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Endoscope-assisted keyhole surgery via an eyebrow incision for removal of large meningiomas of the anterior and middle cranial fossa

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ABSTRACT

Background: Conventional open surgery of large meningiomas has proven to be challenging even in experienced hands. Intense retraction and dissection around neurovascular structures increase morbidity and mortality. In the present study, we retrospectively analyzed the surgical technique, and outcome in 40 patients with large anterior cranial fossa meningiomas extending to the middle fossa. All patients were approached via a supraorbital mini craniotomy.

Methods: It is a retrospective study of 40 patients (12 males, 28 females) who underwent surgery for large anterior cranial fossa meningiomas (diameter >5 cm) extending to the middle fossa in four different neurosurgical centers within 6 years. Depending on the localization of the tumor, the skin incision was between 2.5 and 3 cm long and was made without shaving the patient's eyebrow hair. Subsequently, a keyhole craniotomy was performed of approximately 0.8×1.2–1.4 cm in diameter. Preoperative and postoperative clinical and radiological data were analyzed and discussed.

Results: Headache and psycho-organic syndrome were the most common presenting symptom in all patients. Presenting symptoms were associated with psychological changes in 23 cases, visual impairment in 19 patients, and anosmia in 17 patients. In overall, 36 of 40 patients (90%) showed a good outcome and returned at long-term follow-up to their previous occupations. The elderly patients returned to their daily routine.

Conclusion: With the appropriate keyhole approach as a refinement of the classic keyhole craniotomy to a smaller key"burr"hole, and with use of modern and new designed equipment, it is possible to perform complete resection of large anterior and middle fossa meningiomas with the same safety, efficiency and with less complication rates as described in the literature for large meningiomas even performed with classic keyhole craniotomies.

1. Introduction

Conventional open surgery of large meningiomas has proven to be challenging even in experienced hands. Intense retraction and dissection around neurovascular structures increase morbidity and mortality [1,2]. However, minimally invasive surgical methods like the supraorbital craniotomy via an eyebrow skin incision and a subfrontal approach with minimal brain retraction showed many improvements according to surgical results and outcomes especially in the frontal and middle fossa [1]. Furthermore, the supraorbital surgical technique combined with the use of neuroendoscopy has been shown to be a very effective method in the resection of meningiomas in the anterior skull base [1,3].

In the last two decades, two major routes have been established to approach meningiomas located in the olfactory groove, tuberculum sellae, planum sphenoidale or the medial part of sphenoid wing. These two routes are the endonasal transsphenoidal approach and the supraorbital craniotomy. Both approaches benefits from endoscopic techniques.

The transsphenoidal approach has been shown to be effective and safe for suprasellar tumors that are predominantly located in the midline medial to the carotid arteries [4–15]. With this approach, there is no brain retraction, the optic apparatus manipulation is significantly low, and early identification of the pituitary

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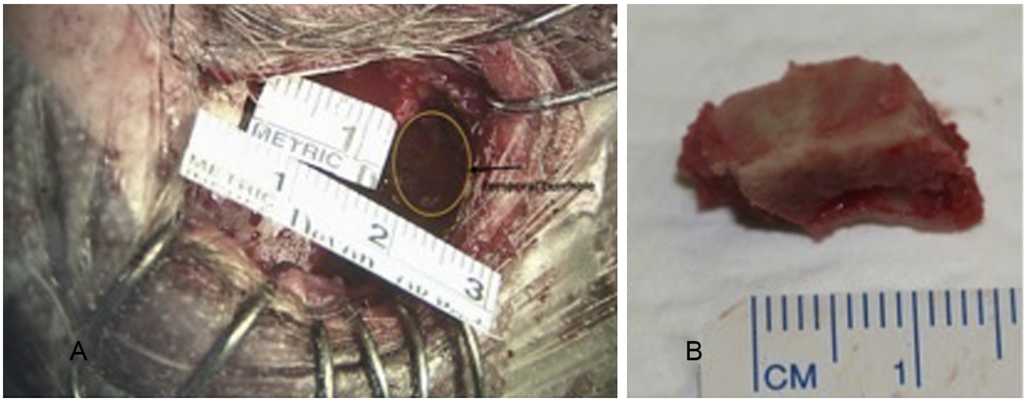

Fig. 1. (A) Size of a small keyhole craniotomy and the size of the eyebrow incision and (B) bone flap measurement.

gland and infundibulum is common [6]. The supraorbital "eyebrow" craniotomy is also performed with minimal brain retraction and allows excellent access to the frontal base, the medial part of the middle fossa and under endoscopic visualization a panoramic view over the whole supra- and parasellar area [3,16,17].

