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Surgical strategy for the treatment of craniofacial tumors with intracranial, extracranial and intraorbital extensions

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Background: *Surgical treatment of craniofacial tumors with intracranial, extracranial and intraorbital extensions requires several surgical teams of different specialties (neurosurgery; ear, nose and throat surgery; and eye surgery (for a separate surgical approach)) to be involved. In addition, because craniofacial approaches require creating several surgical fields, the duration of surgery per se is rather long. The conventional transbasal Derome approach is less traumatic than the anterior craniofacial resection and requires no additional dissections of the face. The subcranial approach (a modification of the transbasal Derome approach) may be a low-invasive alternative to the transbasal Derome approach.*

Purpose: *To assess the efficacy of surgical treatment for craniofacial tumors with intracranial, extracranial, and intraorbital extensions.*

Material and Methods: *We retrospectively reviewed the medical records of 88 patients with craniofacial tumors (particularly, 66 malignant tumors and 25 benign tumors). Of the 88 patients, 12 (14%) were treated with the transbasal Derome approach, and 76 (86%), with the subcranial approach (via the frontal sinus).*

Results: *The percentage attributed to total tumor excision (with clear wound margins) was the same (92%; 11/12 and 70/76 patients, respectively) for the groups of patients treated with subcranial and transbasal approaches. Patients with subtotal tumor excision (7/88 or 8%) had malignant tumors, and the rate of subtotal tumor excision was 8% (1/12 and 6/76, respectively) for the groups treated with the former and latter approaches. Mean duration of surgery was significantly shorter in the subcranial approach than in the transbasal Derome approach (291 ± 24 minutes versus 372 ± 48 minutes; $p < 0.0000$).*

Conclusion: *Craniofacial tumors with intracranial, extracranial and intraorbital extensions can be totally simultaneously excised by transbasal approaches. A modification of the transbasal Derome approach, the subcranial approach (via the frontal sinus) to craniofacial tumors, can be performed easier and faster, is less traumatic, can be lateralized, and showed the same rate of total tumor excision compared to the transbasal Derome approach.*

Keywords:
craniofacial tumors, transbasal approach, subcranial approach

Introduction

A craniofacial tumor, either benign or malignant, typically presents with intracranial, extracranial and intraorbital extensions.[1] The invasion of both the inner and outer bases of the skull is a fundamental feature of this tumor type. Anterior craniofacial resection has been widely employed in the treatment of the craniofacial tumors that involve the floor of the anterior cranial fossa and exhibit further intracranial progression.[2] It combines a bifrontal craniotomy with a Moore's lateral rhinotomy incision. Doing this type of resection requires the involvement of several surgical teams of different specialties (neurosurgery; ear, nose and throat surgery; and eye surgery (for a separate surgical approach)).[3] Because craniofacial approaches require creating several surgical fields, the duration of surgery per se is long. The conventional transbasal or Derome approach combines a bifrontal craniotomy with resection of the supraorbital complex, allowing the resection of intracranial, extracranial, and potential intraorbital extensions of a craniofacial tumor. This approach is less traumatic than anterior craniofacial resection and requires no additional dissections of the face.[4-6] A modification of the transbasal Derome approach, particularly, a subcranial approach (via the frontal sinus), is a less traumatic and technically easier approach, and can be employed as an alternative to the transbasal Derome approach.[7-10]

The purpose of this study was to improve the outcomes of surgical treatment for anterior fossa tumors with intracranial, extracranial, and intraorbital extensions

through the employment of a low-invasive craniobasal approach, namely, the subcranial approach (via the frontal sinus).

Material and Methods

We retrospectively reviewed the medical records of 88 patients with tumors of the floor of the anterior cranial fossa (ACF) who underwent surgical treatment at the Romodanov Neurosurgery Institute from 2014 through 2021. Of these, 40 (45.45%) were women and 48 (54.55%) were men. Patient age ranged from 22 to 72 years, with a mean ± standard deviation of 46.14 ± 1.25 years.

Patients underwent a clinical neuroimaging examination involving magnetic resonance imaging (MRI) and multidetector computed tomography (MDCT) of the skull base and paranasal sinuses, as well as neurological status assessment, as per routine protocols, before and after treatment.

Of the 88 patients, 12 (14%) were surgically treated with the transbasal Derome approach, and 76 (86%), with the subcranial approach (via the frontal sinus).

The transbasal Derome approach allows for the removal of intracranial, extracranial, and intraorbital components of the tumor, and combines a bifrontal craniotomy with bilateral resection of the supraorbital complex (Fig. 1).

