Use of Microvascular Free Flaps in the Reconstruction of the Anterior and Middle Skull Base

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Different reconstruction techniques of the anterior and middle skull base as consequence of a defect after surgical treatment of neoplastic pathologies are described in the literature. The aim of the present study is to present our experience regarding the use of microvascular free flaps for reconstruction of the anterior or middle skull base after large defects caused by removal of malignant neoplasms. From 2000 to 2004, in the Department of Maxillo-Facial Surgery of the University of Rome ''La Sapienza'' and ''Tor Vergata,'' 13 surgical procedures for reconstruction of anterior and middle skull base defects by free flaps were performed in 11 patients. Data on patient demographics, histopathology, location and size of defect, type of reconstruction, and postoperative complications were obtained from medical record charts. A safe soft tissue closure of the intracranial space was achieved in all patients. Defect repair was accomplished by revascularized transfer of rectus abdominis flaps in seven cases, latissimus dorsi muscle flaps in two patients, radial forearm flap in one case, and fibula flap in one case. There were two total flap losses; the secondary defect repair was accomplished in both cases by revascularized transfer of latissimus dorsi muscle flap. No donor site complications were observed in all the flaps. The mean operation time was 85 hours; patients were hospitalized for a mean period of 14 days. The method of choice for the reconstruction of anterior or middle skull base defect should be based upon careful evaluation of the single case and, particularly, the localization and entity of the residual defect. For defects that require large amounts of soft tissue, the latissimus dorsi free flap and the rectus abdominis free flap are the best appropriate choices for reconstructive procedures for anterior and middle skull base tumors.

Key Words: Skull base reconstruction, microvascular free flap, cranial base surgery

Different reconstruction techniques of the anterior and middle skull base as consequence of a defects after surgical treatment of neoplastic pathologies are described in the literature. In consideration of the particular anatomic and topographic localization of this complex, representing the anatomic boundary between the neurocranium and the splanchnocranium, these techniques often require close collaboration between the neurosurgeon and the maxillofacial surgeon.

Malignant neoplasms arising from the maxillofacial complex can spread to and involve the anterior and middle skull base. In fact, a malignant tumour arising from the maxillary sinus can spread upward and involve the ethmoid and the cribriform lamina, eroding it and trespassing into the anterior cranial fossa; in the same way, a tumor originating from the pterigomaxillary or the infratemporal fossa can spread upward and midward to the middle skull base (passing over the pterygoid muscular plane)[1] and trespass into the middle cranial fossa. Therefore, surgical treatment that respects the canons of oncologic radicality can requires the removal of the ethmoidonasal or infratemporal neoplasia ''en bloc'' with the structures forming the anterior or middle skull base.

On the other hand, reconstruction of the structures of the skull base is important because of the need of separating the intracranial compartment from the extracranial one to avoid ascending infections,

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pre-vent cerebrospinal fluid leakage, pneumoencephalon, or possible cerebral herniations.[2]

Over the years, numerous surgical variants for skull base reconstruction have been suggested, from the simplest ones (dermoepidermal free graft, pedicled flaps, galea-pericranium flaps, pericranium flaps), to more complex procedures such as heterologous material, galea-pericranium flaps with rib or iliac crest,[3] and microvascular free flaps.[4–6]

The choice of the reconstructive technique depends upon the entity and localization of the residual defect, the age and general conditions of the patient, and the presence of a highly qualified, multidisciplinary staff.

For descriptive completeness, it is necessary to remember that the reconstruction of the anterior or middle skull base can be performed for pathologies of traumatic or deforming nature as well In these cases, in accordance with the literature, indications regarding the use of microvascular free flaps are rather rare.

In the last 20 years, skull base reconstruction after neoplastic pathologies has been entrusted to the use of microvascular free flaps[4–10] harvested from various anatomic sites of the body (scapula, latissimus dorsi, radial forearm, rectus abdominis, omentum and fascia lata). The most versatile free flaps for reconstruction of the anterior and middle skull base associated with demolition of the pterigomaxillary and infratemporal fossa are latissimus dorsi and rectus abdominis free flaps.[9] When the defect is localized in the anterior skull base with the involvement of the cribriform lamina and the ethmoidal plane, the radial forearm represents the most useful free flap. The aim of the present study is to present our experience regarding the use of microvascular free flaps for reconstruction of the anterior or middle skull base after large defects caused by removal of malignant neoplasms.

