Reconstruction of the Maxilla with Loss of the Orbital Floor and Orbital Preservation: A Case for the Iliac Crest with Internal Oblique

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ABSTRACT

Although many techniques have been described to reconstruct the midface and the maxilla, there remains little agreement on the most effective methods when the orbit itself is preserved but there is loss of the maxilla, orbital floor, and often the medial wall. If the principle of replacing form and function is to be preserved, then a complex three-dimensional bony shape is required, which can support the orbital floor and provide a functioning dentition through an implant-retained prosthesis. At the same time, the oral fistula must be closed and a nasal lining provided. The iliac crest with internal oblique provides a bone structure that can be shaped for the defect and can easily articulate with the malar remnant, the nasal bones, and the upper alveolus. The internal oblique muscle effectively closes the oral fistula and lines the nasal cavity and becomes epithelialized resulting in a natural appearance. This article describes the principles of use of the iliac crest with internal oblique in the reconstruction of this defect and compares this technique with the many other methods reported in the literature. The article is mainly descriptive as there are few comparative studies comparing reconstructive techniques for a similar defect.

KEYWORDS: Maxilla, reconstruction, iliac crest

The loss of the maxilla through trauma or malignancy can result in a series of defects with differing complexity. This ranges from a class I defect in which there is no oro-antral fistula to the loss of the entire maxilla including the orbit (class 4; Fig. 1).¹ This article will concentrate on the class 3 defect in which the maxilla is lost along with orbital support (floor and medial wall) but the orbit is preserved. Removal of the orbit is less of a problem after reconstruction because the function and appearance of the eye do not contribute to enophthalmos, ectropion, ptosis, and diplopia. The hard

palate and alveolar bone have been removed complicating the process of providing a functioning dentition on the side of the ablation. The problem of providing a functioning dentition will increase if it is necessary to extend the resection across the midline (Class 3b to 3c).

The purpose of this article is to discuss the options for the reconstruction of the class 3 defect (without loss of facial skin) assuming a patient medically fit and keen to have the best possible long-term result in terms of facial aesthetics, orbital function, and oral rehabilitation.

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Figure 1 Classification of the maxillectomy defect.

ANATOMY OF THE CLASS 3 DEFECT

The maxilla is a bone covered in mucoperiosteum that provides support for the orbit, lateral nose, dentition, and the facial skin. It contains the maxillary sinus, which lightens the bone and is lined by respiratory epithelium. The immediate bony relations are the nasal bones medially, the frontal and zygomatic bones laterally, and the pterygoid plates posteriorly. The infraorbital nerve leaves the maxilla at the infraorbital foramen and supplies sensation to the upper lip and the lateral nose.

A MULTIDISCIPLINARY APPROACH TO REHABILITATION OF THE MAXILLECTOMY PATIENT

The prosthetic rehabilitation for any patient losing the functioning alveolar bone is an important consideration, and most head and neck teams will work closely with a prosthodontist when deciding on obturation or reconstruction. Class 3 and 4 defects, however, will often be treated with reconstruction, which if not planned with close cooperation with the prosthodontist may result in no dental replacement or oral rehabilitation. At our institution, most patients facing a class 3 defect will have reconstruction as the first line of treatment, followed by oral rehabilitation.

In a class 3 defect, the main problem with obturation is the scarring that results in the classic short upper lip and the tendency for ectropion and enophthalmos to develop around the orbit. Often, the support to the facial skin is also compromised, and all

these complications may be worsened if postoperative radiotherapy is part of the treatment. The retention of the obturator may also be compromised due to its size and extent. In the class 3b defect, there is little alveolus remaining to support the denture and obturator, and the need for a reconstructed maxilla increases.

AIMS OF RECONSTRUCTION

1. To support the orbital contents and reduce the risk of enophthalmos and ectropion.
2. Provide an epithelial-lined structure for the side of the nose to maintain an open airway.
3. Provide support to the facial skin in the anterior face and the zygomatic buttress region.
4. Provide a base for the retention of a dental prosthesis either tissue-borne or implant-retained.
5. Close the oro-antral and oronasal fistulas.
6. Obturate antral region with vascularized tissue to support the orbital reconstruction.

