Orbital Floor Reconstruction with Free Flaps after Maxillectomy

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Abstract

Background The purpose of this study is to evaluate the outcome of orbital floor reconstruction with free flaps after maxillectomy.

Methods This was a retrospective analysis of 34 consecutive patients who underwent maxillectomy with orbital floor removal for malignancies, reconstructed with free flaps. A cross-sectional survey to assess the functional and esthetic outcome was done in 28 patients who were alive and disease-free, with a minimum of 6 months of follow-up.

Results Twenty-six patients had bony reconstruction, and eight had soft tissue reconstruction. Free fibula flap was the commonest flap used ($n = 14$). Visual acuity was normal in 86%. Eye movements were normal in 92%. Abnormal globe position resulted in nine patients. Esthetic satisfaction was good in 19 patients (68%). Though there was no statistically significant difference in outcome of visual acuity, eye movement, and patient esthetic satisfaction between patients with bony and soft tissue reconstruction, more patients without bony reconstruction had abnormal globe position ($p = 0.040$).

Conclusion Free tissue transfer has improved the results of orbital floor reconstruction after total maxillectomy, preserving the eye. Good functional and esthetic outcome was achieved. Though our study favors a bony orbital reconstruction, a larger study with adequate power and equal distribution of patients among the groups would be needed to determine this. Free fibula flap remains the commonest choice when a bony reconstruction is contemplated.

Keywords

- ▶ sinonasal cancer
- ▶ orbital floor reconstruction
- ▶ functional outcome
- ▶ maxillectomy
- ▶ head and neck cancer
- ▶ free flaps

Surgical ablation forms an integral part of the treatment for maxillary sinus malignancies. Advanced-stage lesions also require adjuvant treatment, radiotherapy with or without chemotherapy. The overall outcomes of sinonasal malignancies have significantly improved over the years as a consequence of this treatment approach. Following ablation, reconstruction and rehabilitation also remain an essential part of treatment. Prosthetic rehabilitation after maxillectomy is practiced worldwide. Reconstruction of maxillary defects with autologous tissue, either regional or a free flap, is increasingly done in many centers. Controversy still remains regarding the choice of a

free flap versus obturation. Many times, removal of the orbital walls is also required for adequate clearance of the tumor. The orbital floor (the roof of the maxilla) when removed poses a greater challenge to the reconstructive surgeon. The present study attempts to present the outcome of orbital floor reconstruction with free flaps after maxillectomy.

Materials and Methods

This is a retrospective analysis of the 34 consecutive patients who underwent orbital floor reconstruction with free tissue

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transfer after maxillectomy with preserved orbital contents. Our institutional review board allows the publication of retrospective reviews without a formal submission and review. The study period was 6 years, between January 2004 and December 2009. The clinical case records, operative notes, and follow-up data were analyzed. A cross-sectional survey to assess the functional and esthetic outcome was also performed in 28 patients, who were alive and disease-free and available for evaluation, with a minimum of 6 months of follow-up after the treatment. This part of the study was performed over a period of 1 month in June 2010. Orbital function was assessed in terms of visual acuity and eye movements. Esthetic outcome was objectively studied for abnormalities in position of globe (enophthalmos or hypophthalmos or both) by clinical examination and evaluation of standard clinical photographs. No quantification of the globe position was done. A subjective assessment of the functional and esthetic was also done in these 28 patients. Esthetic satisfaction of the patient regarding the overall facial appearance was graded by the patient on a visual analogue scale ranging from 0 (least satisfied) to 10 (most satisfied). The scores were then grouped into three grades: (1) good, (2) satisfactory, and (3) unsatisfactory. The patients with bony reconstruction versus soft tissue reconstruction and those who underwent primary surgery versus salvage surgery were compared in terms of functional outcome (visual acuity and eye movements) and esthetic outcome (abnormal globe position and patient esthetic satisfaction). Fisher exact test was used for comparison, and $p < 0.05$ was taken as statistically significant.

Results

One hundred twenty-six patients underwent maxillectomy during the study period. Combined modality treatment with surgery followed by radiotherapy with or without chemotherapy was performed. Thirty-nine patients had total maxillectomy including orbital floor removal. ▶Table 1 shows the details of the pathology, indications of surgery (whether primary or salvage), types of maxillectomy, and flaps used.

