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Transcranial surgery for pituitary adenomas

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Abstract Following a century of evolution and refinements in standard surgical techniques, the vast majority of operations for pituitary adenoma to date are performed utilizing transsphenoidal approaches. From current large series one obtains the impression that certainly less than 10% of these tumors require craniotomies. However, still several tumors, which's volume is mainly localized outside of the sella require transcranial approaches, of which the pterional and subfrontal routes are the most widely used. The goal of surgical treatment is rapid eradication of the tumor mass, decompression of visual pathways and elimination of hormonal oversecretion whilst preserving the normal gland and avoiding potential surgical complications. Even with microsurgical techniques and standardized approaches, there is still some mortality associated with transcranial approaches and morbidity is undoubtly higher than with transsphenoidal operations. However, a selection bias must be considered, which shifts tumors with a larger size, less favourable prognosis and higher complication rate into the transcranial series. Moreover, with extended transsphenoidal approaches, lesions have become accessible for transsphenoidal surgery, which previously have been considered as contraindications. In this article current indications and limitations for transcranial surgery of pituitary adenomas, the preoperative workup, surgical techniques, results, and complications are briefly reviewed.

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Evolution of transcranial pituitary surgery

The first actually recorded surgical intervention for a pituitary tumor can be traced back to Frank Thomas Paul (1851–1941) in the year 1893. However, Sir Victor Horsley (1857–1916) was probably the first surgeon, who operated on a pituitary adenoma dating back to the year 1889. It is known, that he used a bifrontal craniotomy. In order to reach the sella region he described a technique of "cerebral dislocation". However, he encountered a cystic lesion, that he described as not inoperable [20]. Because of this experience and Horsley's former laboratory work on sheeps, Frank Thomas Paul eventually consulted Sir Horsley about a case of a young woman with acromegaly. Horsley eventually recommended a subtemporal approach. Paul's pioneering transcranial procedure ended with intractable brain swelling and the consecutive death of the patient eight hours later. Another pioneer of transcranial surgery considering pituitary tumors, Otto Theobald Tiliani in New York, started gathering experience with a bifrontal intradural approach on cadavers in 1903. Almost at the same time Fedor Victor Krause (1857–1937), a surgeon in Berlin, Germany, tried to remove a shot gun bullet from the area of the right optic foramen in a patient who had attempted suicide, by an extradural right frontal approach (Fig. 1). Encouraged by the good outcome of this patient, it was Fedor Krause, who performed the first recorded successful resection of a pituitary tumor utilizing an extradural transfrontal approach avoiding extensive retraction of the frontal lobe in 1905 [19].

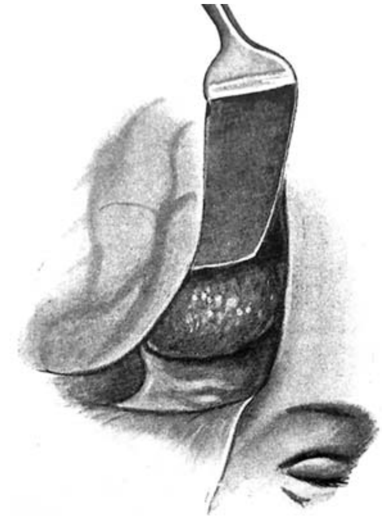

Fig. 1 Fedor Krause's extradural-transfrontal approach. From: Krause F: Chirurgie des Gehirns und Rückenmarks nach eigenen Erfahrungen. Urban & Schwarzenberg, Berlin 1908, Tbl. XVII

The mortality rates of transcranial surgery regarding the pituitary region ranged between 50% and 80% in these days. Between 1904 and 1906 Sir Victor Horsley went on approaching pituitary lesions by transcranial procedures and finally operated a consecutive series of 10 patients with pituitary tumors utilizing both, subfrontal and subtemporal approaches with an improved mortality rate of about 20%.

Lewis Linn McArthur (1858–1934) tried to access a pituitary tumor in 1908 using a right frontal osteoplastic craniotomy including the resection of the supraorbital rim and parts of the orbital roof (Fig. 2). This extradural approach was adopted by Charles Frazier (1870–1936), who later on changed to use an intradural frontobasal approach [13]. After gathering some experience with the transnasal approach to the sella region Frazier finally concluded that the transcranial approach to the sella region has to be considered superior over the transsphenoidal approach in patients with visual symptoms. This conclusion was shared by Harvey Cushing, who initially had also favoured the transsphenoidal approach for pituitary tumors.

