Oral Oncology 99 (2019) 104468

Contents lists available at ScienceDirect

Oral Oncology

journal homepage: www.elsevier.com/locate/oraloncology

Reconstruction of maxillectomy and midfacial defects using latissimus dorsi-scapular free flaps in a comprehensive cancer center

A. Moya-Plana[a,*], M. Veyrat[a], J.F. Honart[b], K. de Fremicourt[b], H. Alkhashnam[b], B. Sarfati[b], F. Janot[a], N. Leymarie[b], S. Temam[a], F. Kolb[b]

[a] Head and Neck Oncology Department, Gustave Roussy Cancer Campus, Villejuif, France
[b] Plastic and Reconstructive Surgery Department, Gustave Roussy Cancer Campus, Villejuif, France

ARTICLE INFO

Keywords:
Sinonasal malignancies
Midfacial defect
Reconstruction
Scapulo-dorsal free flap
Maxillectomy
Orbital floor

ABSTRACT

Background: The standard of care for sinonasal malignancies is a large surgical resection followed by radiotherapy. Midfacial defects resulting from maxillectomy require a complex reconstruction procedure. Given their adaptability, chimeric flaps such as latissimus dorsi-scapular (LDS) free flaps appear to be a good option.
Material & methods: We performed a single-center retrospective study of consecutive patients with sinonasal cancers where a LDS free flap was used for reconstruction. We assessed the postoperative complications and the functional, aesthetic and oncologic outcomes.
Results: Eighty-four patients were included. Primary tumors were staged as T4a in 68% of cases; 38.3% of the patients received induction chemotherapy and 82.7% received adjuvant radiotherapy. Based on our classification of midfacial and palatal defects, the majority of the patients (69%) had a type IIa with interruption of the three facial pillars. The orbital floor was removed in 55.9% of cases. The median follow-up was 45 months. Total flap necrosis with no possible revascularization occurred in 5.9% of cases. For the orbital reconstruction, a revision procedure was needed for necrosis and/or infection of the costal cartilage graft in eight cases (17%). More than 90% of the patients had no functional disorders regarding speaking, swallowing and chewing. Soft palate involvement was a prognostic factor of speech ($p < 10^{-4}$) and swallowing ($p = .005$) disorders. Dental rehabilitation was realized in 70.2% of the patients. No severe complications were observed in the donor site, except for one seroma.
Conclusion: A LDS free flap is a reliable technique for the reconstruction of complex midfacial defects.

Introduction

Sinonasal malignancies are rare and aggressive tumors that represent 3 to 5% of head and neck cancers, with an incidence rate of 10 per million in males and 5 per million in females [1]. The maxillary sinus is the most frequent primary tumor location; with various histological subtypes [2]. Unfortunately, despite advances in imaging and therapeutic strategies, the disease-specific mortality and local failure rates remain high [3,4]. Indeed, nonspecific symptoms often lead to late diagnoses with locally advanced tumors. Surgery with negative margins remains the cornerstone of the therapeutic armamentarium, but the proximity of the tumor to key anatomical structures (e.g., orbital content, internal carotid artery, skull base) causes difficulties for wide tumor resection [4,5]. Moreover, multimodal management is usually indicated with adjuvant radiation therapy alone or combined chemoradiation therapy [6]. In this context, a reconstruction procedure is mandatory after a large surgical resection that has potentially vital (protection of the skull base and vessels from bacteria and desiccation), functional (oculopalpebral, speaking and swallowing) and aesthetic consequences. Midface reconstruction primarily requires an accurate assessment of the surgical defect to determine a clear preoperative reconstruction strategy [7–9]. Then, a therapeutic algorithm is established according to the maxillofacial defect, defining the indications of local, free flaps and/or obturator prostheses. Given the complexity of maxillary reconstruction, chimeric flaps appear to be an interesting alternative with good adaptability to various types of defects [10,11]. Thus, latissimus dorsi-scapular free flaps constitute the gold standard in our practice.

The main objective of our study was to establish the reliability of the use of latissimus dorsi-scapular free flaps in reconstruction after subtotal/total maxillectomy for locally advanced sinonasal malignancies. We then present our classification of midfacial defects and our

* Corresponding author at: Gustave Roussy Cancer Campus, 114 rue Edouard Vaillant, 94805 Villejuif Cedex, France.
E-mail address: antoine.moya-plana@gustaveroussy.fr (A. Moya-Plana).

https://doi.org/10.1016/j.oraloncology.2019.104468
Received 15 July 2019; Received in revised form 4 September 2019; Accepted 22 October 2019
Available online 01 November 2019
1368-8375/

therapeutic algorithm.

