Ten-year Experience with the Supraorbital Subfrontal Approach through an Eyebrow Skin Incision

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OBJECTIVE: More than ever before, the priority in contemporary neurosurgery is to achieve the greatest therapeutic effect while causing the least iatrogenic injury. The evolution of microsurgical techniques with refined instrumentation and illumination and the enormous development of preoperative and intraoperative diagnostic tools enable neurosurgeons to treat different lesions through limited and specific keyhole approaches.

METHODS: Based on our surgical experience, the technique of supraorbital subfrontal craniotomy is described in detail in this article. After an eyebrow skin incision is made, a limited supraorbital craniotomy is performed with a width of 15 to 25 mm and a height of 10 to 15 mm.

RESULTS: We have been using the supraorbital keyhole craniotomy since 1985 and have approached a variety of lesions within the anterior, middle, and posterior cranial fossae. During a 10-year period between July 1994 and June 2004, the lesions treated via the supraorbital approach in our department comprised 1125 intracranial tumors or cystic lesions, cerebral aneurysms, and other miscellaneous diseases, performed by 23 different surgeons and residents. Of these 1125 patients, we operated on 471 of them, and information obtained from 450 contributed to the follow-up data. Three months after surgery, the Glasgow Outcome Scale scores for this very heterogeneous group of patients were as follows: 5 in 387 patients (86.0%), 4 in 29 patients (6.4%), 3 in 16 patients (3.5%), 2 in 10 patients (2.2%), and 1 in 8 patients (1.8%). Of the 450 patients, 229 were treated for intracranial aneurysms, 93 for cranial base meningiomas, 39 for craniopharyngiomas, 23 for pituitary adenomas, 18 for deep-seated brainstem tumors, and 48 for other miscellaneous frontotemporal or suprasellar lesions.

CONCLUSION: In our experience, the supraorbital craniotomy allows a wide, intracranial exposure for extended, bilaterally situated, or even deep-seated intracranial areas, according to the strategy of keyhole craniotomies. The supraorbital craniotomy offers equal surgical possibilities with less approach-related morbidity owing to limited exposure of the cerebral surface and minimal brain retraction. In addition, the short skin incision within the eyebrow and careful soft tissue dissection result in a pleasing cosmetic outcome.

KEY WORDS: Eyebrow skin incision, Keyhole concept, Minimally invasive neurosurgery, Preoperative planning, Supraorbital approach, Surgical anatomy

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At the beginning of neurosurgical history, surgical treatment of intracranial lesions was always related to large craniotomies. This extended approach was necessary for several reasons: diagnostic techniques were poorly developed, localization of the lesions was inaccurate, the craniotomy had to be large enough to find the lesion and to allow investigation of deep-seated areas, the allowable methods of illumination were unsophisticated, and the instruments at that time were not designed for neurosurgery but for general surgery. In addition, operating teams consisted of at least three surgeons; thus, six hands and the large instruments that they held obscured the surgical field (41).

However, in recent decades, the discovery of fundamental anatomic and physiological principles and the improvement of intraoperative visualization provided by the operating microscope, together with refined instrumentation, allowed the evolution of microneurosurgical techniques. These techniques and the enormous development of diagnostic facilities enabled neurosurgeons to treat more complicated neurosurgical diseases through smaller and more specific approaches (*Fig. 1*).

The first neurosurgeon who used the term *keyhole surgery* to describe the extension of this limited trephination was Donald H. Wilson in 1971 (44). However, in our opinion, the keyhole approach in neurosurgery should not aim to limit the craniotomy to the size of a keyhole, which has been a frequent misunderstanding in the past. First of all, the term "keyhole" may imply a concept of geometric construction of the surgical approach with a choice of the correct limited craniotomy as a key characteristic for entering a particular intracranial space and for working with a minimum of traumatization. In choosing the correct keyhole approach for a specific lesion, it becomes possible to dramatically reduce the size of the craniotomy with less need for dural opening, less brain exposure, and less retraction (32, 36).

The concept of keyhole surgery is based on the careful preoperative study of diagnostic images to determine the anatomic windows that provide access to the pathological processes, taking into consideration the individual pathoanatomic situation of the patient.

The special architecture of the suprasellar area offers several anatomic windows to reach deep-seated lesions. Posterolaterally situated windows of the suprasellar area are bordered by the mesencephalon posteriorly and by the temporal lobes laterally; therefore, approaches from these directions require brain retraction (4, 46). With the anterolateral pterional exposure, splitting of the sylvian fissure with manipulation of the temporal lobe must always be included, owing to the fact that the anterior part of the temporal lobe obscures access to the supratentorial structures (25, 29–31, 42). However, when the approach is made from an anterior subfrontal direction, the suprasellar anatomic structures are free for surgical dissection and are not hidden by any brain structures (5, 14–16, 28, 35, 43). This article describes in detail the technique of a limited subfrontal approach with a supraorbital craniotomy through an eyebrow skin incision, which is based on our surgical experience with patients who had a variety of lesions within the anterior, middle, and posterior cranial fossae.

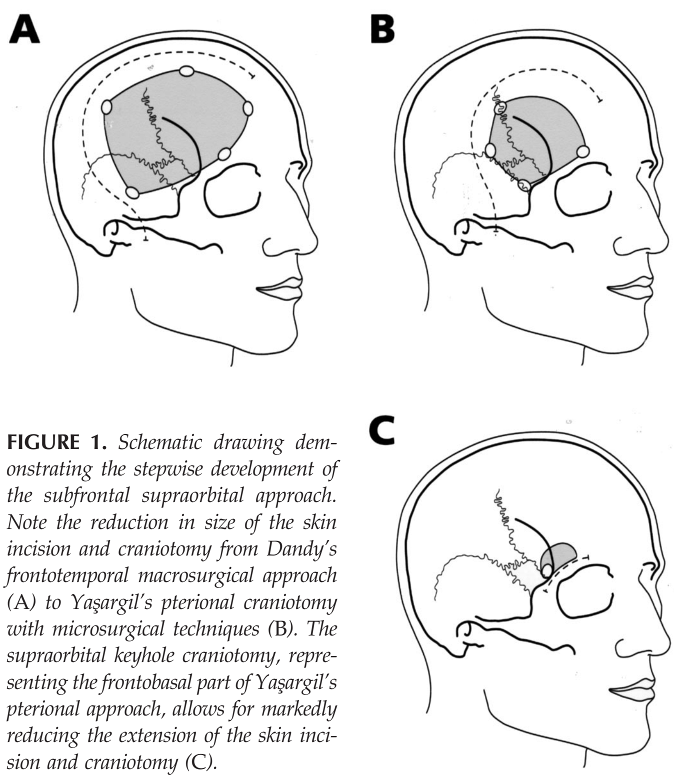

FIGURE 1. *Schematic drawing demonstrating the stepwise development of the subfrontal supraorbital approach. Note the reduction in size of the skin incision and craniotomy from Dandy's frontotemporal macrosurgical approach (A) to Yaşargil's pterional craniotomy with microsurgical techniques (B). The supraorbital keyhole craniotomy, representing the frontobasal part of Yaşargil's pterional approach, allows for markedly reducing the extension of the skin incision and craniotomy (C).*

PATIENTS AND METHODS

One of us (AP) has been using the supraorbital subfrontal approach through an eyebrow skin incision since 1985. In this article, we retrospectively evaluated our clinical material for a 10-year period between July 1994 and June 2004. During this period, 1125 microsurgical intracranial procedures were performed via the supraorbital approach; the operations were performed by 23 different neurological surgeons and residents. Of these 1125 patients, 471 were operated on by us (75 by RR and 396 by AP). The results and complications in this cohort of patients were thoroughly evaluated by reviewing office charts, medical reports, and available x-rays.

In every case before surgery, exact diagnostic imaging was completed to provide an accurate definition of the variations in the anatomic and pathological structures. Preoperative visualization of the individual pathoanatomic situation was of paramount importance for creating limited, less-invasive craniotomies. With the excellent diagnostic capabilities of digital subtraction angiography, computed tomography (CT), and magnetic resonance imaging (MRI), anatomically suitable ways for surgical dissection could be described preoperatively and be included in the surgical procedure planning. With the known individual anatomic details of a specific patient, it was possible to perform an individualized and specific surgical procedure, thus reducing the size of the skin incision, the craniotomy, and the extent of brain traumatization.