A modification of the transbasal Derome approach, particularly, a subcranial approach (via the frontal sinus), is a less traumatic and technically easier approach. The subcranial approach was initiated with a skin incision made along the superciliary arch (a gull wing incision; Fig. 2A). Thereafter, a vascularized periosteal flap was raised from the frontal site to close the postoperative bone defect of the anterior fossa floor (Fig. 2B), and an oscillation saw was used to trephine the anterior wall of the frontal sinus (Fig. 2C).

If the tumor had a lateral extension or the frontal sinus was small, an oscillation drill was used to cut the bone outside the frontal sinus, in the area of the diploë of the frontal bone (Fig. 3).

The excised tumors were examined histomorphologically. Light optical microscopy and immunohistochemical methods, if required, were used for tumor pathohistology.

Surgery efficacy was assessed via the comparison of preoperative and post-operative MDCT and/or brain contrast-MRI data.

Analysis of postoperative complications and performance status based on Karnofsky performance score were conducted to assess the extent to which the surgical approach (subcranial or transbasal) was traumatic. The Karnofsky performance scale (KPS) is a performance status assessment tool which measures the ability of cancer patients to perform ordinary tasks. The KPS is as follows:

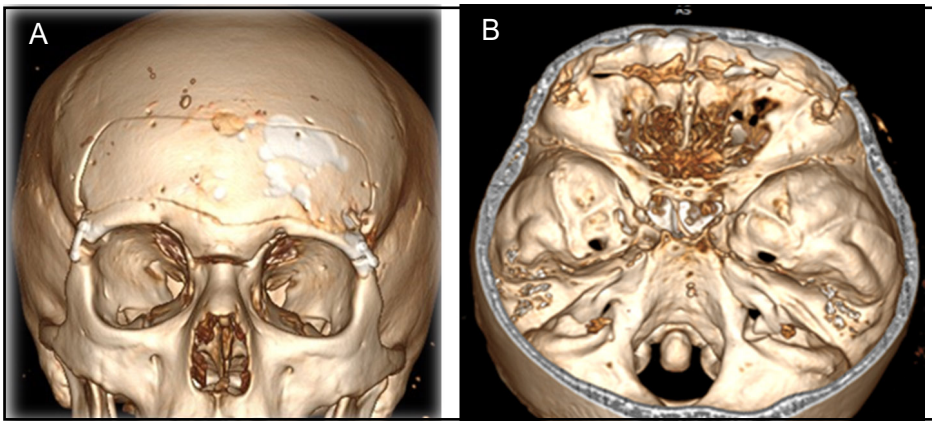

Fig. 1. Transbasal Derome approach with the creation of the bifrontal bony flap (A) and (B) bilateral supraorbital flap

Fig. 2. A modification of the transbasal Derome approach, the subcranial approach (via the frontal sinus): making a skin incision (a gull wing incision) along the superciliary arch (A); raising a vascularized periosteal flap from the frontal site (B), and trephining the anterior wall of the frontal sinus with an oscillation saw

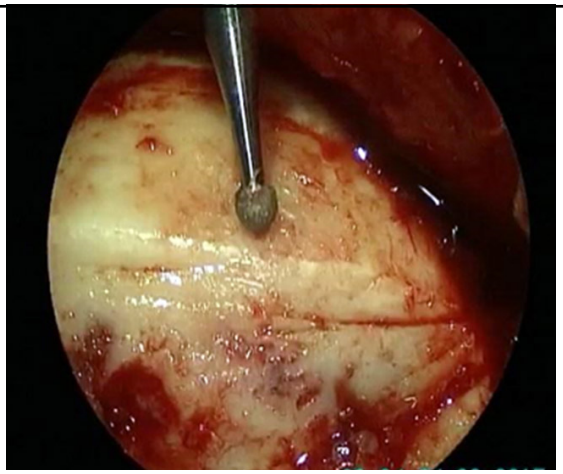

Fig. 3. Expanding the subcranial approach in the diploë of the frontal bone

100, normal, no complaints, no evidence of disease; 90, able to carry on normal activity, minor symptoms of disease; 80%, normal activity with effort, some symptoms of disease; 70, cares for self, unable to carry on normal activity or active work; 60, requires occasional assistance but is able to care for needs; 50, requires considerable assistance and frequent medical care; 40, disabled: requires special care and assistance; 30, severely disabled: hospitalization is indicated, death not imminent; 20, very sick, hospitalization necessary: active treatment necessary; 10, moribund, fatal processes progressing rapidly; 0, dead. Performance status of patients in both groups was assessed with the KPS before and after surgery. Surgery-associated postoperative complications were analyzed in groups and included any deviation from normal postoperative course requiring medical and/or surgical treatment.