Material & methods

This study was performed after obtaining approval from the local Research Ethics Committee in accordance with the World Medical Association – Declaration of Helsinki – ethical principles for medical research. We performed a monocentric study with consecutive patients who required a surgical reconstruction by latissimus dorsi-scapular free flap after subtotal/total maxillectomy between January 1998 and November 2014 in our tertiary cancer center and who were prospectively registered in the Head and Neck Cancer Committee Database of our institution.

The exclusion criteria were flaps raised from the subscapular pedicle (latissimus dorsi or thoracodorsal artery perforator (TDAP)) without bone, musculocutaneous or bony flaps from the circumflex scapular pedicle (scapular crest, scapular or parascapular flap); latissimus dorsi-scapular free flaps used for mandibular defect reconstruction.

For each patient, the data including the patient characteristics, tumor characteristics (histology, TNM stage, primary or salvage surgery, oncologic outcomes), surgical defect characteristics (size, localization, classification stage), flap characteristics (side, anatomic vascular variations, perforator flap or not, type of vascular anastomosis), postoperative complications, and oncologic and functional outcomes were retrospectively collected.

Preoperatively, all patients underwent radiological evaluations by MRI, CT-scan and PET-scan with Doppler vascular imaging of the neck and axillar region. The reconstruction procedure was performed at the same time as the tumor removal (primary reconstruction) or in a later procedure after the first reconstruction failed in another center or after poor results using an obturator prosthesis. The postoperative follow-up was performed by both a head and neck surgeon and a plastic and reconstructive surgeon according to the following schedule: every three months for the first two years with an MRI, every six months during the next three years, then yearly (until at least ten years of follow-up). The functional and aesthetic outcomes were evaluated at a minimum of one year postoperatively through physical examinations (by both surgeons, speech-language pathologists and physiotherapists) and preoperative/postoperative photographs.

Kolb classification of facial defects

A systematic description and analysis of a midfacial defect is detailed in Fig. 1. Three parameters must be defined: horizontal extension (H), vertical extension (V) and soft palate involvement. Then, surgical interruption of the three facial pillars (pterygo-maxillar (PM), zygomatico-maxillar (ZM) and fronto-maxillar (FM)) and orbital floor involvement can be planed. The palatal defect, reflecting the PM pillar interruption (H parameter), is to be adequately described (Fig. 2). Thus, we defined six stages of palatal defects that allow us to establish a suitable reconstruction strategy according to the H and V parameters.

In our therapeutic algorithm, a scapula-dorsal flap reconstruction must be prioritized for type II defects with vertical extension and type III defects with preservation of the contralateral canine pillar. Indeed, our therapeutic algorithm for reconstruction is based on our classification of palatal defects. For a type I defect, where the ipsilateral canine pillar is preserved, a prosthetic reconstruction or a fasciocutaneous free flap (antero-lateral thigh or forearm flaps) are the two options to consider. The main indication for latissimus dorsi-scapular free flaps is type II defect when a bony flap is required to replace the ipsilateral canine pillar. However, in type III with resection of the contralateral canine pillar and type IV defects where the bony defect is wider, a fibula free flap should be performed. Finally, a bone reconstruction is not mandatory for type V and type VI defects where fasciocutaneous free flaps must be considered.

Results

Patient and tumor characteristics

There were 84 patients, including 38 women (45.2%) and 46 men (54.8%; sex ratio 1.2). The median age was 46.6 years (range 10–77). Eighty-one patients presented with malignant tumors, while only three had benign lesions (ossifying fibroma, odontogenic myxoma, ameloblastoma). The characteristics of the primary tumor, its extensions and the midfacial defects are described in Table 1. The three benign lesions had no previous treatment and received no adjuvant radiotherapy.

Surgical procedure

A total of 16 senior surgeons (eight head & neck and eight plastic surgeons) performed the surgical procedures. Tumor resection was generally performed through a transfacial paralateronasal approach (82 cases). All patients underwent reconstruction using a latissimus dorsi-scapular free flap (Fig. 3). The donor site was contralateral to the maxillectomy for every patient except one (who had a medical history of mammary carcinoma). Three patients underwent reconstruction with a second identical ipsilateral flap after the first flap developed total necrosis (2 cases) or the tumor recurred (1 case). Thus, 87 free flaps were raised for 84 patients: 74 latissimus dorsi with scapular tip, 8 with two independent flaps (muscular and/or cutaneous) in the same thoracodorsal pedicle with scapular tip, 3 scapular tips only, and 2 latissimus dorsi with serratus and scapular tip. Twenty-two latissimus dorsi flaps (26.2%) were TDAP flaps for overweight patients. Moreover, to limit postoperative shoulder impairment, the serratus and teres major muscles were systematically sutured to the remaining scapular bone.