Surgical Technique

Positioning and Anatomic Orientation

After induction of endotracheal anesthesia, the patient is placed in a supine position with the head fixed in a three-pin Mayfield headholder and elevated approximately 15 degrees to facilitate venous drainage. Thereafter, the head is rotated to the side opposite the planned craniotomy, the degree of head rotation depending on the site and size of the lesion. According to the individual pathoanatomic structures, for ipsilateral temporal lesions, 15 degrees of head rotation is used; for lesions of the lateral suprasellar and retrosellar area, 20 degrees of head rotation has been found to be sufficient. The anterior suprasellar region requires a rotation of 30 degrees; the anterior fossa and olfactory groove, of 45 to 60 degrees. By choosing the correct angle between 30 and 60 degrees, one can also make contralateral lesions visible. The neck of the patient is retroflected, resulting in an approximate 20 degree angle between the plane of the anterior cranial base and the vertical plane of the axis. This maneuver of retroflexion also supports the gravity-related self-retraction of the frontal lobe (*Fig. 2*). Fine readjustments of the patient's position during surgery are accomplished by tilting the operating table.

After precise definition of the frontal anatomic landmarks (e.g., the orbital rim, supraorbital foramen, temporal line, zygomatic arch, and frontal cranial base), the site of the craniotomy and the line of skin incision are marked on the skin (*Fig. 3A*). Both depend on the site and size of the target lesion; the supraorbital craniotomy is therefore not a standard approach with respect to location and extension.

Skin Incision and Soft Tissue Dissection

The patient's eyelids are protected with sensitive tape, and the skin is prepared with alcohol solution. Our experience has shown that shaving the eyebrow is not necessary to avoid postoperative wound infection. The skin incision runs laterally from the supraorbital incisura and continues within the eyebrow, sometimes extending a few millimeters over the lateral projection of the brow into the frontozygomatic area. To achieve an optimal cosmetic outcome, the incision may follow the orbital rim. The skin incision should not extend medially to the supraorbital nerve to avoid frontal numbness. The superficial temporal artery and the branches of the facial nerve do not cross the surgical field. After skin incision, the frontal skin flap should be dissected subcutaneously upward, thus achieving optimal exposure of the orbicularis oculi and the frontal and temporal muscles (*Fig. 3B*) The skin flaps may be retracted with temporary stitches; the frontal muscle is incised with a monopolar-electrode knife parallel to the glabella; and the temporal muscle is stripped from its bony insertion (*Fig. 3C*). The temporal muscle is retracted laterally and the frontal muscle is retracted upward with strong stitches (*Fig. 3D*). Exposure and mobilization of the temporal muscle should be restricted to a minimum to prevent postoperative problems with chewing. Note that the frontal and orbicular muscles should be gently pushed downward to the orbit, like a flap. Careful dissection and minimal retraction of this muscular layer are essential to avoid a postoperative periorbital hematoma. Local hemostasis must be performed rapidly and with precision.

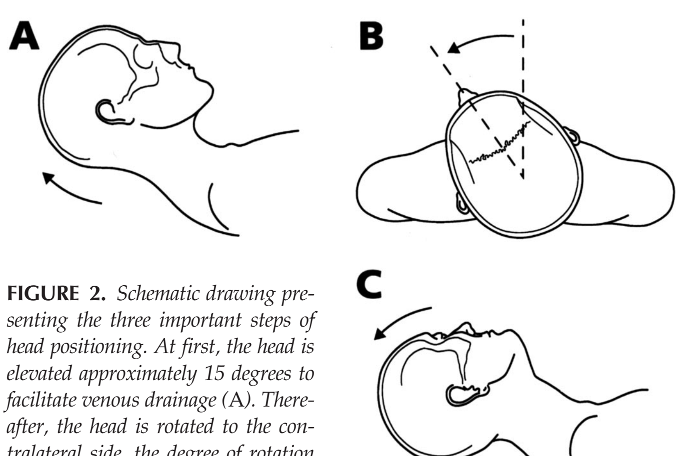

FIGURE 2. *Schematic drawing presenting the three important steps of head positioning. At first, the head is elevated approximately 15 degrees to facilitate venous drainage* (A). *Thereafter, the head is rotated to the contralateral side, the degree of rotation depending on the precise location of the lesion* (B). *The maneuver of retroflexion supports gravity-related self-retraction of the frontal lobe* (C).

Craniotomy and Opening of the Dura

In every case, an osteoplastic craniotomy is performed. With use of a high-speed drill, a single frontobasal burr hole is sufficient and, for cosmetic reasons, should be placed posterior to the temporal line (*Fig. 3D*). Special attention must be given to the placement of this burr hole, particularly with regard to its relationship to the frontal cranial base and the orbit. Note that correct placement but incorrect direction of the drilling procedure can result in penetration of the orbit and not the anterior fossa. A straight-line cut is then made with a high-speed craniotome parallel to the orbital rim from the lateral to the medial position, taking into account the lateral border of the frontal paranasal sinus (*Fig. 3E*). Thereafter, a C-shaped line is sawed from the burr hole to the medial border of the previously made frontobasal line, thus creating a bone flap with a width of approximately 1.5 to 3.0 cm and a height of approximately 1.0 to 2.0 cm (*Fig. 3F*). An important step in the craniotomy procedure after removal of the bone flap is the drilling of the inner edge of the craniotomy (under protection of the dura) with a high-speed drill (*Fig. 3G*). Careful removal of this inner bony edge often significantly improves visualization, and in the further course of the operation, these maneuvers greatly facilitate the use of the operating microscope and surgical dissection with microinstruments. If necessary, small osseous extensions of the orbital roof should also be drilled extradurally. The dura should be opened in a curved fashion, with its base toward the cranial base, and fixed downward with two sutures (*Fig. 3H*). Further dural elevation sutures are not necessary.

Intradural Dissection and Closure

After durotomy, the first step should be the removal of sufficient cerebrospinal fluid by opening the chiasmatic and carotid cisterns (*Fig. 3H*) and occasionally, the sylvian fissure. In the case of high intracranial pressure, the lateral ventricle should be punctured. We do not routinely use a spinal drain. After the removal of cerebrospinal fluid, the frontal lobe usually sinks without retraction; the self-retaining spatula is left in place as a brain protector rather than a brain retractor.

After completion of the intracranial procedure, the intradural space is filled with Ringer's solution at body temperature. The dural incision is sutured watertight by interrupted or continuous sutures. A plate of Gelfoam (Braun AG, Melsungen, Germany) is placed extradurally, and the bone flap is appositioned with one titanium Craniofix plate (Aesculap AG, Tuttlingen, Germany). Note that the bone flap should be fixed medially and frontally without bony distance to achieve an optimal cosmetic outcome. After the final verification of hemostasis, the muscular and sub-

