OSTEOMYOCUTANEOUS PERONEAL ARTERY PERFORATOR FLAP FOR RECONSTRUCTION OF COMPOSITE MAXILLARY DEFECTS

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Accepted 4 August 2005
Published online 14 November 2005 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hed.20345

Abstract: Background. Composite maxillary defects often involve the maxilla, nasal mucosa, palate, and maxillary sinus. We presented the surgical techniques and outcome of the osteomyocutaneous peroneal artery perforator (PAP) flap for reconstruction of composite maxillary defects.

Methods. Six patients underwent an osteomyocutaneous PAP flap reconstruction of composite maxillary defects. The average age was 52 years. The defects were Cordeiro type II in three patients and type IV midfacial defects in another three patients.

Results. No total or partial flap failures occurred. At a mean 12-month follow-up, five patients had a normal speech and were able to eat a regular diet. One patient tolerated a soft diet and had intelligible speech. One patient had ectropion develop. Excellent cosmesis was found in five patients.

Conclusions. The osteomyocutaneous PAP flap represents a further refinement of the fibula flap and increases its versatility, with multiple skin paddles, bone segments, and soleus muscle independently isolated. It is a comparable reconstruction option for composite maxillary defects. © 2005 Wiley Periodicals, Inc.

Keywords: peroneal artery perforator flap; fibula flap; composite maxillary defect; maxillary reconstruction

The maxilla is a complex three-dimensional structure functionally involved in respiration, digestion, and speech. Maxillary projection and shape also determine facial aesthetic appeal. Reconstruction of three-dimensional defects caused by congenital, traumatic, or oncologic anomalies ideally require replacement with comparable tissue in the original position of the defect. Prerequisites for this include properly oriented bony reconstruction; adequate soft tissue coverage of nasal, palatal mucosal, and/or cheek skin defects; and support of the orbital floor with dead space obliteration. The social stigma attached to maxillary defects often requires complete single-stage aesthetic restoration with functional rehabilitation to lessen this burden.1
A number of reconstructive options have been proposed for these complex three-dimensional defects, including the use of a customized prosthesis, 2 pedicled flaps, 3-6 and free tissue transfers. 7-19 Unfortunately, local and regional pedicled flaps are not always amenable to consistently reconstruct three-dimensional defects because of their limited volume and variety of tissue components. The use of soft tissue free flaps provides simultaneous obliteration of maxillary and orbital cavities. 9 However, these do not provide three-dimensional maxillary reconstructions and do not provide structural support for the use of osseointegrated implants. 1

Extensive experience with osteocutaneous free flaps such as the scapula, radial forearm, iliac, and fibula flaps in mandibular reconstruction has translated into their use for maxillary reconstruction. 10-20 Composite osteocutaneous free flaps may provide bone reconstruction, as well as soft tissue coverage in a single-stage procedure. Functional and cosmetic outcomes can be improved with insertion of osseointegrated implants into the transferred vascularized bone to support the dental or orbital prostheses. 1,16,17,19,20 Among osteocutaneous free flaps, the fibula osteoseptocutaneous flap has numerous advantages and has, therefore, been widely accepted as a good option for maxillary reconstruction. 13-20 However, most previous maxillary reconstructions used the fibula flap with a single unit of bone and skin, which may not be suitable for reconstructing composite maxillary defects.

An osteomyocutaneous peroneal artery perforator (PAP) is a refinement of the fibula osteocutaneous flap with two separate skin paddles, an isolated soleus muscle, and multiple bone segments. The purpose of this study was to review the surgical techniques and outcome of the osteomyocutaneous PAP flap for the reconstruction of composite maxillary defects.

MATERIALS AND METHODS

Between May 2003 and March 2005, six consecutive patients underwent an osteomyocutaneous PAP flap for reconstruction of composite maxillary defects at Chang Gung Memorial Hospital. The average age at the time of reconstruction was 52 years (range, 32-85 years). Four patients were men, and two were women.

