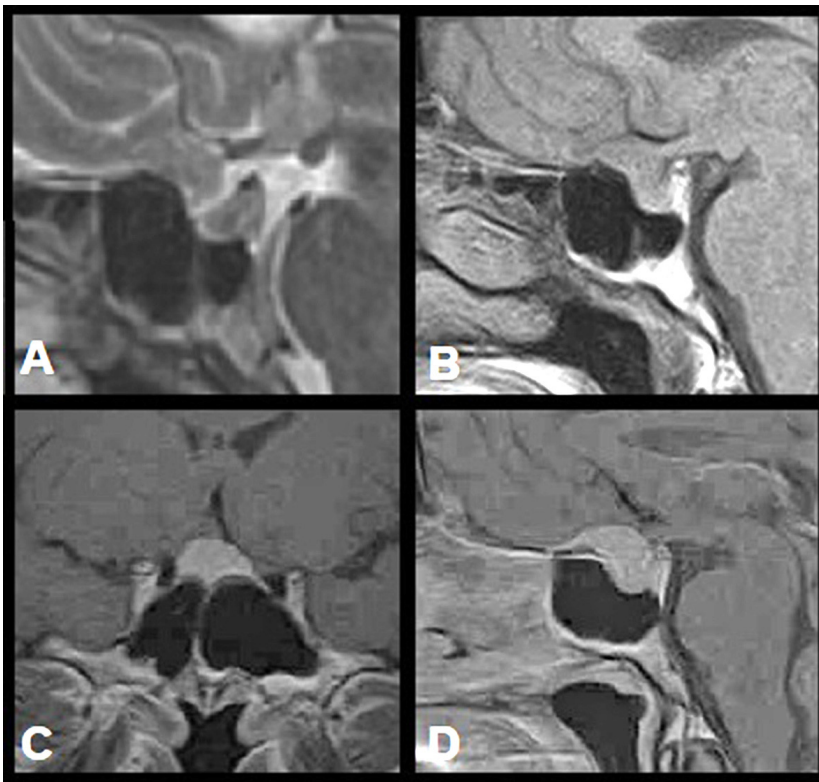


Fig. 2. MRI of the brain demonstrating the importance of assessment and non-contrast regimens while planning the approach: A, B - without intravenous enhancement; C, D - with intravenous enhancement

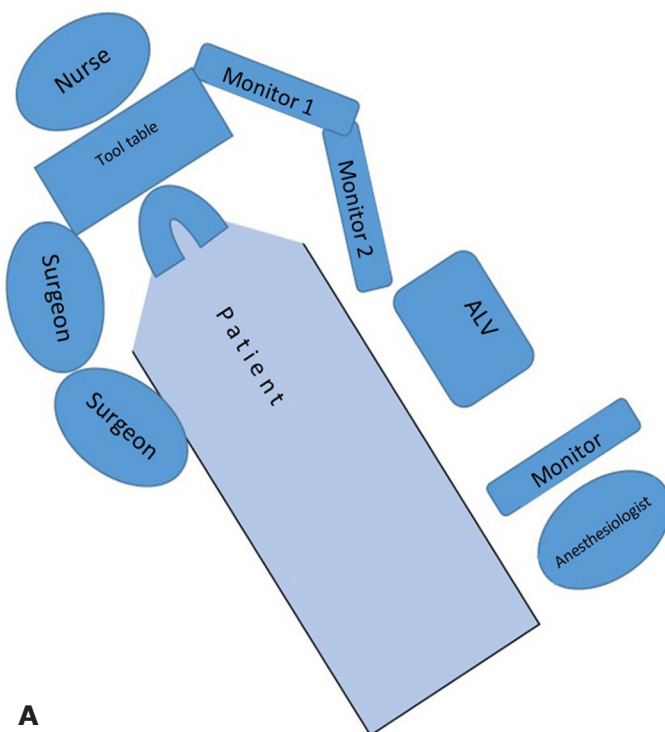


Fig. 3. Scheme of location of the operating team during the intervention at TS meningioma: A - ergonomics of the operating room (surgeons are on the right, monitors are located on the left of the patient, nurse is next to the patient's head) B - position of surgeons' hands and instruments in the nasal passages during a 4-handed intervention