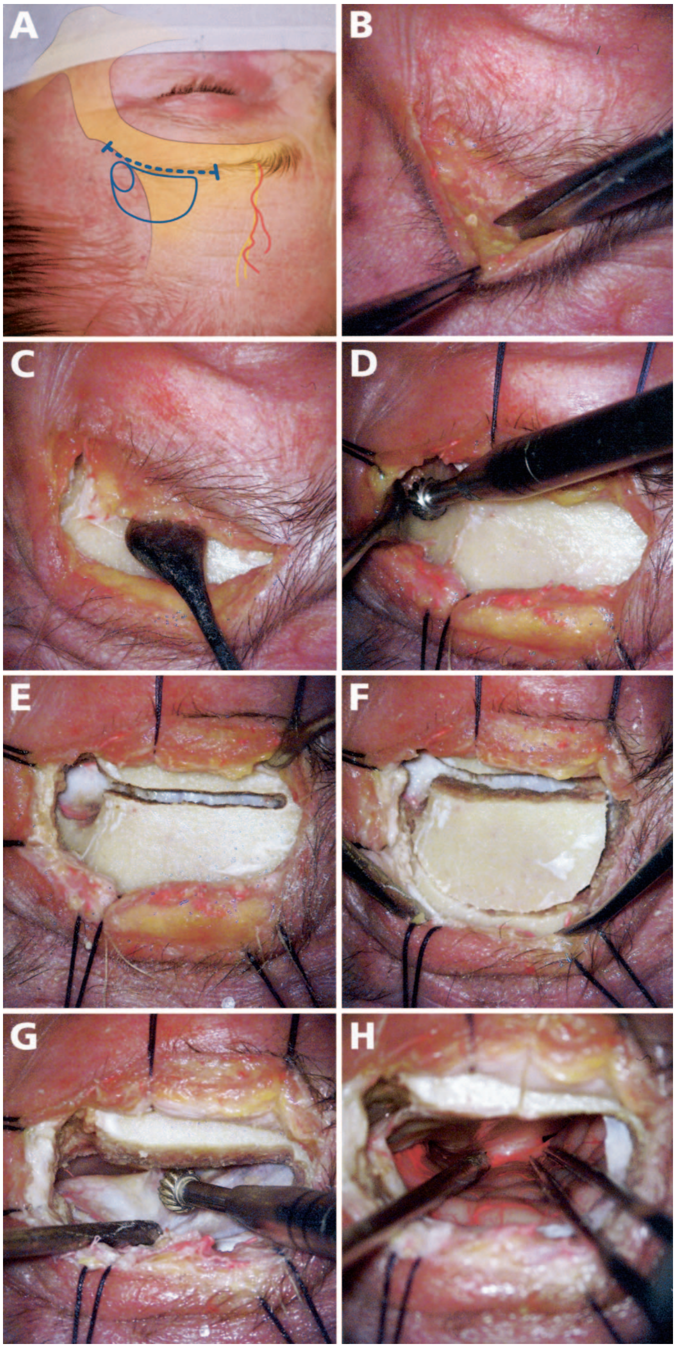

FIGURE 3. *Steps of the supraorbital subfrontal craniotomy, demonstrated in a cadaver specimen. After initial orientation defining the osseous and neurovascular structures of the supraorbital area, the site and size of the craniotomy are determined according to the individual pathoanatomic situation* (A). *The skin incision should be performed laterally from the supraorbital nerve within the eyebrow, extending some millimeters from its lateral boundary, and following the orbital rim. After the skin incision has been made, the subcutaneous tissue is dissected upward* (B), *thus exposing the occipitofrontal, orbicular, and temporal muscles. The temporal muscle is stripped from its bony insertion, and the frontal muscles and their periosteal sheet are cut horizontally, parallel to the orbital rim* (C). *After retraction of the muscular layers with strong stitches, a frontobasal burr hole trephination is performed posteriorly from the temporal line, avoiding penetration of the orbit* (D). *After burr hole trephination, a straight line is cut with the craniotome from the burr hole in the medial direction, just parallel to the orbital rim and taking into account the lateral border of the frontal sinus* (E). *Thereafter, with a C-shaped sawing line, the craniotomy is completed* (F). *After removal of the bone flap, the inner edge of the orbital rim is removed under control of the operating microscope, with use of a high-speed drill* (G). *After durotomy, the left optic nerve can be well approached without rough retraction of the frontal lobe* (H).

cutaneous layer is closed with interrupted sutures, and the skin, with a running suture, sterile adhesive tape, or Dermabond glue (Johnson & Johnson, Somerville, NJ). Because of the limited skin incision, no suction drain is necessary.

RESULTS

During the 10-year period, the lesions treated in our department via the supraorbital approach comprised 1125 operative cases of intracranial tumors, cystic lesions, cerebral aneurysms, and other miscellaneous diseases. Of these 1125 patients, 471 were operated on by us; information obtained from 450 contributed to the follow-up data (*Table 1*.). Three months after surgery, the Glasgow Outcome Scale scores for this very heterogeneous group of patients were as follows: 5 in 387 patients (86.0%), 4 in 29 patients (6.4%), 3 in 16 patients (3.5%), 2 in 10 patients (2.2%), and 1 in 8 patients (1.8%). Of the 8 patients who died, 1 patient had a severe rebleeding episode after removal of a huge pituitary adenoma; two patients died as a result of pulmonary embolism; and five patients died as a result of multiorgan failure after long critical care therapy.

In the group of 229 aneurysm cases, there were 112 patients with subarachnoidal bleeding (48.9%); hence, 117 patients had nonruptured aneurysms (51.1%). There were 56 patients with multiple aneurysms (24.5%), 50 patients with posterior circulation aneurysms (21.8%), and 21 patients with giant aneurysms (9.2%). In 37 cases, surgery was performed after a failed coiling procedure (16.2%). Intraoperative rupture occurred in 4 cases (1.7%), temporary clipping of the vessels was necessary in 4 cases (1.7%), and interventional balloon occlusion supporting the clipping of giant aneurysms was performed in 5 cases (2.6%). In 77 complicated cases, postoperative control angiography was performed, which revealed residual aneurysm in 5 cases (2.2%). Postoperative infarction on CT scans related to the narrowing of blood vessels and not related to arterial vasospasm was observed in 6 cases (2.6%); 4 of these patients experienced subsequent neurological deterioration (1.7%).

In the group of 93 patients with cranial base meningiomas, the most frequent preoperative symptom was visual disturbances. Of the 33 patients (35.5%) with visual disturbances, 19 have experienced marked visual improvement after surgery (56.6%), 9 patients have had no change in visual function (27.3%), and 5 patients have experienced worse vision postoperatively (15.2%). There were 51 patients (54.8%) with large (2.5–4.4 cm) and 18 patients (19.3%) with giant (>4.5 cm)

TABLE 1. Lesions operated on by the authors during a 10-year period via supraorbital craniotomy[a]

Intracranial lesions	No. of cases
Aneurysms	229
Single	173
ICA or its branches	61
MCA	43
ACA and AComA	37
PoCiAn	32
Multiple	56
>2	26
Bilaterally situated	18
Combined with PoCiAn	18
Giant	21
Meningioma	93
Olfactory groove	21
Anterior clinoid process	18
Tuberculum sellae	16
Sphenoid wing	14
Planum sphenoidale	12
Cavernous sinus	12
Craniopharyngioma	39
Pituitary adenoma	23
Astrocytoma	18
Frontal	9
Temporal	6
Optic nerve	3
Epidermoid	14
Metastasis	7
Cavernoma	7
Arachnoidal and colloid cysts	7
AVM	5
Germinoma	4
Plexus papilloma	1
Amygdalohippocampectomy	3
Total	450

[a] ACA, anterior cerebral artery; AComA, anterior communicating artery; PoCiAn: posterior circulation aneurysms; AVM: arteriovenous malformation.

tumors. The largest meningioma that could be radically removed without surgical complications was 8.5 cm in diameter. According to the postoperative MRI scans, the cranial base meningiomas were completely removed in 83 cases (89.2%); in 8 cases, removal was subtotal (8.2%); and in 2 cases, only partial tumor extirpation was surgically possible (2.1%).

Of the 39 patients with craniopharyngiomas, 14 patients presented in our department with recurrent tumors (35.9%). There were 12 patients (30.7%) with large and 7 (17.9%) with giant tumors. Twenty-six patients experienced preoperative visual disturbances (66.6%); postoperative visual improvement occurred in 19 patients (73%); and there was a worsening of vision in 3 patients (11.5%). On the basis of radiological results, the supraorbital subfrontal exposure allowed total tumor removal in 29 cases (74.3%), subtotal in 7 cases (17.9%), and partial in 2 cases (5.1%). One patient died postoperatively as a result of fulminant pulmonary embolism.

In the group of patients with pituitary adenomas, the indication for transcranial surgery was given when the tumor had grown through the diaphragma sellae, making transsphenoidal surgery impossible. This group included 12 patients (52.2%) with large and 7 patients (30.4%) with giant tumors. Of the 23 patients, 14 presented with visual disturbances (60.9%); none of them developed worsening vision after the operation. The preoperative hormonal status was unremarkable in 12 patients (52.2%); 4 of them developed postoperative hypopituitarism after the supraorbital craniotomy. Postoperative imaging in 19 cases disclosed total removal of the tumor (82.6%); in 2 cases, subtotal (8.7%); and in 2 cases, partial (8.7%). One patient died after a severe rebleeding episode on the first postoperative day.

For the entire cohort of 450 patients, the postoperative complications associated with craniotomy via the supraorbital approach through an eyebrow skin incision can summarized as follows: 1) permanent partial supraorbital hypesthesia related to a lesion of the supraorbital nerve was observed in 34 patients (7.5%); 2) permanent palsy of the frontal muscle related to a lesion of the frontal branch of the facial nerve appeared in 25 cases (5.5%). Problems with closing of the eyelids was not noted; 3) problems with chewing were observed in 3 patients (0.6%), but atrophy of the temporalis muscle was not observed in any of them; 4) permanent unilateral hyposmia appeared in 27 patients (6.0%), and bilateral hyposmia with disturbances of tasting was reported by 9 patients (2.0%); 5) wound healing disturbances occurred in 6 cases (1.3%); in 1 case, reoperation with removal of the bone flap was necessary because of wound suppuration; 6) a subcutaneous cerebrospinal fluid pouch in 20 patients (4.4%); in 1 case, surgical revision was necessary; 7) cerebrospinal fluid leak in 12 patients (2.6%): in 7 cases through the frontal sinus and in 5 cases, through the deep paranasal sinuses after removal of the anterior clinoid process. Of these 12 patients, 5 patients underwent surgical reconstruction; in 7 cases, the fistula was closed after lumbar drainage; 8) rebleeding with a space-occupying effect was detected in 4 cases (0.8%). One patient died; the other two patients had a poor neurological outcome despite urgent reoperation; 9) hygroma in 7 cases (1.6%). Because of a space-occupying effect in two cases, surgical therapy was necessary; and 10) epileptic seizures were not observed. For this reason, no anticonvulsive medication was routinely administered.

