Reconstruction of major head and neck defects remains an evolving challenge. This relates to the complexity of head and neck anatomy and the critical role these structures play in function and appearance. In recent decades, this complexity has been further compounded by an aging population of patients with severe comorbidities and by the increased frequency of salvage surgery following radiation and chemoradiation. Therefore, reconstructive surgeons have continually expanded their armamentarium—most recently manifesting in the dominance of free tissue transfer as the primary reconstructive tool for major ablative defects of the head and neck. However, many patients are not good candidates for free tissue transfer because of their medical comorbidities or lack of recipient vessels for anastomosis.

In addition, traditional regional flaps do not always meet the needs of a specific defect. The supraclavicular artery (SCA) flap provides a reliable and versatile reconstructive option to overcome some of these challenges.

The precursor of the modern SCA flap was described by Kazanjian and Converse as the “in charretera” or acromial flap. In Spanish, charretera refers to the strip of cloth on the shoulder to which military honors are attached. In 1979, the flap was modified by Mathes and Vasconez, who performed the first formal anatomic studies and described both the vascular territory and clinical applications of the cervicohumeral flap. Shortly thereafter, Blevins and Luce published a criticism of the flap, noting its high incidence of distal necrosis. Use of the flap remained controversial throughout the 1980s despite several reports by Cormack and Lamberty identifying the SCA and demonstrating its anatomic reliability. In the late 1990s,
Pallua et al,6 rekindled interest in the flap by performing detailed anatomic studies defining the vascular patterns of the “supraclavicular island flap.” Following its initial use in the release of postburn mentosternal contractures, the SCA flap has successfully been used for a variety of indications and is widely reported in the plastic surgery literature.6-9 In 2000, Pallua et al10 published the first description of reconstruction for oncologic head and neck defects. Di Benedetto et al11 subsequently reported the flap as reliable for lining oral cavity defects after oncologic resection. More recently, Chiu and colleagues (Chiu et al,12 Liu and Chiu,13 Henderson et al,14 Chiu et al,15 Levy et al,16 Epps et al,17 and Anand et al18) have used the flap in the reconstruction of: partial and total pharyngeal defects, posterolateral skull base defects, postparotidectomy contouring irregularities, and oropharyngeal defects.

We introduced the SCA flap into our head and neck practice in July 2011. After a relatively seamless integration of the technique, this flap has successfully been used to reconstruct a variety of defects. As our experience with the procedure increased, we discovered key technical aspects of harvest that improve efficiency and protect the vascular pedicle.

### Methods

With approval from the institutional review board (IRB) of the Massachusetts Eye and Ear Infirmary, we retrospectively identified all patients from July 2011 to December 2012 whose surgical defects were reconstructed with an SCA flap. Demographics, including patient age and comorbidities, were recorded, as were pertinent details of the defect, including size, location, and whether the patient had received previous radiation to the region. Complications and outcomes were assessed, and cases were reviewed to identify key technical aspects of the flap harvest. Because this was a retrospective medical chart review that used no personally identifying information, written consent was not required by the IRB or requested of the patients.

### Results

From July 2011 to December 2012, 24 SCA flap reconstructions were performed. Multiple defect types were reconstructed, including neck skin, cheek skin, lip (mucosal and cutaneous), parotidectomy, temporal bone with and without auriculectomy, segmental mandibulectomy, buccal mucosa, peristomal skin, and partial pharyngeal wall defect (Table 1). There was a range of flap sizes, with the mean dimensions measuring 8 × 10 cm. The flap was designed as an island flap, and the pedicle was tunneled in all cases. All donor sites were closed primarily with adjacent tissue advancement. No skin grafting was required. Although initial harvest times for the flap were approximately 75 minutes, these were reduced to 40 minutes by the end of the study period. In our review, we identified 4 important technical modifications that helped make flap elevation more safe and efficient: (1) modification of the soft-tissue pedicle, (2) recognition of noncritical vasculature, (3) technique for creation of a subcutaneous tunnel, and (4) lateral supraclavicular fossa dissection.

