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Frontal sinus and recess osteomas: an endonasal endoscopic approach

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Abstract. *Frontal sinus and recess osteomas: an endonasal endoscopic approach. Background*: Over the last decade, there has been an increase in the use of the endonasal endoscopic approach for removing frontal sinus and frontal recess osteomas. This study aimed to describe an endoscopic endonasal treatment of osteomas without the need for an external approach.
Materials and methods: We performed a retrospective analysis of patients that had received operations over a 5-year period in a single center.
Results: Twenty-nine patients underwent endoscopic osteoma resections. The osteomas were graded according to the Chiu and Kennedy grading system: 12 had type I, 2 had type II, 13 had type III, and 2 had type IV osteomas. The most common indication for surgery was frontal pain. Removal of the osteoma was incomplete in three patients. Of these, one underwent successful transnasal reoperation, and the other two had tumors that extended near the mid-orbital line and were attached to the orbital roof. Based on an 11-point scale (0 - no pain, 10 - maximum pain), the mean pain intensity decreased from 7.5 before surgery to 3.3 ($p<0.005$) after surgery for patients that underwent surgery due to frontal pain.
Conclusion: We found that exclusively transnasal endoscopic resections of frontal sinus osteomas were safe. However, this approach can be inadequate under some conditions. An auxiliary external approach may be required when the frontal ostium is narrow and/or when tumors are extensively attached to the orbital roof, and grow close to the midorbital point.

Introduction

Osteoma is a common, benign neoplasm of the paranasal sinuses. Osteomas affect up to 3% of the population, and they most frequently occur in the vicinity of the frontal sinus ostium. A higher incidence is found in males than in females. The highest incidence occurs in the fifth and sixth decades of life.[1] In most cases, the tumor is slow-growing and asymptomatic; typically, it is diagnosed incidentally during a radiological examination. When present, symptoms depend on tumor size and location; symptoms may include facial pain/headache, facial deformity, anosmia, and orbital displacement. Rarely, intracranial growth with dura erosion leads to a cerebral spinal fluid (CSF) leak, pneumocephalus, meningitis, or cerebral abscess.[2,3]

Based on computed tomography (CT) evaluations, the estimated growth rates of osteomas range from 0.6 to 0.99 mm a year.[4,5] Suggested indications for removal of frontal sinus osteomas include: frontal pain/ headache, drainage blockage, located in the vicinity of the frontal ostium, involvement of more than half the sinus volume, radiologically documented enlargement, or extension beyond the sinus borders.[1,6,7]

Traditionally, frontal sinus osteomas were managed via external approaches, such as the Lynch procedure or an osteoplastic flap (OPF) with obliteration. The advent of endoscopic sinus surgery led to a gradual shift to the "above and below" approach. Endoscopic removal of a paranasal sinus osteoma, augmented with mini-trephination of the anterior table, was first described in 1992.[8] Since then, purely endoscopic removals of frontal sinus osteomas have become more feasible with the popularization of curved irrigated burrs, high definition cameras, and image guidance. Several authors have presented patient series to demonstrate the success of the endoscopic technique.[9-15] In 2001, Shick and Draf described the first series of patients that received a transnasal micro-endoscopic technique for removing frontal sinus and recess osteomas.[13] The authors concluded that complete endonasal resection would most likely fail when the major part of the tumor was lateral to a virtual sagittal plane that crossed the lamina papyracea, or when the tumor was based on the anterior sinus wall. Consistent with those

conclusions, Chiu and Kennedy introduced a staging system for frontal sinus osteomas.[14] In 2009, Seiberling and Wormald presented a series of 23 osteomas that were removed endoscopically with the use of minitrephination, including type IV tumors; that approach overcame the limits suggested by Chiu and Kennedy.[15] Currently, several studies have demonstrated that the endonasal approach may be considered for lesions located lateral to a sagittal plane that crosses the lamina papyracea, lesions that involve the anterior and posterior tables, lesions that extend vertically, beyond 2 cm above the ostium level, or even lesions that fill the frontal sinus.[10,11,15]

