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Endoscopic-assisted maxillectomy: Operative technique and control of surgical margins



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ABSTRACT

Background: When amenable to radical excision, cancer involving the maxilla is typically treated with maxillectomy followed by adjuvant therapy. Posterior tumor extension beyond the maxillary box leads to the invasion of complex areas, where achieving clear margins may be challenging.

Methods: Patients undergoing endoscopic-assisted maxillectomy for nasosethmoidal, maxillary, or hard palate cancer between 2007 and 2017 were included in the study. Surgical technique, margin status, and recurrences were analyzed. Extension of posterior resection was classified in 3 types (type 1: resection of the pterygopalatine fossa; type 2: resection of the pterygoid plates and related muscles; type 3: resection of the upper parapharyngeal space). The analysis of putative risk factors for involvement of margins and local recurrence was performed with special focus on the posterior and medial margin.

Results: The study included 79 patients (75 with available follow-up; mean: 20.6 months, range: 6–101 months), 37 (46.8%) of whom underwent type 1 resection, 34 (43.0%) type 2, and 8 (10.1%) type 3. According to pT category, 57 (72.2%) tumors were classified as T4a/T4b. Posterior and medial clear margins were achieved in 76/79 (96.2%) and 75/79 (94.9%) patients, respectively. T4b category, extension to the ethmoid, sphenoid sinus, pterygoid process, orbital cavity, and premaxillary tissues were significantly associated with a higher rate of margin involvement. None of the factors was significantly associated with medial margin involvement.

Conclusion: Endoscopic-assisted maxillectomy combines several refinements including the facilitated detachment of the maxilla from the skull base and precise delineation of the posterior and medial margins of resection.

Introduction

Maxillary cancer is rare and frequently diagnosed at an advanced stage as a result of its indolent growth in the early phases. Due to this peculiarity, involvement of structures adjacent to the maxillary box is frequent, with the posterior extension being the most critical to be surgically addressed. Similar problems are posed by malignant tumors arising from the superior alveolar ridge and hard palate once they

invade the maxillary sinus.

When amenable to radical excision, cancer involving the maxilla is typically treated with surgery followed by adjuvant radiotherapy, with chemotherapy being indicated as induction or concomitant to radiotherapy in selected cases [1–3]. Tumor resection is accomplished with maxillectomy, which can be customized in accordance with the extension and pattern of growth of the lesion as depicted by morphologic imaging. However, management of the posterior resection margin is the

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most challenging step of the procedure in view of the restricted field of visualization, limited working space, and significant bleeding when approaching this area [4–7]. Furthermore, tumors extending posteriorly tend to invade areas harboring many neurovascular structures such as the pterygopalatine fossa (PPF), infratemporal fossa (ITF), and upper parapharyngeal space (UPS), thus increasing the complexity of resection [8]. In line with these limitations, tumors growing posterolaterally are associated with a higher probability to develop local recurrence and lower survival outcomes compared to tumors with predominant anterior or medial extension [9]. Moreover, local recurrence is most frequently located at the posterior margin of resection and rarely suitable for salvage surgery [8]. Although the extent of the lesion is accurately delineated by imaging, even medial osteotomy is typically performed without visualizing the tumor.

In this scenario, our hypothesis was that transnasal endoscopic surgery could provide some advantages when performing maxillectomy: (1) better visualization of the medial/superomedial component of tumors extended towards the midline; (2) more precise and easy delineation of the posterior resection margin in view of the improved magnification and possibility to carefully dissect neurovascular and muscular structures with optimal bleeding control; (3) possibility in selected cases of avoiding facial incisions via a combination of transnasal endoscopic surgery with a transoral/transvestibular approach.

The present study analyzed all patients receiving endoscopic-assisted maxillectomy (EAM) at two tertiary-care referral centers during the last decade, mainly focusing on the control of the posterior and medial resection margins; furthermore, additional information on the surgical technique and oncological results are reported.

Materials and methods

The institutional databases on sinonasal and oral cancers of the Units of Otorhinolaryngology – Head and Neck Surgery of the Universities of Brescia and Insubria-Varese were retrospectively analyzed. Patients undergoing EAM for a maxillary, naso-ethmoidal, or hard palate/superior alveolar ridge/superior retromolar trigone cancer between January 2007 and December 2017 were included in the study.

Demographics and oncological data

Data on gender and age, site of origin (classified as maxillary, naso-ethmoidal, or hard palate/superior alveolar ridge/superior retromolar trigone), histology (defined and grouped in accordance with the 4th edition of the WHO Classification of Head and Neck Tumours) [10], type of presentation (primary versus recurrent), previous treatment, margin status, and type of adjuvant treatment were retrieved. Patients were retrospectively staged according to the 8th TNM edition [11].

Surgical technique

The surgical approach was classified as “transfacial” when a skin incision (i.e. lateral rhinotomy, Weber-Ferguson incision, Lynch incision, or variants) was performed, or “transnasal-transoral” when EAM was performed exclusively via an endoscopic transnasal and transoral/transvestibular approach.

To provide a thorough description of surgical resection, the extent of maxillectomy was classified in relation to the vertical, horizontal, and posterior extension.

According to the standard classification of maxillectomies [12], the procedure was defined as *inferior maxillectomy* (when the segment of maxilla below the axial plane passing through the infraorbital foramen was removed), *subtotal maxillectomy* (when the superior osteotomy was made along a plane passing between the infraorbital foramen and orbital floor), *total maxillectomy* (when resection also included the orbital floor [eventually extended to the periorbit/extraconal fat]), or *extended maxillectomy* (when the orbital content was also removed).

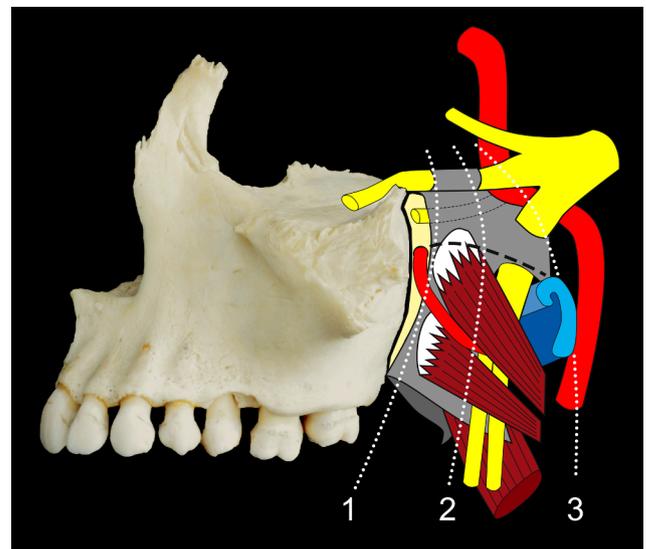


Fig. 1. Scheme summarizing the type of posterior resection. The white dotted lines (1–3) represent the plane of posterior dissection. The black dashed line shows the inferior limit of the potential cranial extension for each type of delineation of the posterior margin. Type 1 posterior resection consists of the removal of the pterygopalatine fossa and can be cranially extended to include the inferior orbital fissure. Type 2 posterior resection requires partial removal of pterygoid plates and muscles and can be superiorly expanded through the drilling/removal of the base of the pterygoid process. Type 3 posterior resection includes the removal of the cartilaginous eustachian tube and adjacent upper parapharyngeal tissues and can be cranially extended by drilling/removing the greater sphenoidal wing and/or fibrocartilago basalis.

The resulting maxillary defect was classified in the horizontal plane according to the modified Okay classification system [13].