Flap-specific complications were limited. Partial loss of the distal 1 cm of the flap occurred in 2 patients. One patient underwent total lower lip reconstruction, and the other required skin and soft-tissue coverage following wide local excision and parotidectomy for a dermatofibrosarcoma protuberans. In each case, the distal tip of the flap did not maintain an adequate blood supply, and localized soft-tissue necrosis occurred. The first patient required further oncologic resection, including segmental mandibulectomy, and the defect was eventually reconstructed with a fibula free flap. The affected area of the second patient healed by secondary intention with local wound care. The remainder of the flap remains viable and healthy. No additional vascular compromise was encountered, and all other flaps survived. Review of these 2 complications reinforces use of the inferior deltoid as the distal limit of flap harvest (Table 2).

Donor site complications were also minimal. Two patients formed small seromas (<35 mL), which were managed with a single aspiration drainage. Two patients experienced small areas of incisional dehiscence along the donor site. Both of these resolved with local wound care (Table 2). There has been no evidence of persistent ipsilateral shoulder or upper extremity weakness by subjective report.

The incidence and severity of surgical complications following total laryngectomy and SCA flap reconstruction were consistent with those historically reported in this population of patients. Peristomal pharyngocutaneous fistulas developed in 2 patients who had partial pharyngectomy defects patched with an SCA flap. Both patients had undergone salvage total laryngectomy following primary chemoradiation. The leaks eventually resolved with routine wound care and nil per os (NPO [nothing by mouth]) status, and both are currently taking an oral diet. In addition, a wound dehiscence oc-
curred between the SCA skin paddle and the superior aspect of the tracheal stoma in another patient. This eventually resolved with wet to dry dressing changes and Dakin solution. Similarly, a small orocutaneous fistula developed following reconstruction of a buccal mucosa and retromolar trigone defect. This also resolved with NPO status and local wound care (Table 2).

Discussion

The SCA flap is a versatile, reliable, pedicled fasciocutaneous flap. This series of patients highlights how this versatility can be applied in complex head and neck reconstruction. Good color and texture match to the skin of the face and neck make the SCA flap excellent for covering cutaneous defects. Its arc of rotation allows for excursion as far superiorly as the lateral canthus, posterior to the auricle, and anteriorly past midline into the submentum and contralateral side of the neck. These characteristics allowed for successful reconstruction of cheek defects with and without concomitant auriculocutaneous, the lower lip, radiated peristomal skin following total laryngectomy, and cutaneous defects of the neck and submentum.

We have found the flap to be particularly ideal for the repair of the cutaneous and soft-tissue defects associated with total auriculocutaneous and total parotidectomy. The color match is superior to that of the radial forearm free flap, while the tissue is equally supple and pliable. Furthermore, the skin paddle and associated vascular pedicle have allowed for successful repair of defects as large as $10 \times 14$ cm with an average size of $8 \times 10$ cm (Table 1).

The SCA flap is also thin and pliable, thus lending itself to the correction of ablative contour irregularities and mucosal defects. Coverage of postauricular skull base and temporal bone defects was successfully achieved with an average flap size of $7 \times 10$ cm and without placing undue tension on the vascular pedicle. These characteristics also make the SCA flap well suited to repair ablative defects of the oral cavity and postlaryngectomy pharyngeal defects (Table 1). Not uncommonly, these patients will present with multiple comorbidities, clinically significant soft-tissue fibrosis in the neck following chemoradiation therapy, or a vessel-depleted neck secondary to previous neck dissections or free flap reconstructions. In these cases, we have also found the SCA flap to be a superlative reconstructive option over the radial forearm or anterolateral thigh free flaps.

