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Submental island flap and bone variation

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The submental island flap is a versatile pedicle flap for reconstruction of head and neck defects. Initially described over 20 years ago, numerous modifications have been described with successful treatment of a wide range of surgical defects including all oral cavity sub-sites and facial defects involving the orbital rim, zygoma, and malar eminence. The current paper is a review of the relevant anatomy, detailed description of the harvest technique, and review of published studies since the submental island flap was initially described.

Introduction

The submental island flap (SIF), introduced in 1993, is a robust and versatile axial regional reconstructive option for the head and neck surgeon.[1] Martin initially described the SIF as a pedicled or free fasciocutaneous, myocutaneous, or osteocutaneous flap. As reconstructive surgeons recognized the SIF's utility, numerous modifications and applications were reported.[2] Modifications were also described to augment flap harvest safety by resident surgeons.[3] The present report is a detailed guide on how the authors harvest the SIF and discussion of the various techniques and applications published in the last 25 years.

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Anatomy

The SIF is an axial flap based on the submental artery (SMA), a branch of the facial artery. The arterial supply is very consistent and can be identified along the superior and medial edge of the submandibular gland travelling anteriorly along the inferomedial border of the mandible.[1,4,5] (Fig. 1) Rarely, the SMA can be a direct branch off the external carotid artery.[1] Anteriorly the SMA travels on top of the mylohyoid muscle and remains deep to the anterior belly of the digastric 70% of the time. The artery can be found superficial to the digastric muscle in the other 30% of cases.[2,4] The distal SMA supplies branches to the platysma, digastric, mylohyoid, periosteum of the mandible, cutaneous perforators, and forms a rich anastomosis network with the contralateral artery.[1] On average, the SMA gives 1-2 skin perforators.[6] Methylene blue dye injection study of the distribution of the SMA identified a skin territory up to 7 cm x 15 cm, and similar studies report skin territory coverage as large as 10 cm x 16 cm.[1,4]

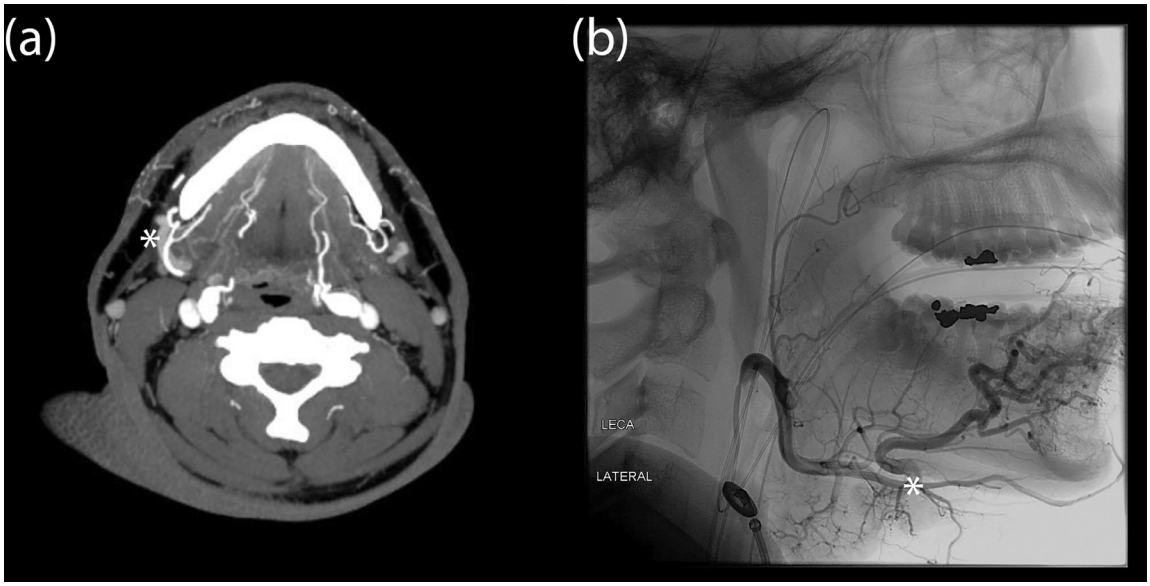

Figure 1 (A) Axial view of a CT angiogram and (B) sagital view of an angiogram demonstrating course of the submental artery. *Indicates Submental artery branching point from the facial artery.

