Objective: To review our experience with the surgical treatment of frontoethmoidal osteomas, focusing on the osteomas that were either localized laterally in the frontal sinus or showing intraorbital involvement.

Design: Retrospective evaluation.

Setting: Tertiary care center.

Patients: Patients with symptomatic frontoethmoidal or intraorbital osteomas who had been treated surgically from 1996 through 2011.

Intervention: Sixty frontoethmoidal osteomas were treated surgically. The lesion involved the far lateral portion of the frontal sinus in 23 cases and the orbital region in 6 cases. In 31 cases, a purely endoscopic approach was performed while a combined procedure was used in 25 patients. In 4 patients, an exclusively external approach was required.

Main Outcome Measure: No recurrence of osteoma.

Results: Radical resection was obtained, except in the case of 2 lesions. No osteoma recurrence was observed during a mean follow-up of 72.6 months.

Conclusions: The size of the osteoma, far lateral extension of the tumor in the frontal sinus beyond the lamina papyracea, and intraorbital involvement are no longer absolute contraindications for purely transnasal endoscopic resection. What is important is that the surgeon should not be dogmatic but rather be ready to change his or her mind during surgery, shifting to an external approach when required.


OSTEOMAS ARE SLOW-growing, benign bony tumors that are often asymptomatic and only discovered incidentally during paranasal sinus imaging. They sometimes cause symptoms owing to their location, which causes obstruction in the sinonasal drainage system, or to their local growth, with the subsequent compression of surrounding neural or vascular structures. Therefore, their treatment depends on the patients' symptoms as well as on the size and site of the tumor. If the “wait and scan” policy is the therapeutic standard for small and asymptomatic osteomas, surgical resection seems to be the main treatment for the symptomatic ones.1 Traditionally, the surgical removal of sinonasal osteomas was performed via an extranasal approach, which produced acceptable aesthetic results and very low recurrence rates.2,3 To remove frontal sinus osteomas, the external osteoplastic approach is still considered to be the gold standard, with frontal sinus obliteration being performed if necessary.4 The advantages of the extranasal surgical technique are a better overview of the osteoma and, possibly, shorter operation time. The disadvantages are lower rates of patient compliance, scarring, and higher morbidity owing to lengthier hospitalization.5

Notwithstanding this, thanks to the improvement of dedicated instrumentation and increasing surgical experience, endoscopic techniques are now a valid alternative in most cases. Lesions involving the ethmoid, the sphenoid, and the medial wall of the maxillary sinus can be resected transnasally. Frontal osteomas are always suitable for a purely endoscopic endonasal resection if they are located medially to a virtual sagittal plane passing through the lamina papyracea, if they originate from the inferior portion of the posterior frontal sinus wall, and if the anteroposterior diameter of the frontal sinus is at least 10 mm.6,6 In recent years, the indications for the type of surgical approach in relation to size and localization of the lesion have changed. In fact, in-
creasing expertise in endoscopic surgery, the introduction of multilangled scopes and angled drills, together with the Draf type III median drainage procedure, have allowed surgeons to transnasally treat osteomas localized more and more laterally, thus extending the procedure beyond the limits previously described. However, the indications for endoscopic surgical treatment and the choice of a specific surgical approach are still controversial and not precisely described. Herein, we present the outcomes of our extensive experience in the treatment of frontoethmoidal and intraorbital osteomas as well as describing the new possibilities and limitations of the endoscopic transnasal technique. Critical considerations and a pertinent review of the recent literature are also given.

**METHODS**

**PATIENT SELECTION AND EVALUATION**

A retrospective evaluation was carried out for all patients who underwent the surgical resection of frontoethmoidal or intraorbital osteomas at the Department of Otorhinolaryngology of the University of Insurbia (Varese, Italy) from 1996 through 2011. This study focused on intraorbital and far lateral frontal sinus osteomas in the whole group. Clinical data, demographic details, surgical details, preoperative and postoperative images, hospitalization time, complications, and follow-up information of the patients were retrieved from a specific database.