Harvey Cushing had adopted and extended the transsphenoidal technique on the basis of the first successful transsphenoidal approach to a pituitary tumor performed by Schloffer in Vienna 1907. After performing 231 transnasal, submucosal approaches to the sphenoid sinus and sella region with a reported mortality rate of 5.6% [23], Harvey Cushing eventually changed his attitude and exclusively performed transcranial approaches, since he was convinced that a better outcome with regard to visual functions could be achieved. For Harvey Cushing's major influence on Neurosurgery at that time, the transsphenoidal approach to the sella region thereafter was almost completely neglected for several decades in the United States.

In Europe, however, the transsphenoidal procedure kept its relevance in the treatment of pituitary tumors. Particularly Norman Dott (1897–1937) and Gérard Guiot (1912–1996) remained committed to the transsphenoidal approach.

However, transcranial surgery for pituitary tumors maintained its importance in approaching lesions in the suprasellar area or the inferior parts of the third ventricle. It was Gazi Yasargil, who demonstrated advantages of transcranial surgery for large excentric suprasellar pituitary tumors utilizing the pterional approach by minimizing

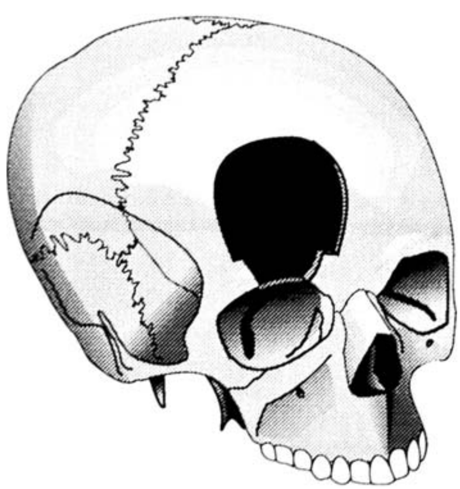

Fig. 2 Frazier's frontobasal approach with resection of the orbital rim and orbital roof. From Landolt AM: History of pituitary surgery: transcranial approach, in: Landolt AM, Vance ML, Reilly PL (eds): Pituitary adenomas. Churchill Livingstone, New York 1996, p. 286

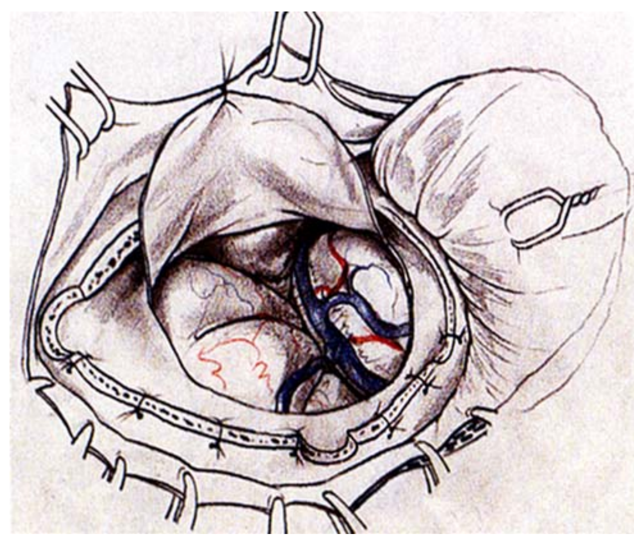

Fig. 3 Yasargil's pterional craniotomy, Sylvian fissure exposed. From: Yasargil MG: Teddy PJ, Roth P (1985): Selective amygdalo-hippocampectomy. Operative anatomy and surgical technique. Adv Techn Standards Neurosurg 12:93–108

brain retraction after splitting the Sylvian fissure and opening of the basal arachnoid (Fig. 3) [34, 35].

During the last two decades most of the asymmetrically configurated pituitary tumors that eventually needed a craniotomy were either approached by his refined pterional approach or a variant of a subfrontal approach. However, these indications have been challenged by the technical advances of endoscopy and the evolution of the extended transsphenoidal approaches during the last few years [8, 12, 18, 21].

Indications for transcranial approaches in pituitary surgery

Analyzing a variety of large clinical series one currently obtains the impression that much less than 10% of pituitary adenomas eventually require craniotomies. The main reasons for the continuously declining necessity of transcranial pituitary surgery are the technical advances and the low mortality and morbidity of transsphenoidal surgery. The mortality rate for a transsphenoidal procedure in experienced hands should be less than 1%. In addition the literature suggests an overall morbidity rate of less than 10%. These data have encouraged more and more pituitary surgeons to consider the transsphenoidal approach as the standard for nearly all pituitary adenomas.