Brown's classification¹ was utilized to type the defects after resection. All patients in this study had class III defects. Free flaps were used for reconstruction of the defects, to achieve oroantral or oronasal separation and to support the orbital contents. Of the 39 patients who had total maxillectomy including orbital floor removal, 34 underwent free tissue reconstruction of the orbital floor and the remaining five had regional flap reconstruction. Twenty-six patients underwent bony reconstruction and eight patients had only a soft tissue reconstruction. Patients with soft tissue reconstruction had some remnant posterior floor of the orbit after resection. Free fibula flap (FFF) was used in 14 patients, tensor fascia lata (TFL) with iliac crest (IC) was used in 9 patients, 1 patient underwent reconstruction with radial artery forearm free flap with bone, and 1 patient had free latissimus dorsi with rib.

▶Fig. 1A, B, C, D shows the maxillectomy defect and the reconstructed outcome in a patient where FFF was

Table 1 Tumor pathology, indications, flaps for total maxillectomy ($n = 34$)

	No. of patients
Pathology	
Squamous cell carcinoma	21
Adenoid cystic carcinoma	9
Sarcoma	2
Others	2
T stage	
T1	0
T2	0
T3	12
T4 ^a	22
Indication	
Primary surgery	22
Salvage surgery	12
Free flaps	
Free fibula flap	14
Tensor fascia lata-iliac crest	9
Free radial artery forearm	4
Rectus abdominis	6
Free latissimus dorsi with rib	1

^aTwo cases of sarcoma were also staged similar to squamous cell carcinoma.

used. ▶Fig. 2A, B, C, D shows the reconstructive outcome of a patient who underwent maxillectomy and reconstruction with TFL-IC flap. Eight patients had a soft tissue reconstruction. Rectus abdominis free flap was used in six. The fascia of the flap was used as a sling for the orbital contents. ▶Fig. 3A, B shows the reconstructive outcome in patient in whom rectus abdominis flap was used. Radial artery forearm free flap without bone was used in two. A Prolene mesh shaped and attached like a sling was used for the orbital support in these two cases. ▶Table 2 gives details of flap reconstruction.

The data on the recipient vessels in all patients were not available. But the majority of patients had anastomosis to the facial vessels in the neck. Six cases had to be reexplored for flap issues. All these patients had venous compromise. Three of these cases had vascular compromise due to the pressure on the pedicle by hematoma in the long subcutaneous tunnel in the cheek. Three other cases had anastomotic issues. Three patients had total flap loss and one had partial flap necrosis. The flap success rate was 91%. FFF was lost in three patients. Two patients were salvaged with contralateral fibula and in one patient TFL-IC was used. Twenty-eight of 34 patients were available for an evaluation of orbital function and esthetic outcome.

Visual acuity was normal in 24 of 28 (86%) patients; it was impaired in 4 (14%) patients. Eye movements were normal in

Figure 1 (A) Intraoperative photograph showing total maxillectomy defect with orbital contents preserved. (B) Outcome at 2 years' follow-up in a patient reconstructed with free fibula osteocutaneous flap, frontal view. (C) Reconstructed outcome, lateral view. (D) Outcome at 2 years' follow-up, three-dimensional reconstructed computed tomographic image.

26 (93%) patients, whereas 2 (8%) patients had defective eye movements. Enophthalmos was noted in 5 (18%) patients and hypophthalmos was seen in 2 (7%). Two patients (7%) had both enophthalmos and hypophthalmos. The difference in functional outcome related to visual acuity and eye movements between the groups with bony and soft tissue reconstruction was not significant ($p = 0.763$ and 0.810 , respectively). But there was a significant difference in the globe position outcome ($p = 0.040$). Among the 28 patients with retained eyeball, esthetic satisfaction was good in 19 individuals (68%), satisfactory in 6 (21%), and unsatisfactory in 3 (11%). The difference between the groups was not significant ($p = 0.201$).

All the patients in the present study had immediate primary reconstruction. A secondary reconstruction was not done in any of the patients. But 12 patients had history of prior treatment, either surgery or radiotherapy. Among the 28 patients who underwent functional assessment, 11 had salvage surgery. But the statistical analysis showed no significant difference in visual acuity, eye movements, globe position, or esthetic satisfaction between the groups of patients who underwent primary or salvage surgery. Because the

analysis was negative, the data are not separately shown. ▶**Table 3** summarizes the functional and esthetic outcome.