While raising the flaps, we noticed that the angular branch of the thoracodorsal artery generally originated from the artery heading to the latissimus dorsi muscle (52%) and the artery heading to the serratus muscle (34.2%). Microvascular arterial anastomoses were mainly placed termino-terminally (90%) on the homolateral facial artery (40%), external carotid artery (36.2%) and lingual artery (17.5%). Regarding the venous pedicle, termino-terminal anastomoses (87.6%) were placed on the homolateral thyrolinguofacial trunk (80.2%). No venous grafts were needed.

For 47 patients (55.9%), the orbital floor was reconstructed using a generally costal cartilage graft (78.7%). Orbital exenteration was necessary in nine cases (10.7%). Finally, in our cohort, 69 patients (82.1%) underwent an elective tracheotomy (mean duration 7.9 days) to prevent airway management issues.

Postoperative outcomes

The mean length of stay was 21 days with a median of 18 days. When total necrosis of the flap occurred, the mean length of stay was 34.2 days. In the first three weeks, 20 patients (22.9%) had to undergo another surgical procedure, as described in Table 2. Of these patients, eight (40%) had received a perforator flap.

In terms of the orbital floor reconstruction, a revision procedure was needed in eight cases (17%) for necrosis and/or infection of the costal cartilage graft.

Oncologic outcomes

The median follow-up period was 45 months (range 6–155). No recurrence was observed in the three patients with a benign tumor. Among the 81 patients with malignancies, forty (49.3%) tumor recurrences were noted, with 32 deaths. Of these recurrences, 25 cases (62.5%) were local and/or nodal with 19 cases of distant relapse and 4 cases of both local and distant relapse.

	Framework	Surfacing	Functional Analysis
Orbito-palpebral region	**ZM pillar** = orbital, malar and zygomatic portions **Orbital walls** = lateral, medial, floor of the orbit	**Eyelid** = superior, inferior **Canthus** = medial, lateral	Eye Medial and lateral palpebral ligaments Superior and inferior tarsal-conjunctival parts Lacrimal duct
Nasal pyramid	**FM pillar** **Nose** = nasal bone, alar cartilage, triangular cartilage, septum	**Nose subunits** = dorsum, tip, columella, ala, lateral part, "soft-tissue" triangle	Mucosa of nasal valve, ala and nasopharynx
Cheek	**ZM pillar** = orbital, malar and zygomatic portions **PM pillar**	**Cheek subunits** = median, lateral, zygomatic, buccal	Muscles Facial nerve with branches to superior eyelid and to upper lip Infraorbital nerve
Upper lip	**FM pillar** **PM pillar**	**Lip subunits** = median, lateral, commissure	Defect size = inferior or equal to one-third of the lip ; half of the lip ; subtotal/ total defect
Palatal vault	Type of defect (I to VI) With or without soft palate involvement		

Fig. 1. Characterization of a midfacial defect. PM: pterygo-maxillar; FM: fronto-maxillar; ZM: zygomatico-maxillar.

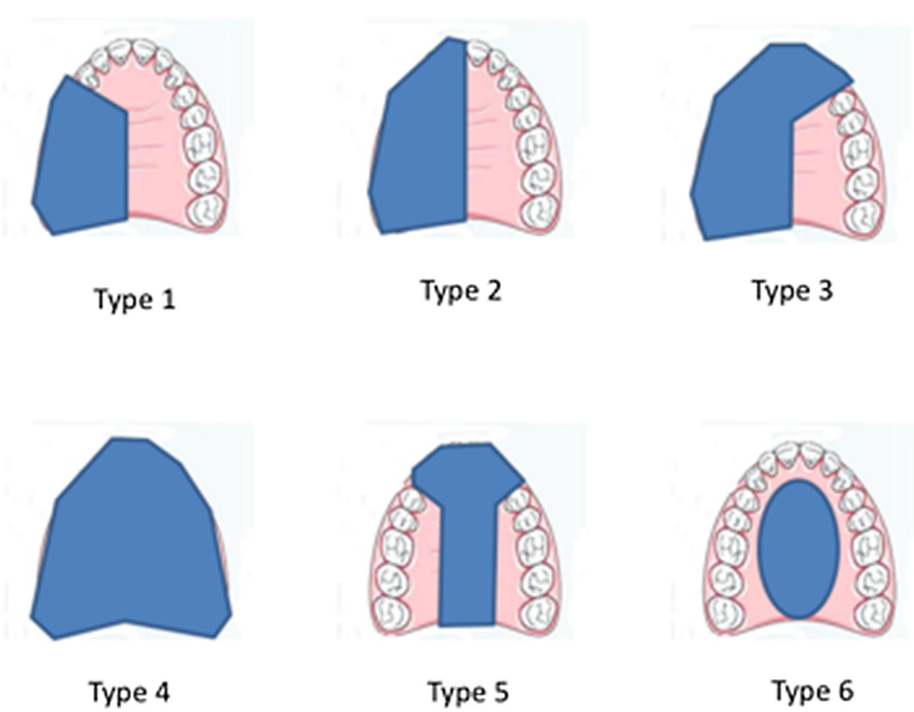

Fig. 2. Classification of palatal defects. Type I: palatal defect sparing the homolateral canine pillar; Type II: hemi-palatal defect; Type III: palatal defect involving the contralateral canine pillar; Type IV: total hard palate removal; Type V: premaxillar defect ± posterior extension preserving the lateral dental arcades; Type VI: hard palate defect preserving dental arcades. (a) for soft palate preservation; (b) for soft palate involvement.