Posterior resection was modulated according to 3 types of extension, as follows (Fig. 1):

- Type 1 posterior resection included removal of the PPF content. This approach was performed when the tumor was inserted on the posterior wall of maxillary sinus and/or determined resorption of the same bony wall and/or for tumors of the hard palate/superior alveolar ridge/superior retromolar trigone extending behind the tuber maxillae. After debulking the nasal and maxillary portion (when present) of the tumor, a type B [14] (or type 2) [15] endoscopic medial maxillectomy was performed; the posterior maxillary wall was partially removed and sent for definitive histological examination; the PPF content was preferably left covered by its periosteum and laterally dissected from the pterygoid plates up to a sagittal plane passing through the infraorbital canal. The pterygoid plates were selectively drilled at the level of the pterygomaxillary junction to detach the maxillary bone from the pterygoid process. For tumors invading the junction between the posterior maxillary wall and orbital floor, the inferior orbital fissure was included in the dissection.
- Type 2 posterior resection consisted of partial removal of pterygoid process and muscles. The indication included tumors extending to the PPF or medial portion of the ITF fat. After completing the steps of a type 1 resection, the pterygoid process was sectioned below the vidian canal. For tumors invading the upper portion of the PPF or inferior orbital fissure, the base of the pterygoid process was entirely resected.
- Type 3 posterior resection included removal of the cartilaginous eustachian tube and adjacent UPS tissues. The typical indications were lesions involving the pterygoid plates, pterygoid muscles, or anterior portion of the tube. After completing a type 2 resection, a mucosal incision surrounding the nasopharyngeal ostium of the eustachian tube as in type 3 nasopharyngectomy was performed

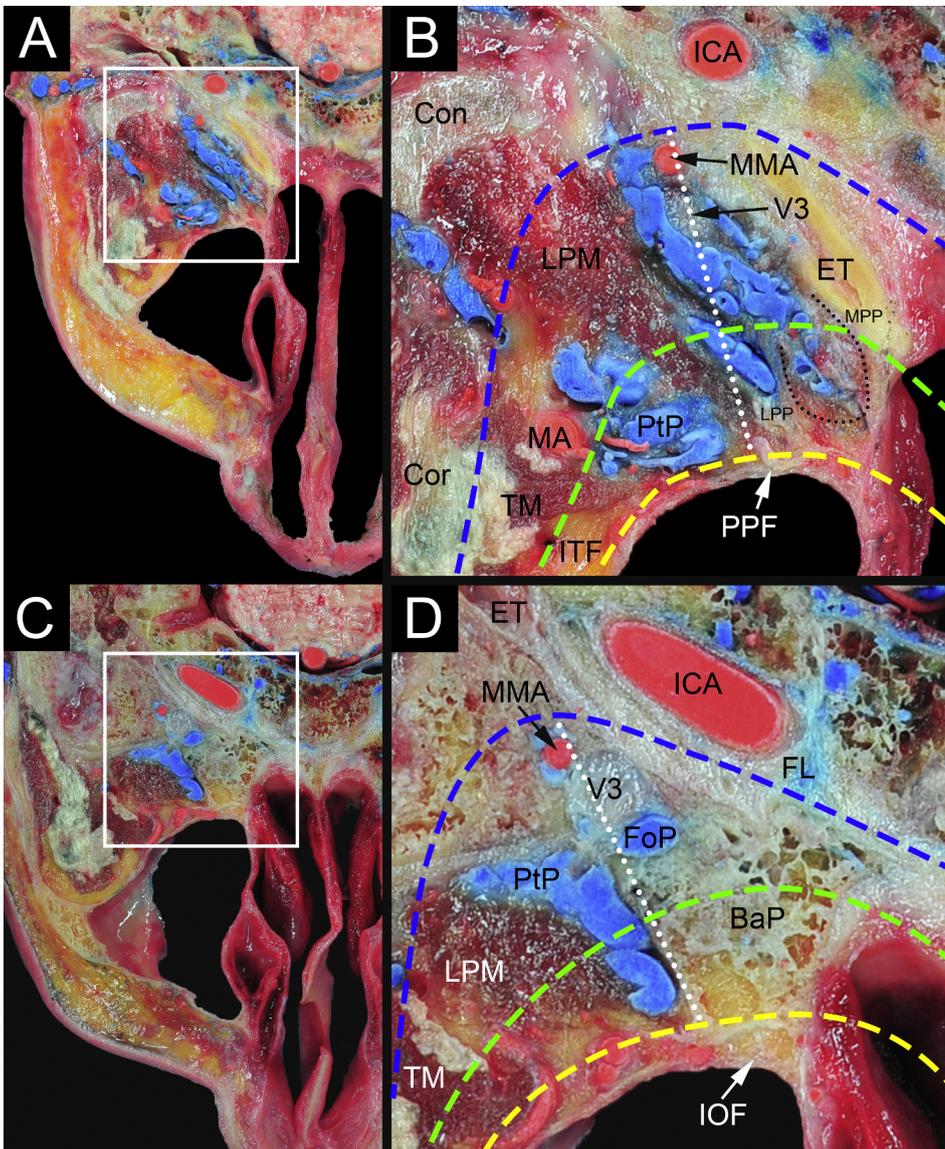
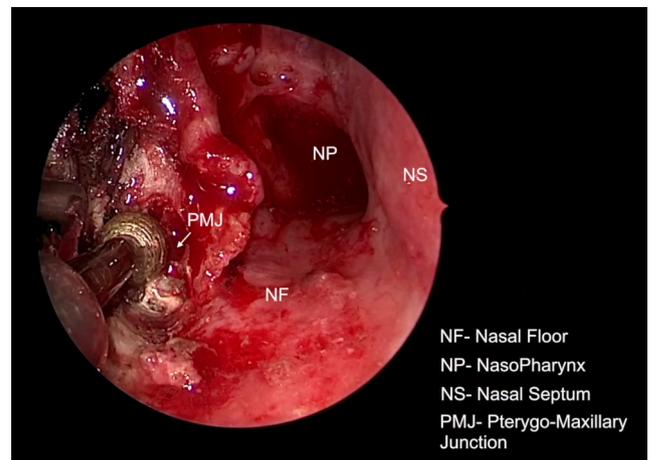


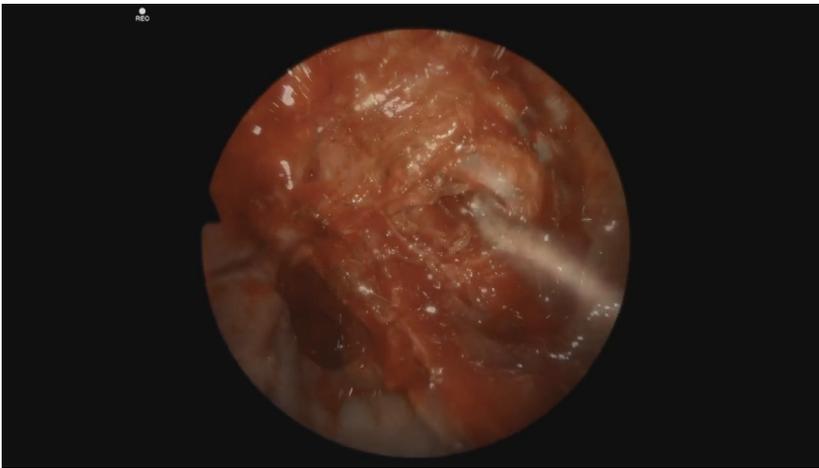
Fig. 2. Anatomical panel summarizing the three types of delineation of the posterior margin. The non-magnified axial sections (A, C) show the position of the magnified images (B, D). Upper images (A, B) pass through the pterygopalatine fossa (PPF), infratemporal fossa, and upper parapharyngeal space, whereas lower images (C, D) at the level of inferior orbital fissure (IOF), base of the pterygoid process (BaP), greater wing of the sphenoid bone, and foramen lacerum (FL). Type 1 (yellow dashed line), 2 (green dashed line), and 3 (blue dashed line) delineations of the posterior margin are depicted in the magnified images. Each incremental type of posterior margin resection can be delineated in the medial portion via the transnasal endoscopic approach and completed laterally through the transfacial/transoral trajectory. The white dotted lines mark the boundary between the medial transnasal and the lateral transoral/transfacial step of the procedure. Black dotted line – pterygoid plates; V3 – Mandibular nerve; BaP – Base of the pterygoid process; Con – Condylar process; Cor – Coronoid process; ET – Eustachian tube; FL – Foramen lacerum (with fibrocartilago basalis); FoP – Foraminal plexus; ICA – Internal carotid artery; ITF – Fat of the infratemporal fossa; LPM – Lateral pterygoid muscle; LPP – Lateral pterygoid plate; MA – Maxillary artery; MMA – Middle meningeal artery; MPP – Medial pterygoid plate; PtP – Pterygoid plexus; TM – Temporal muscle. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

[16,17]. The cartilaginous portion of the eustachian tube, mandibular nerve, and adjacent soft tissues were included in the specimen. For tumors abutting the skull base, the medial portion of the greater sphenoidal wing and fibrocartilago basalis were also removed.

