

Iliac crest free flap in oromandibular reconstruction. 13 cases study

Ricostruzione oro-mandibolare con lembo libero di ala iliaca. Esperienza su 13 casi

A. BAJ, S. FERRARI, B. BIANCHI, F. LAGANÀ, G. BELLOCCHIO, E. SESENNA
Clinic of Maxillo-Facial Surgery, University of Parma, Italy

Key words

Mandibular reconstruction • Free flaps • Iliac crest free flap

Parole chiave

Ricostruzione mandibolare • Lembi liberi • Lembo libero di ala iliaca

Summary

Oromandibular reconstruction following oncological resection is particularly challenging. In this past decade, great improvements have been made, in functional and aesthetic terms, following the introduction of composite free flaps. By means of this reconstructive technique, it is, in fact, possible to restore mandibular continuity, and, consequently, the morphology of the lower third of the face; rehabilitate mastication through osteointegrated implants, and optimise the reconstruction of soft tissue, employing the fascio-cutaneous or muscular portion of these flaps. Between January 1995 and January 2001, 70 oromandibular reconstructions employing osseous free flaps were performed in the Department of Maxillo-Facial Surgery of the Ospedale Maggiore in Parma, and in 13 of these the iliac crest free flap was used. Personal experience is described regarding the indications and use of this flap.

Riassunto

La ricostruzione oro-mandibolare dopo resezione oncologica impone notevoli difficoltà. In questo ultimo decennio abbiamo osservato un notevole miglioramento, in termini funzionali ed estetici, in seguito all'introduzione dei lembi liberi compositi. Con tale modalità ricostruttiva è, infatti, possibile ripristinare la continuità mandibolare, e quindi la morfologia del terzo inferiore del viso, riabilitare la funzione masticatoria mediante impianti osteointegrati ed ottimizzare la ricostruzione dei tessuti molli, utilizzando la porzione fasciocutanea o muscolare di questi lembi. Dal gennaio 1995 al gennaio 2001 sono state effettuate, presso il reparto di Chirurgia Maxillo-Facciale dell'Ospedale Maggiore di Parma, 70 ricostruzioni oro-mandibolari a mezzo di lembi liberi contenenti osso, 13 delle quali utilizzando il lembo libero di cresta iliaca. In questo lavoro gli autori illustrano la personale esperienza riguardo le indicazioni e l'utilizzo di tale lembo.

Introduction

The reconstruction of the lower third of a face disfigured on account of a neoplastic disease, osteoradionecrosis or trauma is a difficult surgical challenge. The tridimensionality of the mandible, its anchoring function for the muscular structures and support for the teeth, as well as articulation at the basicranium, make this element unique in our skeletal system. The defects involving the mandibular segments are not exclusively bony defects, but often involve muscles, sensory and motor nerves, tegument, and teeth¹, for which the need for reconstruction is, in most cases, imperative rather than elective. Since the early 1970's, various techniques have been developed for the reconstruction of mandibular defects (Table I), almost all of which are, however, plagued by a large percentage of complications due to use of these methods, above all, in association with radiation therapy. Immediate reconstruction following major ablative surgery required due to oncological conditions in the encephalic area^{2,3} was thus heavily

criticised during those early years. Technical and scientific advances and in-depth anatomical studies have since made it possible to deal with this complex problem by using a sophisticated technique like that of vascularised free grafts.

The possibility of harvesting osseous free flaps with associated soft tissue has revolutionised the reconstruction of oromandibular defects. The quantity and quality of soft tissue – the qualifying feature of any oromandibular reconstructive technique – resistance to infection and to damage caused by the insults of radiation therapy, as well as the possibility of prosthetic rehabilitation of the osseous free flaps have brought the aims of oromandibular reconstruction to heights that were inconceivable even a decade ago³⁻⁶. There are several vascular systems from which osseous free flaps can be harvested. The two most frequently used, in oromandibular reconstruction, are the peroneal artery system and the deep circumflex iliac artery system, which, respectively, enable the fibula and the iliac crest to be used as sources of vascularised bone⁷⁻⁹. A review of the literature shows

Table I. Mandibular reconstruction.

