Maxillary Reconstruction With the Scapular Angle Osteomyogenous Free Flap

Brett A. Miles, DDS, MD; Ralph W. Gilbert, MD

Objective: To report on experience with the scapular angle osteomyogenous flap for maxillary reconstruction.

Design: Retrospective review of patients undergoing scapular angle reconstruction for maxillary defects at the University Health Network from 2004 through 2010.

Setting: Medical research center.

Patients: Thirty-nine patients were included in the review.

Intervention: Scapular angle reconstruction for maxillary defects.

Main Outcome Measures: Maxillary defects were classified prospectively according to Okay and coauthors. Early and late complications as well as demographic and outcome data was analyzed using SPSS version 16.0 statistical software. Shoulder disabilities were assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire.

Results: Of the 39 patients included in the study, vein grafting was required in 3 (8%). The overall complication rate in the study was 18 of 30 (46%). A total of 16 patients (41%) in the review required revision procedures of some type. The rate of fistula formation was 21% (n=8) in the study group. Fifty-one percent of patients received radiotherapy as part of the treatment as dictated by the tumor board. Statistical analysis did not reveal a correlation between the administration of radiotherapy and postoperative fistula formation (P= .13). Of the 8 fistulas, 1 patient required surgical closure and an additional patient opted for palatal prosthesis. Fifty percent of the fistulas closed spontaneously. Of the 39 patients, 18 (46%) obtained a normal diet and 21 (54%) maintained a soft diet. Regarding shoulder dysfunction, the mean (SD) DASH score obtained was 10.44 (10.33). Eight patients in the study group (21%) underwent neck dissection; the remaining 80% of patients did not have cranial nerve XI manipulation. Statistical analysis did not reveal any correlation between neck dissection and postoperative DASH scores.

Conclusions: This investigation indicates that the angular scapular flap has some advantages over other free-tissue transfer techniques for complex maxillary defect reconstruction. A considerable number (46%) of patients will experience some type of local complications after undergoing these challenging reconstructions, and many (41%) will require revision surgery. Postoperative fistula will often close spontaneously. Donor site morbidity is relatively low according to preliminary analysis.


THE SCAPULAR FREE FLAP HAS been used for mandibular reconstruction since the 1980s and offers many advantages over the fibula or iliac crest (deep circumflex iliac artery) free flap. These primarily relate to the chimeric nature of the subscapular vascular system, allowing for a harvest of multiple, independent skin paddles, serratus muscle with or without rib, latissimus dorsi muscle, and up to 14 cm of lateral scapular bone. This makes it an excellent option for complex composite defects of the head and neck with large soft-tissue requirements, such as mandibular continuity defects with simultaneous intraoral and extraoral components. Primary disadvantages of the traditional scapular flap based on the circumflex scapular artery include short vascular pedicle, inadequate bone quantity to reliably support osseointegrated dental implants, and the fact that simultaneous harvest is not possible. In addition, the linear shape of the bone of the lateral scapula border is not an ideal reconstructive option to reconstruct maxillary defects.

The lack of adequate pedicle length has lead to the technical development of the dorsal angular tip variation, which uses the angular branch of the thoracodorsal artery to supply the scapular tip, rather than the traditional circumflex scapular artery configuration. This modification improves pedicle length, which has facilitated the use of the scapular flap in maxillary reconstruction. In addition, the...
The tip of scapula has a similar structure to the native palate, which is an advantage for infrastructure maxillary defects. Previously, we have reported the technique of reconstruction of maxillectomy defects, as well as the feasibility and safety of this flap for reconstruction of maxillectomy defects. The objective of this study was to update the University of Toronto experience with the scapular angle osteomyogenous flap for reconstruction of the maxilla, with a focus on early and late postoperative complications.

METHODS

A retrospective review was performed of all patients undergoing scapular angle osteomyogenous free-tissue reconstruction for maxillary defects at the University Health Network Princess Margaret Hospital, Toronto, Ontario, Canada, from 2004 through 2010. Patients were identified and data collected from a prospective microsurgical reconstructive database. This database prospectively collects demographic data, clinical and treatment related data, as well as all perioperative complications. Maxillectomy defects were classified at the time of surgery using the classification system developed by Okay et al. This classification is based on defect location, residual dentition, and arch stability for prosthesis retention and opposition of occlusal forces (Table 1). The technique of flap harvest (supine position) and reconstruction has previously been described (Figure 1).