Statistica 6 (StatSoft, Tulsa, OK) software was used for statistical analysis. Kaplan-Meier-method was used to calculate survival rates, and log-rank test was used to detect significant differences between groups. In addition, correlations between parameters were assessed with non-parametric statistics (Gamma, Spearman, and Kendall tau correlation coefficients). Conventional parametric statistic methods were used for quantitative variables, whereas non-parametric statistic methods, for qualitative variables (expressed mostly in percentages).

Results

The craniofacial tumors were classified as benign and malignant based on histological parameters. Malignant epithelial tumors of the paranasal sinuses (cancers of different degrees of differentiation, 36 cases), were the most common malignant craniofacial tumors, followed by adenocarcinoma (10 cases), esthesioneuroblastoma (10 cases), malignant tumors of bone and cartilage, 4 cases (chordosarcoma, 2 cases and osteoblastoma, 2 cases) and hemangiopericytoma, 2 cases.

Meningioma (9 cases) was the most common benign craniofacial tumor, followed by benign tumors of bone and cartilage (osteoma, 6 cases), mesenchyoma (4 cases), cholesteatoma (3 cases), hemangioma (2 cases), and neurofibroma (1 case).

Figure 4 shows anatomic locations of tumor origin. The ethmoid labyrinth was the most common location of origin for the tumors of the floor of the anterior cranial fossa (47; 53.4%), followed by the front sinus (23; 26.2%), nasal cavity (9; 10.2%), and olfactory fossa (9; 10.2%). Intracranial extension (growth into the dura mater) and intracerebral extension was seen in 41 cases (46.6%), and epidural extension, in 47 cases (53.4%). Intraorbital extension was seen in 29 cases (32.9%).

The analysis of radicality of excision for subcranial and transbasal approaches was performed to assess the efficacy of treatment for craniofacial tumors (Table 1). We found a gamma correlation between these approaches in terms of radicality of excision of a malignant craniofacial tumor ($p < 0.05$). The percentage attributed to total tumor excision was the same (92%) for the groups of patients treated with subcranial and transbasal approaches (Table 1). The minimization of surgical approach (employment of the subcranial approach) did not decrease the radicality of the procedure irrespective of the presence of cranial, lateral or intraorbital extension.

Six patients (6.8%) exhibited complications: nasorrhea was seen in 4 cases (including 3 cases in which it was complicated with meningoencephalitis), an abscess between the layers of plasty (complicated with meningoencephalitis) in one case, and intraoperative hemorrhage, in a patient with mesenchyoma. Table 2 and Figure 5 show numbers and percentages of complications for each of the two approaches. The complication rate was twice as high for the transbasal approach as for the subcranial approach (Table 2). We believe this was because, compared with the subcranial approach, the transbasal approach is more traumatic, has another direction and provides another angle of vision of the operative field, and causes larger brain trauma. A decrease in the rate of postoperative complications in the subcranial approach is caused by the two factors: first, the minimized surgical intervention (intracranial and extracranial tumor components can be removed through a single surgical

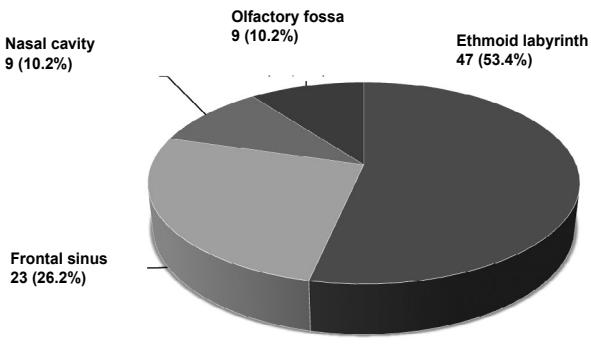

Fig. 4. Locations of origin of malignant and benign craniofacial tumors

Table 1. Numbers (n) and percentages (%) of patients having total and subtotal tumor removal by transbasal and subcranial approaches

Total or subtotal tumor excision		Surgical approaches		Totally
		Transbasal	Subcranial	
Total excision	n	11	70	81
	%	92	92	92
Subtotal excision	n	1	6	7
	%	8	8	8
Totally	n	12	76	88
	%	14	86	100

Note: n, number of patients

Table 2. Numbers (n) and percentages (%) of patients having complications after total and subtotal tumor removal by transbasal and subcranial approaches

Surgical approach		Presence of complications	No complications	Totally
Subcranial	n	2	74	76
	%	1.3	97.7	86
Transbasal	n	4	8	12
	%	33.3	66.7	14
Totally	n	6	82	88
	%	6.8	93.2	100

Note: n, number of patients

approach), and second, the craniobasal exposure employed enables a subcranial approach to the tumor, thus preventing trauma to the brain and surrounding tissues.