Preoperative imaging assessment of the osteomas was based on nasal endoscopy and paranasal computed tomographic (CT) scans that were performed in all the patients studied. Multiplanar reconstructions in coronal, sagittal, and axial planes can help identify the site of origin of the lesion and its relationship with adjacent structures, all of which are relevant findings for selecting the best surgical approach. The solidity of the osteomas was estimated preoperatively with CT densitometry parameters. The greatest diameter of the osteomas was measured in centimeters using a CT image–based system, and an independent sample t test was used to evaluate the association between the size of the lesion and the surgical approach planned for resecting it (SPSS for Windows, version 10.0.1; SPSS Inc). P ≤ .05 was considered statistically significant. Whenever the lesion was found to be massively eroding the bony interface with the anterior skull base or the orbit, magnetic resonance imaging was performed to delineate better the relationship between the osteoma and the adjacent soft tissues (ie, dura, brain, orbital content). When the lesions were strongly attached to the anterior skull base, a preoperative intralumbar injection of 1 mL of sodic fluorescein, 5%, was performed to highlight possible cerebrospinal fluid (CSF) leaks.

**SURGICAL NOTES AND RECENT INNOVATIONS**

The surgical techniques of both endonasal and external procedures have been described previously. The standard external approach involved the osteoplastic flap with coronal skin incision (OPF). To perform the frontal bone osteotomies in a safe manner, an occipitofrontal radiograph (Caldwell projection) of the frontal sinus was deemed necessary to create a template. In recent cases, the magnetic neuronavigation image guidance system (Medtronic Navigation Inc) has replaced the Caldwell projection for an accurate evaluation of the boundaries of the frontal sinus during the tailoring of the osteoplastic flap.

The endoscopic endonasal approach required anterior ethmoidectomy and Draf type II or III frontal sinusotomy, tailored according to the extension of the lesion. Thanks to the Draf type III median drainage (or “Lothrop modified procedure”) with partial removal of the nasal septum, we took advantage of the contralateral nasal fossa to reach the lesion situated in the far lateral region with the greatest angle of tilt. In this way, we were able to obtain all the advantages of the 2-nasotril–hand technique. Since 2008, the magnetic neuronavigation system has been used intraoperatively as a standard method to facilitate orientation during the endoscopic resection of osteomas.

For each different surgical step, the new multilangled, high-speed intranasal drills and shavers (straight, 40°, and 60° curved shavers; 15°, 40°, and 70° standard and diamond drills; Karl Storz), associated with 0°, 45°, and 70° telescopes (Karl Storz) and the Clearvision System (Karl Storz) were used to achieve the maximum control of the tumor boundaries, even when located in the far lateral portion of the frontal sinus.

The endoscopic drill cavitation technique was used to drill out the core of the tumor, obtaining a thin, hollowed bony shell that could be fractured easily and then removed transnasally, leaving clear margins. This gentle resection of the tumor, starting from the center toward the periphery, is extremely selective and conservative for the surrounding tissues.

**FOLLOW-UP CRITERIA**

We followed the patients closely after surgery with periodic endoscopic evaluations (at 1, 3, and 6 months) to avoid frontal scar stenosis. Because osteoma recurrences are very rare, routine periodic postoperative surveillance with paranasal CT scanning is not justified. We performed a CT examination 1 year after surgery and, on its results, made a decision about further radiologic follow-up. The cases of residual lesion or the presence of stenotic frontal sinusotomy during the follow-up were considered to be situations that called for CT reexamination.

From June 1996 through June 2011, we treated 60 cases of frontoethmoidal or intraorbital osteomas. There were 27 females and 33 males, and their ages at surgery ranged from 11 to 77 years (mean age, 44.1 years). The frontal sinus was the site involved in most cases (58 of 60 [97%]), and simultaneous frontoethmoidal extension was observed in 25 of 60 cases (42%). In 6 cases (10%), the osteoma involved the orbital region.