Long-term complications were determined from a combination review of medical charts and a prospective recording of all complications in the senior author’s (R.W.G.) database on maxillary reconstruction. Postoperative shoulder disability was assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire using a cross-sectional technique (time from surgery to completion of questionnaire is variable). The DASH is a region-specific upper limb disability questionnaire that was developed by the American Academy of Orthopedic Surgeons and has been shown to be reliable and valid in patient populations with a variety of upper-extremity disorders. It is a 30-item questionnaire, with each individual item being rated between 1 and 5. The raw score is transformed into a score out of 100 to make the DASH scores more comparable with other measures that are scaled from 0 to 100. A higher score indicates greater impairments and activity limitations.

Statistical analysis was performed with SPSS version 16.0 software (SPSS Inc, Chicago, Illinois). The primary end point of the study was to assess surgical outcomes, which were reported using descriptive statistics. Fisher exact and χ² tests were used to compare nominal data. Institutional review board approval from the University Health Network was obtained for this investigation.

RESULTS

A total of 39 patients underwent maxillectomy and reconstruction with a scapula tip osteomyogenous free flap from 2004 through 2010, all of whom were included in the study. The majority of patients (80%) underwent maxillectomy for malignant neoplastic disease and the remainder (20%) for benign disease. The distribution of histopathologic subtypes for which a maxillectomy was performed is listed as follows: squamous cell carcinoma, 41%; ameloblastoma, 13%; osteosarcoma, 10%; adamantoid cystic, 8%; basal cell carcinoma, 5%; melanoma, 5%; giant cell tumor, 5%; chondrosarcoma, 5%; adenocarcinoma, 3%; solitary fibrous tumor, 3%; and meningioma, 3% (does not total to 100% owing to rounding). The distribution of defects, as classified by Okay et al, is shown in Figure 2. Thirty-six patients (92%) underwent reconstruction at the time of tumor ablation; the remaining reconstructions were performed in a delayed fashion. Secondary reconstruction was performed for the osteosarcoma of the maxilla, for which confirmation of complete tumor removal with clear margins on pathologic examination was obtained prior to proceeding with reconstruction. Microvascular anastomosis was performed using the facial vessels in most cases (87%). The superior thyroid artery was used in 5%, with a variety of other options in the remaining 8% of cases. Vein grafting was required in 3 cases (8%). The venous coupling device (Synovis; Micro Company Alliance Inc, Birmingham, Alabama) was used in 34 (87%) of cases. Coupler size ranged from 1.5 to 3.5 mm, with the majority (72%) of cases using the 2.5- to 3.0-mm coupling device. Four patients (10%) underwent multiple venous anastomoses when 2 veins were available from the subscapular system.

The overall complication rate in the study was 46% (18 of 30). Early and late surgical complications are given in Table 2. A total of 16 of 39 patients (41%) in the review required a secondary revision procedure. The list of revision procedures is presented in Table 3.

The rate of fistula formation was 21% (n=8) in the study group. Twenty patients (51%) received radiotherapy as part of the treatment, of whom 11 (28%) received preoperative radiotherapy and 8 (21%) received postoperative radiotherapy. There was no discernable difference regarding fistula formation and the timing of radiation administration. One patient received preoperative radiotherapy, as well as a course of reirradiation in the postoperative setting. There was no statistically significant difference in the frequency of fistula formation between those who underwent radiotherapy and those who did not (P=.13) Regarding the defect size and location, there was insufficient data available to determine if certain defect locations or sizes were associated with a higher rate of fistula formation.