Discussion

Reconstruction of maxillary defects with autologous tissue, either regional or with a free flap, is increasingly done in many centers. Controversy still remains regarding the choice of a free flap versus prosthetic obturation.² The orbit is an adjacent structure, and when involved requires removal in many cases. This may be just the resection of the orbital walls or may even require an orbital exenteration, where the eyeball is removed. Maxillectomy defects become more complex when critical structures like the orbital walls, ocular globe, and cranial base are resected. Many classification systems are proposed for maxillectomy defects.¹⁻⁴ Brown and Shaw have classified the defects into six types vertically (type I, maxillectomy not causing an oronasal fistula; II, not involving the orbit; III, involving the orbital adnexa with orbital retention; IV, with orbital enucleation or exenteration; V, orbitomaxillary defect; VI, nasomaxillary

Figure 2 (A) Outcome at 2 years' follow-up in a patient reconstructed with, tensor fascia lata with iliac crest free flap, frontal view. (B) Reconstructed outcome, lateral view. (C) Reconstructed outcome at 2 years' follow-up, computed tomographic image, coronal view showing the tensor fascia lata with iliac crest free flap. (D) Computed tomographic image, sagittal view showing the tensor fascia lata with iliac crest free flap.

defect) and four types horizontally (a, palatal defect only, not involving the dental alveolus; b, less than or equal to one-half unilateral; c, less than or equal to one-half bilateral or transverse anterior; d, greater than one-half maxillectomy).¹

Controversy still remains regarding the ideal method of rehabilitation of postmaxillectomy defects, with views for and against prosthetic obturation and flap reconstruction.⁵ Obturation is usually sufficient for oronasal and oroantral

Figure 3 (A) Outcome in a patient reconstructed with free rectus abdominis flap, frontal view. (B) Reconstructed outcome, lateral view.

Table 2 Defect classification and the flap used ($n = 34$)

Defect (type 3)	Reconstruction	No. of patients	Total no. of patients
Bony reconstruction	FFF	14	26
	TFL-IC	9	
	RAFF (osteocutaneous)	2	
	Latissimus dorsi free flap with rib	1	
Soft tissue reconstruction	RAFF (fasciocutaneous)	2	8
	Rectus abdominis free flap	6	

Abbreviations: FFF, free fibula flap; TFL-IC, tensor fascia lata-iliac crest; RAFF, radial artery forearm flap.

separation.⁵ Free flaps are becoming increasingly used worldwide.⁶ Free fibula osteocutaneous flap,^{7,8} free vascularized IC,⁹ scapular flap,^{10,11} free rectus abdominis flap,^{12,13} and vascularized calvarial bone flap¹⁴ free radial forearm flap have been reported, with varying outcome.

The eye can be safely preserved in most patients with ethmoid or maxillary sinus cancers invading the orbital wall. Invasion of the periorbital is an indication for removal of the eyeball.¹⁵ There are also few reports claiming equal outcomes with preservation of the eye when the tumor can be completely dissected away from the orbital fat.¹⁶ Malposition of the globe and nonfunctional eyes frequently result when patients have not had adequate rigid reconstruction of the orbital floor, particularly if they have received postoperative radiotherapy. This underscores the importance of such reconstruction.

The primary goal of a globe-sparing total maxillectomy is to provide adequate support to the preserved globe. When the orbital floor defect is small, no reconstruction is needed. However, for larger defects, rigid support is necessary. A muscular sling or musculofascial sling have been tried with reasonable cosmetic and functional outcome.¹⁷ The other goals of the reconstruction would be to provide oronasal separation and adequate bulk to restore the facial contour. Various reconstructive methods have been described for these defects. These include use of free bone grafts like rib, free bone graft like calvarium covered by a soft tissue flap,¹⁴ titanium mesh covered by a soft tissue flap,¹⁸ pedicled vascularized bone,¹⁴ and free flaps. Free bone grafts tend to resorb and are generally less resistant to infection, more so after radiotherapy.