However, there are still a number of distinct indications for the transcranial approach to pituitary adenomas (Table 1). One of these indications still is a large pituitary adenoma with a dominant extrasellar component in combination with a small, non-enlarged sella turcica (Fig. 4a–d). Most of the expert pituitary surgeons also consider that pituitary adenomas with a dumbbell configuration which harbour an hourglass constriction at the level of the sellar diaphragm should be approach via a craniotomy. Many of these tumors can be expected to have invasively perforated the sellar diaphragm and lack a sort of well defined tumor capsule. From a clinical standpoint they therefore often cause less loss of vision than one would expect from their volume and their suprasellar extension on MRI.

Table 1 Indications for transcranial pituitary surgery

Major indications	
1	Dominant extrasellar tumor component and small sella turcica
2	Dumbbell configuration
3	Large excentric extension into middle, anterior or posterior cranial fossa
4	Coexisting ICA or ACA aneurysm
5	Firm and fibrous pituitary adenoma (during previous procedure)
Minor/relative indications	
6	ICA or ACA vascular anomalies
7	Poor or not all pneumatized sphenoid sinus

Pituitary adenomas with a large excentric extension into the anterior, middle or posterior cranial fossa should also be dealt with by a transcranial approach (Fig. 5). A lesion, such as a coexisting aneurysm of the carotid or anterior cerebral arteries could be dealt with in a single session when a transcranial approach was chosen for the pituitary adenoma. A pituitary surgeon should be alerted by the description of a particularly firm and fibrous pituitary adenoma during a first operative procedure performed elsewhere. If the information is reliable, even an experienced pituitary surgeon should consider a transcranial approach in redo procedures.

These remaining major indications for a craniotomy in the operative management of pituitary adenoma, have recently lessened for the introduction of extended, endoscope-assisted transsphenoidal approaches during the last decade. Apart from these major indications, there are a few anatomical variants in the sella region that not automatically define the need for a craniotomy, but potentially raise the question whether a transsphenoidal approach is the ideal surgical strategy. Depending on both, the personal experience of the surgeon and the technical premises in the operative theatre, these less frequent, relative indications for a transcranial approach to pituitary adenomas are, e.g., vascular anomalies or cases with a not at all or poorly pneumatized sphenoid sinus combined with a large intra- and suprasellar tumor mass.

It has to be emphasized that certainly the large size of a tumor alone is not a contraindication for the transsphenoidal approach. With regard to "giant" pituitary adenomas in which already preoperatively one recognizes that they need both, a transsphenoidal and a transcranial approach, these procedures can be either performed consecutively (Fig. 6a–d) [4, 7, 22, 30], with the transsphenoidal "debulking" as the first step or as simultaneous procedures [2].

Preoperative workup

Generally, the minimal imaging technique required is a proper MR scan that depicts the tumor in T1-weighted images before and after the application of contrast medium at least in sagittal and coronal planes. This 3-D dataset can also be used for planning neuronavigation. Other sequences may be additionally required in an individual case. A skull X-ray is no more mandatory. In selected cases a coronal CT scan is appreciated since it provides much more information about the structure and segmentation of paranasal sinuses. Endocrinological investigations should provide information about the function of the various axes