The venous drainage of the SIF is the submental vein (SMV), which travels alongside the artery and typically empties into the facial vein.[4] The facial vein typically tributes to the internal jugular vein (IJV) 70% of the time and the external jugular vein (EJV) in 30% of cases.[7] In rare cases the SMV can drain into the IJV directly, which severely limits the reach of the SIF.[8]

Although Martin originally described harvesting the SIF without the anterior belly of the digastric, the majority of published studies recommend including the ipsilateral anterior digastric in order to provide additional safety for the perforators and better venous drainage.[4,8] Patel advocated including the ipsilateral mylohyoid for added bulk and safety to the distal SMA and its perforators, especially when teaching young surgeons who may not be as familiar with handling small vessels.[3] When an osteocutaneous SIF is needed, a cuff of mylohyoid or the muscle as a whole should be included with the bony harvest to protect perforators to the periosteum.[8,9]

The marginal mandibular nerve (MMN) is another critical structure that should receive careful attention when harvesting the SIF. The location and course of the MMN vary according to the literature. The nerve may run below, at, or above the inferior margin of the mandible and may have multiple branches after exiting the parotid.[10] In terms of tissue plane, the nerve is superficial to the posterior belly of the digastric and the capsule of the submandibular gland.[11] Traveling anteriorly the nerve runs deep to the parotidomasseteric fascia and will always remain superficial to the facial artery and vein. The anterior border of the masseter muscle is often the crossing point between the facial vessels and the MMN.[11] Once the nerve crosses the facial vessels and the midpoint of the body of the mandible, it remains above the inferior edge of the mandible.[12]

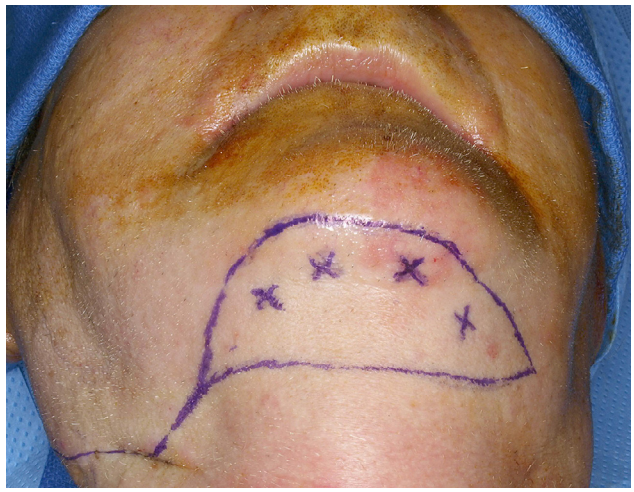

Figure 2 Skin paddle design with perforators confirmed by Doppler. (Color version of figure is available online.)

Harvest technique

1. Design the flap. (Fig. 2)
   a. With the patient supine, the desired skin paddle size is marked. The superior edge of the flap should approximate the inferior border of the mandible for better masking of the incision. While studies have shown that the skin paddle can be as large as 10 cm x 17 cm, the skin paddle is usually determined by the skin laxity.[1,4]
   b. A pinch test can be performed to estimate the short axis of the flap that would still allow for primary closure.
   c. The side of the surgical defect will dictate the side from which the pedicle will originate. Depending on vessel variations, the SIF has been shown to be able to cover any aspect of the ipsilateral face.[5]