Most of the patients (40 of 60 [67%]) complained of frontal headache. Fourteen patients (23%) presented monolateral nasal obstruction, associated with hypoplasia in 7 cases (12%). In 3 cases (5%), a monolateral swelling of the cutaneous frontal region was seen and, in 1 case of bilateral frontoethmoidal osteoma, the frontal swelling involved the glabellar region as well. In the group of patients with orbital extension of the osteoma, epiphora was registered in 2 cases (3%), while proptosis and diplopia were observed in 1 case each (3% total). Polypoid chronic rhinosinusitis was the most frequently associated disease (21 of 60 cases [35%]), followed by ethmoid inverted papilloma and posterior ethmoidal meningoencephalocele, each in 1 case. Moreover, preoperative assessment showed a skull base involvement in 2 patients who, after being informed, were scheduled for resection.
for a skull base duraplasty during the osteoma resection.

A purely endoscopic approach was used in 31 of 60 patients (52%). In 25 cases (41.7%), an endoscopic-external combined procedure was used, whereas in 4 patients (7%) an exclusively external approach was used (osteoplastic flap with coronal incision in 3 cases and Howart-Lynch procedure only in 1 of our first cases).

In the 2 cases with anterior skull base involvement, the resulting skull base defect was localized on the olfactory fissure, with dural exposure but without CSF leaks. The skull base reconstruction was performed through an endonasal endoscopic approach using a mucoperiosteal free graft harvested from the nasal septum (on the same side of the lesion) with an overlay technique. The graft was fixed extracranially, directly on the bony portion of the defect after total removal of the nasal mucosa around the defect.

For the endoscopic group, the mean duration in hospital was 3.9 days (range, 3–7 days), whereas in the combined and external group the mean hospital stay was 5.6 days (range, 4–11 days). In our cohort of 60 patients, complications were registered in 1 patient who underwent a frontal osteoma resection by means of a combined endoscopic-external technique, with persistent diplopia owing to an intraoperative right superior oblique muscle lesion. No serious immediate or delayed complications were observed in any of the other cases. There were no postoperative CSF leaks in any of the patients.

As a whole, the tumors ranged in size from 6 to 60 mm at their maximum points, with a median size of 22.9 mm. In the purely endoscopic group, the median size of the osteoma was 21.1 mm (range, 10–41 mm), whereas in the group of patients who underwent a combined or external approach, the median size was 24.8 mm (range, 6–60 mm). There were no statistical differences between the median sizes of the osteomas in the endoscopic group compared with those in the external or combined group when using the independent sample t test (P = .14), confirming that the dimensional parameter was not the first criterion for planning the surgical approach.

In our series, 2 cases (3%) had a persistence of osteoma after the surgical resection. In both cases, the residual disease (1.0 mm and 1.4 mm in size, respectively), was localized on the frontal sinus floor. To date, the 2 persisting lesions are stable in size and are under CT follow-up.

At the time of writing, we have observed no recurrence in the radically treated patients, with a mean follow-up of 72.6 months (range, 4–184 months).

**FAR LATERAL OSTEOMA**

In our series, 23 of 60 osteomas (38%) were localized in the frontal sinus laterally to the sagittal plane passing through the lamina papyracea. In 3 of 23 patients (13%), an external approach was performed (Howart-Lynch procedure in 1 case and OPF in the other 2); in 13 of 23 patients (57%), an endoscopic-external combined technique was used; in 7 of 23 cases (31%), we were able to resect the far lateral osteoma via a purely endoscopic endonasal approach (Figure 1).