Materials and Methods

From 2000 to 2004, in the Department of Maxillo-Facial Surgery of the University of Rome ''La Sapienza'' and ''Tor Vergata,'' 13 surgical procedures for reconstruction of anterior and middle skull base defects by free flaps were performed in 11 patients (Table 1).

Data on patient demographics, histopathology, location and size of defect, type of reconstruction, and postoperative complications were obtained from medical record charts. Ablation was performed by the neurosurgical and maxillofacial surgical team. The selection of flap was determined by several factors, including the amount of soft tissue required, the need for bulk or contour, and the performance status of the patient. All flap dimensions were determined individually for each patient to obtain the separation between the intracranial and the extracranial compartment as well as the obliteration of the ethmoid or maxillary cavity dead space and re-establishing facial contour. The recipient vessels of choice for the free flaps were external carotid artery and its branches and internal jugular vein and its branches. The flaps were monitored with an external Doppler probe at 8 MHz and by clinical examination of the flap.

Results

During the study period, 11 patients underwent skull base reconstruction after tumor ablation at the department of Maxillo-Facial Surgery of the University of Rome ''La Sapienza'' and ''Tor Vergata.'' The group of patients was represented by five males and six females, with ages ranging between 17 and 76 years. The histopathologic types included adenoid

Table 1. Clinical Cases

Patient	*Histologic Type*	*Involvement*	*Reconstruction (1st Choice)*	*Failure*	*Reconstruction (2nd Choice)*
P1 55YS M	Squamous cell carcinoma	ASB + MSB	Latissimus dorsi		
P2 26YS F	Adenocystic carcinoma	MSB	Rectus abdominis		Fibula
P3 52YS M	Adenocarcinoma	ASB	Radial forearm		
P4 45YS F	Ameloblastoma	MSB	Rectus abdominis		
P5 35YS F	Adenocystic carcinoma	ASB + MSB	Fibula osteomyocutaneous	X	Latissimus dorsi + scapula
P6 68YS M	Adenocystic carcinoma	ASB	Rectus abdominis	X	Latissimus dorsi
P7 60YS F	Squamous cell carcinoma	ASB + MSB	Rectus abdominis		
P8 49YS F	Adenocystic carcinoma	ASB + MSB	Rectus abdominis		
P9 35YS M	Giant cell tumor	MSB	Rectus abdominis		
P10 55YS M	Carcinoma on pleomorphic adenoma	MSB	Rectus abdominis		Fibula
P11 . 65YS F	Adenocystic carcinoma	MSB	Latissimus dorsi		

ASB = anterior skull base; MSB = middle skull base.