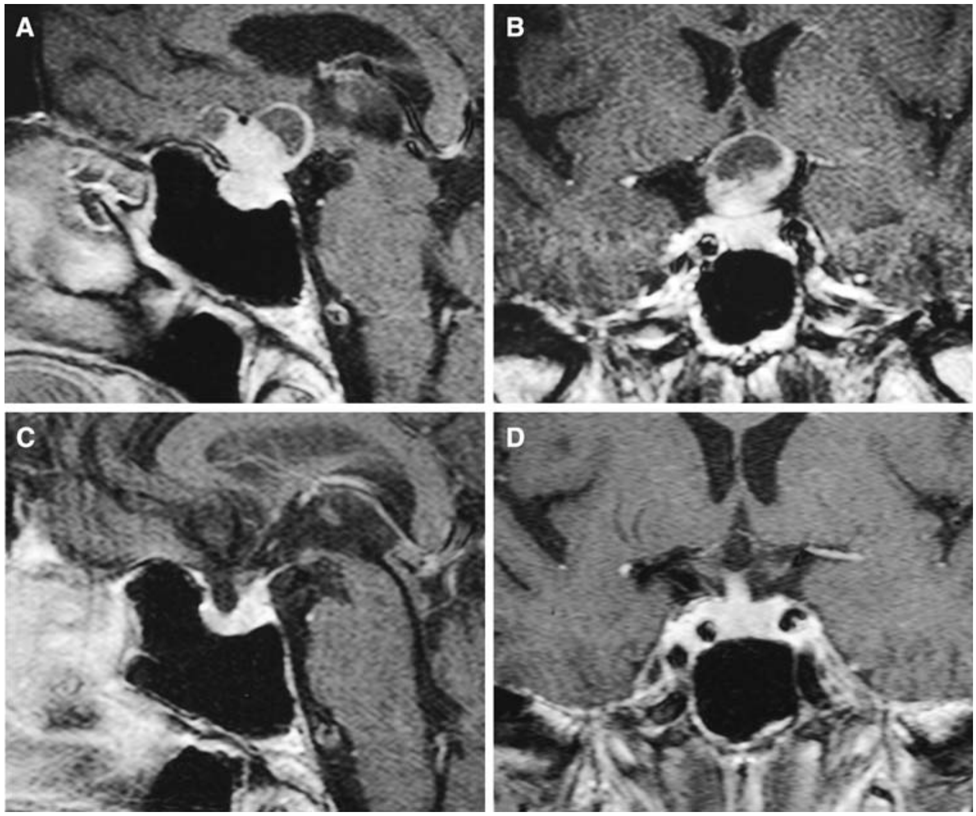

Fig. 4 Preoperative sagittal (**a**) and coronal (**b**) as well as postoperative sagittal (**c**) and coronal (**d**) T1-weighted contrasted MRI scans illustrating a multi-lobated, partially cystic non-functioning macroadenoma with dominant excentric configurated, extrasellar tumor component and small sella turcica. Just like following transsphenoidal approaches the "secondary empty sella" represents the ideal postoperative MRI finding after transcranial resection of such a tumor

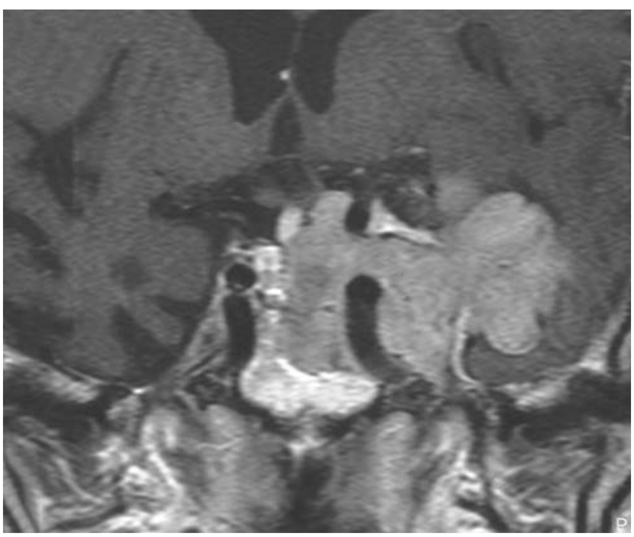

Fig. 5 T1-weighted contrasted MRI scans illustrating infiltrative GH-secreting pituitary adenoma with a large excentric extension into the middle cranial fossa

of the anterior pituitary. The prolactin level is a particularly crucial parameter since in cases of excessive prolactin hypersecretion, a prolactinoma is suspected and consequently, medical treatment with dopamine-agonists is the primary management of choice. Hypopituitarism requires adequate peri-operative substitution therapy. Endocrine evaluation needs to also reveal potential hormonal activity of the lesions and to document the magnitude of hormonal oversecretion. At least in patients with acromegaly and prolactinomas this has been shown to be a prognostic factor for the outcome of surgery in terms of normalization. In all suprasellar extending lesions an ophthalmological evaluation is required, consisting of a perimetric examination and testing of visual acuity. Furthermore, the general health of the patient should be assessed with respect to the threat of complications following surgery.

Transcranial approaches in pituitary surgery

The three standard transcranial approaches for large pituitary adenomas are the pterional approach, and variants of a subfrontal approach, like the frontobasal interhemispheric approach, and the subtemporal approach. In addition to these standard and most frequently used approaches to the suprasellar region, there are specific other transcranial approaches solely utilized in rare cases, for example the orbito-zygomatic approach or the interhemispheric transcallosal approach.

The localisation of the optic chiasm constitutes a crucial landmark in planning transcranial pituitary surgery next to the anatomical relationship between the tumor mass and a virtual vertical line drawn through the tuberculum sellae.