Some of the comments in the literature emphasize the complexity of this defect and highlight the controversy surrounding its management in reconstructive surgery. In 1989, J.J. Coleman made the comment, "Reconstruction of the entire structure is much too complex and simple replacement in a bulk fashion is more appropriate."² In a recent article, the following comment was made: "No single reconstructive technique has been described to achieve all of these goals."³ Although I

would agree that the reconstruction of the entire structure is too complex, I would emphasize tailoring the reconstruction to fulfill as many of the goals set out above. Whereas it may be conceded that all of these goals may not be reached for all patients, I hope to make the case for the iliac crest and internal oblique muscle free flap as that most likely to give the patient an optimum result.

The experience of any single unit in the management of the class 3 defect is limited. At our own institution in Liverpool, we have treated 18 (11%) cases of the class 3 defect out of a total of 168 cases of maxillectomy since 1992. There have been two studies published comparing obturation versus reconstruction, but in one the authors only considered class 2 defects (eight cases),⁴ and in the other from our institution there were only three cases of class 3 defects (two reconstructed and one obturated) from which no conclusion could be made.⁵ In general, patients had less pain and better function with a reconstructive option. I am not aware of any studies, that have compared different reconstructive options for the maxillectomy defect.

RECONSTRUCTIVE OPTIONS

The methods of reconstruction available at present can be divided into six types.

1. Temporalis or temporoparietal composite pedicled flaps for restoration of the orbital floor (with/without obturation).
2. Soft tissue ablation of the defect.
3. Soft tissue ablation of the defect with restoration of the orbital floor with/without maxilla with nonvascularized bone or titanium mesh (with/without obturation).
4. Composite reconstruction of the orbital rim but no replacement of the dentoalveolar bone (with/without obturation).
5. Composite reconstruction of the dental alveolus (with/without reconstruction of the orbital rim with alternative methods).
6. Composite reconstruction of the orbital rim, anterior maxilla, and dental alveolus.

I have reviewed the literature specifically looking at publications relating to the class 3 defect, and this is summarized in Table 1.

1. Temporalis or temporoparietal composite pedicled flaps for restoration of the orbital floor (with/without obturation).

This technique aims to reconstruct the orbital floor alone with a pedicled vascularized flap based on the temporal branches of the maxillary artery (temporalis) or the superficial temporal vessels (temporoparietal

flap). The rest of the defect can be treated with either a free flap to restore the maxilla and maxillary alveolus or simply obturation. This option seems to supply most of the advantages of option 4 in which a free flap is used to provide vascularized bone for the orbital floor but still does not address the support of the facial skin or provide a dental alveolus. The prosthodontist would probably prefer a larger cavity for the obturator afforded by this simpler option. Filling the maxillary defect with soft tissue alone does not provide the basis for dental restoration, which can be achieved by obturation.

2. Vascularized soft tissue obturation of the defect.

This is a reasonably popular technique with 18 cases reported using rectus, radial, and latissimus dorsi. This is an inadequate reconstruction, however, as the failure to address the support of the orbit with bone will result in ectropion, vertical dystopia, and enophthalmos in the longer term. The reconstruction of the orbital floor with either vascularized bone (options 1, 4, 5, and 6) or nonvascularized bone (option 3) is a minimum requirement if a reasonable long-term result is to be achieved in the class 3 defect.

3. Vascularized soft tissue ablation of the defect with restoration of the orbital floor with/without maxilla with nonvascularized bone or titanium mesh (with/without obturation).