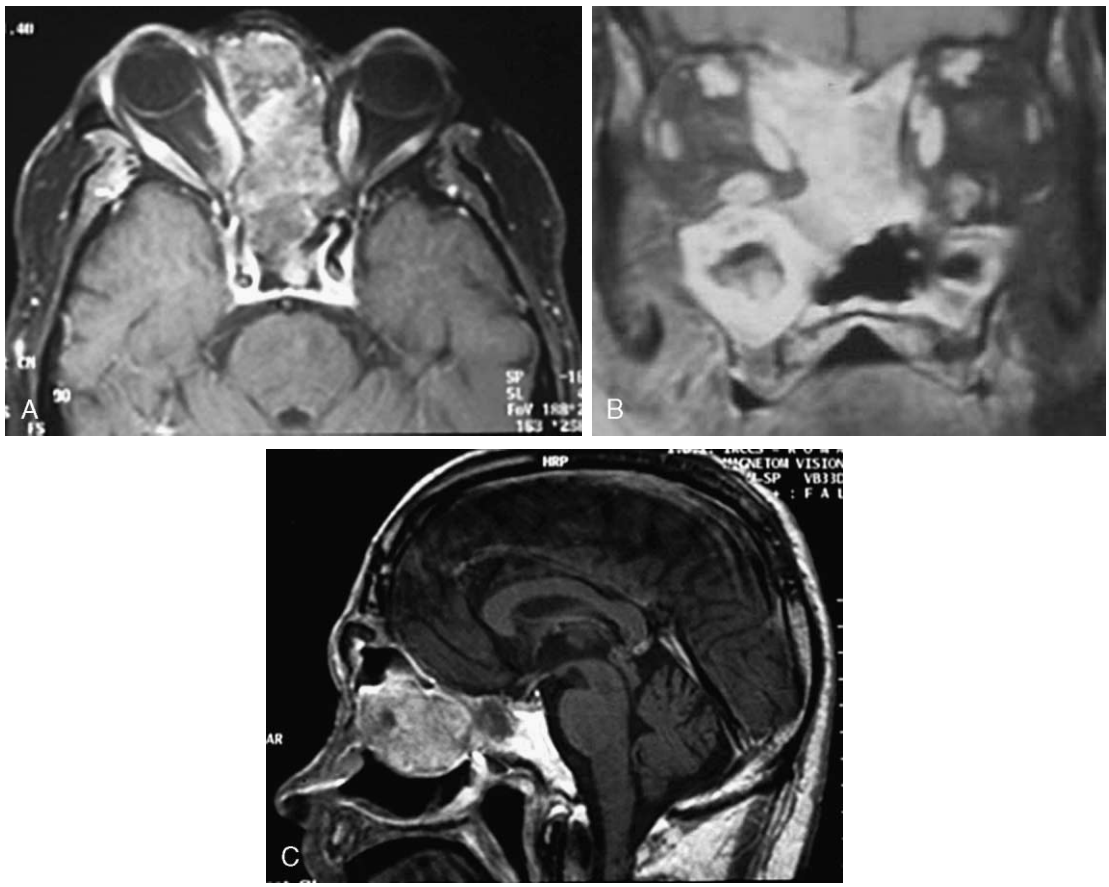

Fig 1 Preoperative magnetic resonance images of patient 3 show extension of lesion involving medial orbital wall and anterior skull base.

cystic carcinoma (5 cases), squamous cell carcinoma (2 cases), adenocarcinoma (1 case), ameloblastoma (1 case), giant cell tumor (1 case), and carcinoma on pleomorphic adenoma (1 case).

Two cases featured a residual defect in the anterior skull base after tumor removal, and these patients underwent reconstruction of the surgical wound to restoring the anatomic boundary between

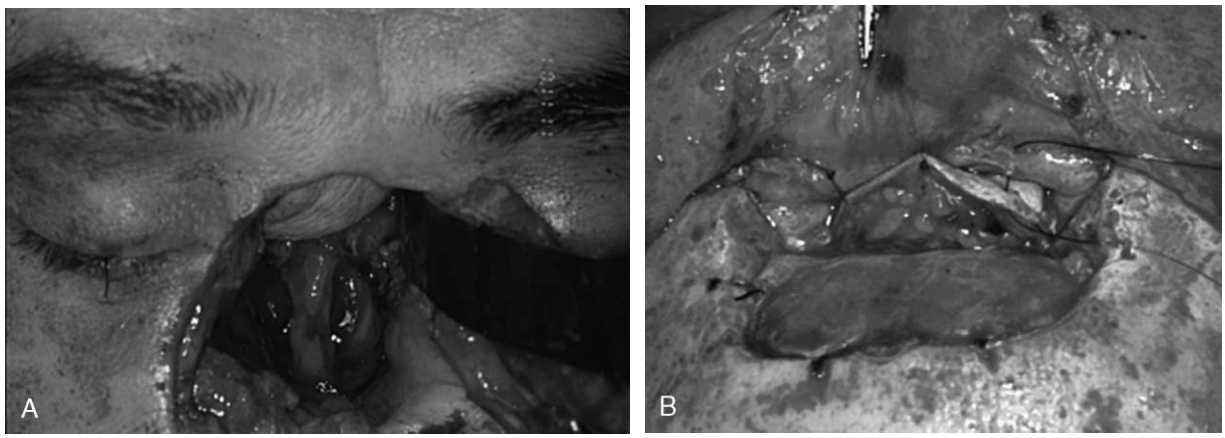

Fig 2 Intraoperative stages. (A) Surgical wound. (B) Reconstruction with a free flap of radial forearm.