The main goals of endoscopic surgery for removing large frontal sinus osteomas are to debulk, fracture the lesion inside the sinus, and then remove the fragments that fit through the created ostium.[10] Reduction in size can be achieved with either a burr or a piezoelectric blade. The two primary difficulties encountered in endoscopic frontal sinus surgery are anatomical, such as narrow, anterior-posterior dimensions of the frontal recess and ostium, and limited access to the narrow supraorbital recess.[10,11,16] These difficulties could be overcome, to some extent, with piezosurgery, because the tip of the piezosurgical tool is slim, easy to maneuver through the narrow frontal ostium, and does not obstruct visualization. However, this tool is limited by the lack of appropriate tips.[17] Another difficulty is poor visualization and poor access to the lateral part of the sinus, particularly the lateral floor of the sinus.[16,18] This area is best accessed from the contralateral nasal cavity, through a perforation in the upper nasal septum.[19]

Debate continues over the limitations, safety, and efficacy of endoscopic removal of frontal sinus osteomas.[20-22] This study aimed to examine the efficacy of endoscopic treatment, without external approaches, for removing osteomas in the frontal sinus and frontal recess regions of the paranasal sinuses.

Materials and methods

This retrospective study analyzed data from frontal recess and frontal sinus osteoma resections performed between September 2008 and September 2012. The University Ethics Committee approved the study. Patient data were excluded when they exhibited fibrous dysplasia, Paget's disease, ossifying fibroma, osteomas treated with a combined approach (endoscopic+OPF), or reoperation after a previous OPF procedure. We included treatment data for 29 patients (22 female and 7 male), with a mean age of 40 years (range 17-66 years).

We analyzed the indications for surgery, type of procedure, symptoms, location of the tumor (based on CT data), operative technique, complications, and outcomes.

Subjects that received operations due to headache/pain had rated the pain intensity before and after surgery based on an 11-point scale (0-no pain, 10-maximum intensity of pain). We analyzed the before-after differences with the Wilcoxon test for pairs.

The size of the tumor was measured along its longest dimension. In addition to an evaluation with the Chiu and Kennedy grading system, the tumors were described according to their level (frontal recess, ostium, or sinus), extension (vertical and/or lateral), and attachment/adjacency to the sinus walls (Table 1). A navigation system was not routinely used during the surgical procedures.

Operative technique

In the first stage of the procedure, an anterior ethmoidectomy was performed with standard functional endoscopic sinus surgery (FESS) instruments and a 30° rigid scope. In small osteomas with limited attachment, no other instruments were necessary. In large osteomas, the frontal sinus ostium was widened with Kerrison punches and/or curved, irrigated 15° and 70° diamond burrs (Karl Storz, Tuttlingen, Germany or Medtronic, Minneapolis, USA). Adequate exposure of the tumor was achieved by performing a Draf IIb, III, or an extended IIb; in this procedure, the intersinus septum or a limited segment of the upper part of the nasal septum was removed. The drill was then used to reduce the size of the lesion and widen the exposure. When the surgeon judged it feasible, mobilization of the tumor was attempted. Large tumors wedged between the walls of the sinus were debulked, and peripheral eggshell fragments were fractured with a curette and gradually removed. At the end of the procedure, 45° and 70° rigid endoscopes (4 mm) were used to control the sinus and ensure complete removal of the lesion. No additional external approaches (minitrephination) were used. No stents were placed into the created ostia.