Free grafts	Autologous Bone
	– rib
	– tibia, fibula
	– mandible
	– iliac crest
	– clavícula
	Heterologous Bone (frozen in liquid nitrogen)
	– mandible
	– rib
	Heterologous Bone
Vascularised grafts	Ceramics and Metals
	Osseous Pedicled Flaps
	– rib
	– clavícula
	– scapula
	Osseous Free Flaps
	– scapula
	– fibula
	– iliac crest
	– radius
– rib	
– metatarsal	

that Authors consider the fibula flap offered the better reconstructive option for mandibular reconstruction, in comparison to the iliac crest, and, therefore, promoted use of the former rather than the latter¹⁰⁻¹². The present report deals with personal experience and the rationale for mandibular reconstruction employing a free flap of iliac crest, in the belief that this flap is particularly indicated for that purpose and is, therefore, not to be evaluated in opposition to, but rather as complementary to the fibula free flap.

Patients and Methods

Between January 1995 and January 2001, 70 oromandibular reconstructions were performed in the Department of Maxillo-Facial Surgery of the Ospedale Maggiore in Parma, 13 of which employed an iliac crest free flap. Of the 13 patients thus treated, 6 females and 7 were males, mean age 40 years; the extent of their defects in bone, soft tissue, and nervous deficit is shown in Table II (according to Urken's 1990 classification). Three patients presented mandibular defects secondary to the surgical removal of mandibular neoplasms, one had mandibular atrophy caused by radiation therapy prescribed during childhood to cure a rhabdomyosarcoma, another was suffering from the effects of a gunshot wound, while the remaining 8 patients presented the outcomes of

surgical removal of malignant neoplasms followed by immediate reconstruction (5 cases of epidermoid carcinoma, 2 cases of osteosarcoma, and 1 case of primary intraosseous mucoepidermoid carcinoma). In our opinion, the iliac crest is the flap of choice for oromandibular reconstruction in young patients or those with a dentulous mandible, both for anterior and lateral defects, and in patients whose bone defect is more pronounced than their soft tissue defect (see discussion for the criteria used for these indications). In 4 cases, we harvested the flap together with the internal oblique muscle, utilizing the latter in the reconstruction of the intraoral soft tissue defects, which were almost exclusively confined to the mandibular crest and floor of the mouth. No osseous myocutaneous flaps were harvested. In one patient with an anterior defect, in which a fibula free flap could not be used and the intraoral soft tissue defect was severe, an iliac crest free flap was used, associated with a fasciocutaneous forearm flap in order to exploit the advantages of the former in the restoration of mandibular continuity and of the latter in the reconstruction of the mouth floor and mobile tongue. In nine patients, the defect was prevalently lateral, while in the remaining four it was anterior; in the lateral defects, the choice of the side from which to harvest the flap was ipsilateral to the lesion in 7 cases and contralateral in two. The choice of side was dictated by the manner in which the osseous portion of the flap was to be adapted and the side on which the microanastomoses were to be performed. The crest was osteotomised, as necessary, from two to four osteotomies, to give an optimal shape to the osseous flap, which was stabilised by means of a THORP-type reconstruction plate in 9 cases and with miniplates in 4, according to whether or not it would be possible to effect preplating with the reconstruction plate directly on the part being operated. In all cases, a BIM was applied for 7 days to maintain occlusion. In the four cases in which reconstruction involved also the condylar portion, the latter was suspended from the glenoid fossa by means of a metal wire. Of the 13 patients, 4 underwent prosthetic rehabilitation with osteointegrated implants. Placement was performed 18 months after radiation therapy in those cases requiring the latter. Treatment was completed with adjuvant radiotherapy in 5 patients, according to routine indications for postoperative radiation therapy. All patients treated for neoplasms were followed-up, after surgery, according to a pre-defined schedule: monthly check-ups for the 1st year, check-ups every two months during the 2nd year, every four months during the 3rd and 4th years, every six months during the 5th year, and annual check-ups after the 5th year. These patients also underwent computed axial tomography (CT) 6 months after surgery and a routine CT, chest x-ray and endoscopy every year.