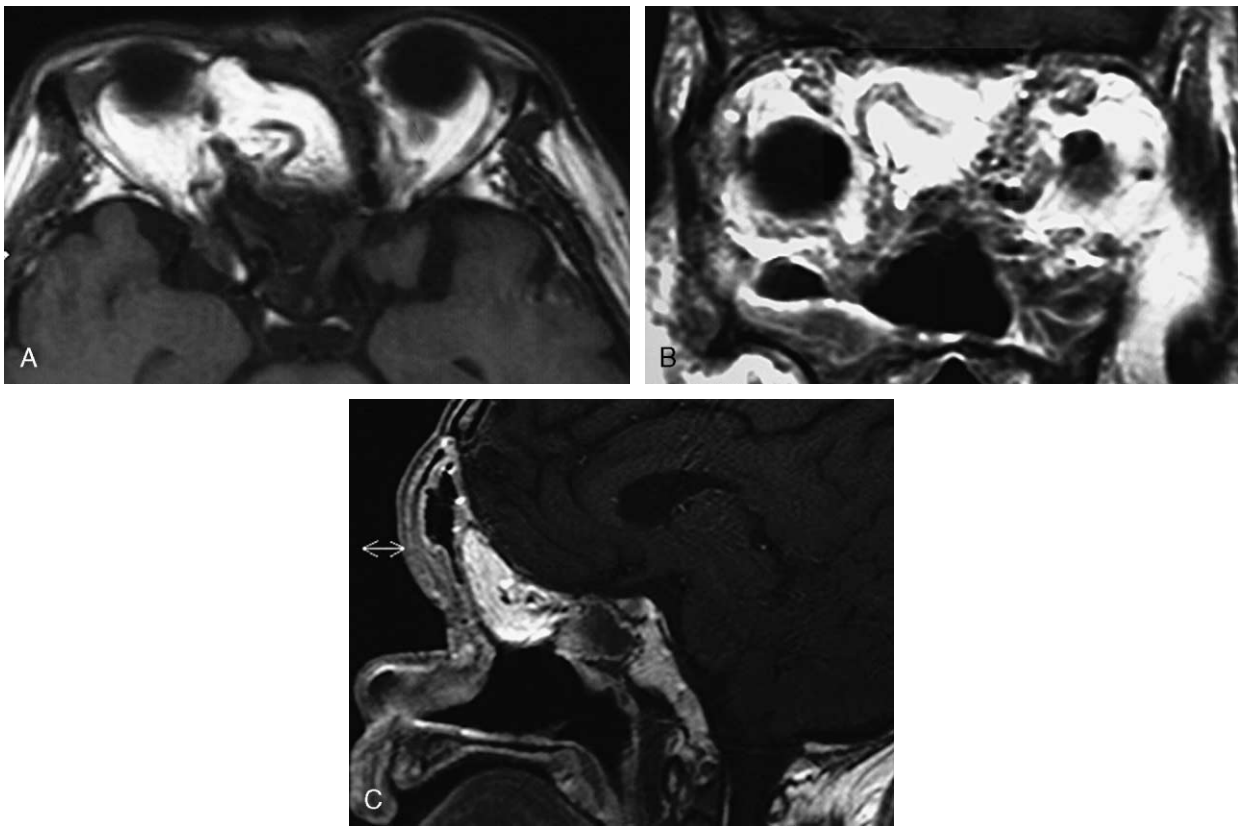

Fig 3 Postoperative magnetic resonance image demonstrates right position of flap and its vascular pedicle.

the splanchnocranium and the neurocranium by rectus abdominis free flap (1 cases) and radial forearm free flap (1 case) (Figs 1 to 3). In cases of reconstruction with rectus abdominis, a subtotal flap necrosis that occurred because of systemic septicemia required a second surgical procedure, and the secondary defect repair was accomplished by revascularized transfer of myocutaneous latissimus dorsi muscle flap.