Illustrative Cases

Sphenoid Wing Meningioma

A 57-year-old man was examined in an internal medicine department because of severe headache, lethargy, and subjective blurred vision. Neurological and ophthalmological examinations disclosed no deficits. Cranial MRI was performed, demonstrating a large sphenoid wing tumor extending from the left anterior clinoid process, with incorporation of the bifurcation of the internal carotid artery (ICA) and compression of the optic chiasm (*Fig. 4, A* and *B*). Because of the progressive nature of the symptoms and the space-occupying effect of the lesion, an indication for surgical removal of the lesion was given. With the patient in the supine position, the head was elevated 15 degrees, rotated 15 degrees to the left, and retroflected 20 degrees. After an eyebrow incision was made on the left side, a supraorbital craniotomy with dimensions of 2.0 × 1.5 cm was completed (*Fig. 5*). After the removal of cerebrospinal fluid from the left chiasmatic cistern, the matrix of the tumor on the anterior clinoid process was attacked, and the basal part of the tumor was extirpated, thus markedly reducing bleeding during further dissection. With the strategy of coagulating and cutting the tumor matrix first and removing the basal slice of the tumor, a well-controlled, piece-by-piece removal of the tumor without rough brain retraction was possible through the limited supraorbital craniotomy. The tumor was well delineated by an arachnoidal sheath toward the surrounding brain tissue, as well as toward the optic nerves, the ICA, and the anterior and middle cerebral arteries (MCAs). Via the subfrontal approach, the temporal part of the tumor was also well visualized and accessed, thereby allowing its complete removal. After a 1-day observation in our neurosurgical intensive care unit, the patient was allowed to walk on the first postoperative day. Examination did not reveal any neurological signs, with intact visual and olfactory function. Minor postoperative headaches were treated with analgesics. The postoperative histopathological investigation revealed a benign meningioma; MRI 3 months after surgery showed complete tumor removal (*Fig. 4, C* and *D*).

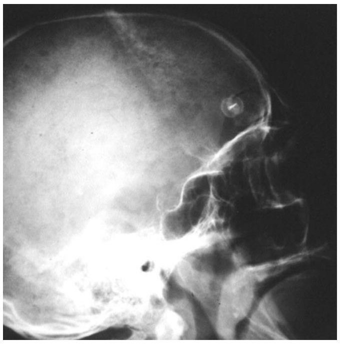

FIGURE 5. *Postoperative plain x-ray in the anteroposterior view, demonstrating the small supraorbital craniotomy after removal of the sphenoid wing meningioma.*

Giant Aneurysm of the ICA

A 46-year-old woman experienced progressively worsening headaches without neurological disturbances. Cranial imaging revealed a large space-occupying lesion near the optic chiasma; a tentative diagnosis was an aneurysm of the anterior communicating artery. In our neuroradiological department, four-vessel angiography was performed, demonstrating a giant paraclinoidal aneurysm of the left ICA (*Fig. 6, A* and *B*). Balloon occlusion of the ICA was not tolerated by the patient,

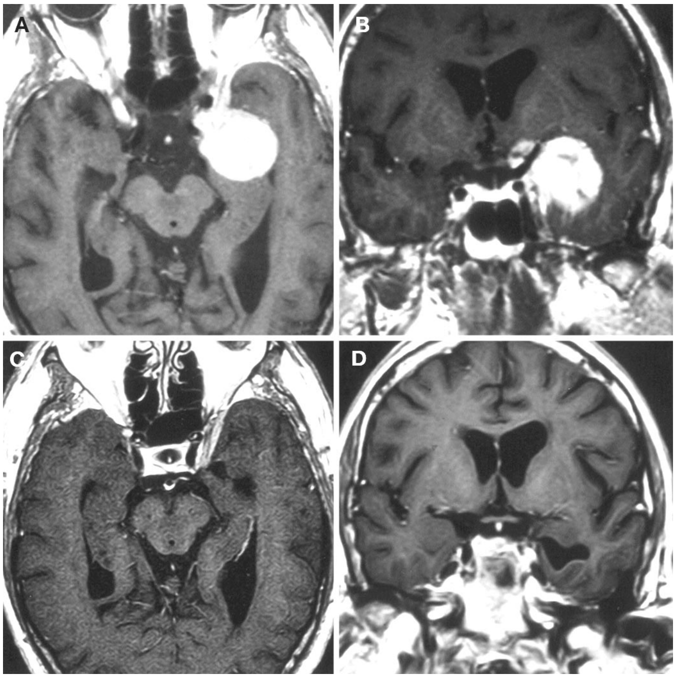

FIGURE 4. *Preoperative and postoperative T1-weighted MRI investigation of a 57-year-old man who had a sphenoid wing meningioma on the left side. The preoperative images show a solid, homogeneous, encapsulated tumor incorporating the ICA bifurcation and compression of the optic chiasm (*A *and* B*). Note the tumor matrix on the anterior clinoid process. The postoperative images reveal complete tumor removal (*C *and* D*).*

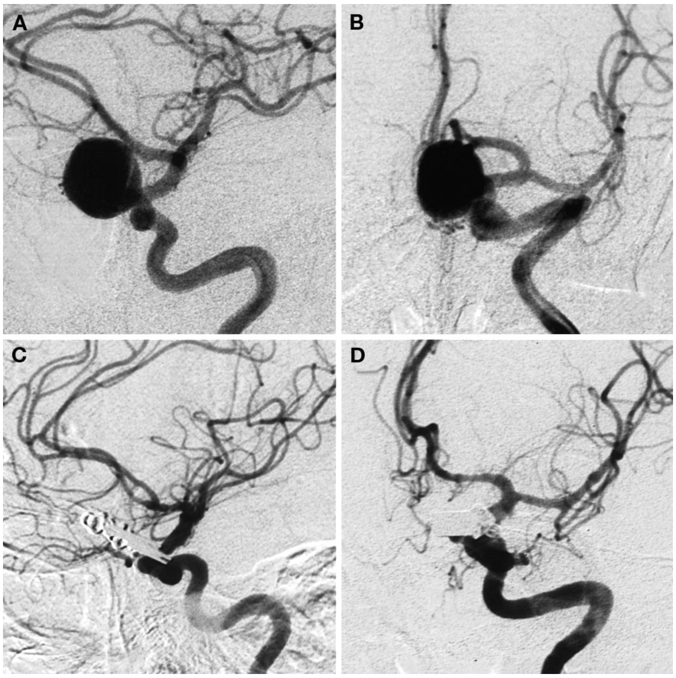

FIGURE 6. *Preoperative and postoperative angiograms in the anteroposterior view of a 46-year-old woman with a nonruptured giant aneurysm of the ICA. The medially directed giant aneurysm (*A *and* B*) was approached from the ipsilateral side, allowing optimal exposure of the narrow neck. The postoperative control images show complete closure of the aneurysm (*C *and* D*).*

who presented with right-sided hemiparesis and aphasia. Preoperative plan imaging revealed a medially directed aneurysm with a relatively narrow neck, thus allowing optimal exposure through an ipsilateral supraorbital approach. After positioning with 15 degree elevation, 25 degree rotation, and 20 degree retroflexion, a left eyebrow skin incision was made with a limited craniotomy of 2.0 × 2.5 cm. Within the subarachnoid spaces, there was no sign of previous subarachnoid bleeding. After the carotid and optic cisterns were opened, the frontal lobe was carefully retracted. The left optic nerve was severely compressed and anterolaterally displaced by the large aneurysm. After the optic canal was opened and the anterior clinoid process drilled, the optic nerve was effectively mobilized and the entire neck of the aneurysm observed. After temporary balloon occlusion of the ICA, the aneurysm collapsed, allowing placement of two straight clips. However, endoscopic control of the clip position showed residual opening of the distal aneurysm neck; for this reason, clip placement was carefully corrected (*Fig. 7*). The postoperative course was uneventful; examination revealed no neurological or visual disturbances, and angiography disclosed complete occlusion of the aneurysm (*Fig. 6, C* and *D*).