All procedures started with the transnasal endoscopic step to address the medial and posterior part of resection. The medial portion of the tumor (i.e. invading the medial maxillary wall, nasal cavity, ethmoid box, and/or nasal septum) was accurately assessed under endoscopic view and managed according to well-established principles of resection of naso-ethmoidal tumors [18–21]. The posterior osteotomy (i.e. at the level of the pterygomaxillary junction) was performed transnasally (Videos 1–2), while the remaining osteotomies were performed via a transoral or transfacial-transoral approach (Fig. 2). At the end of the procedure, the surgical specimen was released from the adjacent structures and removed.



Video 1.



Video 2.

The transnasal-transoral approach was considered the first choice unless contraindicated by any of the following conditions: anterior extension of the tumor to the soft tissues of the cheek; superior extension requiring removal of the periorbit/extraconal fat/orbital content (i.e. total or extended maxillectomy); need for wide exposure during the reconstructive phase.

Whenever the tumor encroached upon the anterior/middle skull base, the resection was extended to include the involved area. Neck dissection was performed according to tumor histology, location, and extension, while reconstruction of the maxillary defect was tailored based on the geometry of the defect, patient's general condition and needs, and life expectancy, following well-accepted principles of management of maxillary and oral cancer [13,22–26].

Follow up and recurrences

Follow-up included endoscopic examination and magnetic resonance imaging (MRI) (or contrast-enhanced computed tomography [CT]) at 2- and 4-month intervals for the first year, respectively. Beyond this period, both outpatient and imaging evaluations were performed every 6 months until year 5 and subsequently once a year. Systemic staging with contrast-enhanced CT scan or PET-CT scan was performed yearly. Follow-up duration and patient status at the last evaluation were assessed. Recurrences were classified as local, regional, and/or distant.

Involved margins and local recurrences

Anatomic distribution of both positive margins and local recurrences was evaluated considering six sites (inferior, superior, medial, lateral, anterior, and posterior).

Statistical analysis

Statistical analysis was performed to verify whether overall, medial, and posterior margin involvement (dependent variables) were significantly associated with site of origin, histology, TNM classification, tumor extension, surgical approach, entity of maxillary resection, and type of posterior margin resection (independent variables) with Chi-square test or Fisher's exact test, as appropriate. The same analysis was performed considering the overall rate of local recurrence and the rate of posterior and medial local recurrence as dependent variables. Significance and closeness to significance were considered for p-values < 0.05 and between 0.05 and 0.10, respectively.

Results

Seventy-nine patients were included in the study. Demographics, clinical-pathologic data, surgical techniques, and adjuvant treatment are summarized in Table 1. Thirty-two (40.5%) patients received inferior maxillectomy, 17 (21.5%) subtotal maxillectomy, 15 (19.0%) total maxillectomy, and 15 (19.0%) extended maxillectomy. The extent of maxillary defect was classified as follows: class 1b in 24 (30.4%) cases; class 2 in 48 (60.8%) cases (2^o in 9 cases, 2^f in 7 cases, 2^{f,z} in 5 cases, 2^{o,z} in 5 cases); class 3 in 7 (8.9%) cases (3^f in 2 cases, 3^{f,z} in 1 case, 3^o in 1 case, 3^z in 1 case).

According to our classification of modular posterior margin resection, the distribution was the following: type 1 in 37 (46.8%) cases, with extension to the inferior orbital fissure in 14 (37.8%) patients; type 2 in 34 (43.0%) cases, with extension to the base of the pterygoid process in 12 (35.3%) patients; type 3 in 8 (10.1%) patients, with removal of the fibrocartilago basalis and greater sphenoidal wing in 3 (37.5%) cases. Craniectomy was required in 10 (12.7%) cases, of which 4 were located at the anterior skull base, 3 at the middle skull base, and 3 involved both. Dura was resected in 7 patients, and reconstruction was obtained with multilayer technique [27]. In relation to posterior resection, craniectomy was required in 1 (2.7%) case of type 1 resection, 3 (8.8%) cases of type 2, and 6 (75.0%) cases of type 3. In 48/79 (60.8%) cases, EAM allowed complete tumor excision avoiding facial skin incisions.

The resulting maxillary defect was managed with flap transposition in 46 (58.2%) cases (16 anterolateral thigh flaps, 12 scapular angle flaps, 6 transverse rectus abdominis myocutaneous flaps, 4 radial forearm flaps, 3 fibula flaps, and 5 temporal flaps); a prosthetic obturator was employed in 33 (41.8%) cases.

Follow-up was available in 75 (94.9%) patients, with a mean duration of 20.6 months, ranging from 6 to 101 months. At last follow-up examination, 52 (69.3%) patients were alive with no evidence of disease, 6 (8.0%) were alive with disease, 14 (18.7%) were dead of disease, and 3 (4.0%) were dead of other causes. Overall, 24 (32.0%) recurrences were observed: 15 (20.0%) patients had local recurrence, 5 (6.7%) regional recurrence, and 10 (13.3%) distant metastasis.

The topographical distribution of positive surgical margins and local recurrences is summarized in Table 2. The medial and posterior margins were involved in 4 (5.1%) and 3 (3.8%) patients. Among patients with available follow-up, medial and posterior local recurrence was observed in 4 (5.3%) cases each. Factors significantly or close-to-significantly affecting the probability of overall positive margins, posterior positive margins, overall local recurrences, and posterior local recurrences are summarized in Table 3. None of the factors included in the statistical analysis was significantly associated with margin

Table 1
Demographics, oncological, and surgical technique information. NOS – Not otherwise specified.