Five cases featured a residual defect in the middle skull base after tumor removal, and reconstruction was accomplished by latissimus dorsi free flap (1 cases) and rectus abdominis free flap (4 cases) (Figs 4 to 6). In two of these cases of reconstruction with the rectus abdominis free flap, we performed a second surgical procedure by harvesting a free flap of fibula to restore the bone contour of the maxillofacial complex, thus obtaining better functional and aesthetic results (Fig 7).

In the remaining four cases, the surgical wound, after tumor removal, was localized in the anterior and middle skull base; immediate reconstruction of the middle skull base was performed with latissimus dorsi free flap (1 case) or rectus abdominis free flap (2 cases), and in only one case was the reconstruction of the surgical wound after tumor removal performed by means of a fibula osteomyocutaneous free flap.

Unfortunately, in one case in this series, partial fibula necrosis occurred because of the complexity of the reconstruction (the fibula was splinted in 4 segments). Therefore, a subscapular system free flap (latissimus dorsiscapular) was harvested during the second surgical treatment. In all cases, particular attention was given to reconstruction of the physiologic boundary between the encephalon and the lower spaces by performing repair of the dural gap with direct suture or with a patch of autologous or eterologous material.

No donor site complications were observed in any of the flaps. The mean operation time was 8.5 hours; patients were hospitalized for a mean period of 14 days.

DISCUSSION

In accordance with most authors, reconstruction of the skull base, as independent from the nature of

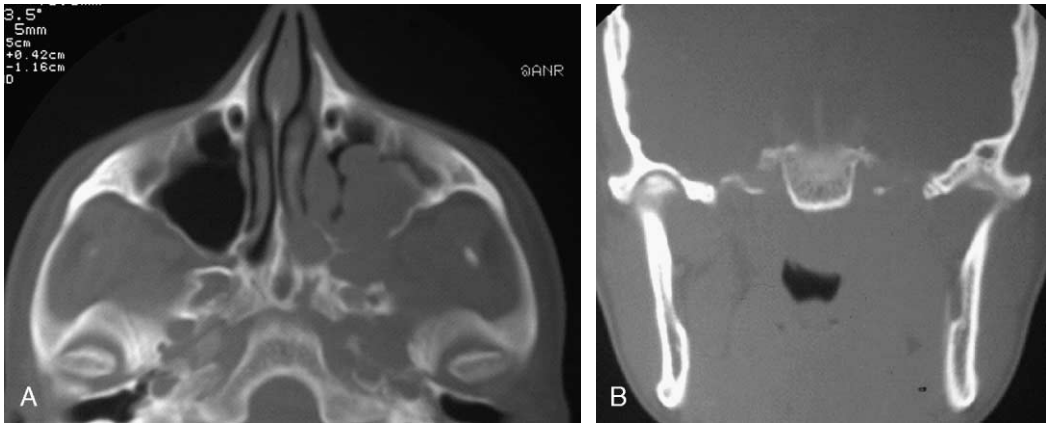

Fig 4 Pre-operative computed tomography scans of patient 2 show wide extension of tumor involving left maxilla, infratemporal fossa, and middle skull base.

the lesion, aims to prevent liquorrhea, ascending infections, cerebral herniation, and to sustain the encephalon, thus avoiding or reducing the risk of pneumoencephalon.[2] Numerous surgical techniques are described in literature for the reconstruction of the anterior and middle skull base and, according to our point of view, the method of choice should be based upon careful evaluation of the single case and, particularly, localization (anterior or middle skull base) and entity of the residual defect.

According to our experience, when limited defects of the anterior or middle skull base occur, reconstruction can be performed simply by repairing the lacerated dura mater (with a direct suture or a patch of valid and well-sutured material on the margins of resection) or by harvesting a pericranium or galea-pericranium local pedicled flap to obtain a valid boundary between the neurocranium and the splanchnocranium.

In other cases, when the dimensions of the defect are larger, in resections that include the maxilla, the orbit, the infratemporal fossa, and the middle skull base, thicker autologous material can be used, such as a pedunculated myofascial flap of the temporalis muscle associated with galea-pericranium and microvascular free flaps. Advances in reconstructive free flap techniques have lead to substantial development in the treatment of skull base tumors. In fact, in cases of tumors involving the skull base, the indication for radical surgery is limited because an adequate reconstruction of the skull base, after its demolition, is often difficult to perform.