This is the most widely reported technique with 59 cases reported using the rectus abdominis flap ($n=28$) or the radial forearm ($n=31$). The radial forearm cases reported have used titanium mesh, which either restores the orbital floor alone and is augmented by obturation or restores the whole of the maxilla including the orbital floor anterior wall and alveolus. It is uncertain whether this reconstruction will withstand radiotherapy, and in the large series reported, there were five cases of titanium dehiscence.²⁰ At Memorial Sloan-Kettering, the preferred option is the rectus abdominis flap, which obturates the defect and is supported by either nonvascularized iliac crest for the body of the maxilla and usually cranial bone for the orbital bone reconstruction.¹² The principle is that the rectus abdominis supplies the vascularized bed for the nonvascularized grafts, but dental rehabilitation will be limited on the side of the defect. In this series (13 surviving patients for assessment), there were 10 patients with ectropion in which this was considered severe in 2 cases. Three patients underwent further bone grafting procedures to address the problems of facial support, and six patients had surgery to correct the ectropion. Only 7 of the 13 surviving patients received a dental prosthesis, and none of these were implant-retained. The results using this

Table 1 Reconstruction of the Class 3 Defect

Author	Year	Type of Flap	Type of Reconstruction	No.	Comment
Askar ⁶	2003	Radial forearm	3	1	Use of palmaris longus tendon to suspend orbit (no dental rehabilitation)
Bianchi ⁷	2005	Rectus with ribs	4	1	Nonvascularized iliac crest for orbital floor and walls (no dental rehabilitation)
Brennan ⁸	2008	Iliac crest and coronoid transfer	1	1	Iliac crest for face and alveolus, coronoid for orbit
Brown ⁹	2002	Iliac crest	6	6	4 survived: 1 no oral rehabilitation, 1 conventional denture, 2 implant retained dentures
Chang ¹⁰	2003	Fibula	6	1	Secondary reconstruction, no comment on oral rehabilitation and oral closure
Chepeha ¹¹	2005	Composite radial	4	4	Obturation
Cordeiro ¹²	1998	Rectus	3	12	With calvarial, rib, or iliac nonvascularized grafts Ectropion occurred in 10 cases
		Temporalis	1	2	Obturation
Davison ¹³	2004	Rectus with vascularized rib	6	4	
Granick ¹⁴	1990	Scapula	6	2	1 case of enophthalmos
Hashikawa ¹⁵	2006	Radial forearm and titanium mesh	3	5	Obturation
Lee ¹⁶	1999	Calvarial bone flap	1	4	Obturation
McLoughlin ¹⁷	1993	Composite radial	4	1	
Muneuchi ¹⁸	2006	Radial	2	4	Costal cartilage for the orbit
		Rectus	2	4	Tip of scapula for orbit
		Rectus	3	4	
		Scapula	4	1	
Nakayama ¹⁹	1994	Fibula	6	1	
Nakayama ²⁰	2004	Radial and titanium mesh	3	18	5 patients with exposed titanium
Peng ²¹	2005	Fibula	6	6	Flap inadequate to restore the infraorbital area and maxilla
Pryor ²²	2004	Temporalis	1	2	Coronoid transfer with temporalis
Sakuraba ²³	2003	Rectus	2	3	With fenestration and obturation
Schmelzeisen ²⁴	1998	Radial	3	1	Iliac crest
		Scapula	4	4	
Schusterman ²⁵	1993	Composite radial	4	1	
		Scapula	6	1	
Shestak ²⁶	1988	Latissimus dorsi	2	3	
Smolka ²⁷	2005	Temporalis	1	4	2 with bone
		Radial	3	3	Iliac crest
		Scapula	6	8	
		Iliac crest	6	1	
Triana ²⁸	2000	Rectus	2	4	With angle of scapula
		Rectus	3	5	
		Composite scapula	6	1	
		Latissimus dorsi	6	1	With scapula
Yamamoto ²⁹	2004	Rectus	3	7	6 with costal cartilage and 1 with titanium
		Scapula	3	1	With titanium
		Latissimus dorsi	4	7	With scapula for orbital rim and 1 also with rib

method of reconstruction indicate that nonvascularized bone grafts supported by a soft tissue free flap are not sufficient to prevent ectropion, facial collapse in the longer term, and a full dental rehabilitation for the class 3 defect.