Variable	Distribution
Gender	Male: 43/79 (54.4%) Female: 36/79 (45.6%)
Age	Mean: 59.8 years Range: 19–87 years
Site of origin	Maxillary sinus: 56/79 (70.9%) Nasoethmoidal complex: 6/79 (7.6%) Hard palate/superior alveolar ridge/superior retromolar trigone: 17/79 (21.5%)
Side	Right: 47/79 (59.5%) Left: 32/79 (40.5%)
Histology	<i>Carcinomas</i> Squamous cell carcinoma: 36/79 (45.6%) Non intestinal-type adenocarcinoma: 2/79 (2.5%) Sinonasal neuroendocrine carcinoma: 2/79 (2.5%) Basal cell carcinoma: 1/79 (1.3%) Carcinoma NOS: 1/79 (1.3%) Intestinal-type adenocarcinoma: 1/79 (1.3%) Sinonasal undifferentiated carcinoma: 1/79 (1.3%) <i>Minor salivary gland carcinomas</i> Adenoid-cystic carcinoma: 11/79 (13.9%) Mucoepidermoid carcinoma: 3/79 (3.8%) Polymorphous adenocarcinoma: 2/79 (2.5%) Salivary duct carcinoma: 1/79 (1.3%) <i>Neuroectodermal tumors</i> Mucosal melanoma: 7/79 (8.9%) Ewing's sarcoma: 2/79 (2.5%) <i>Sarcomas</i> Osteosarcoma: 3/79 (3.8%) Histiocytic sarcoma: 2/79 (2.5%) Undifferentiated pleomorphic sarcoma: 2/79 (2.5%) Chondrosarcoma: 1/79 (1.3%) Fibrosarcoma: 1/79 (1.3%)
Presentation	Primary: 58/79 (73.4%) Recurrence: 21/79 (26.6%)
Previous treatment(s)	Surgery: 21/79 (26.6%) Previous RT: 12/79 (15.2%) Previous CHT: 14/79 (17.7%) Induction CHT: 17/79 (21.5%)
pT classification	T2: 11/79 (13.9%) T3: 11/79 (13.9%) T4a: 38/79 (48.1%) T4b: 19/79 (24.1%)
N classification	N0: 66/79 (83.5%) N1: 3/79 (3.8%) N2: 8/79 (10.1%) N3: 2/79 (2.5%)
Surgical approach	Transnasal-transoral: 48/79 (60.8%) Transfacial: 31/79 (39.2%)
Type of maxillectomy	Inferior maxillectomy: 32/79 (40.5%) Subtotal maxillectomy: 17/79 (21.5%) Total maxillectomy: 15/79 (19.0%) Extended maxillectomy: 15/79 (19.0%)
Type of posterior resection	Type I: 37/79 (46.8%) Type II: 34/79 (43.0%) Type III: 8/79 (10.1%)
Neck dissection	Not performed: 55/79 (69.6%) Performed: 24/79 (30.4%) Elective: 7/24 (29.2%) Therapeutic: 17/24 (70.8%)
Type of reconstruction	Obturator prosthesis: 33/79 (41.8%) Free flap: 39/79 (49.4%) Regional flap: 4/79 (5.1%) Combined reconstruction: 3/79 (3.8%) Obturator and free flap: 1/3 (33.3%) Obturator and regional flap: 1/3 (33.3%) Free flap and regional flap: 1/3 (33.3%)
Margin status	R0: 58/79 (73.4%) R1: 21/79 (26.6%)
Adjuvant treatment	None: 26/79 (32.9%) RT: 38/79 (48.1%) RT-CHT: 11/79 (13.9%) CHT: 4/79 (5.1%)
Adjuvant treatment	None: 26/79 (32.9%)

Table 2
Topography of margin involvement and local recurrence.

Site	Involved margin (21 patients)	Local recurrence (15 patients)
Anterior	4/21 (19.0%)	2/15 (13.3%)
Medial	4/21 (19.0%)	4/15 (26.7%)
Posterior	3/21 (14.3%)	4/15 (26.7%)
Lateral	9/21 (42.9%)	2/15 (13.3%)
Superior	4/21 (19.0%)	4/15 (26.7%)
Inferior	3/21 (14.3%)	3/15 (20.0%)

involvement or local recurrence at the medial site. T4b category, extension to specific subsites (ethmoid complex, sphenoid sinus, pterygoid process, orbital cavity, premaxillary tissues), and procedures classified as extended maxillectomies were significantly associated with a higher rate of microscopic margin involvement.

Discussion

The present study analyzes the added value of an endoscopic transnasal approach to the standard maxillectomy external technique to optimize the radicality of resection. In our experience, this step provided some advantages in exposure of the medial and posterior extent of the lesion, with more precise delineation of the margins of resection. This was shown by the high rate of clear margins that was achieved medially and posteriorly (94.9% and 96.2%, respectively) and the low incidence of local recurrence at these sites (5.3% each). Moreover, the improvement in visualization provided by the endoscopic technique contributed to avoid a facial skin incision in a large proportion of patients (60.8%).

At the beginning of surgery, the medial extension of tumor can be carefully assessed, focusing on the involvement of nasal floor, ethmoid, and nasal septum to accordingly tailor the medial/superomedial margin of excision (Fig. 3). When present, the nasoethmoidal portion of the tumor can be easily debulked via the transnasal route to create a working space and explore the relationship of the lesion with the skull base. The medial maxillary wall must be partially removed to expose the posterior extent of the tumor through the transnasal perspective. Although this maneuver requires a piecemeal resection of a part of the tumor, the safety of multi-bloc excision has been demonstrated by several series of endoscopic transnasal resection for nasoethmoidal malignancies [18–21,28–35]. Furthermore, the portion of the tumor that is encroached when exposing the posterior maxillary wall is either exophytic or infiltrates the medial maxillary wall, which will be entirely removed via the endoscopic medial maxillectomy [14,15].

After assessing the posterior extension of the tumor, the transnasal endoscopic perspective permits delineation of the posterior resection margin under direct control and magnified view and provides the possibility to drill the pterygomaxillary junction, which is the only bony structure anchoring the maxilla to the central skull base (Fig. 3; Videos 1–2). The advantages of the enhanced visualization provided by the endoscopic approach are twofold: from an oncologic standpoint, the delineation of the posterior boundary of resection offers a high probability to provide an adequate margin of excision; from a technical and practical perspective, drilling of the pterygomaxillary junction represents a safer and more precise way to perform the posterior osteotomy compared to the traditional open maxillectomy, where this step is performed with suboptimal exposure and profuse bleeding.

In the present study, we describe 3 types of posterior resection according to the anatomical structures progressively involved. In addition, for each level of posterior dissection, a superior extension was combined in cases growing towards the skull base. Our classification of the posterior margin of maxillectomy was aimed at standardizing the management of posteriorly extended tumors involving the maxilla. In line with the general principles of oncologic surgery, the indication for each type of posterior dissection was selected to leave a cuff of healthy

Table 3
Analysis of risk factors for margin involvement and local recurrence. Histology, extension to nasal septum, lacrimal apparatus, ITF, nasopharynx, hard palate, and soft palate did not affect the overall rate of positive margins and local recurrence, nor the rate of posterior margin involvement and posterior recurrence.