Table 1

Parameters used to describe osteomas of the frontal sinus, ostium, and recess

Side	Level	Extension	Attachment/Adjacency
L - left **R - right**	**0 – recess** **1 – ostium** **2 – sinus**	***L1*** – lateral to the sagittal plane crossing the lamina papyracea ***L2*** – lateral to the vertical line running half way between the sagittal plane crossing the lamina papyracea and midorbital line ***L3*** – lateral to the midorbital line ***V*** – vertical extension 2 cm or more above the level of the ostium ***R*** – filling extended, narrow supraorbital recess ***M*** – crossing the midline	**A**, **a** – anterior wall of the sinus/recess **P**, **p** – posterior wall of the sinus/recess **O**, **o** – orbit/floor of the sinus **+ (1, 2, 3)** – numbers indicate the lateral extension of an attachment (described in *Extension* column) **S**, **s** – intersinus septum **B**, **b** – frontal beak **G, g** – olfactory groove

Extension: the extent of tumor growth into a particular part of the sinus, regardless of whether it was attached. Attachment/adjacency: location of the tumor; tumors were attached or unattached, but adjacent to the indicated structures; lowercase letters indicate a small area of adjacency/attachment (shorter than 0.5 cm); capital letters indicate a large area of adjacency/attachment (longer than 0.5 cm).

In three cases, a piezoelectric system was used in addition to the drill. The piezoelectric system (05.001.400 with a 05.001.4001 handpiece, DePuy Synthes, West Chester, USA) had curved cutting tips, 10.6 cm long (03.000.421S and 03.000.412S).

Postoperative management and follow-up

The postoperative follow-up included saline nasal douches for 3 weeks, starting the day after surgery, and intranasal steroids for up to 4 weeks, starting no earlier than 7 days postoperatively. The sinus cavity was cleaned of crusts every week for at least 1 month. The mean observation period was 15 months (range 1-48 months). Follow-up examinations were performed with nasal endoscopy.

Results

Table 2 displays the tumor parameters, the tumor types (according to Chiu and Kennedy's grading system), and the Draf types used for frontal sinusotomy in each case. Out of 29 patients, 22 complained of frontal pain/headache, and 10 patients were diagnosed with chronic rhinosinusitis (CRS) and osteoma.

The mean lesion size was 1.44 cm (range 0.5-4.8 cm). No tumor had an intracranial or intraorbital extension, and no tumor had eroded the posterior wall of the frontal sinus. In 9 patients, the tumor had extended 2 cm or more above the level of the frontal sinus ostium.

In 10 patients, the lesion had extended laterally to the virtual sagittal plane and crossed the lamina papyracea; of these tumors, three had extended close to the midorbital point, but did not cross it.

Nine tumors could be removed with the FESS instruments alone. Among these, eight were type I tumors, and one was a type III tumor. In 13 patients, additional procedures were performed, including septoplasty, contralateral ethmoidectomy, or posterior ethmoidectomy on the affected side.

In three patients, tumor removal was incomplete. One patient exhibited a 3 mm-long remnant at the posterior rim of the frontal recess. Three years postopertively, revision surgery was necessary, due to frontal pain and the gradual growth of the tumor remnant. The second patient exhibited a tumor extension of 3.5 cm above a narrow sinus ostium that extended to the midorbital line. A 40% remnant of the lesion was not removed, due to impaired lateral visualization with the 70° diamond burr and an inappropriate curvature of the piezoelectric tool. In the third patient, we were not able to remove a large, type IV, ivory osteoma during a single procedure. This patient required a transnasal reoperation. Complete surgery failed, and about 10% of the original volume remained on the orbital floor, close to the midorbital line. The total time of anesthesia in this patient was 11 h.

The remaining 26 osteomas were removed completely during a single procedure.

The average duration of the procedure was 3.9 h (range 1.25-8.5 h). The mean length of each

Table 2

Overview of all the patients included in the study. The parameters for tumor extension and attachment are defined in Table 1