Table II.

Patient	Age	RT	Defect			Reconstruction
			Osseous	Soft tissue	Neurological	
G.F.	57	Post	R-B	B	N ^{IA}	Right iliac crest + Int. Obl. M.
V.G.B.	27	–	S-B	B	N ^{IA}	Right iliac crest + Int. Obl. M.
S.M.	17	Pre	C-R-B-S ^H	–	N ^{IA}	Right iliac crest
S.D.	16	7	S ^H -B-R	B	N ^{IA}	Right iliac crest + Int. Obl. M.
D.R.	58	Post	B-S-B	B-FOM ^A -TM ^{3/4}	N ^B -N ^{IA} -N ^L	Right iliac crest + Forearm
G.A.	51	–	B-R	B	N ^{IA}	Left iliac crest * Int. Obl. M.
M.F.	49	–	B-S-B	B	N ^{IA}	Right iliac crest
C.L.	61	Post	B-S ^H	B	N ^{IA}	Right iliac crest
P.M.G.	58	Post	B	B-FOM ^L	N ^{IA}	Right iliac crest
C.C.	61	Post	S-B	B-C ^M -C ^L	N ^{IA}	Right iliac crest
D.G.M.	24	–	S ^H -B-R	–	N ^{IA}	Right iliac crest
Z.I.	25	Pre	B-R	–	N ^{IA}	Right iliac crest
P.L.	24	–	B-R	–	N ^{IA}	Right iliac crest

RT: radiation therapy; Pre: pre-operative; Post: postoperative. *Osseous defect*: S: symphyseal; S^H: parasymphiseal; B: mandibular corpus; R: mandibular ramus; C: condyle. *Soft tissue defect*: B: buccal mucosa; FOM^A: anterior floor of mouth; FOM^L: lateral floor of mouth. *Neurological defect*: N^{IA}: inferior alveolar nerve; N^B: bilateral defects; N^L: lingual nerve. *Reconstruction*: Int. Obl. M.: internal oblique muscle.

Results

IMMEDIATE

All flaps were successfully transferred, even if, in one case, due to insufficient vascularisation of the forearm free flap associated with the crest, it was necessary to revise the venous anastomosis, which enabled the radial flap to be saved.

The most frequent complication was the formation of moderate haematoma (3 cases) localised between the external portion of the flap and the cheek, while in one case an infected orolaterocervical fistula occurred.

LONG-TERM

The aesthetic results were excellent in all cases and optimal functional results were also achieved. Speech was normal in 12 out of the 13 cases and completely intelligible in the patient in whom reconstruction was effected using two free flaps. All patients can consume a normal diet (the fine functional results were achieved thanks to limited involvement of the intraoral soft tissue).

From an oncological point of view, the patients were followed up from a minimum of 1 year to a maximum of 4 years; in none of the patients has there been evidence of local or locoregional recurrence or of distant metastatic disease.

DONOR SITE

In none of the 13 cases were there any complications at the donor site.

Discussion

Following the use of osseous free flaps in the reconstruction of defects of the lower extremity, great improvements in the results have been achieved in the last decade, in reconstructive surgery, as well as in the correct definition of the time and the need for mandibular defect reconstruction¹³⁻¹⁵. The free flap technique yields aesthetic and functional results far superior to those of other reconstructive systems, and must, therefore, be considered as first choice management in any patient amenable to surgery^{10,16}. In the case of oncological patients, the advantages of immediate reconstruction have now been well defined and guarantee the greatest efficiency in this technique. It has been stressed that so-called "mandibular reconstruction" is not merely the restoration of osseous continuity, but involves a more complex reconstruction comprising intra- and extra-oral soft tissue and, in some instances, also other structures such as the motor and sensory nerves of the region¹⁷⁻¹⁹.