Variable	Involved margins (21/79, 26.6%)	p-value	Involved posterior margin (3/79, 3.8%)	p-value	Local recurrence (15/75, 20.0%)	p-value	Posterior local recurrence (4/75, 5.3%)	p-value
Origin	Maxillary sinus: 18/56 (32.1%)	0.062	Maxillary sinus: 3/56 (5.4%)	n.s.	Maxillary sinus: 10/54 (18.5%)	n.s.	Maxillary sinus: 3/54 (5.4%)	n.s.
	Nasoethmoidal box: 2/6 (33.3%)		Nasoethmoidal box: 0/6 (0.0%)		Nasoethmoidal box: 2/4 (50.0%)		Nasoethmoidal box: 0/4 (0.0%)	
	Palate: 1/17 (5.9%)		Palate: 0/17 (0.0%)		Palate: 3/17 (17.6%)		Palate: 1/17 (5.9%)	
	T2-4a: 10/60 (16.7%)	0.0004	T2-4a: 0/60 (0.0%)	0.012	T2-4a: 11/57 (19.3%)	n.s.	T2-4a: 3/57 (5.2%)	n.s.
T4b: 11/19 (57.9%)		T4b: 3/19 (15.8%)		T4b: 4/18 (22.2%)		T4b: 1/18 (5.6%)		
<i>Local extension</i>								
Ethmoid complex	Not involved: 10/52 (19.2%)	0.040	Not involved: 0/52 (0.0%)	0.037	Not involved: 11/51 (21.6%)	n.s.	Not involved: 2/51 (3.9%)	n.s.
	Involved: 11/27 (40.7%)		Involved: 3/27 (11.1%)		Involved: 4/24 (16.7%)		Involved: 2/24 (8.3%)	
Sphenoid sinus	Not involved: 14/64 (21.9%)	0.050	Not involved: 0/64 (0.0%)	0.006	Not involved: 12/61 (19.7%)	n.s.	Not involved: 3/61 (4.9%)	n.s.
	Involved: 7/15 (46.7%)		Involved: 3/15 (20.0%)		Involved: 3/14 (21.4%)		Involved: 1/14 (7.1%)	
Frontal sinus	Not involved: 18/75 (24.0%)	0.055	Not involved: 3/75 (4.0%)	n.s.	Not involved: 14/72 (19.4%)	n.s.	Not involved: 4/72 (5.6%)	n.s.
	Involved: 3/4 (75.0%)		Involved: 0/4 (0.0%)		Involved: 1/3 (33.3%)		Involved: 0/3 (0.0%)	
Orbital cavity	Not involved: 9/53 (17.0%)	0.007	Not involved: 0/53 (0.0%)	n.s.	Not involved: 10/51 (19.6%)	n.s.	Not involved: 10/51 (19.6%)	n.s.
	Papyracea/periorbit: 3/11 (27.3%)		Papyracea/periorbit: 0/11 (0.0%)		Papyracea/periorbit: 3/11 (27.3%)		Papyracea/periorbit: 3/11 (27.3%)	
Anterior skull base	Extracanal fat: 7/11 (63.6%)	0.073	Extracanal fat: 3/11 (27.3%)	n.s.	Extracanal fat: 2/11 (18.2%)	n.s.	Extracanal fat: 1/11 (9.1%)	n.s.
	Extrinsic muscles: 4/4 (100.0%)		Extrinsic muscles: 0/4 (0.0%)		Extrinsic muscles: 0/2 (0.0%)		Extrinsic muscles: 0/2 (0.0%)	
Pterygoid plates	Not involved: 16/69 (23.2%)	0.073	Not involved: 2/69 (2.9%)	n.s.	Not involved: 13/67 (19.4%)	n.s.	Not involved: 4/67 (6.0%)	n.s.
	Involved: 5/10 (50.0%)		Involved: 1/10 (10.0%)		Involved: 2/8 (25.0%)		Involved: 0/8 (0.0%)	
Pterygopalatine fossa	Not involved: 12/50 (24.0%)	n.s.	Not involved: 0/50 (0.0%)	0.046	Not involved: 11/46 (23.9%)	n.s.	Not involved: 3/46 (6.5%)	n.s.
	Involved: 9/29 (31.0%)		Involved: 3/29 (10.3%)		Involved: 4/29 (13.8%)		Involved: 1/29 (3.4%)	
Premaxillary tissues	Not involved: 10/48 (20.8%)	n.s.	Not involved: 0/48 (0.0%)	0.057	Not involved: 12/46 (26.1%)	0.097	Not involved: 3/46 (6.5%)	n.s.
	Involved: 11/31 (35.5%)		Involved: 3/31 (9.7%)		Involved: 3/29 (10.3%)		Involved: 1/29 (3.4%)	
<i>Surgical technique</i>	Not involved: 11/57 (19.3%)	0.018	Not involved: 1/57 (1.8%)	n.s.	Not involved: 11/54 (20.4%)	n.s.	Not involved: 3/54 (5.6%)	n.s.
	Involved: 10/22 (45.5%)		Involved: 2/22 (9.1%)		Involved: 4/21 (19.4%)		Involved: 1/21 (4.8%)	
Approach	Skin-incisionless: 9/48 (18.8%)	0.050	Skin-incisionless: 0/48 (0.0%)	0.057	Skin-incisionless: 8/47 (17.0%)	n.s.	Skin-incisionless: 2/47 (4.3%)	n.s.
	Transfacial: 12/31 (38.7%)		Transfacial: 3/31 (9.7%)		Transfacial: 7/28 (25.0%)		Transfacial: 2/28 (7.1%)	
Type of maxillectomy	Inferior: 4/32 (12.5%)	0.029	Inferior: 0/32 (0.0%)	n.s.	Inferior: 6/32 (18.8%)	n.s.	Inferior: 3/32 (9.4%)	n.s.
	Subtotal: 4/17 (23.5%)		Subtotal: 0/17 (0.0%)		Subtotal: 4/16 (25.0%)		Subtotal: 0/16 (0.0%)	
Type of posterior resection	Total: 5/15 (33.3%)	n.s.	Total: 0/15 (0.0%)	n.s.	Total: 3/14 (21.5%)	n.s.	Total: 0/14 (0.0%)	n.s.
	Extended: 8/15 (53.3%)		Extended: 3/15 (20.0%)		Extended: 2/13 (15.4%)		Extended: 1/13 (7.7%)	
	Type 1: 9/37 (24.3%)		Type 1: 0/37 (0.0%)		Type 1: 8/35 (22.9%)		Type 1: 3/35 (8.6%)	
	Type 2: 8/34 (23.5%)		Type 2: 2/34 (5.9%)		Type 2: 6/32 (18.8%)		Type 2: 1/32 (3.1%)	
	Type 3: 4/8 (50.0%)		Type 3: 1/8 (12.5%)		Type 3: 1/8 (12.5%)		Type 3: 0/8 (0.0%)	

* Fisher's exact test.
** Chi-square test.