4. Composite reconstruction of the orbital rim but no replacement of the dentoalveolar bone (with/without obturation).

The vascularized bone is used purely for the reconstruction of the orbit in this option with no attempt to

address the support of the facial skin or provide a functioning dental alveolus. The methods reported for this method of reconstruction have been the scapula bone on the circumflex scapula vessels as routine^{18,24,25} or use of the angular branch of the thoracodorsal vessels with latissimus dorsi, which reduces the harvest of bone to the angle of the scapula.²⁸ The other favored method is the composite radial forearm flap (five cases),^{11,17} and one case of the rectus flap with rib has been described.^{7,13} In four of the radial cases reported, obturation has been included to provide the dental and facial support.¹¹ Although this is a reasonable option, it is difficult for the prosthodontist to have an ideal site to retain an obturator (radial forearm skin), and the longer term results may not be stable. For class 3a defects, it may be possible to provide a small denture on the operated side, but dental rehabilitation would not be possible for edentulous cases or for class 3b to 3c with this option.

5. Composite reconstruction of the dental alveolus (with/without reconstruction of the orbital rim with alternative methods).

I was surprised that there was only one instance of a pedicled flap to restore the orbital rim and floor augmented with a free flap to restore the dental alveolus. This would be a reasonable option if a more commonly used composite flap such as fibula were preferred to iliac crest. Use of nonvascularized bone or titanium for the orbit when only the alveolus is being restored without sufficient vascularized tissue to obliterate the sinus risks loss of the graft and is not a recommended treatment. Use of a fibula flap to restore the dental alveolus with an additional pedicled flap to reconstruct the orbit addresses the orbital and dental reconstruction, although there is insufficient bone to support the facial tissues in the longer term.

6. Composite reconstruction of the orbital rim, anterior maxilla, and dental alveolus.

This is the ideal reconstruction, which addresses the main reconstructive problem for this complex defect. Unless a sufficient height and thickness of bone is transferred to span the height of the maxillary bone from the orbital rim to the dental alveolus, then either there is a significant risk of enophthalmos, ectropion, and vertical orbital dystopia or the patient will not have the basis for a full dental rehabilitation. It is immediately apparent from Table 2 that all of the composite flaps apart from radial and lateral arm have been described in similar numbers. This emphasizes the difference of opinion regarding the best method of reconstruction as well as the complexity of the problem itself.

The rest of this article concentrates on the current reconstructive options with the aim of a full reconstruction in terms of form and function for the midface defect (option 6).

COMPOSITE RECONSTRUCTION OF THE CLASS 3 MAXILLARY DEFECT

Use of options 1 to 5 does not address the whole of the reconstructive problem but concentrates on those areas thought to be the most important. Options 2 and 4 ignore the problem of oral rehabilitation and simply obturate the defect with vascularized soft tissue with either titanium or nonvascularized bone to restore the orbital bone loss. In option 5, attempts are made to address the two most important issues, which are the reconstruction of the orbital floor and the restoration of the functioning alveolus, although I could find no cases reported. This option risks orbital complications unless vascularized tissue is used in this area, and the problem of the collapse of the facial skin largely unsupported is also a longer-term risk. This is emphasized by the high number of cases of ectropion reported when no bone is available for the facial and orbital support.¹²

Table 2 Summary of the Reconstructive Options Reported in the Literature (See Table 1)

Reconstructive Option	No. of Cases	Techniques Used
1. Pedicled flap for orbit $\pm$ bone	12	Temporalis + obturation 2, temporalis 4, calvarial bone 4, coronoid transfer 2
2. Soft tissue ablation	18	Rectus 11, radial 4, latissimus dorsi 3
3. Soft tissue + orbital floor	56	Radial 28, rectus 28
4. Composite flap for rim only	190	Latissimus dorsi with scapula 7, scapula 5, composite radial 6, rectus (rib) 1
5. Composite flap for alveolus + pedicle flap for orbit	1	Iliac crest and coronoid transfer 1
6. Composite flap for complete reconstruction	32	Scapula 12, fibula 8, iliac crest 7, rectus (rib) 4, latissimus dorsi with scapula 1

A

B

Figure 2 Natural healing of the muscle to replace the alveolar and palatal mucoperiosteum. (A) Implant-retained bar appliance for the retention of a partial denture after maxillectomy and reconstruction with iliac crest and internal oblique. (B) Denture in place.