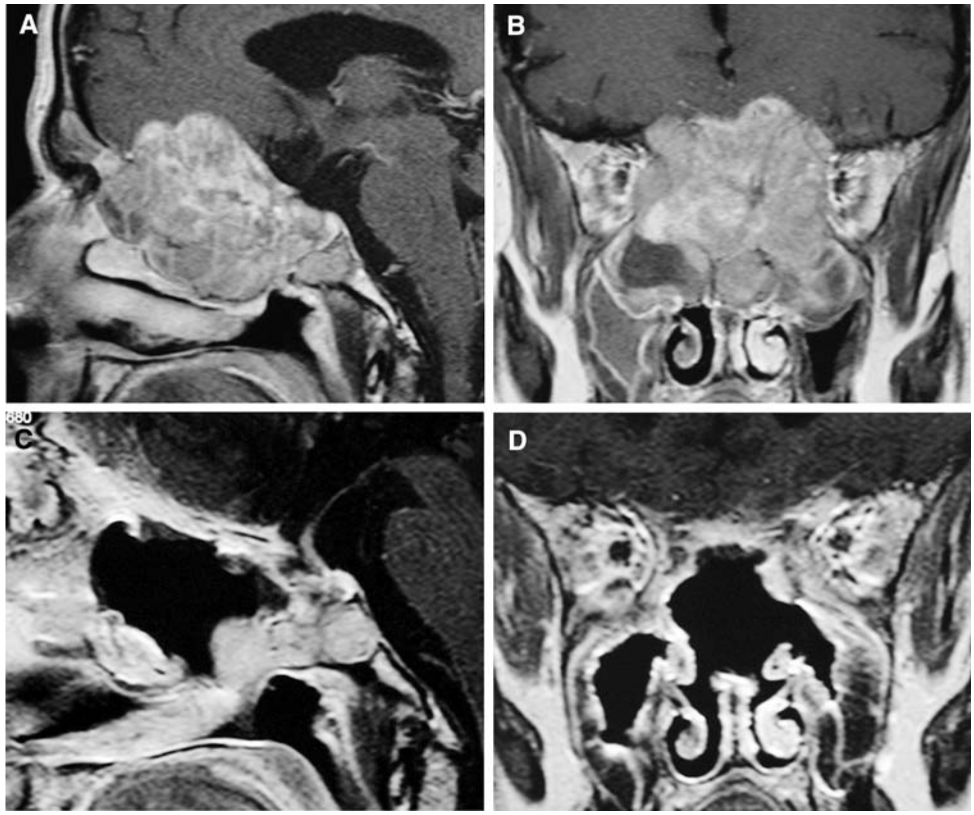

Fig. 6 Preoperative sagittal (**a**) and coronal (**b**) as well as postoperative sagittal (**c**) and coronal (**d**) T1-weighted contrasted MRI scans illustrating a recurrent infiltrative "giant" non-functioning pituitary adenoma involving the anterior cranial fossa, the ethmoid and sphenoid sinus and the nasal cavity before and after a staged transcranial and transsphenoidal approach

The relationship of the optic chiasm to the tuberculum sellae was first categorized by Bergland et al. [5]. The authors demonstrated that 9% of the optic chiasms were prefixed, 11% postfixed and 80% defined as a "normal" position. Regarding the pterional approach, which provides the shortest distance to the suprasellar region and is probably the approach most frequently used at the present time, a normal or postfixed chiasm is considered advantageous because the tumor mass is accessible in front of the optic chiasm and between the optic apparatus and the tuberculum sellae. Nevertheless, in our experience, large suprasellar pituitary adenomas with prefixed optic chiasms can also be resected utilizing the pterional approach, which additionally allows access to the inferior parts of the third ventricle through the lamina terminalis and tumor resection between the optic nerve and the carotid artery through the Lillequist membrane. In patients, in whom the suprasellar tumor mass is mainly localized behind the virtual line through the tuberculum sellae and dorsal the Lillequist membrane, what we call retrosellar extension, we prefer a bilateral frontobasal interhemispheric approach.

For the pterional approach the patient is positioned supine with the head raised about 25° bringing in the operative field above the heart level. The patient's neck is slightly extended and the head is rotated about 25–35° to the contralateral side of the planned craniotomy. Whenever possible the tumor should be approached from the non-dominant side. However, in cases with a marked and severe unilateral visual compromise, the surgeon should think about approaching the tumor lesion from the side of the optic nerve that has suffered more severe loss of function even if this means operating from the dominant cranial base. In our experience it is easier and less risky regarding the microvascular supply to decompress the (the functional better) optic nerve from below, which is more feasible for the optic nerve contralateral to the side of the chosen pterional craniotomy.