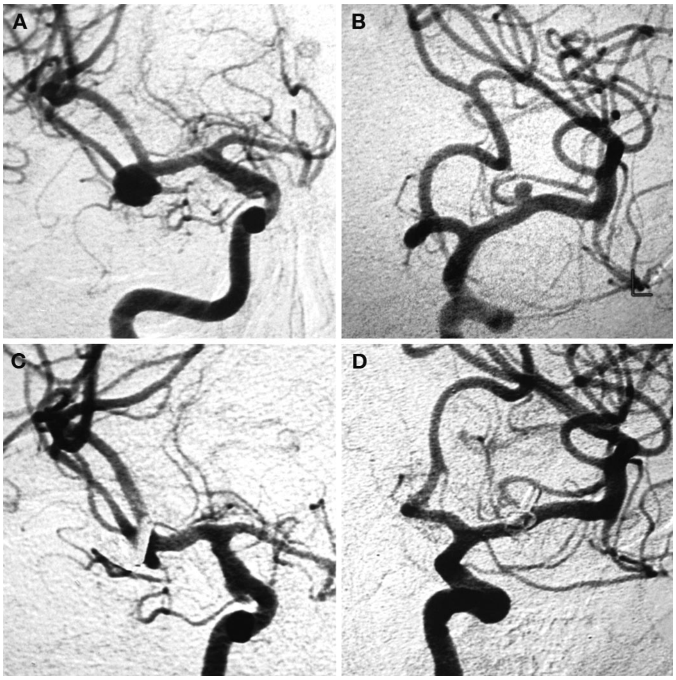

FIGURE 8. *Preoperative and postoperative angiograms in the anteroposterior view of a 55-year-old woman with incidental aneurysms of the MCA on both sides. The right-sided aneurysm is located at the MCA bifurcation directing inferolaterally; the left-sided aneurysm is derived from the origin of the early temporal branch directing anteromedially (*A *and* B*). The postoperative control angiograms show complete closure of both aneurysms (*C *and* D*).*

Bilaterally Situated Multiple Aneurysms

A 55-year-old woman had experienced headache for several months. Neurological examination revealed no deficits. The initial diagnostic procedures included MRI of the brain, during which an incidental aneurysm of the right MCA was found, with no signs of subarachnoid hemorrhage. An indication for surgical therapy of the large (>1 cm) aneurysm was given because of their unfavorable natural history with a tendency to rupture and cause subarachnoid bleeding. After admission to our department, cerebral digital subtraction angiography was performed, which revealed the right-sided aneurysm and, in addition, a small left-sided aneurysm of the MCA (*Fig. 8, A* and *B*). The right-sided aneurysm was located at the MCA bifurcation, and the left-sided aneurysm was located more proximally to the carotid bifurcation at the origin of the early temporal branch. In this pathoanatomic situation, a right-sided supraorbital craniotomy was indicated for approaching the bilaterally located aneurysms. With the patient in a supine position, the head was elevated above the thorax, rotated 35 degrees to the right, and retroflected 20 degrees. A skin incision was performed laterally from the supraorbital foramen within the eyebrow, and a left supraorbital craniotomy was performed with outer dimensions of 1.5 × 2.0 cm. After removal of the bone flap and opening of the dura, the frontal lobe was gently retracted, and the right optocarotid and sylvian cisterns were exposed. The right-sided inferolaterally located MCA aneurysm was carefully dissected and the wide neck successfully clipped. After the clipping procedure, the left-sided contralateral sylvian fissure was opened from the medial to the lateral direction. According to the preoperative diagnostic findings, we located and clipped the aneurysm at the origin of the early temporal branch of the MCA. After surgery, the patient was allowed to walk the following day, and she made an uneventful recovery; however, a postoperative CT scan revealed bifrontal hygromas without a space-occupying effect (*Fig. 9*). The unremarkable results of the neurological examination made additional operative treatment unnecessary. At follow-up 3 months after surgery, digital subtraction angiography was performed, showing complete closure of both aneurysms (*Fig. 8, C* and *D*). The patient returned to her previous employment.

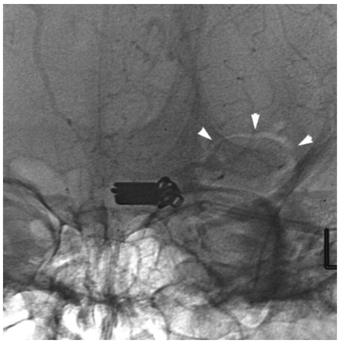

FIGURE 7. *Postoperative x-ray showing the relationship between the aneurysm clips and the limited left-sided craniotomy (*arrowheads*).*

Pituitary Adenoma

A 62-year-old woman was admitted after experiencing a transient ischemic attack in a neurology department. The initial CT scan showed no cerebral infarcts; however, intrasellar and suprasellar lesions were found. Examinations revealed no hormonal or visual disturbances. For planning a transnasal transsphenoidal approach, cranial MRI was performed. However, a thorough analysis disclosed that between the left optical tract and the ICA, the tumor had broken through the diaphragma sellae (*Fig. 10, A* and *B*). For this purpose, transcranial surgery was chosen to allow optimal exposure via a contralateral right-sided supraorbital craniotomy. After positioning with head elevation, 35 degree rotation, and 20 degree retroflexion, a 3-cm eyebrow skin incision was made, and a 1.5 $\times$ 2 cm minicraniotomy was performed (*Fig. 11*). The soft tumor tissue was mobilized piece by piece; the angle between the left optical tract and the ICA was optimally observed through a right-sided craniotomy. Intrasellar tumor remnants were removed with an endoscope-assisted technique. Histopathological analysis disclosed a pituitary adenoma, and the postoperative course was uneventful. Three months after surgery, cranial MRI revealed no residual tumor tissue (*Fig. 10, C* and *D*); endocrinological and ophthalmological examinations revealed normal status.

Brainstem Tumor

A 39-year-old woman experienced an acute onset of headache and vertigo with nausea and vomiting. The clinical examination revealed no neurological symptoms; however, MRI demonstrated a cavernous malformation within the brainstem (*Fig. 12, A* and *B*). Because of the unfavorable natural history of brainstem cavernomas with a high risk for rebleeding episodes within the neural structures, the indication for surgery was given. Preoperative planning images showed that the lesion was close to the pia mater only on the ventral surface of the pons. The deep-seated lesion within the posterior fossa was approached from a ventral direction via a left supraorbital craniotomy (*Fig. 13*). With the patient in a supine position, the head was elevated, turned 30 degrees to right, and retroflected 20 degrees. After an eyebrow skin incision was made and soft tissue dissection completed, a supraorbital craniotomy was performed, with outer dimensions of 1.5 $\times$ 2 cm. The deep prepontine area was approached through the ipsilateral optocarotid and lateral carotid windows. The cavernoma was carefully removed with endoscope-assisted microsurgical techniques. The endoscopic image allowed precise visualization of the cavernoma, including the nervous and vascular structures in the vicinity of the lesion, without excessive retraction of sensitive structures. On the first postoperative day, the neu-

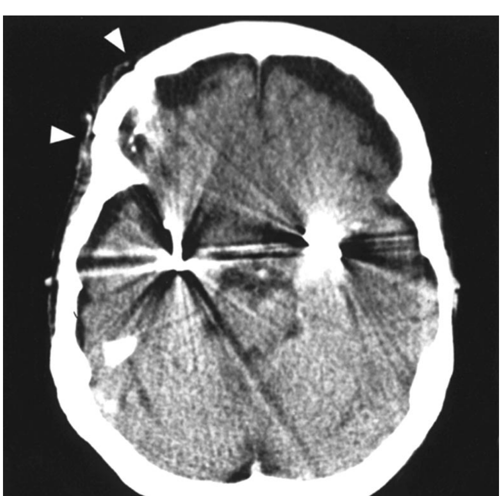

FIGURE 9. *Postoperative CT scan revealing bifrontal hygromas without a space-occupying effect. Note the extension of the right-sided limited supraorbital craniotomy* (arrowheads) *and the position of both aneurysm clips.*

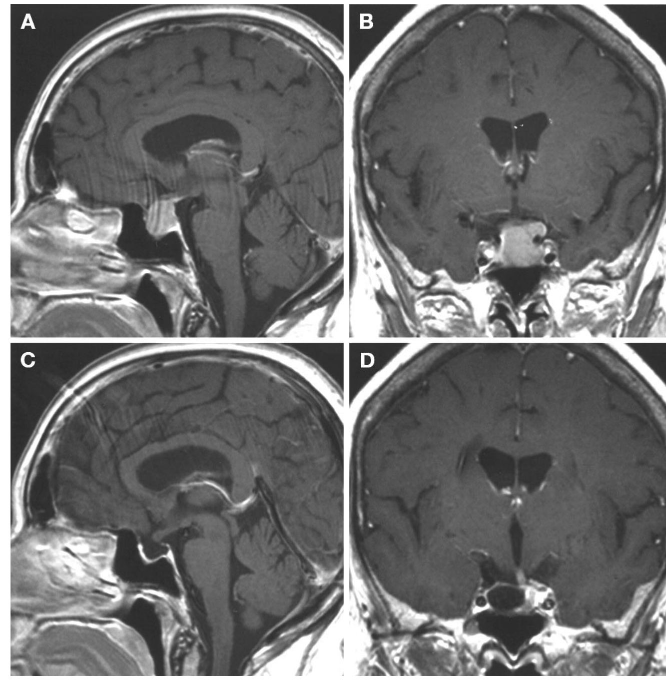

FIGURE 10. *Preoperative and postoperative MRI scans of a 62-year-old woman with an intrasuprasellar pituitary adenoma. Note that the tumor has grown through the diaphragma sellae, making a transsphenoidal exposure impossible* (A and B)*. With endoscope-assisted microsurgical techniques via a contralateral supraorbital craniotomy, the adenoma was completely removed* (C and D)*.*