If we stratify our data according to the year of surgery, we can observe that from 2008, 5 of 7 of the far lateral frontal osteomas that we treated (71%) were successfully managed via an exclusively transnasal endoscopic approach, thanks to the drilling cavitation technique. In the remaining 2 of 7 cases (29%), the lateral extension of the osteoma inside the frontal sinus could be approached endoscopically as well, but neither case was suitable for purely endoscopic resection owing to strong attachment of the osteoma on the anterior or the posterior wall of frontal sinus. As regards radical removal, we reached this goal in 6 of the 7 patients (86%) in the purely endoscopic group, with a slight persistence of the lesion in only 1 case. The clinical findings of these patients, the specific site of attachment and estimated size of the lesions are summarized in the **Table**.

**OSTEOMA WITH INTRAORBITAL EXTENSION**

In 6 of 60 cases (10%), the osteoma arose from the inferior, medial, or superior orbital wall, with simultaneous involvement of the medial portion of the frontal sinus in 3 cases and of the far lateral portion of the frontal sinus in 1 case. All these bony lesions were resected radically, using a purely endoscopic transnasal approach in 4 of 6 cases (Figure 2), a combined procedure in 1 of 6 cases and OPF procedure in the remaining case. The clinical findings of the endoscopically treated patients with the specific site of attachment and estimated size of the lesions are summarized in the **Table**.

**COMMENT**

Historically, the conventional treatment for sinonasal osteomas has been external. The Caldwell-Luc procedure, midfacial degloving, the Howart-Lynch procedure, Moure-Sèbileau lateral rhinotomy, and frontal osteoplasty are the open approaches usually performed to treat sinonasal osteomas.2,3

Data from the literature of the past 15 years seem to confirm the safety and efficacy of minimally invasive endoscopic endonasal techniques in the treatment of selected ethmoidal and frontal osteomas. Traditionally, endoscopic techniques have been advocated for frontal osteomas not extending to a lateral limit passing through the lamina papyracea.6–9 Recently, there have been some reservation as to these limits.5,11 In fact, the powered angled instrumentation allows reaching hidden localizations, such as the supraorbital recess, thus expanding the indications for the endoscopic approach. Currently, even intraorbital invasion is no longer an absolute contraindication for the endoscopic approach, which can be used in selected cases, therefore avoiding external access.

The planning of surgical strategy is crucial for choosing the appropriate approach that will allow complete removal of the lesion with minimal aesthetic or cosmetic discomfort. The radiologic study of the patient’s anatomical features is the prerequisite for correct surgical planning. In this phase, the most crucial finding is the anteroposterior diameter of the frontal sinus, evaluated in relation to the volume of the frontal sinus in order to verify mano-
verability of the angled instrument inside the sinus. Moreover, also the interorbital distance should be considered an important patient-dependent parameter.

In presurgical planning, the surgeon must also take into account the radiological features of the tumor itself, such as site, size, and solidity. In the choice of the appropriate surgical approach, the precise localization of the osteoma (and in particular, the site of its attachment) is certainly a more important parameter than the size of the lesion, which has been demonstrated clearly to play only a marginal role. However, it must be emphasized that massive tumors allow no identification of the site of attachment, and, consequently, resection can turn out to be more difficult. An attempt to evaluate the solidity of osteomas can be performed preoperatively using CT densitometry parameters, but unfortunately it can be defined precisely only during the surgical procedure. Actually, in our experience, the firmness and solidity of the lesion required switching from the endoscopic endonasal procedure to a combined external one in several far lateral frontal osteomas owing to the low speed of the angled drill. This limitation will be overcome in the next few years with the introduction of high-speed, multiangled drills.

Since our previous publication, we have modified the indications for a purely endoscopic approach. Thus, we have been able to resect 7 far lateral frontal osteomas via a purely endoscopic endonasal approach, with a slight persistence of the lesion in only 1 case. Currently, the persistent lesion seems to be stable in size, and the patient was asymptomatic at the 31-month follow-up. Our recent experience seems to support the safety and efficacy of this surgical procedure, even in the case of far lateral extension. In fact, when evaluating these aspects...
Table. Clinical and Pathologic Findings in the Patients Affected by Osteoma With Far Lateral Extension in the Frontal Sinus or Intraorbital Involvement