d. Acoustic Doppler sonography may be used to identify the perforator vessels supplying the skin paddle.
2. Complete the superior incision through the skin and platysma.
3. Identify the ipsilateral submandibular gland.
   a. Dissect to the gland's inferior border and elevate its fascia to expose the gland's superior limit. Due to varying drainage to anterior jugular vein , external jugular vein, common facial vein, and IJV, care should be taken not to ligate vessels until the dominant venous pathway can be identified (See Step 5).
4. Identify the MMN.
   a. The facial vessels, as they cross the inferior border of the mandible, are a key landmark to help identify the MMN, which should travel superficially to both the facial artery and vein.
   b. Once the nerve is identified, dissect and preserve it.
5. Identify the pedicle.
   a. By applying gentle inferior retraction to the submandibular gland, the SMA and veins should be identified at the superior and medial border of the gland or traveling along the inferior border of the mandible. (Fig. 1)
6. Excise the submandibular gland.
   a. Ligate branches off the SMA to the submandibular gland.
   b. Remove the gland in the usual manner, taking care to ensure that the facial artery is only ligated *distal* to the SMA origin if additional length is required. Leaving the facial artery intact allows for retrograde flow from the contralateral artery. Capsular dissection of the submandibular gland with microbipolar can be helpful.
   c. The submandibular gland may be left in situ if removal is not indicated and if feeding vessels from the SMA to the gland can be ligated to allow for mobilization of the flap.
7. The SMA and SMV can be further skeletonized anteriorly until the ipsilateral anterior belly of the digastric is encountered. Care should be taken to not allow vessels, specifically veins, to have unnecessary tension or exposure to drying throughout the dissection and preparation.
8. Complete the inferior incision through the skin and platysma while keeping the location of the pedicle in mind.
9. Subplatysmal dissection of the flap from the contralateral side toward the pedicle can be performed from inferior to superior, or in the direction that protects the pedicle most reliably.
   a. The contralateral MMN can be identified in a similar manner as described above.
   b. Dissection should move anteriorly, raising the flap off the contralateral anterior belly of the digastric.
   c. Once the ipsilateral medial anterior belly of the digastric is encountered, the dissection should be carried *deep* to this muscle in order to include it in the flap and to protect cutaneous perforators. Occasionally perforators can wrap medially around the muscle edge, not through, and extreme caution should be used when approaching the medial aspect of the muscle belly.
   d. For additional bulk, the mylohyoid (and/or SMG) on the ipsilateral side can be included in cases where a level 1a neck dissection is absolutely not indicated.
10. Further skeletonize the pedicle and mobilize the flap to determine if there is tension free reach to the primary defect. Mobilization is only necessary until tension free distal reach is obtained.
    a. *Optional*: Occasionally, the venous anatomy limits the arc of rotation. In this case, the pedicle vein may be ligated and anastomosed to a recipient vein using microvascular technique in order to allow tension free inset. (Fig. 3) A similar approach may be applied to the artery (not shown).
11. Level 1 neck dissection
    a. Skeletonize the SMA and SMV then remove all fibrofatty tissue remaining in level 1a and 1b from the flap tissues. Careful consideration should be given to draining veins.
12. *Optional*: The lingual cortex or the inferior rim of the anterior mandible may be harvested with a cuff of mylohyoid muscle (and periosteum) en bloc with the SIF. (Fig. 4)

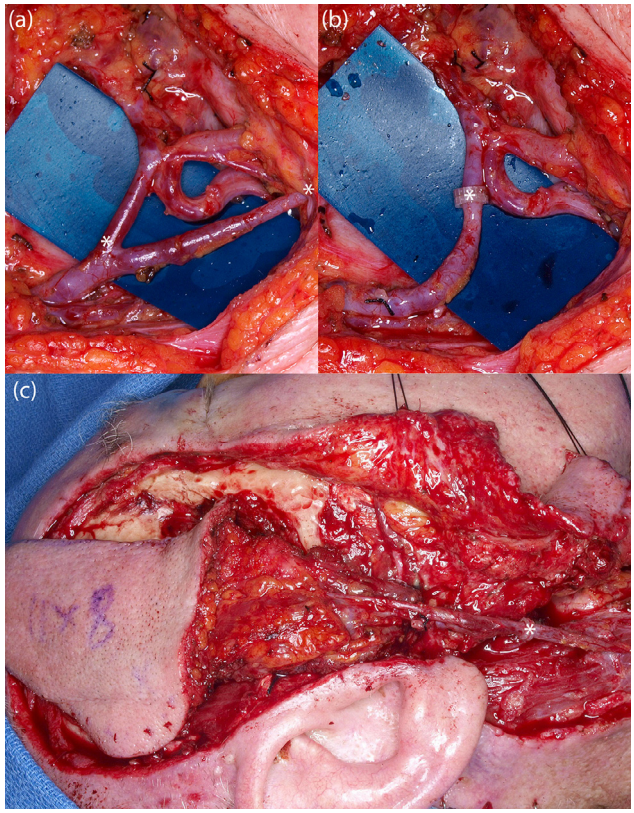

Figure 3 (A) Common facial vein restricting pedicle mobility. *Indicates proposed site of vein ligation. (B) Anastomosis of external jugular vein and common facial vein. *Indicates vein coupler anastomosis site. (C) Flap mobility greatly improved to allow coverage of entire ipsilateral face. *Indicates vein coupler anastomosis site. (Color version of figure is available online.)