Optimal oromandibular reconstruction must restore mandibular continuity and, consequently, the morphology of the lower third of the face, if possible rehabilitate the masticatory function by means of osteointegrated implants, restore sensitivity of the lower lip, reconstruct, if possible, the defects of the intraoral tissue with sensory innervation, and optimise the residual movements of the tongue¹⁵. These various aspects stress the importance of the choice of flap to be used, which must take into account the amount of bone necessary, the position of the defect, the amount and site of soft tissue, and the motor and sensory deficit. In anterior defects, for example, which always require reconstruction, the amount of bone necessary is, in most cases, considerable. The bone must be osteotomised to recreate the natural curve of the mandibular arch and provide enough height to be able to accommodate implants, as well as simulate the height of the mandible. Reconstruction of lateral defects obviously requires a smaller amount of bone and osteotomies are not always necessary. In the reconstruction of soft tissue, careful evaluation is mandatory and should focus on the functional importance of the structures removed along with the mandible (tongue, floor of the mouth, soft palate) in order to be able to design an optimal functional reconstruction, locating and correcting the possible sensory and motor deficits provoked¹⁰. Furthermore, in the choice of the flap to be used, residual morbidity at the donor site must also be borne in mind. The four sites commonly used to harvest osseous free flaps are the fibula, radius, scapula and iliac crest. The characteristics of each are well documented in the literature^{7 16 20-23}. In our personal experience, we have used primarily fibula and iliac crest free flaps. The features of both flaps make them ideal for use in mandibular reconstruction, but there are also specific differences between the two and, therefore, the respective indications differ. In the 13 cases of mandibular reconstruction described here, an iliac

crest free flap was used, following the guidelines outlined in Table II.

OSSEOUS DEFECT

In our opinion, the iliac crest is the flap of choice in young patients and in those with full dentition who present either anterior or lateral defects. In this condition, in fact, the iliac bone, if compared with that of the fibula, presents a better vertical relationship with the residual mandible and is better suited to accommodate rehabilitation through prosthetic implantation, which can be positioned at the same level as the alveolar crest of the native mandible, offering a better prosthetic result. Moreover, as reported in the literature, the crest appears to be the bone best suited, in terms of quality and quantity, to receive osteointegrated implants²⁴. A sufficient height of iliac bone, furthermore, guarantees optimal support for the soft tissue of the lip, with an excellent aesthetic result both in the anterior and anterolateral areas. In anterior reconstructions, the side from which the flap is to be harvested depends primarily on the side in which the microanastomoses are to be effected. In fact, while it is clearly better to position the rim of the crest of the iliac bone inferiorly, the right side will be chosen if the surgeon wishes to place the pedicle on the right and vice versa (Fig. 1a, b). In lateral defects, the natural shape of the crest may be exploited to the utmost to reconstruct this area. The crest may be harvested ipsilateral to the defect, rotated 180° in order to utilise the rim to recreate the inferior margin of the mandible and, if necessary, exploit the angle of the anterior iliac spine to recreate the gonion angle. With this movement, the pedicle is located in a lateral position, which is the position we prefer on account of its close proximity to the neck vessels (Fig. 2a, b). Whether or not it is necessary to perform osteotomies to adapt the curves of the mandibular rims depends on the convergence or divergence of the rim of the crest itself, which varies considerably from one indi-

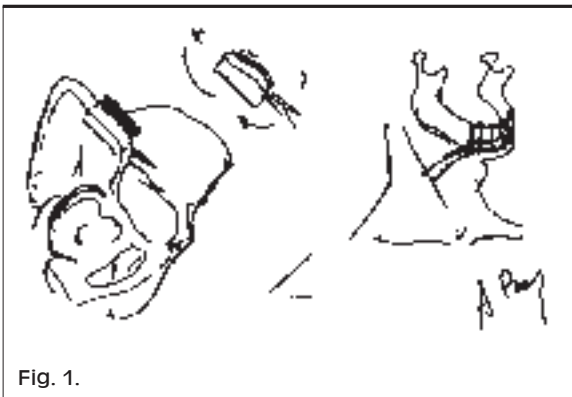


Fig. 1.