After a typical curvilinear skin incision between the zygomatic process/tragus and the midsagittal plane a typical pterional craniotomy is performed. The craniotomy can be extended to the frontal area in tumors with a large suprasellar extension projecting up between the optic nerves or with a subfrontal extension along the planum sphenoidale. Frameless stereotaxy has been proven to be extremely helpful in order to avoid the frontal sinus in these cases. The sphenoid ridge is drilled down medially in a extensive way outlined by Yasargil to minimized retraction of the frontal and temporal lobe [34]. Especially in large lesions the Sylvian fissure is then opened. After gently dissecting the Sylvian fissure proximally and distally using a deep to superficial technique the carotid bifurcation of the A1 and M1 segments and their relationship to the tumor are exposed. To further minimize brain retraction the carotid and chiasmal cisterns should be

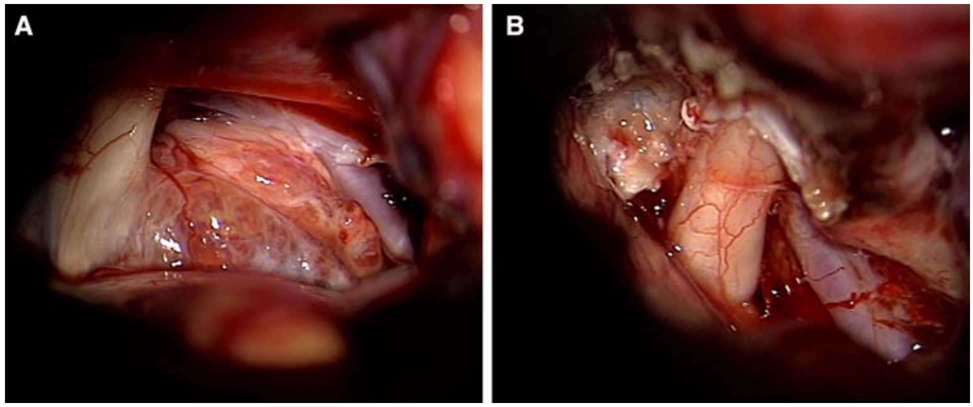

Fig. 7 Non-functioning pituitary adenoma accessed through the optico-carotid triangle, magnified intraoperative visualization through the operating microscope before (**a**) and after (**b**) resection

identified and opened as soon as possible. Drainage of CSF during this dissection will consequently provide brain relaxation and faciliate identification of the tumor capsule and its relationship to the optic apparatus and vascular structures. Most of the suprasellar pituitary adenomas can be accessed through the optico-carotid triangle unless obscured by perforating arteries (Fig. 7a–b). Cystic or soft tumors should be then debulked using curettes or CUSA. Use of the bipolar diathermy should be minimized in order to prevent disruption of microvascular structures which supply the hypothalamus or the optic chiasm. If the optic nerve of the ipsilateral side is severely deformed, displaced or flattened drilling of the optic canal and a consecutive release of the optic nerve may be necessary. It is crucial that after debulking the tumor through the optico-carotid window both the optic nerve and the carotid artery from the contralateral side as well as the pituitary stalk and posterior-lateral to the internal carotid artery the oculomotor nerve are identified before resecting the tumor's capsule and/or arachnoid layer. If the tumor is extremely adhesive to the optic apparatus the surgeon should have in mind that the first aim of the operative procedure is decompression of the optic chiasm and the optic nerve and not a complete resection of the biologically mostly benign tumors when a proper arachnoidal plane cannot be developed. However, for the risk of postoperative haemorrhage into the suprasellar area from tumor remnants, it is important to remove as much adenoma as possible. Hemostatis is achieved by copious irrigation with saline and oxidized regenerated cellulose.

Results of transcranial pituitary surgery

The literature about the operative results of the transcranial pituitary surgery, focusing on three major categories, namely recovery of visual functions, correction of hormonal oversecretion or extent of tumor resection and improvement of a preoperative pituitary deficiency, lacks of two problems: during the last three decades it is dominated by reports on results after transsphenoidal surgery and the remaining few retrospective reports on the one hand focus on non-secreting adenomas and are secondly strongly biased by the preoperative patient selection, that eventually led to the decision for a craniotomy. The reported inclusion criteria regarding tumor size and extension, are mostly not specified in detail and therefore the surgical results are very heterogeneous.

In large series of patients treated either with one of the both approaches it appears to be a trend to a better visual improvement after the transcranial resection of large pituitary adenomas as for example in 300 analyzed cases reported by Patterson et al. [28]. Normalization of vision was reported retrospectively in 17% of patients after transsphenoidal procedures ($n = 70$) and 45% of patients after transcranial surgery ($n = 94$).

However, there are more reports in which the transsphenoidal approach led to a superior or at least similar recovery rate of visual functions, which is also more align with our experience regarding transcranial surgery of pituitary adenomas [26]. Fahlbusch et al. [11] reported about normalization or recovery of impaired visual functions in 80% and 48%, respectively, comparing transsphenoidal surgery with transcranial surgery of pituitary adenomas. Visual acuity and visual fields deteriorated in 2% of cases in the transsphenoidal group in contrast to 22% in the craniotomy group.