Table 1
Malignant tumor characteristics. PM: pterygo-maxillar pillar; FM: fronto-maxillar pillar; ZM: zygomatico-maxillar pillar; CT: chemotherapy; RT: radiotherapy; RT-CT: radiochemotherapy.

	Malignant tumors (n = 81)	
Histologic subtypes	Squamous cell carcinoma	37 (45.7%)
	Adenoid cystic carcinoma	15 (18.5%)
	Mucoepidermoid carcinoma	2 (2.4%)
	Sinonasal undifferentiated carcinoma	2 (2.4%)
	Adenocarcinoma	2 (2.4%)
	Sarcoma	15 (18.5%)
	Mucosal melanoma	3 (3.7%)
	Olfactory neuroblastoma	1 (1.2%)
	Hemangiopericytoma	1 (1.2%)
	Sarcomatoid	3 (3.7%)
T stage (UICC classification)	T2	10 (12.3%)
	T3	10 (12.3%)
	T4a	55 (67.9%)
	T4b	6 (7.5%)
	N stage: N0	76 (90.5%)
Skin infiltration	15 (17.8%)	
Facial pillar involvement	PM alone	15 (17.9%)
	PM + ZM	5 (5.9%)
	PM + FM	6 (7.1%)
	PM + ZM + FM	58 (69%)
Palatal defect classification	Ia 5 (5.9%); Ib 2 (2.9%); IIa 58 (69%); IIb 7 (8.3%); IIIa 9 (10.7%); IIIb 3 (3.6%)	
Orbital floor involvement	47 (55.9%) with exenteration in 9 cases (10.7%)	
Previous treatment	None	34 (42%)
	Induction CT	31 (38.3%)
	RT-CT	8 (9.9%)
	CT + Surgery	4 (4.9%)
	CT + Surgery + RT	4 (4.9%)
	Surgery + RT	2 (2.5%)
	RT alone	1 (1.2%)
Postoperative RT	67 (82.7%)	with RT-CT in 21 cases

Table 2
Postoperative complications requiring a revision procedure.

Total flap necrosis (with no possible revascularization)	5 (5.9%)
Partial flap necrosis	15 (17.8%)
– Bone flap	3 total necrosis/3 partial necrosis
– Musculocutaneous flap	9 partial necrosis
Postoperative hemorrhage	3 (3.4%)
Deep facial abscess	1 (1.1%)
Donor site seroma	1 (1.1%)
Costal cartilage graft necrosis/infection	8/37 (21.6%)

Table 3
Functional outcomes.

	Description	Treatment
Speech disorders	None 76 (90.5%)	
	Rhinolalia 8 (9.5%)	Autologous fat transfer
Swallowing disorders	None 76 (90.5%)	Speech therapist
	Velopharyngeal insufficiency 8 (9.5%)	
Dental rehabilitation	Dental prosthesis 51 (60.7%)	
	Implant-supported prosthesis 8 (9.5%)	
	Insufficient depth of vestibule 23 (27.4%)	Secondary vestibular plasty
Rhinologic dysfunction	Nasal obstruction 8 (9.5%)	
	Nasobuccal fistula 6 (7.1%)	
	Nasocutaneous fistula 4 (4.7%)	Revision surgery
	Frontal mucocele 2 (2.3%)	
Oculopalpebral disorders	Lagophthalmos 19 (22.6%)	
	Chronic epiphora 15 (17.8%)	
	Diplopia 7 (8.3%)	Revision surgery (when feasible)
	Endophthalmitis requiring enucleation 1 (1.2%)	