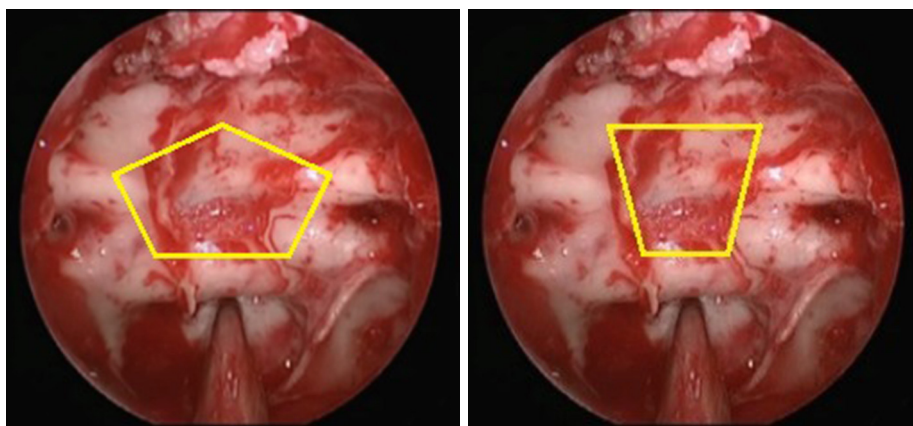


Fig. 4. Pentagonal and trapezoidal shape of the bone window while accessing the tuberculum sellae meningioma

When the nasoseptal flap defects were detected, in 3 cases external sealing of the flap surface and the main bone sinus cavity was performed by "DuraSeal", in one case when the nasoseptal flap was not wide enough, it was fixed using surgical glue "Bio-Glue". The exit site of the sphenopalatine artery was coagulated on the side opposite to pedicle flap. After revision of the nasal passages and nasopharynx, "Merocell" was injected into each nostril under endoscopic control in the direction of the anterior wall defect of the sphenoid sinus.

Lumbar drainage was left in all patients for 2–5 days, which was blocked until the MSCT was performed to assess the severity of pneumocephalus [7].

All operated patients were examined by an ophthalmologist with computer perimetry in the early postoperative period.

Statistical analysis

To estimate the probability of differences (p) in the indicators of independent groups the Student's t -test for unrelated populations was used. A difference of $p < 0.05$ was considered statistically significant.

Results and their discussion

The selected approach, namely the extended endoscopic transnasal transtuberular – transplanar approach, was evaluated in all cases as being adequate to tumour removal and optic nerves decompression. Simpson I removal was achieved in 28 (87.5%), Simpson II in 2 (6.25%), Simpson III in 2 (6.25%) cases. Overall, the use of Simpson classification for the tuberculum sellae meningiomas is not maximally informative.

No access-associated complications have been reported in our study. The deeper olfactory fossa variant (Keros 2-3) is more difficult to perform the endonasal access compatible with a too high nasoseptal flap formation line, causes a statistically significantly higher rate of anosmia (18.7%) compared to a series of endoscopic pituitary adenoma surgery (0.5%, $p = 0.05$).

The average duration of interventions was (4.7 ± 0.2) hours, while the intradural stage (meningioma removal in the narrow sense) lasted only (1.2 ± 0.1) hours.

There were no hemorrhagic intraoperative complications in our study. In one (3%) case, there

was "overpacking" with a fat graft which led to visual impairment in the early postoperative period and required reoperation. This can be considered as intraoperative complication caused by a technical error during plasty [8].

The postoperative period was generally easier than in patients after transcranial interventions. None of the patients required intensive therapy. The average length of postoperative stay in the hospital was 4.2 days. Speaking about postoperative complications 3 (9.38%) cases of postoperative CSF leak were reported but only 1 (3.13%) case of postoperative CSF leak required reoperation. Multi-layer CSF re-plasty was performed using fascial and fat graft from the thigh, preformed nasoseptal flap (recognized as viable) and "TachoComb" [3]. The data obtained on the incidence of postoperative CSF leak indicate that this rate was the same or statistically significantly lower than the average given in the literature (10%) (**Table 1**). It is impossible to compare the obtained results of transnasal and transcranial surgical interventions due to the use of selection while forming indications for certain types of interventions. Two cases of postoperative CSF leak were treated conservatively for several days by prescribing dehydration therapy and carrying out a revision (re-insertion) of the lumbar drainage.

In the early postoperative period improvement in visual acuity and visual fields expansion was noted in 26 (81.2%) patients, which was confirmed by results of ophthalmic examination and optical coherence tomography, in 4 (12.5%) - no dynamics of visual disturbances, in 2 (6.2%) - a slight decrease of visual acuity.