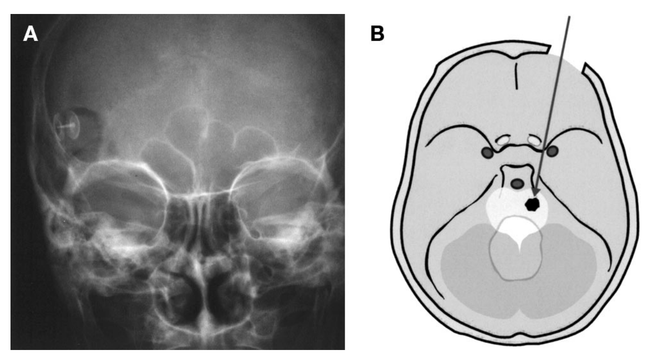

FIGURE 11. *Postoperative x-ray* (A) *demonstrating the right-sided supraorbital craniotomy and the corresponding schematic diagram* (B)*.*

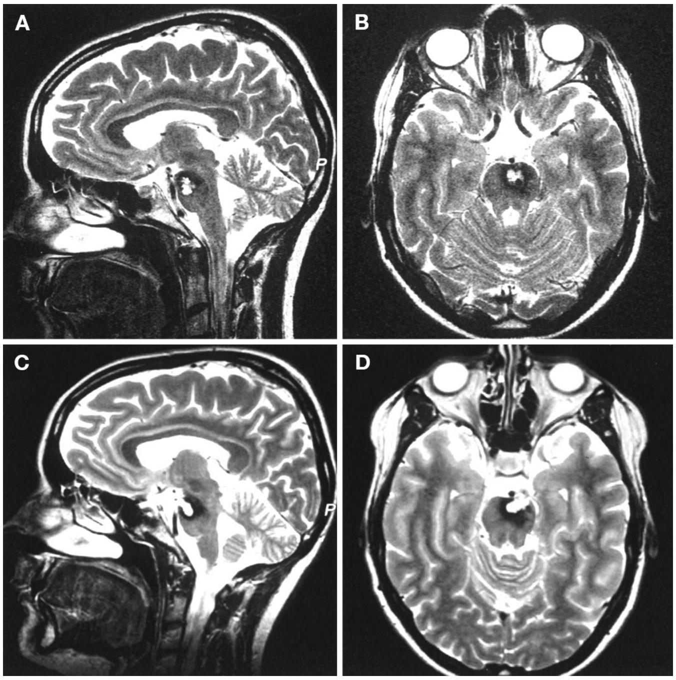

FIGURE 12. *Preoperative and postoperative MRI scans of a 39-year-old woman with a ventrally situated pontomesencephalic brainstem cavernoma (*A *and* B*). The postoperative scans 3 months after surgery reveal complete removal of the cavernous malformation (*C *and* D*).*

rological examination revealed slight right-sided hemiparesis. Histopathological examination of the removed specimen disclosed a cavernous malformation. After intensive neurophysiological training, the patient recovered neurological function and subsequently returned to her previous employment. An MRI study 3 months after surgery demonstrated complete removal of the cavernoma (*Fig. 12, C* and *D*).

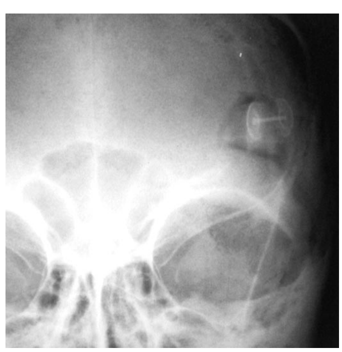

FIGURE 13. *After extirpation of the brainstem cavernoma, in the postoperative plain x-ray, the limited supraorbital craniotomy is evident.*

DISCUSSION

History of the Subfrontal Approaches

A subfrontal and transfrontal approach was first described by Francesco Durante in 1884 for resection of an olfactory groove meningioma; the postoperative course was uneventful, and the patient experienced no neurological deficits (41). The first supraorbital subfrontal exposure was reported by Fedor Krause in the first volume of his pioneering work, *Surgery of the Brain and Spine*, published in 1908 (22). As did Durante, Krause created a combined skin, periosteum, and bone flap to avoid postoperative bone infection. Tandler and Ranzi (40) in 1920 approached this area by a similar exposure for suprasellar lesions. Although the craniotomy was large, Krause (22) and Tandler and Ranzi (40) used an extradural route; the frontal, parietal, and temporal portions of the cortex were not exposed directly to air, as the dura was opened at the sphenoid ridge. McArthur (27) in 1912 and Frazier (12) in 1913 removed the supraorbital arch in their frontal approach to the pituitary body, reducing postoperative complications owing to excessive retraction of the frontal lobe.

Harvey Cushing performed the first complete removal of a tuberculum sellae meningioma via subfrontal exposure in 1916 and reported his experiences on the resection of 28 tumors in his classic publication of 1938, coauthored by Louise Eisenhardt (6). In 1920, Heuer (19) described his subfrontal approach to chiasmal lesions, and Dandy (41) published the results of his first eight cases with frontobasal meningiomas in 1922. The authors exposed a large cortical surface, causing cortical microinjuries with the possibility of subsequent postoperative epileptic seizures. Extended openings were necessary to illuminate deep-seated intracranial operating fields and to ensure adequate visual control for the surgeon. However, development of diagnostic imaging and surgical technique allowed a stepwise reduction in the size of skin incisions and craniotomy. One decade later, approaching the suprasellar area, Dandy reported a frontolateral pterional, or so-called "hypophyseal," approach, with the skin incision concealed behind the hairline.

However, these deep-seated locations provided only narrow working spaces in close vicinity to eloquent structures, and a number of neurological surgeons worldwide started to use microsurgical techniques, including the surgical microscope, in neurosurgery (23). Dandy's frontolateral pterional approach was refined with the microsurgical techniques of Yaşargil et al. (45) in 1975, with drilling of the sphenoid ridge. A limited frontolateral approach to aneurysms of the anterior circulation was described by Brock and Dietz (3) in 1978.

In 1982, Jane et al. (20) reported a supraorbital exposure to aneurysms and other lesions of the suprasellar area, as well as to orbital lesions. This approach was modified by Delashaw et al., whose technique included fracturing the orbital roof (9) or including a temporal extension of the craniotomy (10). The inferior extension of the supraorbital craniotomy by removal of the orbital rim was also described by Delfini et al.(11), using an alternative technique with two bone flaps. Al-Mefty (1) and Al-Mefty and Fox (2) published their experience concerning a supraorbital-pterional approach to cranial base lesions by incorporating the superior and lateral orbital walls; Smith et al. (38) and Zabramski et al. (46) described extended temporal and orbitozygomatic bone removal, which provided wide access to the anterior and middle cranial fossae.

Most variations of these supraorbital and subfrontal approaches have included extensive soft tissue and bony exposure and brain retraction, causing a possible increase in surgical morbidity not related to the lesion itself (1, 17, 18, 26, 46). However, similar to the aforementioned pioneering presentation on a small frontolateral approach from Brock and Dietz (3) in 1978, new publications on the subfrontal exposures describe limited skin incision and soft tissue dissection, with limited craniotomy and brain retraction, thus minimizing the intraoperative traumatization of eloquent structures. In 1998, van Lindert et al. (43) reported their surgical experience on a supraorbital subfrontal craniotomy with an eyebrow skin incision for the treatment of 197 intracranial aneurysms. Czirják et al. (7, 8) published their experience in 2001 and 2002, and Ramos-Zúniga et al. (37) presented the transsupraorbital approach in 2002. In 2001, Steiger et al. (39) described a small orbitocranial approach through a frontotemporal hairline incision for approaching aneurysms of the anterior communicating artery.