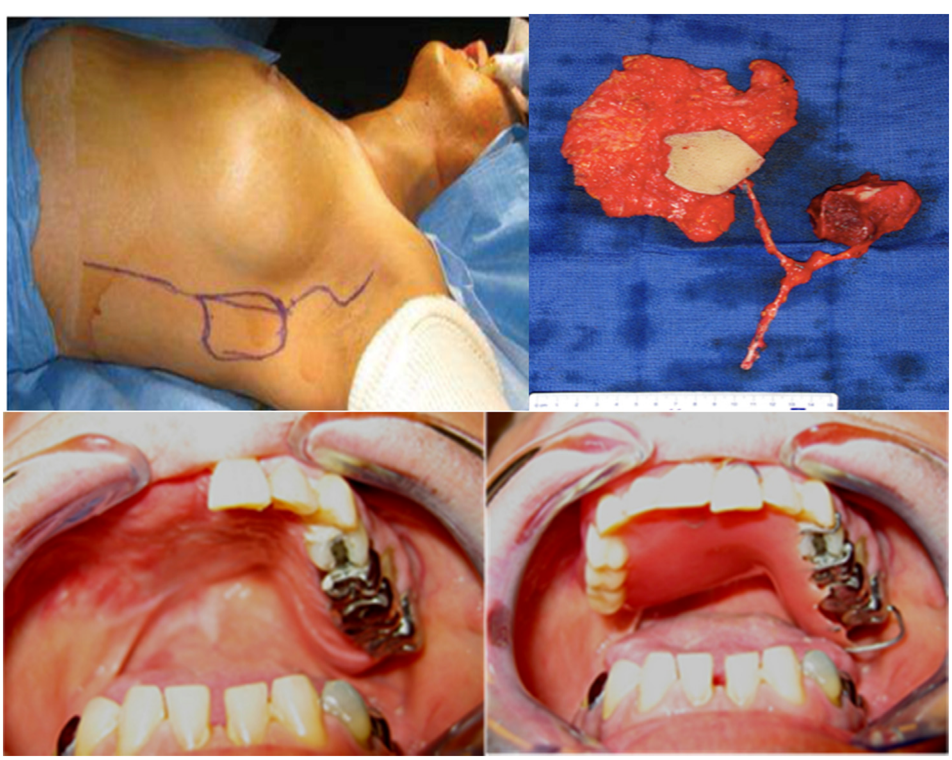

Fig. 3. Latissimus dorsi-scapular free flap. (A) Skin incision. (B) Scapular bone was used to reconstruct the palatal defect, while a musculocutaneous flap brings volume to the maxillary sinus defect. The cutaneous part constitutes the lateral wall of the nasal fossa. (C) Dental rehabilitation after right total maxillectomy with a type IIa palatal defect.

Table 4
Secondary procedures after primary reconstruction of the midfacial defects. FAMM: facial artery musculomucosal, ALT: anterolateral thigh.

Secondary procedure	No. of patients
Vestibular plasty (skin graft, radial forearm free flap)	23 (27.4%)
Autologous fat transfer (cheek, paranasal, lip, soft palate)	19 (22.6%)
Local cutaneous flaps (paramedian forehead flap, labial advancement flaps, rotation cheek flap, eyelid flaps)	9 (10.7%)
Secondary costal cartilage graft (orbital floor)	8 (9.5%)
Canthopexy	6 (7.1%)
Commissuroplasty with fascia lata graft	5 (5.9%)
Local mucosal flaps (FAMM, palatine, buccinator)	4 (4.7%)
Free flaps (radial forearm, ALT, TDAP)	4 (4.7%)
Ectropion correction	3 (3.5%)
Hemifacial lift	2 (2.4%)

Functional and aesthetic outcomes

Specific functional results are presented in Table 3. Soft palate surgery is a poor prognostic factor for speech ($p < 10^{-4}$) and swallowing ($p = .005$) disorders. Indeed, among 12 patients with soft palate involvement, eight presented with rhinolalia and/or velopharyngeal insufficiency (five presented with both); in contrast, no such functional issues were noted when sparing the soft palate. In these cases, autologous fat transfer allowed for partial improvements, but several procedures were often required. Moreover, because of the complexity of the procedure, orbital floor reconstruction negatively impacted the functional results, leading to both oculopalpebral and aesthetic issues.

As local recurrence cases were excluded, aesthetic evaluations were performed in 68 patients with results graded as good, acceptable and mediocre. Poor aesthetic outcomes were observed in 31 patients with oculopalpebral disorders (lagophthalmos, enophthalmos, ectropion, canthal dystopia), in 17 patients with cheek retraction, and in 12 patients with labial retraction. Secondary procedures were necessary for forty patients (47.6%), as shown in Table 4. As expected, the incidence of revision surgery was correlated with the number of interrupted facial pillars ($p = .003$). Interestingly, preoperative/postoperative radiotherapy (RT) or chemotherapy (CT) were not prognostic factors.

Regarding the donor site, only one case of seroma was noted. At six months, functional evaluations according to the *Disabilities of Arm, Shoulder & Hand* score (DASH score) showed no residual disability.