In the present study, we analyzed surgical technique, and outcome in 40 patients with large meningiomas located in the frontal fossa and partly extended into the middle fossa. All patients were treated via a keyhole craniotomy as large as necessary to host the instruments and as small as possible to achieve the best surgical result. Furthermore, we compared surgical strategy with conventional fronto-temporal and pterional approaches presented in the literature for removing large fronto-temporo-basal meningiomas.

2. Patients and methods

2.1. Patient population

Within 6 years (2008–2013), 40 patients (12 males, 28 females) underwent surgery in the frontal and temporal skull base for large meningiomas in four different neurosurgical centers. We define the meningiomas as large if the diameter was bigger then 5 cm. Meningiomas were located bilaterally in the olfactory groove ($n = 17$), tuberculum sellae ($n = 7$), medial sphenoid wing ($n = 12$, right sided $n = 7$, left sided $n = 5$), planum sphenoidale ($n = 3$), and anterior side of the falx cerebri ($n = 1$) (Table 1). The mean patient age was 59 years (range, 38–80 years).

All patients underwent postoperative MRI during the follow-up period at 1 week, 3 months, 12 months, and every year thereafter. Ethical approval for performing the retrospective study was not needed.

Table 1
Summary of characteristics in 40 patients with giant intracranial meningiomas.

Characteristics	No. of patients (%)
Preoperative symptoms	
Psychological deterioration	23 (57.5%)
Visual disorder	19 (47.5%)
Anosmia	17 (42.5%)
Resection Simpson grade	
Simpson I	32 (80%)
Simpson II	8 (20%)
Histology subtype	
Meningothelial	19 (47.5%)
Fibroplastic	10 (25%)
Transitional	5 (12.5%)
Psammomatous	3 (7.5%)
Atypic WHO II	3 (7.5%)

2.2. Surgical performance

Depending on the localization of the tumor, the skin incision was between 2.5 and 3 cm long and was made without shaving the patient's eyebrow hair. Subsequently, a key"burr"hole craniotomy was performed of approximately $0.8 \times 1.2–1.4$ cm in diameter. Primary goal was radical tumor removal, Simpson I°. Surgical time was 3–6 h, depending on the consistence of the tumor, the infiltration of the olfactory, optic and oculomotor nerve. Skin incision followed the shape of the eyebrow without shaving it, started lateral to the supraorbital foramen and remained strictly into the eyebrow. Afterwards, the subcutaneous tissue was carefully dissected frontally. The frontal muscle was cut and the temporal muscle retracted laterally, the typical key"burr"hole was placed fronto-basal and posterior to the temporal line (Fig. 1A). The bone flap had an ellipsoid shape with extensions maximal to $0.8 \times 1.2–1.4$ cm (Fig. 1B).

After bone removal the most important step of the craniotomy was drilling the inner edges of the skull to widen the surgical corridor. Small osseous extensions of the superficial orbital roof were drilled extradural to achieve better visualization after dura opening. The view into the entire skull base ipsi- and contralateral improved while debulking the tumor.

Intradural tumor dissection was performed intermittently using microscope (Fig. 2A), and endoscope on an endoscope-assisted, endoscope-controlled technique basis.

The 3D-endoscope was placed on a holding arm for fixation above the surgical field. After the craniotomy was done, the 3D-endoscope was placed above the surgical field like a microscope, and the optical information was given to the surgeon via the integrated monitor placed in front of the surgeon's eyes. Next step was to creating the surgical corridor with the help of the operating microscope, and in interchange to the 3D-endoscope the tumor was debulked. At the end of the surgery the 3D-endoscope helped the surgeon to remove the lesion remaining above the neurovascular structures with spending light and sight in front of the target point. We transformed the monitor of the 3D-endoscope unit to a kind "occular" of the surgical microscope. The light and sight in the surgical region of interest came from the positioning of the telescope above the surgical field.

CUSA was not used because of in situ ergonomic problems. The craniotomies were as minimal as that ultrasonic dissector could not be introduced to reach these deep-seated skull base meningiomas. For tumor removal, the below described tube shaft microinstruments, in combination with bipolar, scissors, different dissectors and small suction devices were used.

Tumor removal strategy followed an interaction between tumor matrix coagulation, cutting, debulking, and at the end careful dissection between skull base, neurovascular structures and remained