Vascular Anatomy and Angiosome

The SCA flap is based on the SCA—a perforator that arises from the transverse cervical artery in 93% of patients and the suprascapular artery in the remaining cases.12,19-21 The artery has a diameter of 1.1 to 1.5 mm and typically arises 3 to 4 cm from the origin of the transverse cervical artery, offering a pedicle length ranging from 1 to 7 cm.10,12 The anatomic location of the SCA is extremely predictable and constant. It is found in a triangle formed by the dorsal edge of the sternocleidomastoid (SCM) muscle anteriorly, the external jugular (EJ) vein posteriorly, and the medial part of the clavicle. Two veins drain the flap: 1 into the transverse cervical vein and the other into the EJ or subclavian vein.10

In cadaveric studies using India ink, Pallua et al10 demonstrated that the vascular territory of the SCA extends from the supraclavicular region to the shoulder cap, with the distal part of the angiosome extending to the ventral surface of the deltoid muscle. More recent assessments using computed tomographic angiography have reinforced these findings and demonstrated that the distal portion of the flap is dependent on interperforator flow from direct linking vessels and recurrent flow through the subdermal plexus.22,23 The area of this angiosome ranges from 8 to 16 cm in width by 22 to 35 cm in length.10,11,19,22 Our clinical experience supports these findings. Flaps were designed within the dimensions of the angiosome on the ventrolateral surface of the deltoid, and all demonstrated excellent viability. The only exceptions occurred when the distal aspect of the flap extended beyond the inferior aspect of the deltoid in 2 patients.

Key Surgical Techniques

The harvest of the SCA flap has been well described in several articles, but pertinent points will be detailed.10-12,24 At the beginning of each case, the neck and arm circumferentially down to the elbow are prepared in the surgical field. The patient remains in the supine position. A Doppler probe is used to mark the location of the SCA and its associated vein, both within the triangular fossa (bordered by the SCM, EJ, and clavicle) and as they course over the clavicle. A fusiform skin paddle is designed over the ventrolateral aspect of the deltoid with its axis aligned on the proximally auscultated Doppler signal (Figure 1). Incisions are made circumferentially around the skin paddle and from the medial apex of the skin paddle to the clavicle. Bilateral, subdermal skin flaps are then raised to the approximate width of the skin paddle. At the clavicle, the subdermal elevation extends from the lateral attachments of the SCM to a point 3 cm lateral to the identified pedicle as it cross the clavicle (Figure 2). The flap is raised in a subfascial plane over the deltoid muscle in a distal to proximal direction (Figure 3).

Table 2. Postoperative Complications

<table>
<thead>
<tr>
<th>Surgical Indication</th>
<th>Patients, No.</th>
<th>Complication and Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharyngeal wall defect status post total laryngectomy</td>
<td>2</td>
<td>Pharyngocutaneous fistula; resolved spontaneously with NPO and local wound care</td>
</tr>
<tr>
<td>Posterolateral skull base defect</td>
<td>2</td>
<td>Seroma at the donor site; resolved with a single aspiration</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Incisional dehiscence at the donor site; resolving with local wound care</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Necrosis of the distal tip of the skin paddle; healing by secondary intention with local wound care</td>
</tr>
<tr>
<td>Oral cavity defect</td>
<td>1</td>
<td>Orocutaneous fistula; resolved with NPO and local wound care</td>
</tr>
<tr>
<td>Cutaneous defect: lip</td>
<td>1</td>
<td>Partial flap loss of the distal portion of the skin paddle; patient required additional oncologic ablation and revision reconstruction with fibula free flap</td>
</tr>
<tr>
<td>Irradiated parastomal wound</td>
<td>1</td>
<td>Wound dehiscence; resolved with wet to dry packing changes and Dakin solution</td>
</tr>
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</table>

Abbreviation: NPO, nil per os (nothing by mouth).
Proximally, a fascial pedicle is maintained that encompasses the flap vessels and approximates the width of the skin paddle (Figure 4). This technique, previously described by Di Benedetto et al.,11 protects the flap vasculature by preventing kinking, partial compression, and undue tension. The fascial pedicle should extend from the lateral attachment of the SCM to a point about 3 cm lateral to the identified vascular pedicle at the clavicle. This technical modification provides adequate tissue to protect the vasculature without additional dissection or exposure.