However, there is no doubt about the fact, that both, the risk of a new postoperative hormonal dysfunction, as well as the rate of persisting pituitary deficiency is definitively larger for the transcranial approaches [27, 31]. In a retrospective series of 155 patients with non-secreting pituitary adenomas reported by Wichers-Rother et al. the adrenocorticotropic and the thyroid axis were significantly more often impaired after transcranial surgery than after transsphenoidal surgery during long-term follow-up [32].

With regard to the extent of tumor removal the series of Guidetti et al. [15] was divided in a subgroup of patients

Fig. 8 Preoperative sagittal (**a**) and coronal (**b**) as well as postoperative sagittal (**c**) and coronal (**d**) T1-weighted contrasted MRI scans illustrating an infiltrative "giant" non-functioning pituitary adenoma before and after resection via a pterional craniotomy. Note the preservation of the deformed anterior pituitary and infundibulum but also invasive tumor remnants in the cavernous sinus and clivus

with massive suprasellar tumor extension (in contrast to a second stratified group with moderate suprasellar tumor extension without further specified stringent criteria regarding tumor size). In conclusion they report about a gross total resection in 40% of cases in the transsphenoidal group in contrast to 42% in the transcranial group. Improvement of visual functions was observed in 50% of the transsphenoidal cases versus 60% of the transcranial cases [15]. If correct indications have been chosen transcranial surgery for pituitary adenomas provide excellent results regarding tumor removal depending on the adenoma tissue texture and the rate of adhesions (Fig. 8a–d).

Complications

Most of the potential complications in transcranial pituitary surgery do not differ much from the common complications encountered in general transcranial neurosurgery like a local infection at the craniotomy site, a CSF-collection below the skin flap, a consecutive atrophy of the temporal muscle, deterioration of cranial nerve functions, consecutive development of a false aneurysm, cerebral ischemia or the occurrence of a meningitis. One of the major threats is haemorrhage into the former tumor cavity after adenoma debulking. Although the technical advances that have emerged throughout the last three decades lowered the morbidity and also mortality associated with transcranial pituitary surgery substantially, more dramatic complications still occur from time to time. However, the general morbidity rate of transcranial pituitary surgery is low in experienced hands [6, 24, 30, 33, 36]. In our series of 3890 procedures since 1982 the mortality rate was 2.3% displaying 6 out of 259 transcranial procedures.

Apart from general complications of transcranial surgery, the specific location of the sella turcica next to vulnerable vascular and neural structures at the cranial base results in more specific complications. Postoperative loss of pituitary functions is generally more common in transcranial pituitary surgery in comparison to the transsphenoidal approach to these tumors. In our experience, outlined in the retrospective analysis of 721 patients with non-functional pituitary adenomas, 15% of patients demonstrated a new pituitary deficiency after transcranial surgery in comparison to only 1.4% of patients after transsphenoidal adenomectomy (excluding postoperative disturbances of the neurohypophyseal function) [27]. Taking into account that preoperatively already some degree of hypopituitarism was recognized in 85% of patients in the transsphenoidal, and 86.3% in the transcranial group, 19.6% of the transsphenoidally operated patients resumed normal postoperative pituitary functions, compared to none after transcranial surgery. Some improvement of pituitary functions was found in 30.1% of patients in the transsphenoidal group in comparison to only 11.3% in the transcranial group. Pituitary deficiency remained unchanged in 48.9% in comparison to 73.7% comparing the transsphenoidal and the transcranial groups, respectively.

Diabetes insipidus either as the result of a manipulation of the pituitary stalk or the hypothalamus is also more common in transcranial surgery than following transsphenoidal approaches to pituitary tumors. However, next to the general higher incidence of a newly occurring diabetes insipidus and the higher number of persistency of an already preoperatively impaired function of the neurohypophysis, the rate of a new permanent diabetes insipidus during long-time follow-up is still substantially lower for pituitary adenomas than for other suprasellar pituitary tumors (e.g. craniopharyngiomas) [17]. Nevertheless, transient diabetes insipidus represents a common event in the immediate postoperative period after transcranial pituitary surgery [25]. In a series of 721 patients with non-functioning pituitary adenomas transient polyurea with a low urinary specific gravity occurred in up to 34% of cases. However, permanent diabetes insipidus eventually occurred only in 3.2% of patients in the transcranial group in comparison to 0.3% of patients in the transsphenoidal group [27].