Discussion

The midfacial reconstruction of defects caused by sinonasal tumor resection constitutes a highly complex and technical challenge. Indeed, the maxillary bone is the centerpiece of the midface. Maxillectomy is responsible for tremendous vital, functional and aesthetic consequences that reconstruction strategy has to solve. Moreover, sinonasal malignancies require multimodal management with a high rate of adjuvant treatments, such as RT and CT [4,6]. Chiqurupati et al. showed that RT was a poor prognostic factor for functional outcomes and quality of life [12], with the maxillary obturators having a low tolerance due to RT-induced xerostomia [13,14]. Moreover, dental alteration occurs earlier in patients with obturators [15]. Thus, free flaps seem to be the gold standard when treating locally advanced tumors. Chimeric latissimus dorsi-scapular free flaps are, in our opinion, a perfect strategy to cope with complex midfacial defects.

To the best of our knowledge, this study represents the largest cohort reported in the literature [10,11]. The follow-up period is significantly long, which is mandatory for evaluating the functional outcomes of such complex surgical procedures. Indeed, treating sinonasal malignancies requires not only a well-trained multidisciplinary surgical team but also anesthesiologists, prosthetists and speech therapists dedicated to head and neck oncology. Unlike other studies [7,9], we report the results of a surgical technique performed by a great number of surgeons (eight head and neck surgeons and seven plastic surgeons). Thus, this study provides highly reliable results on this reconstruction technique that are easy to extrapolate to other centers.

We showed that the latissimus dorsi-scapular free flap is a reliable technique for the reconstruction of complex midface defects. Indeed, despite large maxillary defects (interruption of three facial pillars in 70% of the patients) and a high rate of adjuvant RT (more than 80% of the patients), 90% of patients had no functional disorders in terms of speaking, swallowing and chewing. Moreover, in our series, no severe complications were observed in the donor site, except for only one seroma, and no infections or scar issues occurred; in contrast, the complication rate reported in the literature is approximately 5–10% [11]. Thus, our postoperative protocol is well established and features a systematic 8-day drainage protocol and the use of a compressive bandage in the first 48 h.

However, the overall complication rate is not negligible, with five total flap necroses (5.7%) and three isolated bone necroses (3.5%), which is within the range reported in previous studies (up to 10% for such events) [11,15,16]. Regarding the incidence of total necrosis, 80% occurred in patients who had received prior treatment, such as CT-RT and/or surgery, emphasizing the benefit of primary reconstruction. These results are consistent with previously reported studies who identified as intraoperative fluid use greater than 7 L, surgery duration longer than 10 h, procedure performed by several microsurgeons, and postoperative RT as prognostic factors of free flap failure [16]. Moreover, the importance of the learning curve for this complex surgery was recognized in several studies, which defined a threshold of 70 procedures before a surgeon can be considered an “expert” [16]. However, this threshold is quite difficult to pass considering the scarcity of this malignancy and the extreme variability in the resulting defects.

Orbital floor reconstruction remains one of the main surgical challenges as achieving both acceptable functional and aesthetic outcomes is difficult, even more after RT [17,18]. Moreover, local complications due to this reconstruction process are common. Indeed, Yu showed that the complication rate was significantly higher when orbital reconstruction was required [16]. A large variety of surgical procedures exist, from those that use titanium mesh to those that use autologous material (fascia lata, costal cartilage, parietal bone, iliac crest, etc.). Hanasono compared several procedures but found no clear benefit of one specific technique [8]. However, in our experience, synthetic materials appeared to be more suitable for conformation, while bone or cartilage grafts seem to have a higher rate of local infection. These local infections usually occur due to a contact between the bacteria of the nasal cavity and the reconstruction material, when the skin paddle replacing the medial wall of the maxillary sinus is not tight. Thus, to prevent this complication, we chose not to reconstruct the medial wall of the orbit with cartilage graft or synthetic materials but only with the usual skin paddle combined with the intranasal placement of a silastic sheet maintaining the orbital content into the orbital cavity until the complete healing of the flap, as previously described in endonasal endoscopic surgery [19]. This procedure allows us to lower the risk of contamination of the reconstruction material. We recently chose to prioritize 3D-printed titanium prostheses and observed promising results as soon as the material was well isolated from the nasal cavity by the flap.

As expected, secondary procedures are very common after this type of complex reconstruction. Indeed, in our study, 47.6% of patients required at least one revision surgery, which is consistent with the rates in the literature (ranging from 41 to 57% of cases) [10,23]. The most frequent revisions are vestibular plasty to allow suitable dental rehabilitation and procedures for orbito-palpebral disorders.

We chose to use a scapular bone graft for alveolar bone and hard palate reconstruction to prioritize functional outcomes such as swallowing, speech and the use of a dental prosthesis. Other conformation strategies, where the latissimus dorsi-scapular free flap is employed to manage midfacial defects by using the scapular tip bone flap vertically in the malar area to reconstruct the zygomatic bone and maxilla, have been described [20–22]. Orbital floor reconstruction was eventually realized with a 3D-printed titanium mesh [20]. Other teams such as the one led by Piazza [24] placed the bone graft vertically to treat the orbital floor defect and horizontally following palatal resection.