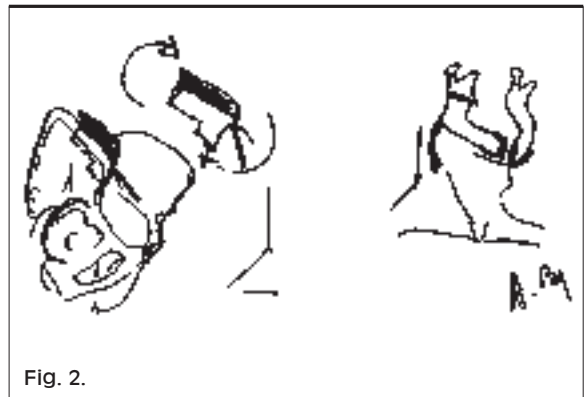


Fig. 2.



Fig. 3. Preoperative OPG: shows severe right hemimandibular atrophy.



Fig. 4. Post-operative OPG: iliac crest free flap in situ with osteointegrated implants.

vidual to another. If the resection involves also the mandibular condyle, we prefer to use the fibula free flap since reconstruction of the ramus and condyle, as well as placement in the glenoid, are undoubtedly easier, due both to its length and limited size. It is, therefore, easier to recreate a more physiological mandibular profile, in compared to that obtained from the crest, given the rather closed angle that is obtained with the latter.

SOFT TISSUE DEFECT

According to reports in the literature, and Urken in particular, the iliac crest free flap is exploited primarily because it guarantees a very considerable amount of soft tissue (skin, internal oblique m.), making it suitable for use in composite defects requiring a large amount of this tissue. Unlike Urken's proposal, we used the crest for reconstruction when the soft tissue defect was limited, since, in our opinion, despite the considerable amount of skin and muscle that can be harvested along with the crest, the former may be difficult to use on account of the complex anastomotic involvement with the underlying

bone. We, therefore, used the iliac crest for osseous defects associated with limited soft tissue defects related to the alveolar mucosa, to small portions of the floor of the mouth or to the oral vestibule, which we preferred to fill using the internal oblique muscle¹⁸. This muscle, initially over-abundant, later adapts to the defect after atrophy. The muscle removed from the iliac bone, in its inferior portion can be brought inside the oral cavity both by lifting it internally or by wrapping it around the bone graft externally. We make use of the former in the case of mucous defects that are not exclusively limited to the alveolar crest, but extend to portions of the floor, and the latter when it is necessary to cover the means of fixation or add thickness to the cheek area. If the defect involves the skin, also this free flap, like the others, reveals its limit in its own cutaneous component which, if utilised on the outside of the oral cavity, does not allow good aesthetic results due to the difference in colour. The same may be said for the use of the cutaneous portion of the flap inside the oral cavity where, on the one hand, its limited mobility does not optimise the movements of the residual tongue when the



Fig. 5. Patient's pre-operative occlusion.



Fig. 6. Post-operative occlusion.



Fig. 7. Pre-operative frontal view.