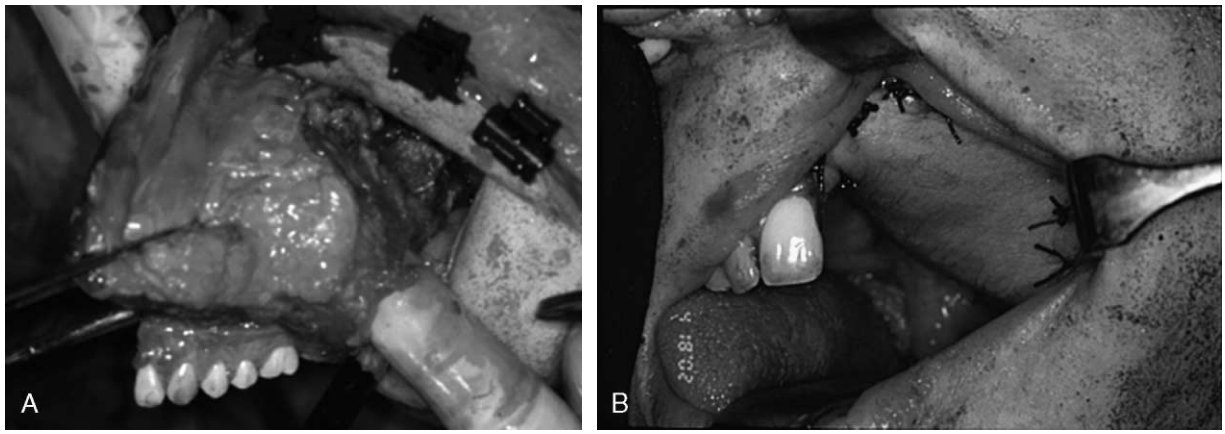

Fig 5 Weber-Fergusson and Schramm-Seckar approach in patient 2 with intraoral view of skin paddle of rectus abdominis.

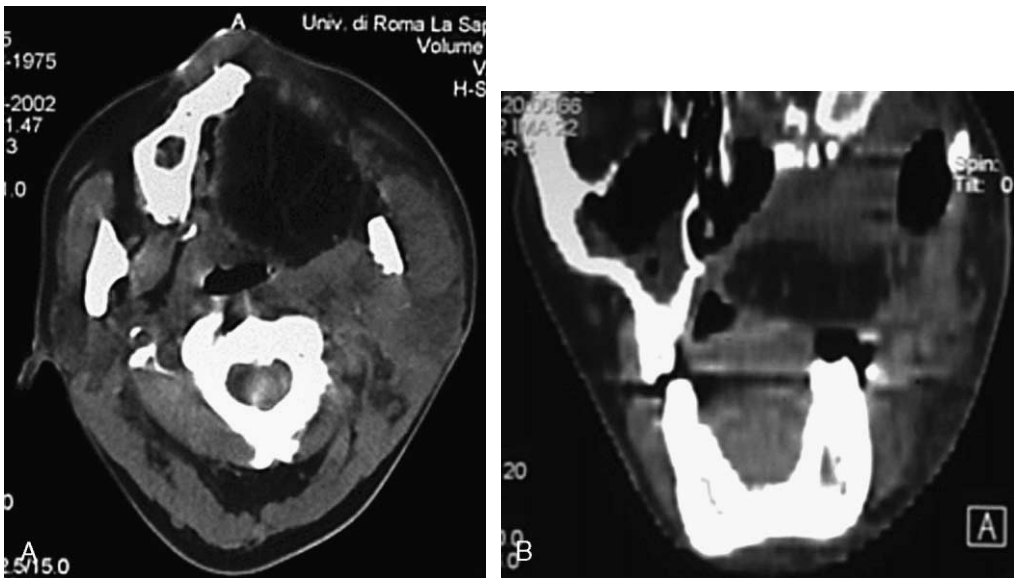

Fig 6 Postoperative computed tomography scans of patient 2 showing reconstruction with rectus abdominis myocutaneous microvascular free flap with perforating vessels in center of image.