### Table 1. Maxillectomy Defect Classification by Okay et al

<table>
<thead>
<tr>
<th>Defect</th>
<th>Classification</th>
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<tbody>
<tr>
<td>la</td>
<td>Defect includes any central portion of hard palate, non–tooth bearing.</td>
</tr>
<tr>
<td>lb</td>
<td>Defect includes unilateral alveolar structures and palate posterior to the maxillary canine or isolated premolar defects.</td>
</tr>
<tr>
<td>II</td>
<td>Defect includes unilateral alveolar structures and palate including the canine with the anterior margin within maxilla. This class includes transverse palatotomy defects that involve &lt;50% of hard palate.</td>
</tr>
<tr>
<td>III</td>
<td>Defect includes any portion of hard palate and tooth-bearing maxillary alveolus, including both canines. This class includes total and transverse palatotomy defects that involve &gt;50% of hard palate.</td>
</tr>
<tr>
<td>f</td>
<td>Defect involves orbital floor and/or rim.</td>
</tr>
<tr>
<td>z</td>
<td>Defect involves zygomatic buttress.</td>
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with fistula formation. In the 8 patients who developed a fistula, 4 closed spontaneously, 1 patient required surgical closure of the fistula, and another patient opted for a palatal prosthesis. The status of the fistula could not be determined in the other 2 patients because 1 patient was lost to follow-up and the other died of distant disease. It should be noted that there were no flap failures in this series.

Dietary function, according to patient report, was excellent overall in the study group, with all patients returning to an oral diet within 6 weeks of surgery. Eighteen patients (46%) obtained a normal diet and the remaining 21 (54%) were able to maintain a soft diet. Regarding prosthetic rehabilitation, 22 patients (56%) did not undergo prosthetic rehabilitation owing to several factors, including lack of resources for osseointegrated dental implants, inadequate maxillary structure and/or vestibular anatomy required for prosthetic retention, or patient desires. Of the 3 patients who underwent osseointegrated implant reconstruction, none required thin-

Figure 1. Series of photographs (A-C) demonstrating a right hemimaxillary defect (class II) reconstruction with the scapular angle osteomyogenous free flap and 8-month follow-up photograph (D) showing excellent mucosalization of the intraoral portion of the flap.

Figure 2. Distribution of maxillary defects as classified by Okay et al.7
ning of the mucosalized epithelium prior to implantation.

Twenty-six patients completed the DASH questionnaire in the postoperative period. The median and mean follow-up time from surgery to completion of the DASH questionnaire was 12.5 and 13.4 months, respectively (range 5-25 months). The median DASH score obtained was 8 (range, 0-34) and the mean (SD) score was 10.44 (10.33). Eight patients in the study group (21%) underwent neck dissection at the time of surgery, which involved dissection of level IIB requiring manipulation of the accessory nerve. The remaining 80% of patients did not have substantial accessory nerve manipulation. Analysis of the data did not reveal any correlation between the performance of neck dissection and postoperative DASH scores ($P = .48$); however, not all patients completed the questionnaire, with a response rate of 67%. Therefore, the effect of neck dissection on DASH scores needs to be interpreted with caution.

**COMMENT**

Historically, the management of large postmaxillectomy defects was problematic and often left patients with unacceptable functional and cosmetic results. Prosthetic obturation continues to be a common means to reconstruct the postmaxillectomy defect in the present era. While rehabilitation with obturation continues to have an important role in some maxillectomy defects, there are notable advantages of reconstructive microsurgery in terms of function and cosmesis, especially when combined with implant-retained prostheses. Microvascular reconstructive techniques offer a variety of solutions to achieve the goals of maxillary reconstruction, namely, they allow for separation of the oral cavity from the nasal cavity and paranasal sinuses, provide adequate orbital and facial support, provide osseous structure for implantborne prosthesis, and allow for appropriate soft-tissue aesthetic contour. Osseointegrated dental implant technology is arguably as notable in terms of functional rehabilitation. Nevertheless, patients undergoing these procedures continue to experience considerable functional and aesthetic morbidity and continue to challenge reconstructive surgeons worldwide.

A variety of microvascular reconstructive techniques have been described for maxillary reconstruction. Composite microvascular transfers available for maxillary reconstruction include the fibula, iliac crest, radial forearm, and scapular flaps. As previously discussed, the scapular flap has several advantages for complex reconstructive situations owing to the chimeric nature of the subscapular vascular system. Free-tissue transfer techniques using the subscapular system (including the angular artery modification) are undoubtedly the most versatile in head and neck reconstruction and has been used for a variety of extensive defects including, for example, malignant and benign tumors, trauma, radiation necrosis, and odontogenic tumors. This flap has been used in pediatric applications as well and does not appear to result in significant growth disturbances. The subscapular system offers distinct advantages in elderly patients or patients with gait disturbances who are not candidates for fibular or iliac crest transfer. In addition, the scapular system offers superior bulk of tissue for extensive soft-tissue defects when compared with fibular or iliac crest transfers.