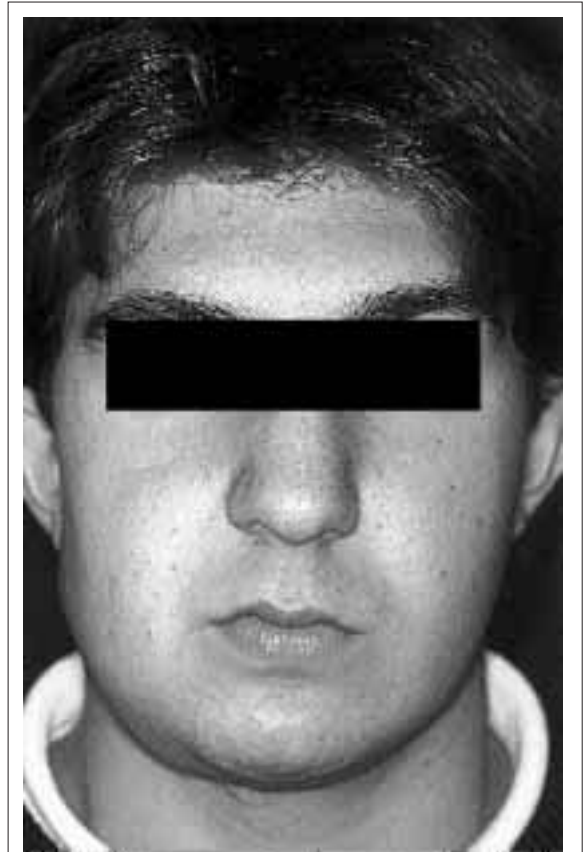


Fig. 8. Post-operative frontal view.

latter has been involved in the removal of a neoplasm and, on the other, its limited pliability prevents the oropharyngeal and soft palate areas, often involved in the removal of tumours of the trigone and tonsillar area, from being adequately reconstructed. Furthermore, the thickness of the obligatory muscle cuff makes iliac crest reconstruction of these areas functionally unsatisfactory. In our opinion, the flap of choice, in these situations, is the fibula free flap which, thanks to the greater freedom of the cutaneous component, lends itself to more functional intraoral reconstructions. In cases of extensive soft tissue sacrifice, we often decide upon the reconstructive option with two free flaps, an osseous free flap and a fasciocutaneous flap. Only in a situation in which the fibula is not usable, do we employ the iliac crest for composite defects with widespread soft tissue sacrifice. In one case, in the series, since use of the fibula for reconstruction after anterior glosso-pelvi-mandibulectomy was impossible, we decided to use the crest which, however, for the above-mentioned reasons, was associated with a second flap, as suggested by several authors¹⁷⁻²⁵, so as to exploit the potential of the iliac crest as a source of vascularised

bone and the pliability and ease of handling of the fasciocutaneous forearm free flap for the reconstruction of the mouth floor and part of the mobile tongue. The indications given here are equally valid for secondary reconstructions, provided they do not require the supply of tegument, due to the limited tissue mo-

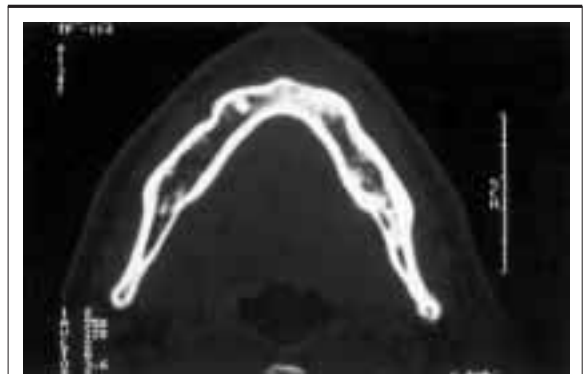


Fig. 9. CT of mandible: neoplastic infiltration of mandibular bone.



Fig. 10. Intraoperative view: iliac crest free flap is shaped and positioned to reconstruct continuity of mandibular arch, stabilised by means of reconstruction plate.



Fig. 11. Intra-operative view: harvesting of cervical rotation flap to reconstruct external side of lower lip.