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age, y</th>
<th>Localization</th>
<th>Site of Attachment</th>
<th>Maximum Size, mm</th>
<th>Osteoma Resection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/51</td>
<td>Far lateral</td>
<td>Frontal beak</td>
<td>36</td>
<td>Radical</td>
</tr>
<tr>
<td>2/M/27</td>
<td>Far lateral</td>
<td>Frontal beak</td>
<td>24</td>
<td>Radical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frontal floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/M/59</td>
<td>Far lateral</td>
<td>Lateral lamina of cribriform plate</td>
<td>25</td>
<td>Radical</td>
</tr>
<tr>
<td>4/M/24</td>
<td>Far lateral</td>
<td>Lateral frontal wall</td>
<td>18</td>
<td>Radical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frontal floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/M/22</td>
<td>Far lateral</td>
<td>Posterior frontal wall</td>
<td>12</td>
<td>Persistence (1 mm) on frontal floor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frontal floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6/M/38</td>
<td>Far lateral</td>
<td>Frontal floor</td>
<td>24</td>
<td>Radical</td>
</tr>
<tr>
<td>7/M/61</td>
<td>Far lateral + intraorbital</td>
<td>Frontal beak</td>
<td>41</td>
<td>Radical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anterior frontal wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/M/19</td>
<td>Intraorbital</td>
<td>Lamina papyracea (orbital side)</td>
<td>33</td>
<td>Radical</td>
</tr>
<tr>
<td>9/M/17</td>
<td>Intraorbital</td>
<td>Lateral lamina of cribiform plate</td>
<td>19</td>
<td>Radical</td>
</tr>
<tr>
<td>10/M/18</td>
<td>Intraorbital</td>
<td>Lamina papyracea (orbital side)</td>
<td>11</td>
<td>Radical</td>
</tr>
</tbody>
</table>

*All procedures used a purely endoscopic endonasal surgical approach; in patient 5, this procedure was a scheduled skull base reconstruction.

Figure 2. A huge bony-like intraorbital lesion. Coronal (A) and axial (B) computed tomographic (CT) images showing a huge bony-like intraorbital lesion. Coronal (C) and axial (D) CT images taken 1 year after the endoscopic endonasal removal of the osteoma, showing the radical resection of the lesion, with the orbital content herniated into the ethmoid, leaving no ocular symptoms in the patient.
in the far lateral group, we did not find any increased rate of complication. To be clear, the only clinically relevant complications in our series belong to the OPF procedure group.

Currently, we still consider the following as exclusion criteria for an exclusively endoscopic endonasal approach: a small anteroposterior diameter of the frontal sinus in relation to a large volume frontal sinus (in this case, the intrasinus maneuverability of the angled instruments is reduced); erosion of the posterior wall of the frontal sinus with a large intracranial multiloculated osteoma; extension of the tumor through the anterior frontal plate; relevant posttraumatic anatomical changes in the frontal bone structure; and lateral or superolateral orbito-wall attachment of the lesion. In these latter cases, the lesion can be better exposed and drilled out through an osteoplastic flap sinusotomy, whether combined or not with the endoscopic endonasal approach, to achieve a radical resection.

The large insertion base of the lesion on the posterior or anterior wall of the frontal sinus is a condition that makes a purely endoscopic endonasal resection of the osteoma more difficult, but it should not be considered an absolute contraindication. In these cases, we try to remove the lesion transnasally, according to the cavitation technique, with a surgical team ready to perform a combined external approach if required. However, in the case of a lesion massively eroding the anterior or posterior frontal wall, an external approach is usually recommended, and reconstruction is required to maintain a regular frontal outline anteriorly and to close the intracranial space posteriorly.7

The endoscopic drill cavitation technique can be performed both transnasally, when possible, and externally through the OPF approach.13 Notably, even when an osteoma is removed through an extravasal approach, endonasal surgery might be helpful to preserve or rehabilitate the natural drainage pathways, especially in the frontal sinus region.14 We are so convinced of the effectiveness of restoring sinus physiologic function that we never perform frontal sinus obliteration with fat tissue in order to avoid late complications related to fat reabsorption and to reduce the risk of frontal sinus superinfection. In our philosophy, we always try to rehabilitate the frontal sinus, combining the external procedure with an endoscopic endonasal approach (Draf type II or III drainage) to ensure adequate ventilation and mucociliary drainage of the frontal sinus itself.