The histologic tumor types were squamous cell carcinoma in three patients, sarcoma in two patients, and verrucous cancer in one patient. The composite maxillary defect after tumor ablation was involved in nasal mucosa, palate, alveolar ridge, and nasal bone in three cases (Cordeiro type II) and extended to the infraorbital rim in another three cases (Cordeiro type IIIA). 11 The patients and surgical data are summarized in Table 1. The ultimate outcomes of diet and speech were evaluated at the clinic. The cosmesis of patients was

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Sex</th>
<th>Age</th>
<th>Pathology</th>
<th>Maxillary bone defects</th>
<th>Fibula bone length</th>
<th>No. of osteotomies</th>
<th>Skin paddles and replacements</th>
<th>Muscle size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>42</td>
<td>Left maxillary, low-grade osteosarcoma</td>
<td>Alveolar ridge, nasal wall</td>
<td>5 cm</td>
<td>0</td>
<td>9 × 16 cm (palate and buccal)</td>
<td>14 × 6 × 3 cm</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>42</td>
<td>Left maxillary, myofibroblastic sarcoma</td>
<td>Alveolar ridge, nasal wall</td>
<td>7 cm</td>
<td>1</td>
<td>5 × 7 cm (nasal) 7 × 8 cm (palate)</td>
<td>12 × 6 × 2 cm</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>85</td>
<td>Right maxillary, SCC (T4N0M0)</td>
<td>Orbital floor, nasal wall, alveolar ridge</td>
<td>8 cm</td>
<td>1</td>
<td>6 × 10 cm (nasal) 6 × 8 cm (palate)</td>
<td>12 × 5 × 2 cm</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>53</td>
<td>Left maxillary, SCC (T4N0M0)</td>
<td>Orbital floor, nasal wall, alveolar ridge</td>
<td>8 cm</td>
<td>1</td>
<td>8 × 11 cm (nasal) 8 × 10 cm (palate)</td>
<td>13 × 5 × 3 cm</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>58</td>
<td>Right maxillary, verrucous cancer</td>
<td>Alveolar ridge, nasal wall</td>
<td>5 cm</td>
<td>1</td>
<td>6 × 8 cm (nasal) 8 × 10 cm (palate)</td>
<td>13 × 6 × 3 cm</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>32</td>
<td>Right maxillary, SCC (T4N0M0)</td>
<td>Orbital floor, nasal wall, alveolar ridge</td>
<td>14 cm</td>
<td>3</td>
<td>7 × 8 cm (nasal) 9 × 8 cm (palate)</td>
<td>10 × 6 × 3 cm</td>
</tr>
</tbody>
</table>

Abbreviations: M, male; F, female; SCC, squamous cell carcinoma.

Table 1. Baseline data of six consecutive patients who underwent osteomyocutaneous peroneal artery perforator flap for reconstruction of composite maxillary defects after tumor ablation surgery.
evaluated at the clinic with a score of excellent, good, fair, and poor.

**Surgical Techniques.** After tumor ablation by the surgical oncologist, the nasal and palatal defects were measured with two sterile green towel templates tailored to fit the defects (Figure 1). The direction of pedicle was also marked on the palatal green towel template. A paper ruler was used as a template for determination of required bone segments (Figure 2). A piece of $4 \times 4$ gauze was used for the measurement of the required volume of soleus muscle (Figure 2).

Preparation of the recipient site was started with the intermaxillary fixation between the residual maxilla and the mandible. The recipient vessels, either the ipsilateral facial vessels or superficial temporal vessels, were identified and dissected out. The subcutaneous tunnel was created for the donor pedicle to reach the recipient vessels.

The ipsilateral leg was selected for flap harvest because of the more favorable orientation of the donor pedicle to reach the ipsilateral recipient vessels. Septocutaneous perforators, predominantly located at the middle and distal thirds of fibula, were mapped at the posterior margin of the fibula with a pencil ultrasound Doppler. The perforators in the lateral proximal third of the leg were mostly musculocutaneous perforators. The skin paddle design was longitudinally designed with at least two septocutaneous perforators included (Figure 3). The osteomyocutaneous PAP flap was planned and harvested using a modified technique of fibula osteoseptocutaneous flap. On the basis of our clinical experience, two to four myocutaneous perforators in the proximal third of the lateral leg can be identified. These myocutaneous perforators piercing into the deep fascia, between the peroneus longus and soleus muscles, nourish the lateral part of soleus muscle. A segment of soleus muscle was harvested.
based on a myocutaneous perforator originating from the main source peroneal vessels (Figures 3 and 4).

The pedicle was divided, and the required fibula bone segments were cut according to the paper rule template on the back table (Figure 4). The skin island of the osteomyocutaneous PAP flap was divided according to two green towel templates into two separate skin paddles with each independent perforator. Consistent with the concept of a perforator flap, the posterolateral intermuscular septum between the skin and fibula periosteum was divided to gain more mobilization of skin islands.