Patient No	Chiu	Side	Level	Extension	Attachment	Size [cm]	Indication	Draf type
1	I	R	1		apo	0.5	P	II a
2	I	L	0		Po	0.6	CRS	II a
3	I	R	1		p	0.6	P	II a
4	I	L	1		Ps	0.6	CRSp	II b
5	I	R	0		B	0.8	CRS	II a
6	I	L	0	*R*	po	0.8	P	II b
7	I	R	0,1		OB	0.8	P	II b
8	I	R	0		OP	1.0	P	II a
9	I	R	0		pO	1.0	P	II b
10	I	R	1		Po	1.0	P	II b
11	I	L	0		Po	1.1	CRS	II a
12	I	L	1		BSpg	1.2	P	II b
13	II	R	1,2		Apg	0.8	P	II b
14	II	L R	0,1 0		APosBG G	1.7	CRSp	II b/ III
15	III	L	2	*L1*	apo1	0.6	P, CRS	II b
16	III	R	2	*L1*	a1	0.8	P	II b
17	III	R	2	*L1*	o1	0.8	CRS	II a
18	III	L	2	*L1*	aPos1	1.0	P	II b
19	III	R	2		Psg	1.2	P	III
20	III	L	2	*L1*	APO1	1.4	P	II b
21	III	L	1,2	*V*	APB	2.0	P	II b
22	III	L	1,2	*V,M*	ApSBg	2.0	P	II b/ III
23	III	R L	2 2	*V* *V*	APSBg APSB	2.0	P	III
24	III	R L	1,2 1,2	*V* *V*	APoBg APBg	2.2	P	III
25	III	R	2	*L2,V*	Ao1	2.3	P	II b
26	III	R	2	*L2,V,M,R,*	APO2	3.0	P	III
27	III	R L	0,1,2 2	*L1,V*	Apos B	3.0	CRS	III
28	IV	R	1,2	*L1,V*	APS	2.2	P, CRSp	III
29	IV	L R	0,1,2 1,2	*L2,V* *L1,V*	APO2 APo	4.8	P, CRS	III

Chiu: tumor type according to Chiu and Kennedy's grading system. P: pain/headache; CRS: chronic rhinosinusitis without polyps; CRSp: chronic rhinosinusitis with polyps.

procedure was 2.2 h for Draf IIa, 3.2 h for Draf IIb, and 6.6 h for Draf IIb/III and III.

The total time of anesthesia was linearly related to the osteoma size (Figure 1).

There were no intraoperative complications (CSF leak, hemorrhage, or orbital hematoma).

Four patients exhibited exposure and disruption of a limited area of the periorbita, with no consequences except eyelid ecchymosis in three patients, and in one case, emphysema. The average postoperative hospitalization stay was 2.5 days (range 1-5 days). The frontal ostium closed in three cases and narrowed in two cases.

The mean headache/frontal pain intensity decreased from 7.5 before surgery to 3.3 after surgery ($p<0.005$, data available for 21 patients). The pain was completely resolved in 13 patients, decreased in 7 patients, and remained unchanged in 1 patient. To date, the 2 patients with incomplete tumor removals remain asymptomatic.