As described by Alves et al.,24 we frequently encounter a prominent vessel within the deltopectoral groove and anterolateral to the clavicle (Figure 5). In many cases, adequate length cannot be achieved without transecting this vessel. Initially, we occluded them with nontraumatic microvascular clips and observed the distal flap for bleeding to ensure viability. Because there were no alterations in distal bleeding, these vessels are now routinely transected without further delay in the harvest or concerns for flap viability.

At the clavicle, the dissection transitions to creating the subcutaneous tunnel. We raise a subdermal flap proximal to the lateral border of the SCM. At this point, the dissection is medial and superficial to the pedicle, which remains safely tethered deep in the neck. Approximately 2 cm above the clavicle, we transect the platysma muscle to connect the tunnel into the anterior neck. This third technical point again allows for expeditious creation of the tunnel, while ensuring the safety of the underlying vascular pedicle.

The periosteum of the inferior clavicle is then incised, and subperiosteal dissection continues over the clavicle and into the supraclavicular fossa. The elevated periosteum of the superior clavicle is then carefully incised, allowing access into...
the soft-tissue component of the fossa. This maneuver releases the flap, increasing its maximal excursion. If additional length is required, the middle plane of the deep cervical fascia is released, with care taken not to injure the underlying transverse cervical vessels and its branches. The distal aspect of the EI venous system is also identified and preserved. If additional length is still needed, incisions can be created medially and laterally to further release the pedicle from its inferior attachments. Using these maneuvers can be critical for gaining length and avoiding the need to go beyond the angiosome. In retrospect, the 2 cases of partial flap loss could likely have been avoided with additional dissection as described herein and not extending the skin paddle further to gain length.

The SCA flap is then brought through the tunnel and rotated into the defect. Attention is turned to closure of the donor site. With wide undermining—both superiorly over the shoulder and anteriorly onto the chest—primary closure can routinely be achieved (Figure 6). In the rare instances that this is not possible, skin grafting may be used.

Complications
In general, the complications we have experienced with the SCA flap have been self-limiting and have not detracted from our confidence in the flap. In all but 1 case, the SCA flap successfully reconstructed a variety of head and neck defects. A multitude of factors likely contributed to the 1 notable failure, including design of the skin paddle beyond the inferior aspect of the angiosome, positive margins of the ablative defect, and suboptimal contouring of the skin paddle in an effort to reconstruct a full thickness, composite defect of the mentum and anterior mandible.

Donor site morbidity is also minimal. Thus far, all donor site incisions have been closed primarily without the need for skin grafting. The incisions have healed with excellent cosmetic results. Furthermore, there have been no reports of prolonged or persistent weakness or of decreased range of motion, at the shoulder joint.

Conclusions
Our experience with this initial series of 24 patients demonstrates that the SCA flap is a versatile and reliable reconstructive option for a multitude of head and neck defects. Over the past decade, the SCA flap has received increasing interest and use from the plastic surgery community, but there has been little mention of it in the otolaryngology–head and neck surgery literature. In our experience, we have identified 4 key maneuvers during harvest that have not been previously highlighted. These key maneuvers, combined with an understanding of the vascular anatomy and surgical technique, allow for safe and efficient incorporation of the SCA flap into an otolaryngology surgeon’s reconstructive armamentarium. As a final point, we want to emphasize that, despite its versatility and multiple applications, the SCA flap has not completely replaced the need for free tissue flaps. This flap should be viewed as an important part of the reconstructive algorithm, but one should continue to assess the needs of the patient and identify the tissue which will best meet those needs.
Supraclavicular Artery Flap

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Conflict of Interest Disclosures: None reported.

REFERENCES