Table 3 presents the general condition of patients in the subcranial group and transbasal group as assessed by the mean preoperative and postoperative Karnofsky performance scores.

After surgery, there was a statistically significant improvement ($p < 0.05$; 0.041) in the general condition of patients in the subcranial group as assessed by the Karnofsky performance score (Table 3 and Fig. 6). In other words, minimally invasive subcranial surgery not only reduced the number of complications, but also improved the general condition of patients already in the early postoperative period due to decompression of the brain along with smaller trauma to the surrounding tissues.

The use of the subcranial approach for the removal of intracranial tumors with cranial, lateral or intraorbital extensions enabled a significantly reduced ($p < 0.0000$) mean duration of surgery against the transbasal Derome approach (291 ± 24 minutes versus 372 ± 48 minutes).

Table 3. General condition of patients in the subcranial group and transbasal group as assessed by the mean preoperative and postoperative Karnofsky performance scores

Surgical approach	Subcranial approach (mean Karnofsky performance score)	Transbasal approach (mean Karnofsky performance score)
Preoperative general condition of patients	74.62	70.87
Postoperative general condition of patients	79.3	72.9
Significance of difference	p < 0.05 (0.041)	p > 0,05 (0.229)

Discussion

Anterior craniofacial resection has been widely employed in the surgical treatment for craniofacial tumors extending to the anterior fossa floor and further intracranially and intraorbitally.[11] It combines a bifrontal craniotomy with a Moore's lateral rhinotomy incision. Doing this type of resection requires the involvement of several surgical teams of different specialties (neurosurgery; ear, nose and throat surgery; and eye surgery (for a separate surgical approach)). [12]

Craniofacial approaches to craniofacial tumors are used to reduce trauma to the brain (without the need for brain resection) due to the reduction in the angle of attack towards the tumor as well as a more expanded visualization of the operative field due to the basal exposure of the surgical wound.[13] A modification of the transbasal Derome approach, particularly, its low- invasive version, the subcranial approach (through the front sinus), is less traumatic and easier than the transbasal Derome approach. [14-16]

Some authors have reported a reduced visualization in the subcranial approach in cases with large tumors having lateral extensions.[17] In the current case series of cases, when the tumor had a lateral extension or the frontal sinus was small, an oscillation drill was used to cut the bone outside the frontal sinus.

We believe that the use of the transbasal Derome approach and its modification, the subcranial approach, in patients with craniofacial tumors with intracranial and extracranial and intraorbital extensions may be an effective alternative to the anterior craniofacial resection, and confirm the clinical efficacy of the transbasal Derome approach and its modification, the subcranial approach. [18, 19]

Maintenance of the patient's quality of life in the postoperative period is an important criterion for the efficacy of surgery. The patient's quality of life in the postoperative period depends on the presence and severity of postoperative complications. Gil and colleagues [20] aimed to determine the rate and type of complications after craniofacial resection during the 10-year period preceding their study. In that period, patients had higher rates of comorbidity, dural invasion, high-grade malignancy, and wide resections. The types of complications developing after craniofacial resection for malignant tumors were as follows: intracranial, wound, systemic and intraorbital complications. There was a 19% decrease in the rate of postoperative wound complications, but not in other complications, in that 10-year period. Therefore, the use of low- invasive approaches to the removal of craniofacial tumors is important.

Conclusion

First, craniofacial tumors with intracranial, extracranial and intraorbital extensions can be totally excised by the transbasal Derome approach and its modification, the subcranial approach (via the frontal sinus), with the rate of total tumor excision being the same (92%) for the groups of patients treated with subcranial and transbasal approaches.

Second, the subcranial approach (via the frontal sinus) is a less traumatic and technically easier approach, with the complication rate being half of that for the transbasal approach.

Finally, the use of the subcranial approach for the removal of intracranial tumors with cranial, lateral or intraorbital extensions enabled a significantly reduced ($p < 0.0000$) mean duration of surgery against the transbasal Derome approach (291 ± 24 minutes versus 372 ± 48 minutes).

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Disclosures

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Abbreviations: *ACF, anterior cranial fossa; MDCT, multidetector computed tomography; MRI, magnetic resonance imaging*