Postoperative hypopituitarism occurred in 5 (15.6%) patients. They required hormone replacement therapy with hydrocortisone and L-thyroxine, 2 (6.2%) had a syndrome of inadequate secretion of antidiuretic hormone, manifested by hyponatremia and requiring conservative treatment.

All patients underwent rhinoscopy on the 3rd–4th day, 23 (71.8%) – 1 month after surgery to assess the sinonasal destruction, 17 (53.0%) – also after 6 months. In all cases the viability of the nasoseptal flap

Table 1. Duration and radicality of surgical interventions for meningioma of the tuberculum sellae and the incidence of postoperative CSF leak according to different authors

Source	Total number of patients	Average duration of operation, hrs.	postoperative CSF leak, %	Radicality (Simpson I)
K. Qian et al. [11]	34	3,2	11,8	31 (91,2%)
A.B. Kassam et al. [13]	35	3,1	10,3	30 (86,4%)
C.H. Snyderman et al. [12]	75	3,5	25,3	57 (81,4%)
Our results	32	4,7	9,4	28 (87,5%)

the condition of the turbinates and sense of smell, which in most cases was restored 3-4 months after surgery were assessed. In 6 (18.7%) cases the sense of smell was lost due to the need of expanded approach and traumatization of the nasal septum mucosa.

According to the pathomorphological study of the operative material, Grade I meningiomas accounted for 93.75%, Grade II meningiomas accounted for 6.25%. There were no Grade III anaplastic meningiomas. During the five-year follow-up, there were no fatal cases of continued growth of the TS meningioma according to MRI. Catamnesis data were unavailable in 4 (12.5%) cases due to loss of contact with patients.

Endoscopic transnasal removal of tuberculum sellae meningiomas has many advantages that have been described in the literature. Our experience also demonstrates this [9].

Above all this is the complete absence of brain traction during surgery and limited manipulation at the optic nerves during their decompression. The meningioma is removed from the top down, from the brain and chiasma towards the formed trepanation window. Complete removal of hyperostosis and rapid devascularization of the tumour is possible. The stage of arachnoid dissection and removal is performed on a completely devascularized tumour. The possibility of limiting manipulations with the arachnoid membrane reduces the risk of impaired blood supply of visual structures and the pituitary gland.

However, the main disadvantage of endoscopic transnasal removal of the tuberculum sellae meningioma is the high risk of postoperative CSF leak. As the analysis of results has shown that the incidence of postoperative CSF leak and the development of complications can be reduced to 3% and less. This has been achieved only with considerable experience in endoscopic neurosurgery due to improvement of the technique of multi-layer plasty of intraoperative defects of the skull base using an adequate nasoseptal mucosa-periosteal flap (in all patients). However, performing all stages of approach and plastic without involving an additional ENT surgical team affects the duration of the intervention which is longer in our series compared to the data in literature (*see Table 1*). The presented surgical series shows that we are gradually gaining experience and improving the technique of certain stages of interventions and the overall duration of the surgeries tends to be shorter. According to Kassam classification of degrees of

complexity of endoscopic transnasal neurosurgery of the skull base, common in the USA [10], basal meningioma surgery belongs to level III-IV, i.e. above sinonasal and predominantly sellar surgery. Therefore, the transition to surgery in open cerebrospinal fluid spaces is possible only in case of significant experience in performing technically simpler endonasal surgery and only in neurosurgical centres with a high number of such cases per year.

A better cosmetic effect compared to transcranial interventions, an easier course of the postoperative period, the operation without brain traction and through a minimal surgical "corridor" are important arguments in favour of endoscopic surgeries especially regarding their perception by patients. However, the patient should be informed about the consequences of sinonasal destruction, the risk of olfactory loss, the peculiarities of postoperative follow-up and the treatment by an ENT specialist.

Endonasal extended approach to the tuberculum sellae meningioma is a relatively simple midline approach requiring orientation to symmetrical anatomical structures. This facilitates understanding of the intervention steps and does not require the use of neuronavigation, but with complex septation and small pneumatization of the sphenoid sinus, it significantly complicates the access step technically, requiring the use of high-speed burs, wide nasal septum resection, sphenotomy, turbinectomy, etc. From our experience, analysis of surgical technique and effective plasty of surgical defects with extended (on tubercle and planum) endoscopic approach does not allow to be classified as minimally invasive.

Reducing the incidence of postoperative CSF leak in our series to <10% gives reason to consider other criteria for choosing transnasal or transcranial approach to the tuberculum sellae meningioma, taking into account the radicality of tumour removal and better functional outcome of surgery. In our opinion, these criteria are as follows. The tumour matrix should only be in the region of the tuberculum sellae, not widely spread to diaphragm of sella turcica, optic nerves canals or cavernous sinuses. Endonasal surgery is also technically, possible, but it is non-radical and less safe due to the inability of total removal of the entire tumour volume.