Fig. 12. Pre-operative OPG.

bility determined by the radiation therapy which these patients often undergo. The transplants were completely successful, with excellent aesthetic and functional results. The latter aim, rather than through the restoration of mandibular continuity, is achieved principally through the effective reconstruction of the intraoral soft tissue which, in our indications for the use of the iliac crest, is generally minimally involved in the resection.

In conclusion, principal indications for the iliac crest free flap are, in our opinion, in the mandibular reconstructions of young patients or of those who have maintained their mandibular heights, in defects in which the sacrifice of the osseous component is greater than that of the mucosa component, and in cases in which it is not possible to harvest the fibula free flap.



Fig. 13. Post-operative OPG.



Fig. 14. Pre-operative frontal view of patient.

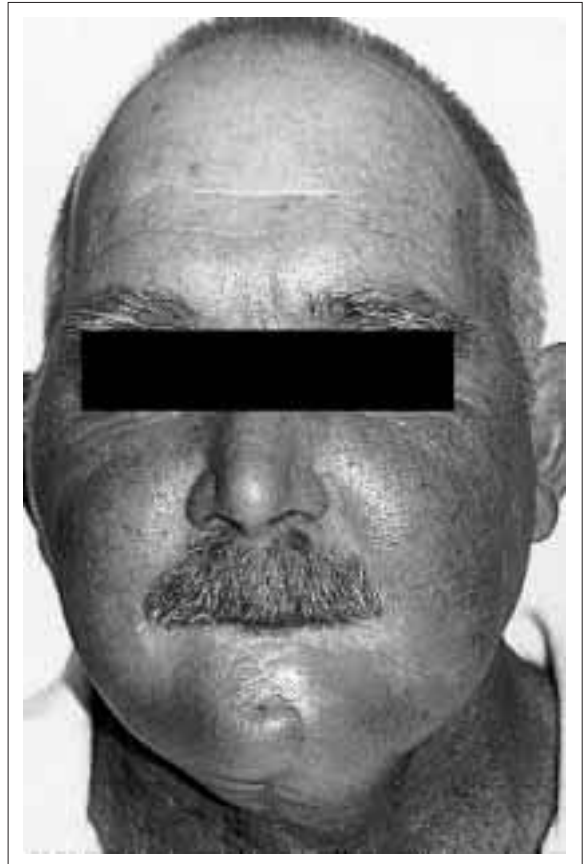


Fig. 15. Post-operative frontal view.

We are, therefore, convinced that this reconstructive option should be implemented in selected cases and that it is not to be considered a stand-by or second-

resort flap in mandibular reconstructions, but should have precise, even if limited, indications of its own.

References

- ¹ Moscoso JF, Urken ML. *The iliac crest composite flap for oromandibular reconstruction*. Otolaryngol Clin North Am 1994;27:1097-117.
- ² Kuriloff DB, Sullivan MJ. *Mandibular reconstruction using vascularized bone grafts*. Otolaryngol Clin North Am 1991;24:1391.
- ³ Lawson W, Baek S, Loscalzo L. *Experience with immediate and delayed mandibular reconstruction*. Laryngoscope 1988;92:5.
- ⁴ Daniel R. *Mandibular reconstruction with free tissue transfers*. Ann Plast Surg 1978;1:346.
- ⁵ Ostrup L, Fredrickson J. *Reconstruction of mandibular defects after radiation using a free living bone graft transferred by microvascular anastomoses: An experimental study*. Plast Reconstr Surg 1975;55:563.
- ⁶ Urken ML, Buchbinder D, Weinberg H, Vickery C., Sheiner A, Parker R, et al. *Functional evaluation following microvascular oromandibular reconstruction of the oral cancer patients: a comparative study of reconstructed and non-reconstructed patients*. Laryngoscope 1991;101:935-50.
- ⁷ Hidalgo DA. *Fibula free flap: a new method of reconstruction*. Plast Reconstr Surg 1989;84:71-9.
- ⁸ Rmasastry SS, Toker JB, Swartz WM. *Internal oblique muscle flap: an anatomic and clinical study*. Plast Reconstr Surg 1984;73:721-30.
- ⁹ Urken ML. *Composite free flaps in oromandibular reconstruction: review of the literature*. Arch Otolaryngol Head Neck Surg 1991;117:724-32.
- ¹⁰ Cordeiro PG, Disa JJ, Hidalgo DA, Hu QY. *Reconstruction of the mandible with osseous free flaps: a 10 year experience with 150 consecutive patients*. Plast Reconstr Surg 1999;104:1314-20.
- ¹¹ Hidalgo DA, Rekow A. *A review of 60 consecutive fibula free flap mandible reconstructions*. Plast Reconstr Surg