With regard to osteomas invading the orbital region, we performed radical resection in 4 cases using the endoscopic endonasal techniques. In more detail, the intraorbital lesions can be treated transnasally, taking advantage of the same surgical hints used for frontal osteomas located extremely laterally. In fact, osteomas arising from intranasal bony structure grow laterally toward the orbital region, compressing but preserving the periorbital layer.14 We can resect this kind of osteoma by considering the intraorbital extension as a corridor to pass through, without needing to expose all the external boundaries of the lesion. In the 2 intraorbital osteomas approached externally, a simultaneous involvement of the medial portion of the frontal sinus was observed, and the external approach was not required for resecting the orbital component of the osteoma but rather for better treatment of the erosion of the anterior frontal wall. The subsequent herniation of the orbital content in the ethmoid should not be considered a problem because the periorbital layer is preserved, protecting the patient from diplopia, enopthalmos, or facial deformity. In fact, it is well known that preservation of the periorbit does not allow the orbital content to expand. Our extensive experience in orbital treatment of sinonasal cancers15 clearly demonstrates that in the case of periorbital preservation there is no need for reconstruction. Furthermore, the experience gained in transnasal intraorbital approaches confirms the low rate of morbidity and complications of the technique, even in the case of intraorbital dissection.16,17 At the time of writing, based on our considerable experience in this field,15-17 we advise that medial orbital wall reconstruction be used only in the case of major damage to the periorbit or in extensive intraorbital dissection. No reconstruction is required when the periorbit is spared.

In conclusion, our increasing experience seems to demonstrate that far lateral extended lesions can also be treated well with purely endoscopic endonasal approaches. Obviously, we have not stated that endonasal endoscopic techniques are the gold standard of care in the case of far lateral osteomas, but we would like to add our experience to the currently small body of data on this topic. What is critical is that the surgeon should not be dogmatic and should be ready to change his or her mind during surgery, shifting to an external approach when required.

In conclusion, currently, the transnasal endoscopic approach proves to be a valid alternative to traditional open surgery in the treatment of frontoethmoidal and intraorbital osteomas. Moreover, the endoscopic technique enables shorter hospitalization time, preserves the natural endonasal drainage pathways, or creates new ones, but requires lengthier surgical training and greater experience. The introduction of the multiaxled scopes and drills, together with increasing skill in the endoscopic approach and the 2-nostril–4-hand technique, represents a further evolution that expands the indications for the endoscopic approach to include lesions that only a few years ago were not thought to be suitable for endoscopic endonasal resection. We conclude that size of the lesion, far lateral extension of the tumor in the frontal sinus beyond the lamina papyracea, and intraorbital involvement no longer represent absolute contraindications for purely transnasal endoscopic resection.

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Author Contributions: Dr Castelnuovo had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Turri-Zanoni, Dallan, Battaglia, Bignami, and Castelnuovo. Acquisition of data: Terranova, Battaglia, and Karligkiotis. Analysis and interpretation of data: Turri-Zanoni and Battaglia. Drafting...
of the manuscript: Turri-Zanoni, Terranova, Battaglia, and Karligkiotis. Critical revision of the manuscript for important intellectual content: Dallan, Battaglia, Bignami, and Castelnuovo. Statistical analysis: Turri-Zanoni, Battaglia, and Karligkiotis. Administrative, technical, and material support: Terranova. Study supervision: Turri-Zanoni, Dallan, Bignami, and Castelnuovo. Financial Disclosure: None reported.

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