Table 3 Functional and esthetic outcome

Functional outcome(<i>n</i> = 28)	No. of patients			<i>p</i> value
	Total	Bony reconstruction (<i>n</i> = 20)	Soft tissue reconstruction (<i>n</i> = 8)	
Visual acuity				
Normal	24 (86%)	17	7	0.763
Impaired	4	3	1	
Eye movements				0.810
Normal	26 (93%)	19	7	
Abnormal	2	1	1	
Esthetic outcome (<i>n</i> = 28)				
Globe position				0.040
Normal	19 (68%)	16	3	
Abnormal	9	4	5	
Enophthalmos	5	2	3	
Hypophthalmos	2	1	1	
Enophthalmos+ hypophthalmos	2	1	1	
Patient aesthetic satisfaction				
Good	19 (68%)	15	4	0.201
Satisfactory/unsatisfactory	9	5	4	

Vascularized flaps would provide a rigid support to the globe and at the same time have lesser chance of resorption, exposure, or infection, as observed with bone grafts or implants. Vascularized calvarial bone based on the temporal artery as a pedicled flap has been reported.¹⁴ Temporalis muscle with coronoid process has also been used as a pedicled flap.^{15,19–21} In all these techniques, the secondary goals of palatal obturation and restoring the facial contour may not be adequately achieved. A microvascular composite free flap with bone and soft tissue would be an ideal choice to reconstruct such a complex defect. The free flaps described include free fibula osteocutaneous flap, radial forearm osteocutaneous flap, IC osteomusculocutaneous flap with internal oblique, and free latissimus dorsi scapular osteomusculocutaneous flap.

Free fibula osteocutaneous free flap is the commonest flap used for maxillary reconstruction. But there is less thickness of the bone to cover the depth of the orbital floor. The thickness of the fibula depends on how it is placed. If it is placed with its width anteroposteriorly, ~1.5 cm is covered. If placed straight, the bone depth is about 1 cm. Contouring the fibula bone to match the shape of the orbital rim is difficult. Advantages are that the free fibula has the maximum pedicle length and that enough bone is available that can be osteotomized to form the anterior maxillary and alveolar segment. And the skin paddle for the palatal obturation is an added advantage with free fibula. The thickness available for deep circumflex iliac artery (DCIA) flap is the upper surface of the IC bone. This is less than 1 cm and may not be enough to cover the orbital floor defect completely. But the contour of the bone matches that of the orbital rim. The height of the harvested IC can be tailored to the height needed for the anterior maxilla. Pedicle length is poor and the palatal defect cannot be adequately covered, due to the lack of skin. A scapula osteocutaneous flap is another choice. Two bone segments can be fashioned on different branches of the same vessel. The bone segment is thick enough to cover the orbital floor as well as the anterior maxilla and alveolar arch. Skin paddle availability is an advantage but the pedicle length is a problem.

The technique and advantages of the TFL-IC flap for orbitomaxillary reconstruction is recently reported.⁹ The vascularized bone provides a reliable and permanent support

to the globe; the IC placed in the horizontal position can cover the orbital floor entirely, and the muscle provides adequate soft tissue to achieve oronasal separation and to replace the lost bulk of the midface. The shape and contour of the IC matches the orbital floor perfectly, thereby achieving the primary goal of reconstruction very well. The TFL muscle is flat at its distal two-thirds, making it suitable for palatal obturation. In addition to this, the huge cutaneous territory of the TFL-IC flap gives the freedom to design the skin paddle away from the bone, making it possible to use the skin to reconstruct the cheek skin as needed. The flap is very simple to harvest, with a fairly constant and reliable anatomy. Donor site morbidity is minimal whether the skin is harvested or not. The abdominal wall musculature is left undisturbed, making it less morbid than the deep circumflex iliac artery flaps. The length of the pedicle is a limitation. But direct anastomosis was possible in eight cases, and only one case needed vein graft for both the artery and vein.

Our policy in type III defects is to do an immediate free flap reconstruction in a surgically fit patient. We did not use the obturator in any of our patients in this study. We preferred a bony reconstruction in most of the cases. In the initial period of this study, our choice was mostly FFF except in three cases; in two of these cases, the orbital bony defect was small with associated large mucosal palatal defect, where radial forearm flap with bone was used. In the latter part of the study, we started using TFL-IC flap. This flap is specifically considered when there is large anteroposterior orbital floor defect and when the defect requires a large skin paddle. In other cases, the fibula remains the choice. Soft tissue flaps were used in a few cases where the anteroposterior defect in the orbital floor was less than half of the total anteroposterior length and where the orbital periorbital could be preserved intact. If a soft tissue flap is used, we prefer to use free rectus abdominis flap due to the availability of large skin paddle and muscle tissue. In two cases where a long pedicle was required, a radial forearm flap was used. But even in such defects, the choice at present is a bony reconstruction. Obtaining a palatal seal was considered equally important as providing the orbital support. A palatal seal was achieved in all the cases. Of the flaps used, the fibula skin paddle is most difficult to be manipulated and oriented for the palatal cover. ► Fig. 4A, B, C shows the