At the Princess Margaret Hospital, the angular scapular angle osteomyogenous flap is the preferred reconstructive modality for Okay et al’s class II and III defects. In the past, maxillary reconstruction with the traditional scapular flap based on the subscapular system was limited by the short pedicle length and more frequent need for vein grafts. The angular scapular angle osteomyogenous flap overcomes this disadvantage by providing superior pedicle length when compared with the circumflex scapular artery for scapular reconstructions. Seitz et al performed anatomical evaluation of 135 angular arteries and determined variable branching patterns. However, the authors noted that regardless of the pattern the mean length of the angular branch and the thoracodorsal artery together was 148 mm, and when the subscapular artery was added the overall length became 167 mm. Wagner et al confirmed these data in 2008 and found that the pedicle length originating from the circumflex scapular vessels varied from 6.7 to 9.0 cm (mean, 7.5 cm), whereas the pedicle length of the angular vessels varied.

### Table 2. Complications Documented After Reconstruction

<table>
<thead>
<tr>
<th>Complication</th>
<th>Early &lt;4 wk, No. (%)</th>
<th>Late &gt;4 wk, No. (%)</th>
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<tbody>
<tr>
<td>Facial infection</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Facial seroma</td>
<td>1 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Donor site infection</td>
<td>1 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Donor site seroma</td>
<td>3 (8)</td>
<td>0</td>
</tr>
<tr>
<td>Global malposition</td>
<td>1 (3)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Ectropion</td>
<td>7 (18)</td>
<td>0</td>
</tr>
<tr>
<td>Epiphora</td>
<td>3 (8)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Palatal fistula</td>
<td>8 (21)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Bone/hardware exposure</td>
<td>2 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>VPI</td>
<td>1 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Loss of dentition</td>
<td>1 (3)</td>
<td>0</td>
</tr>
<tr>
<td>Inadequate gingivobuccal sulcus</td>
<td>0</td>
<td>14 (36)</td>
</tr>
<tr>
<td>Aesthetic compromise, overcontoured</td>
<td>NA</td>
<td>5 (13)</td>
</tr>
<tr>
<td>Aesthetic compromise, undercontoured</td>
<td>NA</td>
<td>2 (5)</td>
</tr>
</tbody>
</table>

**Table 3. Required Revision Procedures**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Frequency, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestibuloplasty and STSG</td>
<td>6 (15)</td>
</tr>
<tr>
<td>Incision, drainage, and packing</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Dacryocystorhinotomy</td>
<td>3 (8)</td>
</tr>
<tr>
<td>Eyelid revision procedure</td>
<td>3 (8)</td>
</tr>
<tr>
<td>Hardware removal</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Aesthetic recontouring procedure</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Coronectomy</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Palatal fistula closure</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Bone graft</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>

Abbreviation: STSG, split-thickness skin graft.
from 13.0 to 15.0 cm (mean, 14.1 cm). The authors reported a mean increase of 6.6 cm in pedicle length when comparing the 2 techniques. In the present series, the rate of vein grafting using the angular branch was (8%), and there were no flap failures in the series, indicating that the scapular angle osteomyogenous flap offers reliable vasculature for microvascular anastomosis. These findings are consistent with those of other investigations. Furthermore, preoperative planning for vein grafting should be considered in all maxillary microvascular reconstructions.

While the overall complication rate with this flap was 46%, the majority of complications were minor and easily managed (Table 2). Globe malposition was encountered early in 1 patient and as a late complication in 2 patients (7.6%). This represents the difficulty in estimating adequate orbital volume and predicting soft-tissue contraction postoperatively. Greenstick fracture and plating of a section of thin mediastinal scarpa bone to support the globe may facilitate adequate orbital reconstruction and prevent enophthalmos. Mild postoperative seroma at the donor site was commonly observed (often enough to be considered a normal sequelae of scapular tip flap harvest); however, seromas requiring management or prompting imaging procedures were less common (8%). Serious medical complications occurred in 3 patients (8%), and 1 death occurred, highlighting the considerable medical morbidity often observed in head and neck patients. Minor revisions are not infrequent, with 41% patients in the review undergoing a revision procedure (Table 3). The majority of the procedures involved re-establishing the gingivo-buccal sulcus, which was commonly obliterated postoperatively. Application of prosthetic splints may alleviate this problem; however, careful contouring is required to prevent compression of the vascular perforators. Formal vestibuloplasty with a split-thickness skin graft is often required prior to prosthetic rehabilitation, and patients should be informed of this fact. In addition a notable number of patients (15%) underwent revision procedures such as eyelid repositioning and dacryocystorhinostomy for epiphora and ec troversion when the medial orbit or lacrimal fossa was involved in the resection.