The presence of hyperostosis and/or pneumatized tuberculum sellae beneath the tumour is an argument for choosing the endonasal approach of tumour

removal. Manipulations with this anterior cranial fossa configuration are less convenient with a transcranial approach, limiting its radicality.

Variants with tumour deviation from the midline and involvement of the anterior semicircle vessels in the tumour structure were considered as absolute or relative contraindications to endonasal interventions. In the conditions of a narrow endonasal corridor, we can see the vessels of the anterior semicircle "from the inside" (from the tumour). Therefore, we do not control the supraclinoid segment of the ICA, the bifurcation of the ICA, and we cannot conduct a safe dissection of the tumour "along the course of the vessel".

The size of the tumour suitable for endonasal removal is discussable and in view of the above criteria is not in itself decisive. However, we found a direct correlation between the tumour size and the duration of intervention. In our opinion, this is due to the longer execution of the stages of fragmentation and internal decompression of tumour in the conditions of a small trepanation window, the inability of effective use of an ultrasonic aspirator through the nose. We recommend selecting tumours <3 cm in any MRI dimension.

Transcranial interventions were performed in patients who decided not to undergo endonasal

meningioma removal. For example, we recommend a transcranial anterolateral approach for tumour removal with microsurgical controlled dissection along vessels encompassed by the tumour tissue [12] (**Fig. 5**).

Other factors limiting the possibility of total resection of the tumour with any access should also be kept in mind: its dense consistency, significant bleeding, widespread tumour matrix, prior surgery or adjuvant radiation therapy.

Given the importance of using a nasoseptal flap for the plasty of the skull base defect as shown in our study, reoperations, reusability and viability of the flap are debatable.

Conclusions

The approach to the selection of patients for endonasal interventions at meningioma of the tuberculum sellae, preoperative examination of patients, intervention, bony defect plastic surgery, possible intra- and postoperative complications, methods of their prevention, indications and contraindications for transnasal intervention are determined, ophthalmological and endocrinological consequences of the intervention are analyzed.

At the current stage of the development of neurosurgery, endonasal surgical removal of the