Some authors recommended postponing the reconstruction procedure after RT and/or after a minimum follow-up period to improve the detection of local recurrence. However, in our center, primary reconstruction is systematic in our therapeutic strategy for both functional outcomes and quality of life. Indeed, although postoperative RT was almost systematically performed, this flap appeared to be reliable in our series. Moreover, improvements in radiological techniques (MRI, CT-scan) can help detect local recurrence. Finally, in a cohort of sinonasal SCC with primary reconstruction through free flaps, we previously showed that oncologic outcomes where were comparable to those in the literature with no oncologic disadvantages [4]. Although Mucke observed an improvement in oncologic outcomes using primary reconstruction in head and neck malignancies [25], our results could be explained by the particular aggressiveness of sinonasal tumors.

Regarding the use of latissimus dorsi-scapular free flaps, we support the use of these flaps because of their versatility and adaptability to different types of maxillary defects, such as Brown who perform this technique for stage II to VI defects of his classification [9]. However, Lenox indicated that this flap should only be applied for stage II defects according to the Brown classification and argued that this flap potentially lacks the volume for large defects [26]. In our therapeutic algorithm, scapula-dorsal flap reconstruction must be prioritized for type II defects with vertical extension and type III defects with preservation of the contralateral canine pillar. A prosthetic solution is usually suitable for type I defects, while type IV defects need a large bone graft, such as a fibular free flap. In the case of type V defects, we recommend a radial forearm flap associated with an iliac crest graft and/or a prosthesis.

However, this study has a retrospective design, which induces some bias in the data collection and analysis. Thus, comparing the results of obturator prostheses and free flaps in a single trial remains difficult. Indeed, we believe that a randomized trial would not be ethical as both techniques are, in our experience, complementary and are probably suitable for different types of midfacial defects and patients. Moreover, we had a high rate of elective tracheotomy. Indeed, in our series, 82.1% of the patients underwent an elective tracheotomy, with a mean hospitalization duration of eight days, to prevent airway management issues. However, Brickman [27] recently showed that, for 143 patients with primary reconstruction after maxillectomy using free flaps, postoperative respiratory complications were rare (less than 10%), with no clear differences between patients who did and did not undergo tracheotomy, while patients with cardiopulmonary risk factors were more likely to undergo perioperative tracheotomy. Thus, although tracheotomy may be avoided in a subset of patients, we still believe that patients with large maxillary defects, patients with defects involving the soft palate, and patients who received preoperative RT or have cardiopulmonary risk factors must be considered for tracheotomy.

Finally, as we previously mentioned, orbital floor reconstruction remains the main challenge considering the high rate of postoperative complications both with autologous grafts (costal graft) and titanium.

Conclusion

Midfacial defects resulting from total maxillectomy require a complex reconstruction procedure. An accurate analysis and classification of each defect are mandatory to plan a satisfactory reconstruction. In our experience, the latissimus dorsi-scapular free flap is a reliable reconstruction technique for large maxillofacial defects. The functional results are good, even after postoperative RT. However, new techniques need to be developed for specific areas such as the orbital floor and soft palate to improve the aesthetic and functional outcomes.

Funding

No funding was required for this study.

Declaration of Competing Interest

None declared.