Although angular scapular angle osteomyogenous flap has excellent ability remucosalize in oronasal reconstruction, oronasal/oroantral fistula formation was not uncommon (21%) in our patient population. Several factors including adjuvant therapy, medical comorbidity, and defect considerations likely contribute to the development of this complication, although most commonly the fistulas resolved spontaneously. Although 51% of the patients underwent radiotherapy at some point during the course of treatment and statistical analysis did not reveal a significant correlation, the present study was insufficiently powered to delineate the effect of radiation on fistula formation. Regarding the defect size and location, there was insufficient data available to determine if certain defect locations or sizes were associated with fistula formation. Regardless of the etiology, the vascu larized muscle inherent to the scapular tip flap and inset intraorally seems to provide an excellent ability for spontaneous closure of postoperative fistula. Therefore, a period of observation (8-12 weeks) is recommended when fistula occurs in the setting of a viable flap. Nevertheless, postoperative fistula may persist after scapular tip reconstruction, and revision closure may be required as evidenced in this investigation.

The benefits of prosthetic rehabilitation, especially in conjunction with osseointegrated implants, are widely recognized and contribute significantly to patient quality of life. Unfortunately, in our patient cohort, 22 patients (56%) did not undergo prosthetic rehabilitation of any type owing to several factors including financial considerations, lengthy treatment plans with resulting patient “burn out,” and poor survival outcomes with advanced maxillary malignant tumors. Only 3 patients (8%) in our investigation underwent prosthetic rehabilitation with osseointegrated dental implants, which is a reflection of the lack of financial coverage for dental implants in the province of Ontario, rather than technical issues related to the reconstruction.

Based on the reported DASH scores there is likely some minimal long-term donor site morbidity associated with scapular flap harvest. The mean (SD) DASH scores obtained in the study were higher than reported population normative data (10.44 [10.33] vs 1.85 [5.99]). However, it should be stated that the magnitude of the dysfunction is relatively low (normal DASH scale, 0-100), and a DASH score 10 points higher than normative data likely indicates minimal change in function according to extremity investigations. In fact, normative data for the DASH questionnaire collected in a large general population survey conducted by the American Academy of Orthopaedic Surgeons indicated that the mean DASH score for the general population is 10.1, which is similar to the population scores in the present study. One limitation of the present data are the long interval prior to administering the DASH questionnaire (13.4 months). The DASH scores obtained at earlier intervals (12 weeks to 6 months after surgery) may have indicated more notable dysfunction that resolved over time, which may have been undetected by the study design. The short-term effects of shoulder dysfunction after scapular flap harvest remain unknown. We have not found shoulder morbidity to be a significant clinical problem with the scapular tip harvest. The effect of neck dissection (involving cranial nerve XI) in the setting of ipsilateral scapular harvest may be a factor influencing these results; however, the extent to which it contributed to DASH scores remains unknown, since the present study lacks sufficient power to determine the respective contributions of neck dissection and scapular harvest regarding shoulder dysfunction.

In conclusion, this investigation and other work indicates that the angular scapular flap has several advantages over other free-tissue transfer techniques in terms of the versatility of muscle, skin, and osseous components for complex maxillary defect reconstruction. In addition, osseointegrated implants are possible with this flap, and donor site morbidity is low.

Submitted for Publication: March 16, 2011; final revision received May 3, 2011; accepted September 18, 2011.

Correspondence: Ralph W. Gilbert, MD, University Health Network, 200 Elizabeth St, Ste 8N879, Toronto ON M5G 2C4, Canada (ralph.gilbert@uhn.on.ca).
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