ILIAC CREST WITH INTERNAL OBLIQUE

The class 3 maxillary defect without the loss of facial skin or the soft palate is formed by the loss of bone covered in mucoperiosteum. As a result, the vascularized iliac crest with internal oblique provides the ideal oral and mucosal reconstruction and provides sufficient bone in both height and depth to address the orbital, facial, and dental support. Use of the muscle in the oral cavity provides an ideal oral lining, which requires minimal preparation for the placement of dental implants if the proposed prosthesis is implant-borne (Fig. 2). The height of the bone easily reaches the

floor of the orbit, the zygomatic buttress, and the nasal bones, and this graft can be shaped to fully articulate with the residual facial skeleton (Fig. 3). The orbital floor has to be reconstructed with either more bone from the hip donor site (nonvascularized) or the cranium, the coronoid process on temporalis, the outer cranial bone on a temporoparietal flap, or shaped titanium. The internal oblique provides the vascularized bed for nonvascularized grafts or titanium to survive without infection by obliterating the sinus cavity and lateral nasal defect with vascularized muscle.

If the defect involves the lateral nasal bones, then the iliac crest can easily be fashioned to complete the reconstruction of the lateral nasal bones and articulate with the remaining nonresected bone. (Figs. 3 and 4)

There are some complex midface defects with extensive bone loss that can only be reconstructed with this option illustrated in the following case.

Figure 3 Fashioned iliac crest graft to articulate with the nasal bones, zygomatic buttress, and alveolus.

CASE REPORT (CLASS 3b)

This woman was referred to the head and neck service in Liverpool after the treatment for a slow-growing carcinoma arising in the maxilla. The condition was diagnosed in April 2000 when she underwent a class 2 maxillectomy on the right side and temporalis flap reconstruction for what was diagnosed at the time as a myoepithelioma. The patient developed further disease on the left side treated in a similar way with a temporalis from the left. Osseointegrated zygomatic implants were then placed bilaterally to try and provide an implant-retained prosthesis, which was not possible as further recurrent disease developed on the right side, which was the current situation at the time of her referral to the head and neck unit in December 2003.

Figure 4 Class 3b defect reconstructed with iliac crest and internal oblique. (A) Iliac crest graft in place with separate bone from the iliac crest to articulate with the nasal bones and form the orbital floor. (B) Eighteen months postoperative facial view demonstrates good support of the orbit and facial tissues. (C) Orthopantomogram shows the extent of the reconstructed maxilla.

The problem of bilateral facial collapse with a slow-growing recurrence in the right maxillary region is clear in Fig. 5A–C. Further attempts at resection would result in a class 3b maxillary defect extending across the midline as far as the zygomatic buttress on the left side. Fortunately, the left orbital floor was intact, and there was no sign of recurrent disease on this side requiring further resection. Intraoperative photographs (Fig. 5E, F) illustrate the reconstructive problem and show use of the iliac crest with internal oblique muscle, which in our view is the only option that will provide sufficient height and depth of bone to support the right orbital floor

reconstruction, the alar base bilaterally, and provide a basis for a full dental rehabilitation. The muscle successfully closed the small oronasal fistula, and the overall reconstructive result was a marked improvement on the facial appearance at presentation (Fig. 5G, H).

COMPOSITE FIBULA FLAP

This flap has been described many times for the treatment of the class 2 defect, which is probably the best option as the pedicle length is a distinct advantage and the height and depth of bone is sufficient to

Figure 5 Case report of a patient with recurrent myoepithelioma requiring a class 3b maxillectomy. (A) Facial view prior to reconstructive surgery with an extensive recurrence on the right side. (B) Lateral view to show the extent of the facial collapse. (C) A further view to show the nasal collapse. (D) Computed tomography (CT) scan to show the extent of the recurrent tumor on the right side.