It is obvious that during recent decades, various subfrontal and frontolateral approaches to the suprasellar area have been described, although differently named exposures were in fact quite similar. However, in his pioneering description in 1908, Fedor Krause (22) already realized the essence of the subfrontal supraorbital exposure: the suprasellar anatomic structures are free for surgical dissection from an anterior direction of view, and the anterior part of the temporal lobe does not obscure access to the deep-seated areas.

Concept of the Supraorbital Keyhole Craniotomy

In an article titled "Limited Exposure in Cerebral Surgery," published in 1971, Wilson (44) quoted the famous neurosurgeon Dr. William Halsted, who, in 1924, expressed his opinion "... that the tendency will always be in the direction of exercising greater care and refinement in operating ..." (44). Today, on the threshold of the 3rd millennium, this fundamental philosophy of minimally invasive therapy should be emphasized more than even before: operating with a minimum of iatrogenic traumatization and achieving a maximum of efficiency in neurosurgical therapy.

One of the most important goals in reducing surgical traumatization is limiting brain exposure and retraction by using limited and more specific craniotomies (28, 34, 36). Exposure of brain tissue for several hours during surgery during extended craniotomies always means an injury of the surface by nonphysiological surroundings, such as room air, irrigation media, and cover material. In addition, since Landis (24) in 1934 described the physiological range of capillary pressure, it has been shown in a number of experimental and clinical studies that brain retraction causes significant intraoperative traumatization to brain tissue and may cause permanent neurological deficits. To minimize brain retraction, various methods have been proposed, e.g., application of special anesthetic techniques to achieve brain relaxation, special brain retractor systems and instruments, and special positioning techniques of the patient (33). However, the best retraction is no retraction. Careful choice of an adequate, less-invasive surgical approach with minimal brain exploration and retraction may result in a significant reduction of traumatization to intracranial structures.

Of course, intracranial lesions located close to the surface require a craniotomy that is at least as large as the lesion itself, whereas in our opinion, deep-seated lesions can be exposed through smaller, more limited approaches. These craniotomies provide excellent visualization of objects that are deep seated or even contralaterally located because the intracranial field widens with increasing distance from the approach entrance (13, 21, 28, 32).

The major point as to why the small supraorbital craniotomy works is the use of this keyhole concept in neurosurgery, which offers a safe and adequate intracranial exposure. In addition, from the anterior subfrontal direction, the suprasellar and parasellar regions are free for surgical dissection, by using the anatomic windows between their structures to approach deep-seated lesions, even within the posterior fossa (*Table 2.*).

TABLE 2. Anatomic structures that can be exposed via the supraorbital subfrontal approach[a]

Ipsilateral	Midline	Contralateral
Orbital roof	Olfactory groove	Orbital roof
Anterior clinoid process	Planum sphenoidale	Anterior clinoid process
Posterior clinoid process	Tuberculum sellae	Basal frontal lobe
Roof and lateral wall of the CS	Lamina terminalis	Sylvian fissure
Basal frontal lobe	Pituitary stalk	Temporal pole
Sylvian fissure	AComA	ICA, OphthA, PComA, AChA
Temporal pole	Distal BA	A1, A2, M1, M2, P1, P2, SCA N I, N II, N III
Uncus hippocampi		
ICA, OphthA, PComA, AChA		
A1, A2, M1, M2, P1, P2, SCA		
N I, N II, N III, N IV		

[a] CS, cavernous sinus; AComA, anterior communicating artery; ICA, internal carotid artery; OphthA, ophthalmic artery; PComA, posterior communicating artery; AChA, anterior choroidal artery; BA, basilar artery; A1 and A2, 1st and 2nd segments of the anterior cerebral artery; M1 and M2, 1st and 2nd segments of the middle cerebral artery; P1 and P2, 1st and 2nd segments of the posterior cerebral artery; SCA, superior cerebellar artery; N I, olfactory nerve; N II, optic nerve; N III, oculomotor nerve; N IV, trochlear nerve.

Limitations of the Supraorbital Craniotomy and Selection of Cases

It is indisputable that limited craniotomies have different shortcomings during their completion. Uniportal microsurgical dissection through a keyhole approach is afflicted with general disadvantages, such as narrow viewing angles and the necessity for almost coaxial control of the microinstruments used through narrow anatomic windows. The size of the lesion does not play an important role; our experience also demonstrates that large or giant tumors can be removed through keyhole craniotomies. By using the strategy of coagulating and cutting the tumor matrix first and then removing the basal slice of the tumor, a well-controlled, piece-by-piece removal of the lesion can be achieved without significant brain retraction or extended destruction of cranial base structures. However, if the diameter of the craniotomy is reduced to less than 15 to 20 mm, the application and maneuverability of most conventional microinstruments become limited. The invention of special keyhole-adapted microinstruments (33) and new approaches, such as biportal microsurgical exposure, may partially solve this problem (16). In addition, the application of intraoperative imaging, such as neuronavigation, intraoperative CT, MRI, and three-dimensional ultrasound, make safe intraoperative orientation possible.

The most important disadvantage of the small, less-invasive keyhole approach is the loss of intraoperative light and sight, causing significantly reduced optical control during surgery. For the purpose of bringing light into the surgical field and controlling deep-seated microinstruments with adequate magnification, the optical properties of modern surgical microscopes can be effectively supplemented by the optical properties of endoscopes. In the 450 supraorbital craniotomies that we performed, endoscope-assisted microsurgical techniques were used in 135 cases, with the advantage of higher light intensity, a clear depiction of details in close-up positions, and an extended viewing angle. With additional modern video technology, the full use of endoscope-assisted microneurosurgery could be achieved (32, 34, 36).

The limitation of the usefulness of the supraorbital craniotomy is not a technical but an anatomic one. For example, a deep temporobasal extension of a lateral sphenoid wing meningioma requires a pterional and not a subfrontal exposure. However, with the help of our illustrative cases, we have demonstrated that despite limited craniotomies, wide intracranial areas could be effectively approached, including extended, bilaterally situated, or even deep-seated lesions. With endoscope-assisted techniques, hidden corners of the surgical field could also be safely controlled without additional extension of the craniotomy.

Of course, extended approaches with frontotemporobasal craniotomies allow changing of the operative corridor around the suprasellar structures at different angles during surgery. However, preoperative planning with definition of the correct surgical gateway allows limitation of the surgical exposure requiring minimally invasive and maximally effective therapy.

CONCLUSIONS

We conclude that the limited supraorbital subfrontal approach offers adequate visualization and safe surgical manipulation within eloquent anatomic structures. Our more than 10-year experience revealed clear advantages of the limited keyhole craniotomy compared with the extended approaches of the past, thus contributing to improved postoperative results and shorter hospitalization times because of a reduction in the risk of complications, such as bleeding or rebleeding with neurological deterioration, postoperative epilepsy, leakage of cerebrospinal fluid, infection, scarification, and cosmetic disturbances. We strongly suspect that supraorbital craniotomy similar to that used in our department will be a widely accepted approach, not only for highly experienced specialists but also for young residents in their neurosurgical training.

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COMMENTS

The authors presented an overview of the literature of the subfrontal approaches. There is no doubt that pros and cons do exist, but the authors are convinced that the cons are widely outnumbered by the pros. The authors are aware that most of the actions throughout the surgery using this approach are to be conducted in co-axial direction, and that is why they also have admitted that this approach does necessitate the use of new, delicate, and specially designed micro-surgical instruments. With the description of the approach and with the presentation of different clinical cases, the authors have proved that this approach has its value for selected pathologies unless they are intermingled with the vital neural and vascular structures at the cranial base. There is no doubt that there are better approaches for complex cranial base lesions than the one described by the authors. Again, to be realistic, to go after a large, not necessarily giant aneurysm originating from the under aspect of the intradural internal carotid artery and involving more than 50% of the internal carotid artery wall circumference necessitating the circumferential cut of the dural ring would, through this approach, be very dangerous. An aneurysm, as they presented in *Figure 6*, with a narrow neck and projecting medially, can be dealt with through their approach, particularly if the clipping is combined with the Dallas maneuver. Every neurosurgeon with moderate experience of vascular pathologies and AVMs does know how many AVMs there are at the base of the brain. Therefore, advocating this approach for the AVMs is somewhat unrealistic at least. If the authors are of different opinion, why didn't they include a complex AVM with their case presentations? The bottom line is that the approach described is not safe for complex cranial base lesions occupying several compartments and encasing the neural and vascular structures. With all respect to the authors, one must question why they did not include among the figures one complex meningioma—the presented meningioma in *Figure 4* is far from being a complex one. It does not compress the chiasm; it only touches it.