- 1995;96:585-96.
- ¹² Shpitzer T, Neligan PC, Gullane PJ, Boyd BJ. *The free iliac crest and fibula flaps in vascularized oromandibular reconstruction: comparison and long-term evaluation*. *Head Neck* 1999;21:639-47.
- ¹³ Cordeiro PG, Hidalgo DA. *Conceptual consideration in mandibular reconstruction*. *Clin Plast Surg* 1995;22:61.
- ¹⁴ Komisar A. *The functional result of mandibular reconstruction*. *Laryngoscope* 1990;100:364-74.
- ¹⁵ Urken ML. *Reconstruction of the mandible following resection for head and neck cancer*. *Head Neck Surg* 1994;8:301-20.
- ¹⁶ Farwell DG, Futran ND. *Oromandibular reconstruction*. *Facial Plast Surg* 2000;16:115-26.
- ¹⁷ Urken ML, Weinberg H. *The combined sensate radial forearm and iliac crest free flaps for reconstruction of significant glossectomy-mandibulectomy defects*. *Laryngoscope* 1992;102:543-58.
- ¹⁸ Urken ML, Weinberg H. *The internal oblique-iliac crest free flap in composite defects of the oral cavity involving bone, skin and mucosa*. *Laryngoscope* 1991;101:257-70.
- ¹⁹ Hidalgo DA, Pusic AL. *Free-flap mandibular reconstruction: a 10-year follow-up study*. *Plast Reconstr Surg* 2002;110:438-49.
- ²⁰ Swartz VM, Banis JC, Newton ED. *The osteocutaneous scapular flap for mandibular and maxillary reconstruction*. *Plast Reconstr Surg* 1986;77:530-45.
- ²¹ Soutar DS, Widdowson WP. *Immediate reconstruction of the mandible using a vascularized segment of radius*. *Head Neck Surg* 1986;8:232.
- ²² Taylor GI, Townsend P. *Superiority of deep circumflex iliac vessels as the supply for free groin flaps: clinical work*. *Plast Reconstr Surg* 1979;64:745.
- ²³ Takushima A, Harii K, Asato H, Nakatsuka T, Kimata Y. *Mandibular reconstruction using microvascular free flaps: a statistical analysis of 178 cases*. *Plast Reconstr Surg* 2001;108:1555-63.
- ²⁴ Moscoso JF, Keller J, Genden E. *Vascularised bone flaps in oromandibular reconstruction. A comparative anatomic study of bone stock from various donor sites to assess suitability for enosseous implants*. *Arch Otolaryngol Head Neck Surg* 1994;120:36-43.
- ²⁵ Wei FC, Demirkan F. *Double free flaps in reconstruction of extensive composite mandibular defects in head and neck cancer*. *Plast Reconstr Surg* 1999;103:39-47.

■ Received June 11, 2002.

■ Accepted October 9, 2002.

■ Address for correspondence: Dr. A. Baj, Cattedra e Divisione di Chirurgia Maxillo-Facciale, Università degli Studi di Parma, via Gramsci 14, 43100 Parma, Italy. Fax +39 0521 259761. E-mail: bajalessandro@hotmail.com