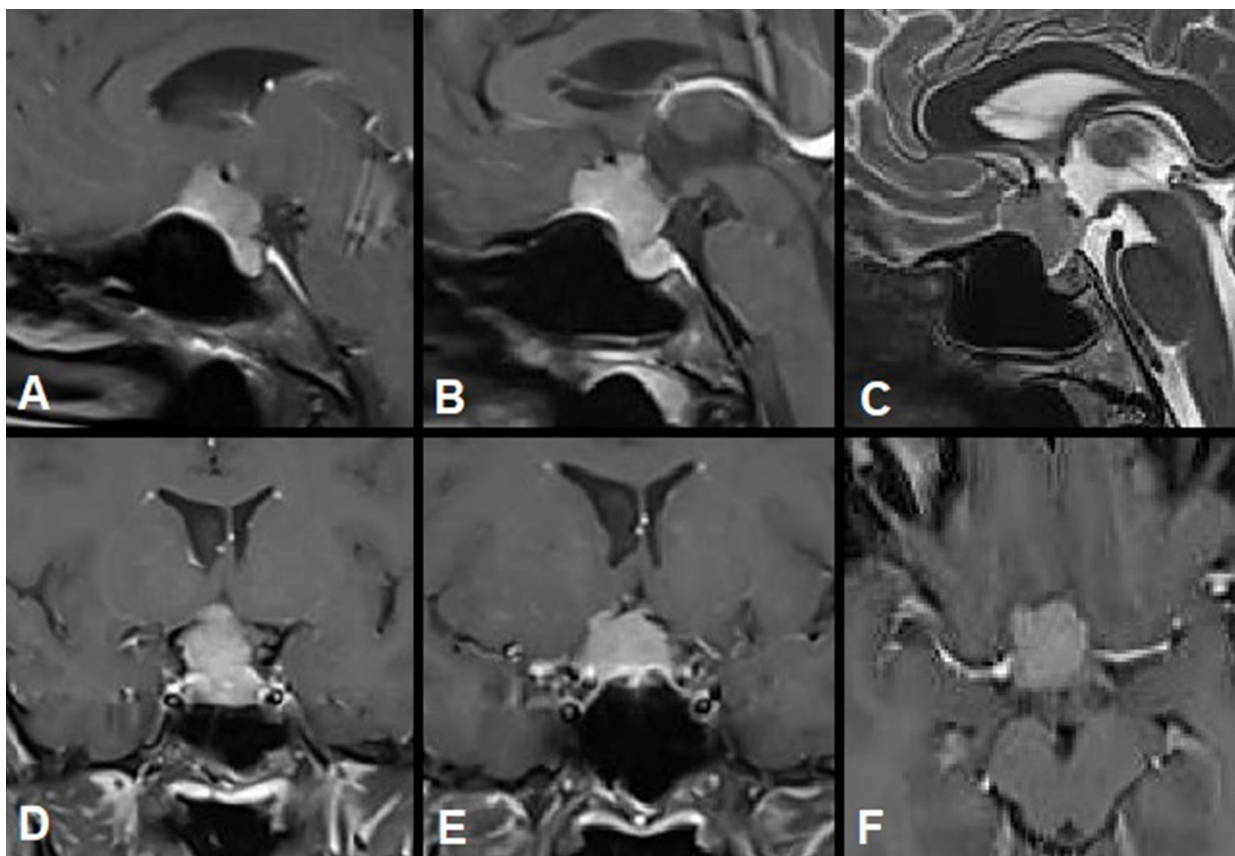


Fig. 5. Intravenous-enhanced MRI of the sellar region. Meningioma of the tuberculum sellae with contraindications for endoscopic endonasal intervention: A, B, C - coverage of the anterior cerebral artery - anterior communicating artery complex and spread towards the posterior communicating artery; D, E - asymmetric spread of the tumour over the supraclinoid segment of the internal carotid artery and spread towards the posterior communicating artery; F - lateralization of the meningioma to the right, towards the posterior communicating artery

tuberculum sellae meningioma is a safe alternative to transcranial microsurgery in many patients with this pathology. Our study made it possible to determine the criteria for selecting cases of the tuberculum sellae meningioma, optimal for endonasal removal. Based on a comprehensive analysis of instrumental and intraoperative data, variants of hyperostosis and variable anatomy of the tuberculum sellae were identified for which endonasal removal should be considered as the method of choice.

The main complications of endonasal interventions include: intraoperative damage of neurovascular structures, postoperative CSF leak, meningitis, necrosis of the nasoseptal flap, hemorrhages in the tumour bed, "overpacking" with a fat graft, which leads to reduced visual acuity in the early postoperative period, anosmia. In our opinion, the incidence of major complications in the described surgical series is low and acceptable, and complications that can lead to a fatal outcome, such as meningitis and hemorrhagic complications, were absent.

The safety and efficacy of endonasal surgery for meningioma of the tuberculum sellae is ensured by patients selection, sufficient experience in performing endoscopic neurosurgical interventions by two surgeons in 4 hands, and perfect performance of multi-layer plasty of the skull base defect with obligatory use of a nasoseptal flap.

The presence of a wide tumour matrix with spread to the optic canals is a contraindication to endonasal removal of the tuberculum sellae meningioma. In such cases, significant or complete bony decompression (with extradural clinoidectomy) should be planned. We did not plan endonasal interventions when the tumour encompasses arteries of anterior semicircle. This approach is subjective and reflects the level of our surgical technique in endoscopic interventions at this time. Further advances in such surgery will contribute to reducing the list of contraindications to endonasal surgery for the tuberculum sellae meningioma.

We can talk about the higher radicality of removing the tuberculum sellae meningioma through the nose only in cases of pronounced hyperostosis, which can be removed completely extradurally when performing an extended transtuberular-transplanar approach. Comparing the radicality of transcranial and endonasal interventions for the tuberculum sellae meningiomas is incorrect due to specific approaches to selecting patients for each of the approaches or variants of its implementation. Comparison of selective groups, randomised according to the tumours size and topographic anatomical features, was not performed.

Extended endonasal binostril approach, namely transtuberular-transplanar, with nasoseptal flap formation and wide resection of the posterior parts of the nasal septum cannot be considered minimally invasive, especially in view of the data of postoperative follow-up and endoscopic rhinoscopies. Assessment of the long-term effects of surgical sinonasal destruction for the patient is predominantly subjective and requires further analysis and discussion.

Disclosure

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

All procedures performed on patients comply with the ethical standards of institutional and national ethics committees, the 1964 Declaration of Helsinki and its amendments or similar ethical standards.

Informed consent

Informed and voluntary written consent was obtained from each patient.

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