The flap inset began with the fibula bone fixation with a Leibinger miniplate (Stryker, Detroit, MI) or interosseous wire from the nasal site to the zygomatic site (Figure 5). The peroneal vessels were passed through the tunnel to reach the recipient vessels. One mobile skin island was sutured to a nasal defect with 3-0 Vicryl sutures; the other skin paddle was for palatal lining. The maxillary sinus was obliterated with the isolated soleus muscle, which also provided orbital floor support and cheek augmentation (Figure 5). Particular attention should be paid not to twist, kink, or compress the skeletonized perforators of the skin paddles and soleus muscle during flap insetting.

The ipsilateral facial or superficial temporal artery was anastomosed to the peroneal artery with 9-0 Ethilon interrupted sutures. The double microclamp was released after completion of arterial anastomosis to check any compromise of venous backflow. Then the venous anastomosis proceeded. The wound was approximated after Penrose drain placement. The donor site was closed with a split-thickness skin graft harvested from the ipsilateral thigh in each case.

RESULTS

All six flaps survived. The average fibula length used for bony reconstruction was 7.8 cm (range, 5–14 cm). Although no osteotomy was required in one patient, one and three osteotomies were performed in four patients and one patient, respectively. The size of the skin paddle ranged from $5 \times 7$ cm to $8 \times 11$ cm for nasal lining and $6 \times 8$ cm to $9 \times 16$ cm for palatal lining. The size of soleus muscle ranged from $12 \times 5 \times 2$ cm to $14 \times 6 \times 3$ cm. Facial vessels were used as the recipient site in four patients, and superficial temporal vessels were used in two patients. One flap required reexploration because of venous thrombosis due to the size discrepancy between the flap peroneal vein and superficial temporal vein. A vein graft successfully bridged the peroneal vein to a branch of the internal jugular vein. No partial flap loss was obtained. No patients had wound infection or chronic sinusitis.

At a mean 12 months of follow-up (range, 3–24 months), there was no evidence of tumor recurrence. Adequate bone healing and soft tissue
coverage of the oral and nasal mucosa were achieved in all patients. Acceptable maxillary contour and symmetry were also radiologically observed in all patients (Figures 6–8). Five patients had normal speech and were able to eat a regular diet without difficulty using their residual dentition. One patient tolerated a soft diet and had intelligible speech that was similar to preoperative conditions. One of three patients with orbital floor involvement had ectropion develop. Excellent cosmesis was found in five patients and good cosmesis in one patient. No donor site morbidity was obtained. Osseointegrated dental implants were used to improve cosmesis in one patient (case 1) 1 year postoperatively.

DISCUSSION

Reconstruction of composite maxillary defects remains a challenge to reconstructive surgeons. A composite maxillary defect, if left unreconstructed or if reconstructed with a poorly designed reconstruction, may lead to various dysfunctions that include oronasal fistulas, enophthalmos, orbital dystopia, feeding and speech problems, and loss of facial contours.25,26 Essential goals of maxillary reconstruction include wound healing, restoration of function, and cosmesis.19 These include proper support of orbital contents, maximizing speech and swallowing functions, and reestablishing midfacial projection and vertical facial height.26 The dead space, if not obliterated, usually accumulates fluid and causes secondary infection and flap failure.27 Even when the dead space seals itself and the flap survives completely, the flap

**FIGURE 6.** At 10-months’ follow-up, the panoramic radiograph view of reconstructed maxilla revealed good bony union and alignment.

**FIGURE 7.** Photographs show the symmetric facial contour of a patient at 10 months’ follow-up, frontal view (A) and lateral view (B). The patient is now able to eat a regular diet and speak normally. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]
may contract, causing a sunken appearance and resulting in difficulties in swallowing, speaking, and chewing. Volume deficiency is poorly tolerated in the head and neck reconstruction performed with the use of soft tissue flaps, especially in patients undergoing postoperative radiotherapy.

Maxillary reconstruction using different osteocutaneous free flaps has been addressed, including the scapula, radius, iliac, and fibula. No single reconstruction option has been described to achieve consistent wound healing, sealing sinal nasal cavities, obliterating the defect, supporting the orbit, and restoring the facial contour. Conventional osteocutaneous flaps may not provide the adequate mobility and volume of tissue required for three-dimensional maxillary reconstruction and obliteration of dead space.