At present, reconstructions performed through free flaps allow much wider and radical resections, early radiotherapy, when required, and effective chemotherapy. The latissimus dorsi free flap and the rectus abdominis free flap are the most frequently used reconstructive procedures for anterior and middle skull base tumors.

The free flaps of second choice are the radial forearm free flap and the omentum free flap; the first ensures thinner exiguous dimensions; the second is less indicated because of its reduced consistency. In particular, the radial forearm flap is indicated in all cases in which reconstruction of the ethmoidal planum is needed and the pericranium flap cannot be used (such as when it involves in the neoplasm or in cases of relapse when this flap was used previously).

The latissimus dorsi free flap can be harvested with its muscular component or with a relative myocutaneous component. Its main advantages are higher volume and the conspicuous length and caliber (minimum 3 mm) of the vascular pedicle; the length of the vascular pedicle (up to 16 cm), represented by the thoracodorsal vessels, also allows one to carry out microanastomoses with distant (submandibular) vessels when closer vessels are damaged or have already undergone traumatic insults during the

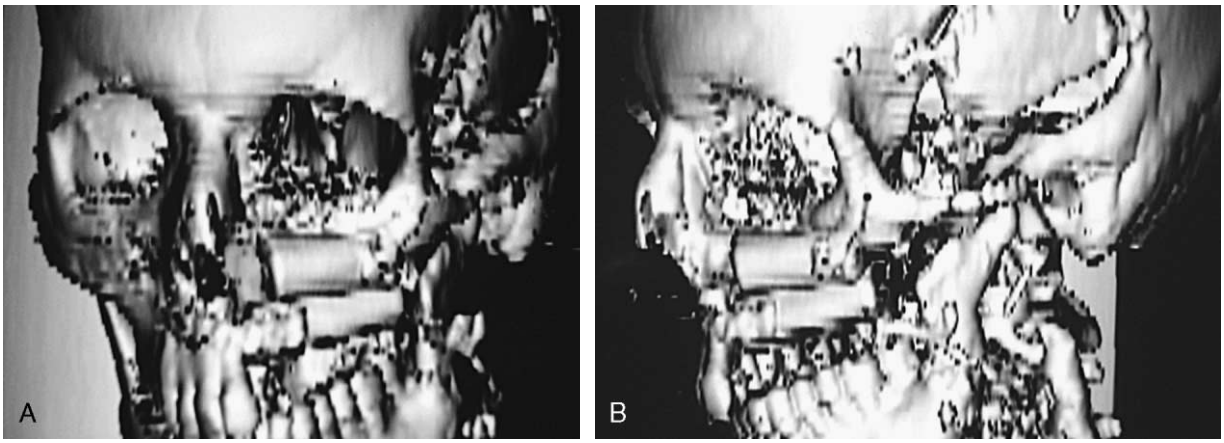

Fig 7 Three-dimensional computed tomography scans show restoration of zygoma and upper jaw performed in patient 2 fibula free flap after second surgery.

demolitive surgery. The main disadvantage of latissimus dorsi free flap reconstruction is the fact that harvesting requires the patient to lie on his or her side during surgery, with consequent remarkable increase of operative time.

The rectus abdominis free flap offers the advantage of thick, muscular tissue associated with a large cutaneous island when such is required; the deeper inferior epigastric vessels and branches of the internal iliac artery, which can be easily found and are endowed with a large caliber, represent its vascular pedicle. The rectus abdominis free flap can be harvested simultaneously with the preparation of the recipient site and vessels (2 surgical staff are required), thus not requiring the patient to lie on his or her side, with consequent remarkable reduction of surgical time. The main disadvantages of this free flap are represented by the short length of the vascular pedicle (in regard to the latissimus dorsi flap) and weakening of the abdominal wall after its harvesting. In fact, a short vascular pedicle requires execution of microanastomoses with recipient vessels near the lesion, unless a vein graft is carried out to reach the more distant vessels; moreover, the weakening of the abdominal wall may be cause herniations or laparoceles.

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