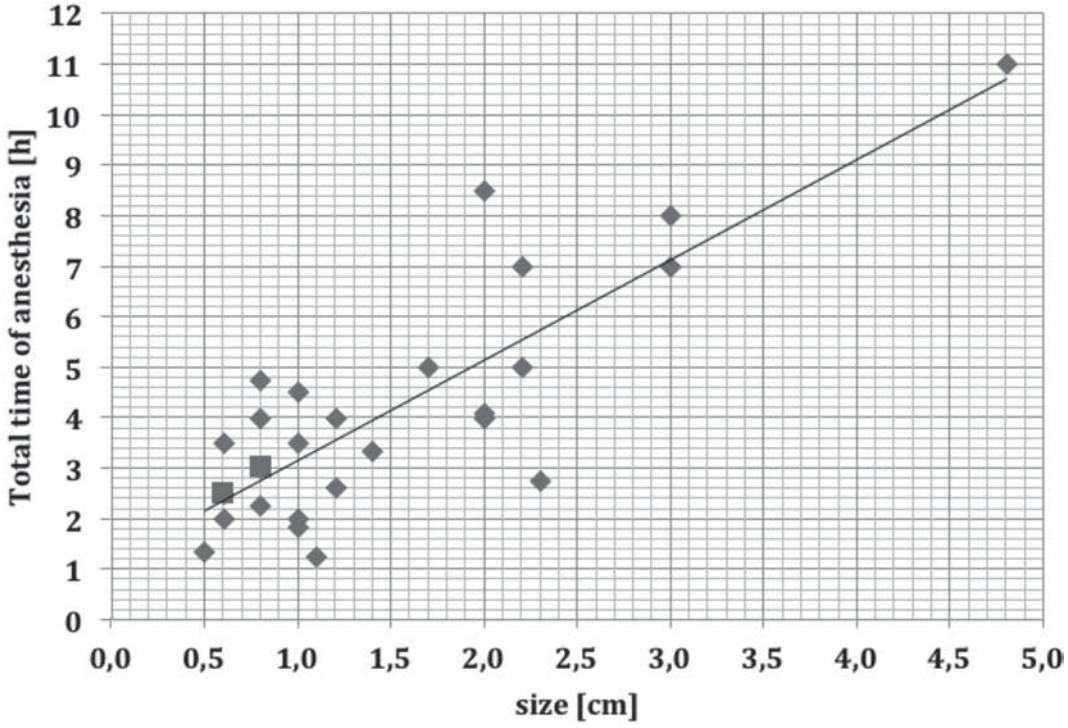

Figure 1
Relationship between the total time of anesthesia and osteoma size. R^2=0.69. Squares represent overlapping data points (2 data points at 0.6 cm, 2.5 h, and 3 data points at 0.8 cm, 3 h).

Discussion

We failed to remove osteomas completely in two patients with involvement the orbital roof near the midorbital line. According to Seiberling and Wormald, all areas of the frontal sinus could be accessed and treated with different types of burrs, including the 70° burr used for patients in their study.[15] Timperley *et al*. explored accessibility to the frontal sinus through the median drainage pathway in 10 cadaver heads.[16] They found that a 70° burr, controlled optically with a 70° scope, provided satisfactory contact with the anterior and posterior walls of the sinus. However, those tools were limited for contacting the orbital roof. The orbital roof was only satisfactorily accessed in 35% of cases. Becker *et al*. found that the ability to visualize an instrument at the lateral limit of the sinus after a Draf III procedure was successful in only 54% of cases.[18]

We provided detailed descriptions of the lateral extensions of osteomas in the frontal floor (orbital roof) to assess the feasibility of transnasal endoscopic surgery. Access to the lateral sinus floor was found to depend on the anterior-posterior distance between the outer periostium of the frontal beak and the olfactory fossa.[16] On the other hand, the shape of the posterior wall of the frontal sinus and the olfactory fossa also influenced the accessibility of the frontal sinus. This shape is variable, and often the sides are asymmetrical; thus, it is difficult to develop a fully reliable tool that can be used for comparing efficacy among different cases.

The main advantages of purely endoscopic surgery of the frontal sinus are that it eliminates the risk of frontal hypoesthesia and scar formation, and it requires short hospitalization times. Thus, in our opinion, trephination or minitrephination of the anterior table should be rarely used. Seiberling and Wormald suggested that one of the disadvantages of the endoscopic approach was the long duration of surgery, particularly for solid, ivory type osteomas.[15] There is little data available on the