Hyponatriaemia (<132 mmol) as a consequence of water retention related to inappropriate ADH secretion is also commonly seen in the postoperative period, mostly a few days after the operative procedure. Although one may occasionally encounter a patient with delayed hyponatriemia, the occurrence of fluid overload and water retention practically never displays a permanent problem either after transcranial or transsphenoidal pituitary surgery, unless resulting from the wrong dosage of DDAVP utilized to correct a permanent diabetes insipidus [16].

With regard to diabetes insipidus biphasic (polyurea–hyponatriemia) and also triphasic (polyurea–hyponatriemia–polyurea) fluid balance patterns are encountered after transcranial as well as after transsphenoidal surgery for pituitary tumors. The triphasic pattern is strongly predictive of permanent diabetes insipidus [16, 29].

In large excentric pituitary adenomas the optic apparatus is already compromised in most cases. The chronicity of visual impairment due to mechanical compression by the mostly slowly increasing pituitary adenomas results in the reduced tolerance of the optic nerves and the chiasm regarding mechanical manipulation during operative procedures. As a consequence visual deterioration is not uncommon in patients in whom the pituitary mass required a transcranial approach. Especially after resecting calcified tumors, e.g. craniopharyngiomas, visual deterioration is frequently seen depending on the adhesion of the calcified tumors to the optic chiasm, optic nerves and the suprasellar arachnoid [11, 17, 26]. Similar to the experience from patients surgically treated via transsphenoidal approaches, a few general factors which are associated with a higher risk of postoperative visual deterioration have been identified, namely prior radiotherapy, previous surgery, a long history of preoperative visual impairment and invasive tumor growth to the suprasellar arachnoid [1, 3, 9, 11, 24]. It is mostly reported, that the main reason for postoperative visual deterioration is the impairment of the blood supply by distorting small vessels to the optic nerves and the optic chiasm after dissecting suprasellar tumors [7, 9].

Disruption of the blood supply from perforating arteries may also result in postoperative hypothalamic injury, which is one of the most specific complications in transcranial surgery for pituitary tumors. Damage of hypothalamic nuclei occurs either as a result of direct surgical injury as a consequence of dissecting adhesive and infiltrative tumors or delayed after haemorrhage or ischemia in the hypothalamic area. Analog to the incidence of postoperative visual deterioration, hypothalamic injury is more often seen in patients having received prior surgery or radiotherapy. Typical clinical manifestations include diabetes insipidus together with symptoms of body temperature dysregulation, progressive obesity, loss of memory functions and disruption of circadian sleep rhythms. In rare but severe cases hypothalamic injury may also lead to acute and lethal dysregulation of fluid balance and body temperature with a depressed level of consciousness [14].

Impairment of cranial nerve functions, especially of the third nerve, represent a frequent complication after transcranial surgery of invasive supra- and especially parasellar tumors involving the cavernous sinus [10].

Summary

While to date, the vast majority of pituitary adenomas are resected via transsphenoidal approaches, still a few situations remain in which a craniotomy is required. Thus, a universal pituitary neurosurgeon should be also able to master transcranial operations. Generally speaking, a transcranial approach should be considered when the major volume of the tumor is located outside of the sella and when there is no wide communication between intra- and suprasellar tumor components. The pterional approach utilizing a front-temporal craniotomy and subfrontal approaches, either uni- or bilateral, are most widely used if a transcranial approach is required. Quite recently, reports of extended transsphenoidal operations have challenged whether the traditional contraindications for transsphenoidal surgery still exist. However, it is also a matter of individual experience of the surgeon and what he feels comfortable with, which makes him decide to undertake an extended transsphenoidal procedure or a craniotomy. Current literature focuses on outcome and complications after transsphenoidal surgery with and without use of the endoscope and unfortunately only few recent data are actually available on the results of transcranial operations for pituitary adenomas, derived from modern microsurgical series with a significant number of patients treated. Thus, many data on outcome derive from reports dating back to the pre-microsurgical period, with the amount of resection not determined by magnetic resonance imaging, endocrine deficiencies and oversecretion syndromes not measured by reliable assays and long-term outcome confounded by the routine use of postoperative irradiation. Although both, outcome in terms of the radicalness of tumor resection and the rate of complications is to date unfavourably biased by the selection of patients in favour for transsphenoidal surgery, there are undoubtly patients who need transcranial surgery considering the size, localization and extent of their pituitary adenomas. Although, data on recovery of vision are controversial, it seems that the visual outcome is better after transsphenoidal surgery. Impairment of pituitary function is more frequent after transcranial procedures. Data on the rate of total tumor resections are sparse, but based on the selection criteria for transcranial approaches to date one would assume that hardly any one of the large and invasive tumors who need this operation, as a primary intervention or in addition to transsphenoidal surgery, will be completely excised.

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