Figure 4 (A) Line diagram showing the reconstruction with free fibula flap. (B) Line diagram showing the reconstruction with tensor fascia lata with iliac crest flap. (C) Line diagram showing the reconstruction with a soft tissue flap, free rectus abdominis. The fascia of the flap (shown in pink) was used as a sling for the orbital contents.

schema of reconstruction with FFF, TFL-IC, and soft tissue reconstruction, respectively.

The lack of an inferior bony support and the increased orbital cavity volume accounted for the enophthalmos, hypophthalmos, or both. The lack of bony support can be due to the transverse bony loss of the rim or the anteroposterior bony loss in the floor. Bony reconstruction replaced the support in a much better way than the soft tissue reconstruction. A Prolene mesh support for the orbital contents was used only in two patients where free radial forearm soft tissue flap was used. We do not favor the use of titanium mesh in these patients with malignant pathology as they receive postoperative radiotherapy or chemoradiotherapy. These treatments can result in the extrusion of the metal implant. In cases where the free rectus abdominis was used, a fascial sling was used for the orbital support. Though the fascial sling or the Prolene mesh was expected to compensate for the loss, more patients with soft tissue reconstruction had abnormal globe position. The fascia was not tough enough to hold the orbital contents in position. One other challenge is to obtain the concavity of the inferior orbital rim. It is difficult to mimic the concavity of the inferior orbital rim as this requires multiple small osteotomies on fibula.

Imola and Schramm have reported the functional outcome after orbital preservation with maxillectomy.¹⁶ They studied 66 patients who underwent surgical treatment for sinonasal malignancy encroaching on the orbit. Overall eye function was graded as functional without impairment in 54% of patients, functional with impairment in 37%, and nonfunctional in 9%. Globe malposition (enophthalmos or hypophthalmos) was the most common abnormality that was seen in 34 patients (63%) and was associated with the lack of adequate rigid reconstruction of subtotal or total orbital floor or multisegment orbital defects. However, enophthalmos was asymptomatic in the majority of cases, and persistent diplopia occurred in only 9%. Various ocular sequelae were present in 41% of functional eyes. Radiation therapy increased the risk of ocular complications. Stern et al reported on orbit-preserving maxillectomy in 28 patients.²² Eighteen patients had part or the entire orbital floor resected; nine patients were treated with radiotherapy and nine had surgery only. Only 3 of 18 patients in this group (17%) retained significant function in the ipsilateral eye.

In the present series, with reconstruction of orbital floor after total maxillectomy, the visual acuity was normal in 86% of patients in whom the eyeball was retained. Eye movements were normal in 93% patients. Though the difference in functional outcome was related to visual acuity, eye movements was not statistically significant among those who had bony reconstruction or not; the patients with no bony reconstruction had more morbidity related to abnormal globe position. The patients in whom only soft tissue reconstruction was done had some remnant bony orbital floor, but the majority still had sagging and indrawing of the eyeball. The esthetic satisfaction was also good in the majority of the patients, and there was no significant between the groups in this aspect. Our study favors a bony orbital reconstruction. The soft tissue fibrosis and healing problems in such salvage

surgery can have profound impact on the reconstruction. But the present study showed no statistically significant difference in functional and esthetic outcome between the groups of patients who had primary surgery versus salvage surgery after prior radiotherapy or surgery.

Conclusion

Free tissue transfer has improved the results of reconstruction of orbital floor after total maxillectomy, preserving the eye. Good functional and esthetic outcome was achieved. Though visual acuity, eye movement, and patient esthetic satisfaction were comparable between those who had a bony reconstruction or not, abnormal globe position was seen more often in those patients with no bony reconstruction. Though our study favors a bony orbital reconstruction, a larger study with adequate power and equal distribution of patients among the groups would be needed to determine this. FFF remains the commonest choice when a bony reconstruction is contemplated.

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