The presentation of a complex craniopharyngioma also is missing. It is difficult to understand the authors' explanation that less damage is caused to the brain because they are using retractors only to protect the brain, and that by this approach, they also reduced the need for a larger dural opening. On the contrary, as is shown in *Figure 3H*, a large surface of the brain at the base of the frontal lobe is exposed and the opening of the dura is not small. By the other approaches, when the dural cut is performed along the sylvian fissure, the brain is much less exposed, and in addition "the protection" of the brain with the spatula is not needed. In fact, the entire central cranial base is easily exposed without using any retraction of the brain, and at the end of surgery, the dura is watertightly closed. It also is very difficult to understand why the authors are against cutting the arachnoidea along the sylvian fissure and splitting it. This gives the surgeon a large corridor without any brain retraction. The authors write, "When approaching from an anterior subfrontal direction, the suprasellar anatomical structures are free from surgical dissection and not hidden by any brain structures." This quotation is supported by six of their references. Again, with all due respect, I still think that by using different angles, on can go around the optic nerve(s), chiasm, optic tracts, and all the vessels of the circle of Willis, which is at least very difficult if one has to use only one direction, and, after all, at the cranial base the brain tissue is much less an obstacle than the visual apparatus and vascular structures. In their conclusion, the authors write that limited "key-hole craniotomy" may contribute to the improved postoperative result. They believe that the hospital stay will be short because there will be fewer complications such as bleeding, neurological deterioration, postoperative epilepsia, CSF leak, infection, and cosmetic disturbances. This simply is not true. Postoperative epilepsy, CSF leak, infection, and neurological deterioration following the extradural approach to the cranial base is much less frequent than it is presented in the approach advocated by the authors in this report. Therefore, the emphasized cosmetic result is questionable because there are patients who prefer to have a larger scar behind the hairline than a small one along the eyebrow. Although the presented approach does have its applicability, it is nevertheless doubtful that it will ever replace the modificed approach(es) from the side and through the sylvian fissure in cases of difficult central cranial base vascular and tumorous pathologies.

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The supraorbital (subfrontal frontolateral) approach represents one of the major gateways not only to the anterior cranial base but also to all segments of the circle of Willis and to portions of the middle and posterior fossa (1). It belongs to the basic repertoire of any neurosurgeon concerned with intracranial microsurgical procedures. The eyebrow incision adds a cosmetic pointing for patients with high hairline. Its limitations include the lateral extension due to the course of the temporal branch of the facial nerve and the superior extension due to limited skin retraction. Still, this is a powerful approach, and, of course, we should be cautious to directly correlate its invasiveness and potential for traumatization to the size of the craniotomy alone.

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This is a very large series of patients who presented different pathologies and were treated surgically through a minimal opening named the "supraorbital subfrontal approach." As said by the authors, this is a report on their experience and not a demonstration of the advantages of this technique. There is no comparison with other surgical approaches and no results are given that may present this technique as beneficial for the patients in terms of morbidity, length of stay, and other such determinants.

The skin incision is appealing as long as there is nonwound complication. Then, there are probably many surgeons who use skin incision behind the hairline and perform a bone flap, which is barely larger than the one described here. The authors certainly are very skillful to work through such a limited opening. However, even if I were as clever as they are, I would not feel so comfortable. My main concern would be to have no security in case of problem necessitating a change to the angle of view, which is only one, or to enlarge the field. This is especially true for AVM, some aneurysms and even some meningiomas developed in the vicinity of the optic nerve.

Furthermore, one of the advantages put forward by the authors is the absence of retraction. I cannot believe that surgeons using standard subfrontal or pterional approaches are retracting the brain. The principle to avoid retraction has been applied since microsurgical techniques and the other approaches were introduced. Exposure to air is probably very similar because air is entering the subdural space everywhere the cerebrospinal fluid has been drained.

Finally, I guess that manipulations of the structures are not different following approaches. A meningioma of the anterior clinoid needs the control of the optic nerve and carotid artery regardless of the surgical approach. In fact, this technique probably is very attractive for the patient who may believe that limited opening means limited surgery. The main advantage I find in this supraorbital subfrontal approach is that it forces the surgeon to precisely define the tumor developments and a course of action. This certainly is a very educative process that satisfies the surgeon and the patient if the problems have been anticipated. If this is not the case, consequences may be difficult, complicated, and incomplete treatment. Therefore, I would not encourage anyone to start immediately with this technique. Surgeons should keep their usual technique, with which they are comfortable, and progressively reduce the size of the bone opening before jumping to the supraorbital subfrontal approach. The authors probably have followed a similar pathway before obtaining expertise they reported, and for which they have to be commended.

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In this article, Reisch and Perneczky presented probably the largest series of patients operated via the eyebrow keyhole approach. Although the authors stated many advantages of this approach, we would like to mention some of the disadvantages. Skin incision has to be in the middle of the eyebrow to achieve the best possible cosmetic results. This is sometimes difficult to achieve because some patients have short eyebrow and incision have to be extended off the eyebrow onto the lateral side of the head. In addition, some women trim their eyebrow and make them very narrow. In such circumstances, postoperative scarring is more visible. Furthermore, bipolar coagulation in the skin and subcutaneous tissue should be minimal to prevent eyebrow hair loss around the incision line.

Fibers of orbicularis muscle should not be cut but should be longitudinally divided. Longitudinally incision through orbicular muscle should go laterally towards superior temporal line to allow sufficient bone exposure. One should be careful not to cut the frontal branch of the facial nerve. Galea-periost layer prevent sufficient spreading of the wound. Galea-periost layer should be cut along the superior temporal line to allow sufficient bone exposure. After surgery, this layer should be reapproximated together with temporal fascia. Frequently, the lateral branch of the supraorbital nerve run in the middle of the operative field. In those cases, this branch should be cut to allow sufficient exposure of supraorbital frontal bone.

Except for pediatric cases, trepanation in the temporal fossa followed by osteoclastic supraorbital craniotomy should be done. In adults, the dura is attached firmly inner table and cutting the bone in one piece may tear the dura and the rip will be difficult to repair. The superior orbital roof frequently is uneven and drilling is necessary or the orbital roof can be removed, preserving the supraorbital rim, which is important for the postoperative cosmetic results. After osteoclastic craniotomy, cranioplasty can be done using Palacos or Bone Source. A cosmetic result is excellent.

If needed, the supraorbital rim and the anterior one-half of the orbital roof can be removed in one piece. In children, osteoplastic craniotomy can be done in one piece, including the supraorbital part of frontal bone, supraorbital rim, and anterior half of the orbital roof. This piece of bone is easy to reattach using titanium micro plates. The rest of the orbital roof can be removed osteoclastically and the optic canal unroofed and anterior clinoid process drilled out by high-speed drill.

The frontal sinus frequently is extended laterally and frequently has to be opened. In these cases, the sinus must be very carefully sealed because there is no periostal vascularized graft to cover the sinus after packing it with muscle and fat. In case of intraoperative aneurysm rupture, there is no room for "third hand" and second suction. A special instrument should be designed and applied because the operative field is sometimes very deep (e.g., basilar tip aneurysm) and craniotomy small. Sometimes it is difficult to relieve the vascular clip from the clip-applier because there is no room for clip-applier opening. Meticulous hemostasis of the dura, bone edge, muscle, and subcutaneous tissue should be done to prevent postoperative superior eyelid swelling and hematoma because subgaleal drainage is unusual in this approach.

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In the present paper, a master of what I personally prefer to refer to as the "trans-supraciliar subfrontal approach" conveys the current technical details, reports on the type of pathologies that have been treated through 952 consecutive cases, and outlines the anatomical structures that may be reached through this approach. Although our aim is to treat the patient, we as surgeons do inflict some degree of trauma to the skin, cranium, and brain in every case. The surgical corridor we use in the subfrontal approach is obviously between the orbital roof and the frontal lobe. Despite this, we have utilized skin incisions and craniotomies that mainly, and often to a superfluous extent, uncover the frontal area. By using the technique presented here, the skin and cranial wounds are reduced, and, consequently, the head trauma the craniotomy represents minimized as is the exposure of brain surface to air and maybe the degree of brain retraction. On the other hand, the approach limits the angle around pathological processes and more retraction is sometimes needed to reach the basal cisterns and release cerebrospinal fluid.

At present, endovascular treatment of aneurysms is becoming increasingly popular as it is less invasive than surgery. This occurs despite the fact that surgical treatment is more effective in closing the aneurysm. For the benefit of the patient, it is important that we as surgeons continue to grow by developing more refined techniques. The present paper is an example of such a contribution. The technique presented here probably will become increasingly popular as more surgeons become familiar with it. This also will reveal its advantages and limitations more clearly.

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