Minimal donor site morbidity is one of the important issues in free tissue transfer for head and neck reconstruction. Different tissue components nourished by the same pedicle may be simultaneously transferred as a composite flap. Koshima et al introduced the "chimeric flap" concept by using more than two different flaps anastomosed to the same pedicle with flow-through technique. The major advantage of the chimeric flap is the independent mobility of skin, muscle, and bone as a single-unit tissue transfer. These various components of the chimeric flap facilitate three-dimensional reconstruction in the head and neck region. However, the chimeric flap technique requires two pairs of microsurgical anastomoses and two donor sites (anterolateral thigh flap and vascularized muscle or bone graft). Our osteomyocutaneous PAP flap includes several different tissue components from one donor site as a composite flap that is nourished by the same pedicle without additional flow-through anastomosis.

Futran et al reported that the fibula osteocutaneous free flap is highly reliable for reconstruction of the midface. Peng et al also reported a series of successful reconstructions for alveolar arch defects using fibula free flap. We modified the fibula flap to the osteomyocutaneous PAP flap incorporating two independent skin paddles, an independent soleus muscle component, and several bone segments for reconstruction of three-dimensional composite maxillary defects. The mobility of the standard osteocutaneous fibula flap skin paddle is usually restricted because of its broad attachment to the posterolateral intermuscular septum. A larger skin paddle in the conventional fibula osteocutaneous flap with deepithelialization and folding may compromise the distal skin circulation. Two separate skin paddles of the osteomyocutaneous PAP flap may accommodate in a 90-degree direction between the palatal and nasal mucosa defect. The osteomyocutaneous PAP flap eliminates the size of the required skin paddle and skin graft coverage.

The independent soleus muscle of the osteomyocutaneous PAP flap is used to obliterate the maxillary sinus dead space and to reduce the risk of acute and chronic infection. Bulk from the soleus muscle segment can also help to support the orbital floor and to provide cheek augmentation.
The fibula and soleus muscle provide a supportive scaffold against soft tissue contraction after the radiotherapy, which may affect speech, respiration, swallowing, and facial appearance. Futran et al.\(^{19}\) reported that the fibula free flap is limited when orbitozygomatic support is the primary object. We have successfully applied the osteomyocutaneous PAP flap to three patients with infraorbital rim resection.

The fibula flap has a longer pedicle, which can be lengthened by designing the required bone segment more distally and removing the fibula bone proximally. The pedicle length of this flap also depends on the required bone length. When the patient needs only alveolar ridge reconstruction, the required bone segment will be short, and the pedicle may be long enough to reach to the recipient vessels. The ipsilateral facial vessels are usually the preferred recipient vessels in terms of vessel size and location. The precisely designed and osteotomized fibular bone segments allow reconstruction of the alveolar ridge, molar eminence, and orbital rim simultaneously. When the patient needs a longer bone segment for both alveolar ridge and infraorbital reconstruction, the geometry of the pedicle becomes more difficult. The distal fibular bone segment may inset to the alveolar defect, and the proximal bone segment may inset to the infraorbital rim or zygomatic arch. The direction and location of the pedicle may be closer to the ipsilateral facial vessels. The superficial temporal vessels can be dissected more distally to gain 4 to 5 cm in length. With this design, none of the six patients required a vein graft for the primary reconstruction, except during the reexploration of the patient in case 4.

Functional results can be improved with insertion of osseointegrated implants into the transferred bone segments to support the dental or orbital prostheses. Although some authors had successfully used simultaneous osseointegration before radiotherapy,\(^{32}\) others reported high failure rates.\(^{33,34}\) In our center, osseointegrated dental implants will be considered in patients with low-grade malignant maxillary tumors as long as the patients are disease free for a long term.\(^{35,36}\) One of our patients (case 1) had received osseointegrated dental implants for better cosmesis rather than for improving eating or speech functions 1 year postoperatively.

Although many advantages of the osteomyocutaneous PAP flap exist, the tedious dissection of each septocutaneous and myocutaneous perforator can be time consuming and technique demanding. Care must be taken to avoid any twisting or compression of the isolated perforators during the flap inset. Preoperative accurate planning with surgical templates is the key to achieve a successful reconstruction in composite maxillary defects.

In summary, the osteomyocutaneous PAP flap represents a further refinement of the fibula flap and increases its versatility with multiple skin paddles, bone segments, and soleus muscle independently isolated. The osteomyocutaneous PAP flap is a comparable reconstruction option for composite maxillary defects.

REFERENCES