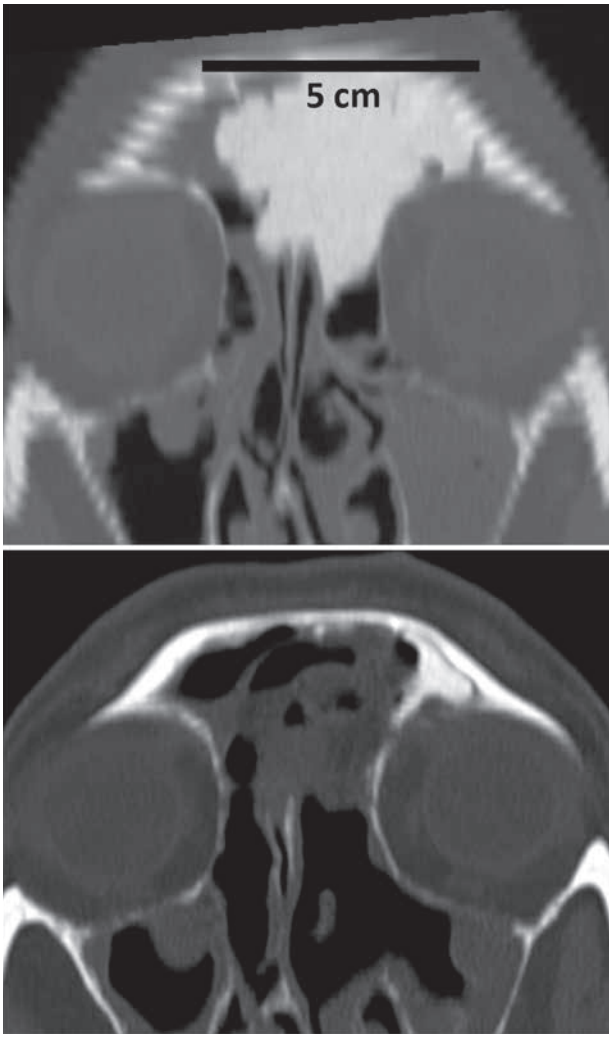

Figure 2
CT images show the nasal sinus region before (top), and after (bottom) removal of a type IV osteoma. The tumor parameters are described in Table 2 (Patient 29). Scale bar: 5 cm.

duration of these procedures. In our study group, procedures that involved tumors smaller than 2 cm lasted no longer than 5 hours (Figure 1). In one case, were not able to remove a large, ivory, type IV osteoma (4.8×4.8 cm), despite the use of staged surgery (Figure 2). The total anesthesia duration for that procedure was 11 h. In long procedures, the question arises as to whether the surgeon should change to an OPF approach or leave a remnant to be removed in another procedure. In the specific case mentioned, the patient had requested not to have an OPF. Nevertheless, in case of tumor recurrence, the use of an OPF seems the most appropriate option.

Use of the diamond burrs or the piezoelectric system reduces the risk of inadvertent laceration of dura, periorbita, or subcutaneous tissue, but it is rather time consuming. The endonasal drill system that we used during the large osteoma type IV removal stopped automatically several times during prolonged drilling, due to motor overheating. This factor contributed to the decision to leave a tumor remnant in that particular case. Use of cutting curved burrs, or a pneumatic powered drill (when technically possible) increases the pace of the tumor removal, but it also increases the risk of complications.

In the present study, image guidance was not used routinely. Posterior wall of the frontal sinus was the most important anatomical landmark. When the wall could not be exposed adequately on the affected side, we used the Draf III or extended Draf IIb approach to visualize the contralateral posterior wall.

Mobilization of the tumor is another factor that influences the duration of the procedure and the late outcome of surgery. Detaching the tumor makes it possible to spear the sinus mucosa. In contrast, drilling down the wide attachment of the tumor creates a large area of denuded bone, which increases the risk of scarring.[9] In the present study, multiplanar CT reconstruction could not always provide distinct differentiation between a loose and solid attachment to the sinus wall.

We described four patients with small lesions and concurrent CRS. These osteomas would probably not have been removed under asymptomatic conditions. In our opinion, such small osteomas should be removed in CRS patients to provide adequate sinus drainage.

Conclusions

This study demonstrated the safety of exclusively transnasal endoscopic resection of frontal sinus osteomas. However, in a narrow frontal ostium and/or in tumors with a wide attachment to the orbital roof that extends close to the midorbital point, complete removal might be restricted, due to inadequate visualization and the limitations of available operating equipment. Piezoelectric surgery is a valuable tool that can be used for frontal osteoma removal, particularly in cases with a small-diameter frontal sinus ostium; however, there is a need for improvement in the design of tips for endonasal surgery.

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