References

[1] Maghami E, Kraus DH. Cancer of the nasal cavity and paranasal sinuses. Expert Rev Anticancer Ther 2004;4(3):411–24. https://doi.org/10.1586/14737140.4.3.411.
[2] Sanghvi S, Khan MN, Patel NR, Yeldandi S, Baredes S, Eloy JA. Epidemiology of sinonasal squamous cell carcinoma: a comprehensive analysis of 4994 patients: SNSCC Incidence and Survival. The Laryngoscope 2014;124(1):76–83. https://doi.org/10.1002/lary.24264.
[3] Porceddu S, Martin J, Shanker G, et al. Paranasal sinus tumors: peter maccallum cancer institute experience. Head Neck 2004;26(4):322–30. https://doi.org/10.1002/hed.10388.
[4] Paré A, Blanchard P, Rosellini S, Aupérin A, Gorphe P, Casiraghi O, et al. Outcomes of multimodal management for sinonasal squamous cell carcinoma. J Craniomaxillofac Surg 2017 Aug;45(8):1124–32.
[5] Moya-Plana A, Bresson D, Temam S, Kolb F, Janot F, Herman P. Development of minimally invasive surgery for sinonasal malignancy. Eur Ann Otorhinolaryngol Head Neck Dis 2016 Dec;133(6):405–11.
[6] Lund VJ, Stammberger H, Nicolai P, Castelnuovo P, Beal T, Beham A, et al. European position paper on endoscopic management of tumours of the nose, paranasal sinuses and skull base. Rhinol Suppl 2010 Jun;1(22):1–143.
[7] Cordeiro PG, Santamaria E. A classification system and algorithm for reconstruction of maxillectomy and midfacial defects. Plastic Reconstruct Surgery 2000;105:2331–46. [discussion 2347-2338].
[8] Hanasono MM, Silva AK, Yu P, Skoracki RJ. A comprehensive algorithm for oncologic maxillary reconstruction. Plast Reconstr Surg 2013;131:47–60.
[9] Brown JS, Shaw RJ. Reconstruction of the maxilla and midface: introducing a new classification. Lancet Oncol 2010;11:1001–8.
[10] Miles BA, Gilbert RW. Maxillary reconstruction with the scapular angle osteomyogenous free flap. Archiv Otolaryngol-Head Neck Surgery 2011;137:1130–5.
[11] Clark JR, Vesely M, Gilbert R. Scapular angle osteomyogenous flap in postmaxillectomy reconstruction: defect, reconstruction, shoulder function, and harvest technique. Head Neck 2008;30:10–20.
[12] Chigurupati R, Aloor N, Salas R, Schmidt BL. Quality of life after maxillectomy and prosthetic obturator rehabilitation. J Oral Maxillofacial Surgery: Off J Am Assoc Oral Maxillofacial Surgeons 2013;71:1471–8.
[13] Kornblith AB, Zlotolow IM, Gooen J, et al. Quality of life of maxillectomy patients using an obturator prosthesis. Head Neck 1996;18:323–34.
[14] Brown J, Bekiroglu F, Shaw R. Indications for the scapular flap in reconstructions of the head and neck. Brit J Oral Maxillofacial Surgery 2010;48:331–7.
[15] Germain MA, Hartl DM, Marandas P, Julieron M, Demers G. Free flap reconstruction inthetreatment of tumors involving the hard palate. Europ J Surg Oncol: J Europ Soc Surg Oncol Brit Assoc Surg Oncol 2006;32:335–9.
[16] Yu P, Chang DW, Miller MJ, Reece G, Robb GL. Analysis of 49 cases of flap compromise in 1310 free flaps for head and neck reconstruction. Head Neck 2009;31:45–51.
[17] Sampathirao LM, Thankappan K, Duraisamy S, et al. Orbital floor reconstruction with free flaps after maxillectomy. Craniomaxillofacial Trauma Reconstruct 2013;6:99–106.
[18] Suarez C, Ferlito A, Lund VJ, et al. Management of the orbit in malignant sinonasal tumors. Head Neck 2008;30:242–50.
[19] Karligkiotis A, Appiani MC, Verillaud B, Herman P. How to prevent diplopia in endoscopic transnasal resection of tumors involving the medial orbital wall. Laryngoscope 2014 Sep;124(9):2017–20.
[20] Choi N, Cho JK, Jang JY, Cho JK, Cho YS, Baek CH. Scapular tip free flap for head and neck reconstruction. Clin Exp Otorhinolaryngol 2015;8:422–9.
[21] Bulut OC, Federspil PA, Plinkert PK, Simon C. Reconstruction of maxillary defects using a free scapular angle flap. Hno 2013;61:321–6.
[22] Kakibuchi M, Fujikawa M, Hosokawa K, et al. Functional reconstruction of maxilla with free latissimus dorsi-scapular osteomusculocutaneous flap. Plastic Reconstruct Surgery 2002;109:1238–44. [discussion 1245].
[23] Kosutic D, Uglesic V, Knezevic P, Milenovic A, Virag M. Latissimus dorsi-scapula free flap for reconstruction of defects following radical maxillectomy with orbital exeneration. J Plastic, Reconstruct Aesthetic Surgery: JPRAS 2008;61:620–7.
[24] Piazza C, Paderno A, Taglietti V, Nicolai P. Evolution of complex palatomaxillaryreconstructions: the scapular angle osteomuscular free flap. Curr Opin Otolaryngol Head Neck Surg 2013;21:95–103.
[25] Mucke T, Wolff KD, Wagenpfeil S, Mitchell DA, Holzle F. Immediate microsurgical reconstruction after tumor ablation predicts survival among patients with head and neck carcinoma. Ann Surg Oncol 2010;17:287–95.
[26] Lenox ND, Kim DD. Maxillary reconstruction. Oral Maxillofacial Surg Clin North America 2013;25:215–22.
[27] Brickman DS, Reh DD, Schneider DS, Bush B, Rosenthal EL, Wax MK. Airway management after maxillectomy with free flap reconstruction. Head Neck 2013;35:1061–5.