Figure 5 (Continued) (E) Intraoperative view to show the reconstruction of the right side of the maxilla and support of the orbital floor. (F) Further intraoperative view showing the nasal piriforms carved out of the iliac crest. (G) Postoperative facial view showing good support of the orbit. A temporary tarsorrhaphy was required in the early postoperative period. (H) Postoperative lateral profile. (I) Reconstructed CT scan during the planning for implants, which could not be performed due to further recurrent disease. As a result, no longer-term photographs are of value as the recurrence involved the right orbit.

reconstruct the resultant defect and provide a reasonable lining for an implant-retained oral prosthesis. Extending this flap to the class 3 defect has been described,^{21,30} but this requires three osteotomies and a complex orientation of the skin islands to reconstruct the nasal lining and to close the oronasal and antral fistula. The three osteotomies risk the blood supply to the bone, and by the time this is done, the length of the pedicle will be considerably shortened losing this advantage. The other problem with this option is the articulation of the bone with the resulting defect. Articulation of the segment restoring the orbital rim can be easily achieved from the zygomatic buttress, but articulation with the nasal bones especially if part of these has been removed with the resection can be more difficult. The vertical osteotomy must then articulate with the remaining dental alveolus, which is often more medial than the position of the residual nasal bones. It is difficult therefore to correctly articulate the bone from the nasal region to the dental alveolus and shape the nasal piriforms as seen in Fig. 5. This option is not possible for alveolar defects crossing the midline (class 3b to 3c) as the position of the alveolar segment is determined by the extent of the nasal bone resection. A similar problem arises with the articulation of the component of the graft replacing the dental alveolus. In some way, this bone must articulate not only with the vertical component of the graft or the midline dental alveolus but also with some residual bone in the region of the posterior maxilla. It is unusual in most maxillectomies to leave the pterygoid plates, which would mean articulating with the residual zygomatic buttress that is already taken up by the bone used to reconstruct the orbital rim. Peng et al²¹ reported the largest series of maxillary reconstruction using this flap and conclude that the flap is inadequate to restore the anterior wall of the maxilla and the orbital rim in the class 3 defect.

The composite fibula flap is very useful in the reconstruction of the midface as long as the defect is a relatively low maxillectomy not requiring bilateral alar support. As in mandibular reconstruction, the flap requires extensive manipulation to fit defects in which the height of the bony reconstruction is paramount as in the class 3 maxillectomy.

COMPOSITE SCAPULA FLAP

The standard composite scapula flap on the circumflex scapula vessels is well-known, but the tip of the scapula can also be used on the angular branch of the thoracodorsal system. This allows for use of the latissimus dorsi muscle as well as skin if required. The main advantage of this approach is the increased pedicle length of the thoracodorsal vessels, although

the amount of vascularized bone is reduced relying only on this blood supply. The pedicle length possible for the standard flap with a better blood supply to the bone is much shorter and akin to the iliac crest. There is an option to lengthen the artery by the dissection of the thoracodorsal artery, which can be used as a reverse-flow system to vascularize the flap based on the circumflex scapula vessels. The multiple valves in the thoracodorsal vein reduce this option for a longer venous pedicle. The scapula bone is often thin and inadequate for an implant-retained prosthesis, and although sufficient height of bone can be harvested to restore the anterior maxilla, this thin bone may not be sufficient to provide a basis for orbital support. In cases in which a part of the nasal bone requires removal, there may be insufficient bone to fully restore this area. If the flap is based on the circumflex scapula vessels, there may be insufficient tissue to fully obturate the antral region and support a nonvascularized bone graft for the orbital floor or the shaped titanium mesh. The skin island in the scapula flap is often thick, and this may cause ptosis of the flap into the oral cavity. Use of a dental prosthesis in such circumstances is difficult, and the preparation required for an implant-retained oral prosthesis would require extensive reduction of the oral flap with potential problems related to scarring in the region of the upper lip.

LATISSIMUS DORSI WITH THE TIP OF THE SCAPULA SUPPLIED BY THE ANGULAR BRANCH OF THE THORACODORSAL PEDICLE

The main advantage of this option is the extra pedicle length due to use of the thoracodorsal vessels to provide the blood supply to the composite part of the scapula supplied by the angular branch of the thoracodorsal system. The latissimus dorsi muscle is very useful for the full ablation of the antral dead-space and to provide a reliably vascularized bed for any nonvascularized graft used to reconstruct the orbital floor and medial wall. The muscle will epithelialize well and provide a natural environment for any dental rehabilitation that is planned. The main disadvantage of this option is the relatively thin bone at the tip of the scapula, which can provide a reconstruction of the orbital floor or the anterior antral wall but is insufficient in height and depth to provide a reliable basis for an implant-retained oral prosthesis.