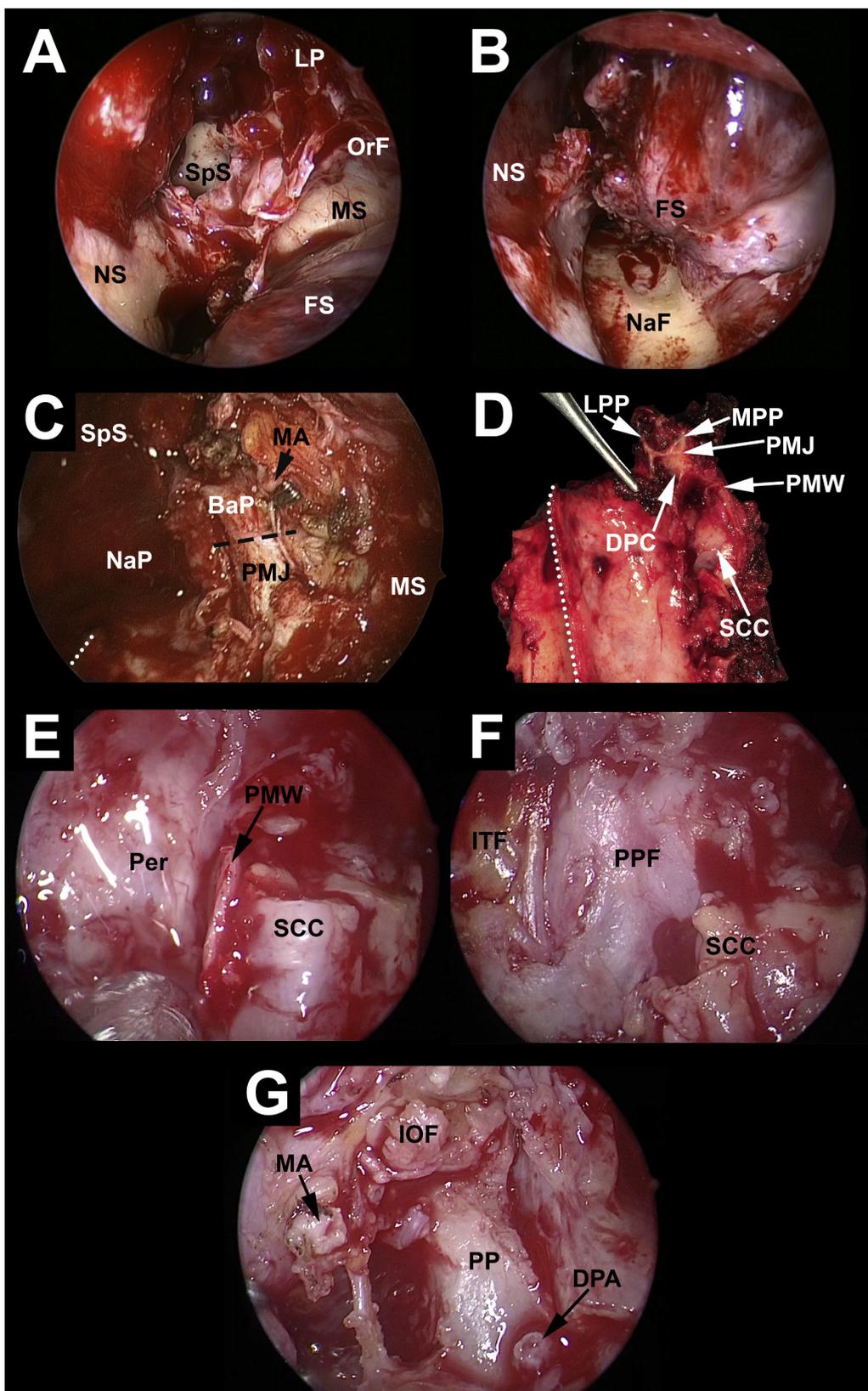


Fig. 3. Pictures highlighting some benefits of endoscopic-assisted maxillectomy. A, B. The endoscopic transnasal approach enables a precise assessment of the relationships of a fibrosarcoma (FS) of the left maxillary sinus (MS) with the orbital floor (OrF), lamina papyracea (LP), ethmoidal complex, sphenoid sinus (SpS), nasal septum (NS), and nasal floor (NaF). C, D. Endoscopic view of the surgical field after type 1 posterior delineation (C) and surgical specimen (D) in a patient with squamous cell carcinoma (SCC) of the left superior alveolar ridge extended to the maxillary sinus. The medial (MPP) and lateral (LPP) pterygoid plates are drilled (black dashed line) below the base of the pterygoid process (BaP). This step makes it substantially easier to detach the pterygomaxillary junction (PMJ) from the skull base, thus facilitating the last phases of the maxillectomy. E. Exploiting the magnification of the endoscopic view, the posterior border of a squamous cell carcinoma of the right maxillary sinus is identified in close contact with the posterior maxillary wall (PMW), which seems infiltrated by the lesion. The periosteum (Per) of the pterygopalatine fossa does not show signs of macroscopic infiltration. F. The pterygopalatine fossa (PPF) and infra-temporal fossa (ITF). G. Type 1 posterior delineation is completed by ligating the descending palatine artery (DPA) and maxillary artery (MA) and by removing the entire content of the pterygopalatine fossa. The pterygoid process (PP) is therefore exposed and considered the posterior bed of resection after confirming the non-involvement of the pterygopalatine fossa with frozen sections. White dotted line – inferior insertion of the nasal septum; DPC – Descending palatine canal; MA – Maxillary artery; NaP – Nasopharynx; PMW – Posterior maxillary wall.

tissue at the dorsal portion of the resection (Fig. 4) and was rewarded with a low rate of microscopic involvement of the posterior margin (3.8%). In fact, an 87.5% free posterior margin was ensured even in tumors with far posterior extension requiring a type 3 resection, while the overall rate of posterior margin control was exceedingly high (96.2%). This finding is of paramount importance when considering

that free margins and local control are independent positive prognostic factors in tumors involving the maxillofacial skeleton [36–39]. Other authors have reported lower rates of posterior margin control (78.3%) [6] or comparable results using more extensive approaches requiring mandibulotomy and/or inferior labiotomy with harvest of a cheek flap [4,5,7]. McMahon et al. reported 88.6% rate of clear posterior margin