RECTUS ABDOMINIS FLAP WITH RIB

Although four cases of complete reconstruction of the class 3 defect have been reported in the literature,¹³ this option has many disadvantages. Very few head and

neck surgeons have experience of this composite flap, for the main reason that the blood supply from the inferior epigastric vessels to the bone is relatively poor. The rib cannot be reliably osteotomized to adapt to the shape of this complex defect, and so a complete reconstruction, which is adequate and reliable, is much less likely than the options already discussed. The oronasal fistula must be closed with the rectus skin and so the risk of the flap hanging down into the mouth (ptosis) is relatively high. On the other hand, the length of the pedicle is an advantage, and although there is a risk of incisional hernia, the donor site is generally well tolerated.

DISCUSSION

In the classic class 3a defect, the main requirement to restore form and function is the provision of adequate bone with sufficient mucosal cover. The maxilla is a complex three-dimensional bone structure covered in mucoperiosteum. It is a static structure that provides support for the dentition and the orbit as well as support for the facial tissues. The iliac crest is the best source of vascularized bone and can be shaped to fit into the maxillary defect so that articulation with the residual bone is easily achieved. The bone can also be adapted to form support for the anterior dentition in larger dentoalveolar defects as in class 3b to 3c. Use of muscle to obturate the maxillary defect and close the oronasal and antral fistulas is ideal, as although the muscle atrophies and scars, this process helps to restore the firm and immobile hard palate. The complete replacement of the anterior maxilla gives adequate support to the orbital tissues and reduces the risk of ectropion and other orbital complications (Fig. 4).

The composite scapula flap is probably the best alternative to the iliac crest as it provides sufficient height of bone to restore the facial profile and provide support for the dental alveolus. Alternative methods must be used for the full restoration of the orbital support as in all the methods described, but this is less easy with this method as the bone is very thin in the more medial part of the scapula.

In my view, use of the latissimus dorsi flap using the angular branch of the thoracodorsal vessels to vascularize the tip of the scapula provides insufficient bone to restore the maxillary alveolus. Use of muscle to close the oronasal fistula is an advantage, but the lack of bone thickness reduces the reliability of good long-term results.

Use of the fibula flap for the class 3 defect requires extensive manipulation of the bone graft. The main problem with this option is the articulation of

the graft to the defect especially in the region of the maxillary alveolus and the increasing risk to bone vascularization due to the multiple osteotomies and 90-degree angles of orientation. These factors shorten the available pedicle length, and there may still be poor support of the facial tissues in the long-term.

The popularity of the fibula graft for the reconstruction of the facial skeleton is related to the long pedicle length, the ease of two-team harvesting, the quality of the bone (although low in height), and the well-tolerated donor site. As a result, the flap has been manipulated to reconstruct virtually any defect including those in which the height of the mandible or the maxilla is the most pressing factor. In the class 3 defect of the maxilla, the main requirement of the bone is height so that the graft can span the distance between the orbital rim and the maxillary alveolus. Use of skin in the mouth is a disadvantage both in terms of the preparation required to place implants and the unnatural appearance and feel to the tongue. With the advantage clearly provided with the iliac crest and internal oblique muscle, one has to question why this option has not gained similar popularity for this class 3 defect.

Arguments Against Use of the Iliac Crest with Internal Oblique

The main arguments against use of the iliac crest with internal oblique have been the excess bulk of the muscle, the short pedicle, and the poorly tolerated donor site.

1. Excess muscle bulk.

I do not accept that the muscle is too bulky for use in the class 3a to 3c defect of the maxilla. If the bone is placed vertically as previously suggested,³¹ this leaves a reasonable opening for the muscle to be passed through the oro-antral and nasal fistula to lie behind the bone. If there is too much bulk in this area, the muscle can be shortened as appropriate. There should be no concern for any excess muscle bulging down into the oral cavity as this will atrophy over 3–4 months and leave a very natural oral cavity. The inconvenience to the patient is minimal, and the temporary excess is well tolerated.

2. Short pedicle.

There is no doubt that the pedicle length is less than that with the fibula flap but similar in length to the circumflex scapula vessels even after dissecting out the subscapular system. There is no doubt that use of vein grafts if required will increase the rate of flap failure, and this is more likely to be

required with the iliac crest donor site. Is this sufficient reason, however, to use simpler alternatives (radial, rectus, latissimus dorsi, latissimus dorsi with the angle of the scapula, and fibula) when the final form and function may be compromised? If the answer to that question is yes, then it should be accepted in surgery that a less appropriate donor site is preferred on account of the increased risk of flap failure. Unfortunately, this is not the reason given for the preference for alternative techniques even though in the papers read for this article, most of the techniques quoted claim to adequately solve the problem. In the long series of fibula flaps reported by Peng et al,²¹ there was an admission that this donor site was inadequate for the class 3 defect but an adequate alternative was not stated.

I would argue that in these days of very high success rates for free tissue transfer, we should be searching for the best possible reconstructive options in midface surgery. There are ways of solving the problems of a short pedicle in use of the iliac crest with internal oblique, and indeed these methods may be useful for any flap used in midface reconstruction in which the problem of the recipient vessels being further from the reconstructed site is always a factor.

In the preparation of the vessels for midface reconstruction, the facial vessels are always prepared in continuity. The pedicle is passed under the cheek skin but over the body of the mandible at which site it is usually necessary to perform the anastomosis. A vertical up-cut in the horizontal neck incision—as long as the mandibular branch of the facial nerve is dissected out and protected—can improve access to these vessels. If the artery is a poor outflow and will not adequately perfuse the flap, then an arterial (radial) or venous (saphenous or cephalic) graft is required and is usually successful. It is possible to increase the pedicle length by dissecting out the external carotid artery after the branching of the linguo-facial trunk, and there is the possibility of using the superficial temporal artery although this run-off may also be unreliable.

Additional pedicle length can be acquired by starting the bone cut more distally from the anterior superior iliac spine. This is especially useful in maxillary reconstruction as the bone length is usually shorter than that required for mandibular reconstruction. This decision should not be made until it is clear that the part of the bone being harvested is well vascularized by both the deep circumflex iliac artery and the ascending branch to internal oblique.

3. Donor-site morbidity.

I would argue that there is no difference between the fibula and iliac crest donor site from three articles published in the literature. Haughey et al³² compared 12 iliac crests and 9 fibulas and concluded that the iliac crest was better for the dentate mandible but made little of the donor-site difference. The group from Toronto reported on 59 iliac crests and 58 fibulas with similar results for the donor sites.³³ Although seven patients in the iliac crest group reported pain compared with one patient in the fibula patients, there were five with motor weakness in the fibula group compared with three with the iliac donor site. In our own study,³⁴ patients were brought back for an orthopedic assessment and the completion of the Harris hip score and a similar ankle score as well as the University of Washington questionnaire. In this study comparing 19 iliac crests and 16 fibula donor sites, the iliac crest was better tolerated in terms of pain and function with no effect on general quality of life domains. We have also performed a study asking patients their preference for the site of their scar if a free flap is required, and the result favored the iliac crest site over the fibula site.³⁵ On balance, there would not seem to be a significant difference in the toleration of either donor site.

CONCLUSION

It is important that we continue to strive for excellence in reconstructive surgery after the ablation of head and neck cancer. Although factors such as familiarity with a donor site or a site with a favorable pedicle may influence the choice of flap, this must not be at the expense of a less than adequate result in the reconstructive site. In the class 3a to 3c maxillary defect, the reconstruction must address the three factors of orbital support, facial support, and the provision of an adequate base for dental rehabilitation. Iliac crest with internal oblique muscle can address these three factors in the simplest and most effective way while also providing vascularized muscle to obliterate the defect, line the lateral nasal region, and close the oro-antral and nasal fistula. It is recognized that the short pedicle may cause surgical challenges in some cases, but the advantages of the superior reconstruction in this site outweigh any increased risk of flap failure.

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