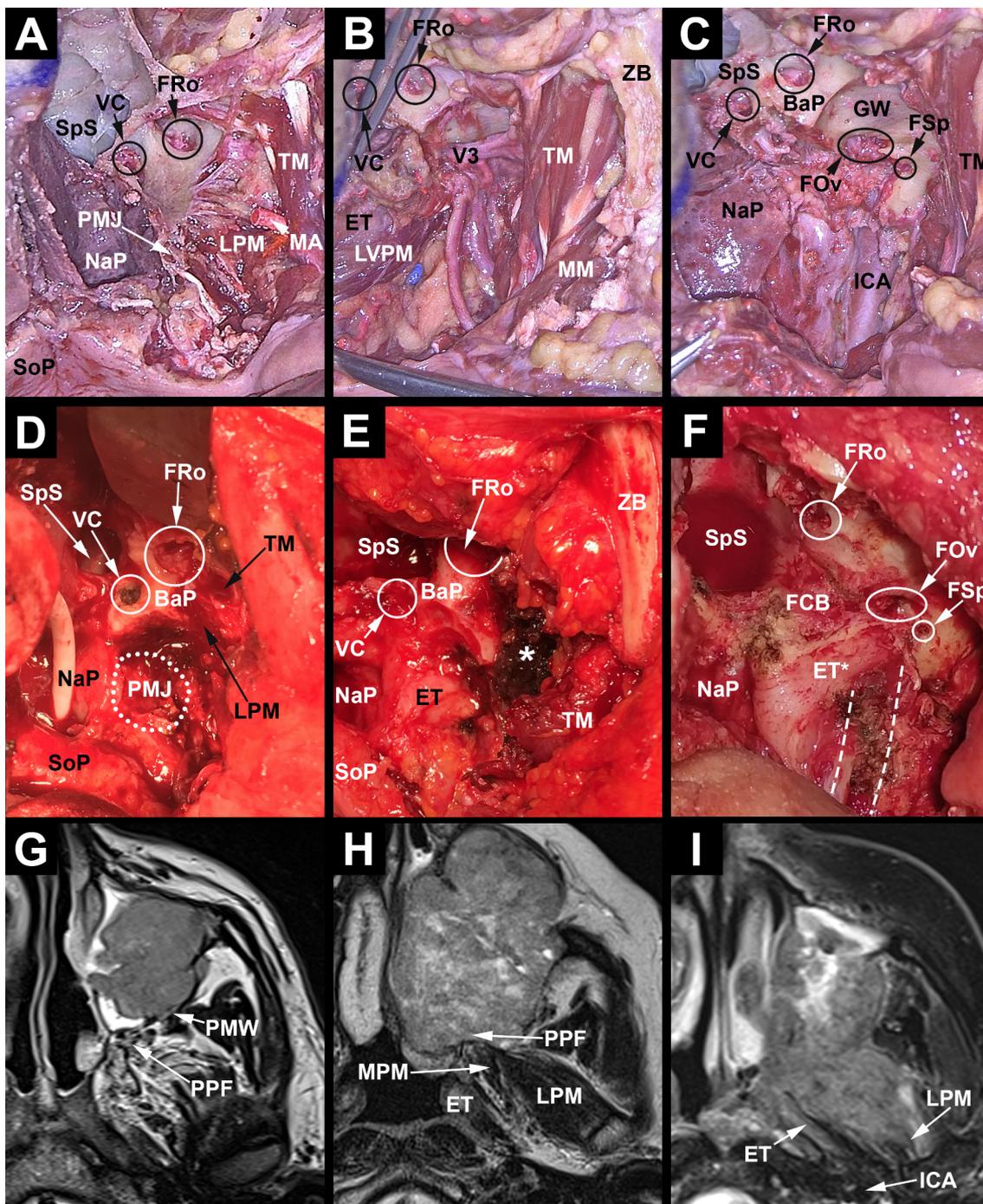


Fig. 4. Panel including the anatomical (A–C) and surgical (D–F) view of type 1 to 3 posterior delineations along with the respective axial T2-weighted MRI images (G–I) summarizing the 3 possible levels of posterior extension of maxillary tumors. Type 1 posterior delineation (A, D) consists of the removal of the pterygopalatine fossa (PPF) with full exposure of the pterygoid process, from the basipterygoid (BaP), which is identified at the level of the vidian canal (VC) and foramen rotundum (FRo), to the pterygomaxillary junction (PMJ). To facilitate the detachment of the surgical specimen during the last phases of the maxillectomy, the pterygoid process is drilled at the level of the pterygoid plates or pterygomaxillary junction (white dotted circle). The patient showed in images D and G was affected by a spindle cell squamous cell carcinoma of the left maxillary sinus extended to the posterior maxillary wall (PMW), which was radically excised with a total maxillectomy with type 1 posterior resection. Type 2 posterior delineation (B, E) also includes removal of all the pterygoid plates and related insertions of the medial (MPM) and lateral (LPM) pterygoid muscles. This resection allows the exposure of the plane of the Eustachian tube (ET) and mandibular nerve (V3), which is covered by a hemostatic oxidized-cellulose biodress (white asterisk) in the image E. The patient showed in images E and H was affected by a high-grade non-intestinal type adenocarcinoma of the left maxillary sinus, which was radically resected through a total maxillectomy with type 2 posterior delineation. Type 3 posterior delineation (C, I) consists of resecting the eustachian tube, mandibular nerve, middle meningeal artery, and surrounding parapharyngeal tissues as cuff of healthy tissue in far posteriorly extended tumors. This procedure leads to expose the greater wing of the sphenoid bone (GW) along with the foramina ovale (FOv) and spinosum (FSp). The internal carotid artery (ICA, white dashed lines) runs in the deep boundary of the resection bed and is therefore at risk of injury in such procedure. The patient shown in images F and I had a poorly differentiated squamous cell carcinoma of the left maxillary sinus with invasion of the pterygoid process and muscles. A total maxillectomy with type 3 posterior resection extended to the coronoid process and temporal muscle (TM) provided a radical excision of the tumor. The eustachian tube was only partially resected (ET*) and the cranial extension of the tumor was managed by subtotally removing the fibrocartilago basalis (FCB) that fills the foramen lacerum. LVPm – Levator veli palatine muscle; MA – Maxillary artery; MM – Masseter muscle; NaP – Nasopharynx; SoP – Soft palate; SpS – Sphenoid sinus; ZB – Zygomatic bone.

using the anterolateral corridor through zygomatic and coronoid osteotomies [40]. Interestingly, tumors also showing a vertical vector of growth (as evident from the invasion of the ethmoid complex and sphenoid sinus) were significantly associated with a lower chance of radicality at the posterior margin of resection (80.0–88.9%) compared with those without postero-superior extension (100.0%). This finding is in line with the evidence that skull base invasion is an independent factor that reduces survival in patients with maxillary cancer [41]. In our series, superior involvement requiring a craniectomy was recorded in 10 (12.7%) cases and the endoscopic approach greatly favored the management of skull base resection.

Our data showed that the lateral resection margin (ITF, temporal muscle, zygomatic bone) was the most frequently involved (11.4%). This fact could be related to the propensity of tumors reaching the infratemporal content or medullary bone of the zygomatic process to grow microscopically far beyond the macroscopic limits of the lesion. On the other hand, this highlights that there is room for improvement, especially focusing on the control of the lateral margin of maxillectomy. The imaging-based planning of osteotomies [42] and intraoperative navigation guidance [43–45] represent promising refinements to tackle this problem.

Notably, although most tumors included in the present series were locally advanced (T4a/T4b: 72.2%), 60.8% of maxillectomies were performed avoiding facial skin incisions. This possibility, as described in a previous anatomical study [46] and case-series [47,48], is provided by the optimal visualization and ability to easily detach the maxilla from the skull base under direct control.

The crude rate of local recurrence in the present study (20.0%) favorably compares with the 3-year cumulative rate of 42.2% in a sample of 379 patients with squamous cell carcinoma of the maxillary sinus [49]. Other series describing a technique intended to improve the posterior margin control showed comparable rate of recurrence (21.4% [5], 29.0% [6], 32.3%) [7] with similar or slightly longer follow-up duration (mean: 20.1, 43.4, 38.4 months, respectively) with respect to the present study. In the series described by McMahon et al., the rate of local recurrence in patients undergoing maxillectomy via anterolateral corridor approach was as low as 11.4%, with a median follow-up of 27–36 months [40].

Despite the low rate of medial and posterior positive margins, local recurrence at these sites was observed in roughly half (8 patients, 53.3%) of patients with local recurrence in our series (Table 2). Interestingly, in only 3 (37.5%, 2 posterior and 1 medial) of these 8 failures was the respective margin involved by the tumor. A possible explanation for this mismatch might be related to the notable rate of adverse features observed in the remaining 5 patients who presented clear medial and posterior margins. In fact, at least two adverse features were present in each patient: recurrent tumor (3 patients), aggressive histology (5 patients; Ewing sarcoma [1 patient], intermediate-grade mucoepidermoid carcinoma with multiple nodal metastases [1 patient], mucosal melanoma [1 patient], poorly differentiated squamous cell carcinoma [1 patient]), and perineural and/or lymphovascular invasion (5 patients). These characteristics lead to hypothesize the presence of tumor budding/satellitosis, which in turn could justify local recurrences even in areas corresponding to margins that were pathologically rated as negative.

The study has some limitations that should not be neglected. First, it is based on a retrospective observational analysis over a 10-year period. Second, survival outcomes were intentionally excluded from the analysis of the series in view of the histological heterogeneity of tumors and inclusion of various sites of origin. Third, a matched-pair analysis with non endoscopic-assisted maxillectomies (which would have increased the quality of the analysis) was not deemed feasible, as the variability in terms of histology, site, and historical period of treatment would have hampered the quality and validity of the comparison.

In this light, we believe that further prospective investigations on

larger series are required to confirm the added value of the endoscopic transnasal approach in performing maxillectomy.

Conclusion

EAM combines several refinements ranging from the easy, practical, and selective drilling of the pterygomaxillary junction to the precise delineation of the medial and posterior margin of resection, along with sound skull base management. From an oncologic point of view, control in terms of microscopic infiltration of the posterior and medial margin of resection was excellent. Head and neck surgeons treating cancer that involves the maxilla could benefit from adequate training in endoscopic transnasal surgery, which can provide the technical basis to improve delineation of the posterior and medial margin while facilitating tumor excision.

Conflict of interest statement

None declared.

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References

- [1] Choi EC, Choi YS, Kim CH, et al. Surgical outcome of radical maxillectomy in advanced maxillary sinus cancers. *Yonsei Med J* 2004;45:621–8.
- [2] Hanna EY, Cardenas AD, DeMonte F, et al. Induction chemotherapy for advanced squamous cell carcinoma of the paranasal sinuses. *Arch Otolaryngol Head Neck Surg* 2011;137:78–81.
- [3] Kovacs AF, Eberlein K, Hulsmann T. Organ preservation treatment using TPF-a pilot study in patients with advanced primary and recurrent cancer of the oral cavity and the maxillary sinus. *Oral Maxillofac Surg* 2009;13:87–93.
- [4] Balm AJ, Smeele LE, Lohuis PJ. Optimizing exposure of the posterolateral maxillary and pterygoid region: the lower cheek flap. *Eur J Surg Oncol* 2008;34:699–703.
- [5] Chatni SS, Sharan R, Patel D, et al. Transmandibular approach for excision of maxillary sinus tumors extending to pterygopalatine and infratemporal fossae. *Oral Oncol* 2009;45:720–6.
- [6] Kreeft AM, Smeele LE, Rasch CR, et al. Preoperative imaging and surgical margins in maxillectomy patients. *Head Neck* 2012;34:1652–6.
- [7] Sun J, Shen Y, Weng YQ, et al. Lateral lip-splitting approach for total and subtotal maxillectomy. *J Oral Maxillofac Surg* 2009;67:1197–205.
- [8] McMahon JD, Wong LS, Crowther J, et al. Patterns of local recurrence after primary resection of cancers that arise in the sinonasal region and the maxillary alveolus. *Br J Oral Maxillofac Surg* 2013;51:389–93.
- [9] Yoshimura R, Shibuya H, Ogura I, et al. Trimodal combination therapy for maxillary sinus carcinoma. *Int J Radiat Oncol Biol Phys* 2002;53:656–63.
- [10] El-Naggar AK, Chan JKC, Grandis JR, et al. WHO classification of head and neck tumours. Lyon: International Agency for Research on Cancer; 2017.
- [11] Brierley JD, Gospodarowicz MK, Wittekind C. TNM classification of malignant tumours. Wiley-Blackwell; 2017.
- [12] Shah J, Patel S, Singh B. Head and neck surgery and oncology. Mosby Elsevier; 2012.
- [13] Urken ML, Roche AM, Kiplagat KJ, et al. Comprehensive approach to functional palatomaxillary reconstruction using regional and free tissue transfer: report of reconstructive and prosthodontic outcomes of 140 patients. *Head Neck* 2018;40:1639–66.
- [14] Schreiber A, Ferrari M, Rampinelli V, et al. Modular endoscopic medial maxillectomies: quantitative analysis of surgical exposure in a preclinical setting. *World Neurosurg* 2017;100:44–55.
- [15] Turri-Zanoni M, Battaglia P, Karligkiotis A, et al. Transnasal endoscopic partial maxillectomy: operative nuances and proposal for a comprehensive classification system based on 1378 cases. *Head Neck* 2017;39:754–66.
- [16] Castelnovo P, Dallan I, Bignami M, et al. Nasopharyngeal endoscopic resection in the management of selected malignancies: ten-year experience. *Rhinology* 2010;48:84–9.
- [17] Castelnovo P, Nicolai P, Turri-Zanoni M, et al. Endoscopic endonasal nasopharyngectomy in selected cancers. *Otolaryngol Head Neck Surg* 2013;149:424–30.
- [18] Castelnovo P, Battaglia P, Turri-Zanoni M, et al. Endoscopic endonasal surgery for malignancies of the anterior cranial base. *World Neurosurg* 2014;82:S22–31.
- [19] Nicolai P, Battaglia P, Bignami M, et al. Endoscopic surgery for malignant tumors of the sinonasal tract and adjacent skull base: a 10-year experience. *Am J Rhinol* 2008;22:308–16.
- [20] Nicolai P, Castelnovo P, Bolzoni Villaret A. Endoscopic resection of sinonasal malignancies. *Curr Oncol Rep* 2011;13:138–44.

- [21] Hanna E, DeMonte F, Ibrahim S, et al. Endoscopic resection of sinonasal cancers with and without craniotomy: oncologic results. *Arch Otolaryngol Head Neck Surg* 2009;135:1219–24.
- [22] Okay DJ, Genden E, Buchbinder D, et al. Prosthodontic guidelines for surgical reconstruction of the maxilla: a classification system of defects. *J Prosthet Dent* 2001;86:352–63.
- [23] Zhang WB, Wang Y, Mao C, et al. Cervical metastasis of maxillary squamous cell carcinoma. *Int J Oral Maxillofac Surg* 2015;44:285–91.
- [24] Piazza C, Paderno A, Del Bon F, et al. Palato-maxillary reconstruction by the angular branch-based tip of scapula free flap. *Eur Arch Otorhinolaryngol* 2017;274:939–45.
- [25] Cherubino M, Berli J, Turri-Zanoni M, et al. Sandwich fascial anterolateral thigh flap in head and neck reconstruction: evolution or revolution? *Plast Reconstr Surg Glob Open* 2017;5:e1197.
- [26] Cherubino M, Turri-Zanoni M, Battaglia P, et al. Chimeric anterolateral thigh free flap for reconstruction of complex cranio-orbito-facial defects after skull base cancers resection. *J Craniomaxillofac Surg* 2017;45:87–92.
- [27] Mattavelli D, Schreiber A, Ferrari M, et al. Three-layer reconstruction with iliotibial tract after endoscopic resection of sinonasal tumors. *World Neurosurg* 2017;101:486–92.
- [28] Krischek B, Carvalho FG, Godoy BL, et al. From craniofacial resection to endonasal endoscopic removal of malignant tumors of the anterior skull base. *World Neurosurg* 2014;82:S59–65.
- [29] Lund V, Howard DJ, Wei WI. Endoscopic resection of malignant tumors of the nose and sinuses. *Am J Rhinol* 2007;21:89–94.
- [30] Lund VJ, Stammberger H, Nicolai P, et al. European position paper on endoscopic management of tumours of the nose, paranasal sinuses and skull base. *Rhinol Suppl* 2010;22:1–143.
- [31] Lund VJ, Wei WI. Endoscopic surgery for malignant sinonasal tumours: an eighteen year experience. *Rhinology* 2015;53:204–11.
- [32] Moya-Plana A, Bresson D, Temam S, et al. Development of minimally invasive surgery for sinonasal malignancy. *Europ Ann Otorhinolaryngol, Head Neck Dis* 2016;133:405–11.
- [33] Snyderman CH, Carrau RL, Kassam AB, et al. Endoscopic skull base surgery: principles of endonasal oncological surgery. *J Surg Oncol* 2008;97:658–64.
- [34] Villaret AB, Yakirevitch A, Bizzoni A, et al. Endoscopic transnasal craniectomy in the management of selected sinonasal malignancies. *Am J Rhinol Allergy* 2010;24:60–5.
- [35] Meccariello G, Deganello A, Choussy O, et al. Endoscopic nasal versus open approach for the management of sinonasal adenocarcinoma: a pooled-analysis of 1826 patients. *Head Neck* 2016;38(Suppl 1):E2267–74.
- [36] Bristol IJ, Ahamad A, Garden AS, et al. Postoperative radiotherapy for maxillary sinus cancer: long-term outcomes and toxicities of treatment. *Int J Radiat Oncol Biol Phys* 2007;68:719–30.
- [37] Nishio N, Fujimoto Y, Fujii M, et al. Craniofacial resection for T4 maxillary sinus carcinoma: managing cases with involvement of the skull base. *Otolaryngol Head Neck Surg* 2015;153:231–8.
- [38] Ozsaran Z, Yalman D, Baltalarli B, et al. Radiotherapy in maxillary sinus carcinomas: evaluation of 79 cases. *Rhinology* 2003;41:44–8.
- [39] Paulino AC, Marks JE, Bricker P, et al. Results of treatment of patients with maxillary sinus carcinoma. *Cancer* 1998;83:457–65.
- [40] McMahon JD, Crowther J, Taylor WM, et al. Anterolateral corridor approach to the infratemporal fossa and central skull base in maxillectomy: rationale and technical aspects. *Br J Oral Maxillofac Surg* 2015;53:814–9.
- [41] Nazar G, Rodrigo JP, Llorente JL, et al. Prognostic factors of maxillary sinus malignancies. *Am J Rhinol* 2004;18:233–8.
- [42] Bernstein JM, Daly MJ, Chan H, et al. Accuracy and reproducibility of virtual cutting guides and 3D-navigation for osteotomies of the mandible and maxilla. *PLoS One* 2017;12:e0173111.
- [43] Tarsitano A, Ricotta F, Baldino G, et al. Navigation-guided resection of maxillary tumours: the accuracy of computer-assisted surgery in terms of control of resection margins – a feasibility study. *J Craniomaxillofac Surg* 2017;45:2109–14.
- [44] Catanzaro S, Copelli C, Manfuso A, et al. Intraoperative navigation in complex head and neck resections: indications and limits. *Int J Comput Assist Radiol Surg* 2017;12:881–7.
- [45] Feichtinger M, Pau M, Zemann W, et al. Intraoperative control of resection margins in advanced head and neck cancer using a 3D-navigation system based on PET/CT image fusion. *J Craniomaxillofac Surg* 2010;38:589–94.
- [46] Rivera-Serrano CM, Terre-Falcon R, Duvvuri U. Combined approach for extensive maxillectomy: technique and cadaveric dissection. *Am J Otolaryngol* 2011;32:417–21.
- [47] Liu Z, Yu H, Wang D, et al. Combined transoral and endoscopic approach for total maxillectomy: a pioneering report. *J Neurol Surg B Skull Base* 2013;74:160–5.
- [48] Hanazawa T, Yamasaki K, Chazono H, et al. Endoscopic contralateral transmaxillary approach for pterygoid process osteotomy in total maxillectomy: a technical case report. *Auris Nasus Larynx* 2018;45:622–5.
- [49] Ashraf M, Biswas J, Dam A, et al. Results of treatment of squamous cell carcinoma of maxillary sinus: a 26-year experience. *World J Oncol* 2010;1:28–34.