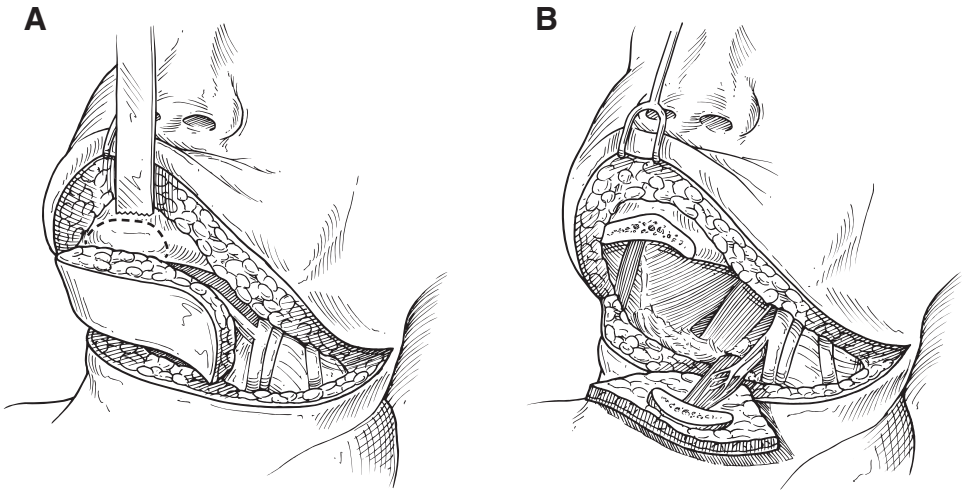

Figure 4 (A) Exposed mandible after flap and pedicle dissection with propose osteotomy site. (B) Pedicled submental island flap harvested with bone following osteotomy.

a. Dissection of level 1a should be completed as clinically indicated prior to proceeding with bony harvest. Careful dissection and preservation of the vascular pedicle will allow for adequate treatment of the level 1a nodal basin.
b. Expose the inferior border of the anterior mandible by raising the subplatysmal flap from the superior incision to this level along the desired length of bone. The incorporated bone has been reported to measure up to 10×2 cm, but typically bone segments are considerably smaller than this. Anticipate patient variability however 4 cm bone stock from the body or symphyseal/parasymphyseal segments is a reasonable estimate. Keep in mind that possible bone stock is osteotomy dependent and harvest site may require plate reconstruction.
c. Identify and expose the mental nerves to prevent injury.
d. Perform the mandibular osteotomy of the body, symphyseal and/or parasymphyseal region with a powered saw. The cut may be angled to preserve the anterior inferior margin and excise only the lingual aspect of the mandible. In this way, the mandible's visible contour and mental foramina are preserved. Include the periosteum and a cuff of attached mylohyoid muscle to preserve blood supply to the bone.

13. Close the secondary defect primarily in layers with standard surgical drain placement.
    a. It may be helpful to place the head in a less extended position.
    b. Standing cone deformities can be relaxed by extending incisions posteriorly along the inferior border of the mandible.

Discussion

The applications and reconstructive potential of the SIF have been well reported. Initially described as a pedicled monoaxial myocutaneous flap in the otolaryngology literature, the SIF is ideal for cutaneous facial defects because of its excellent facial skin match, reliable vascular supply, and a relatively hidden donor site with minimal donor site morbidity.[13] Over the last 25 years, the flap's utility has vastly expanded as reconstructive surgeons have employed it as a pedicled, hybrid, or free tissue cutaneous, myocutaneous, fasciocutaneous, or osteocutaneous flap. The SIF is suitable for a range of defects, including all intraoral subsites, laryngeal defects, bony defects (maxilla, zygoma, and orbital rim), and cutaneous defects of the neck to as high as the forehead.[2,8,9,14-16]

The breadth of reconstructive applications has been significantly facilitated by pedicle modifications as reported by Sterne et al.[5] The facial artery may be divided distal to the SMA allowing for pedicle lengthening by 1 cm-2 cm. Additional length may be gained by dividing the submental or common facial vein (whichever is on tension) and anastomosing it to a vein more proximal to the defect, thus converting to a hybrid flap. (Fig. 3) Lastly, the proximal facial artery may be ligated with reliance on reverse or retrograde flow from the contralateral facial artery.[5,16]

The SIF is also reported as an osteocutaneous flap to reconstruct bony defects involving the facial skeleton.[8,9,15,17] The harvest technique to incorporate osseous tissue described in the literature utilizes the lingual cortex of the mandible with a cuff of mylohyoid with dimensions up to 10 cm $\times$ 2 cm of cortical bone.[8,15] Al Felasi et al. described a successful pedicled osteomyocutaneous SIF utilizing a full thickness 5 cm $\times$ 1 cm segment of the inferior rim of the mandible for reconstruction of the inferior orbital rim following a radical maxillectomy.[9] In the same report, a postoperative scintigraphy scan was performed 6 months after surgery and confirmed bony vascularization that was comparable to surrounding normal bone.

The primary concern with the SIF (other than the technical aspects of its harvest and reliable venous drainage outcomes) is the oncologic safety of mobilizing level 1 lymph nodes that may harbor neoplastic disease. This is

of particular interest in patients where postoperative radiation may not be indicated, yet observation of occult lymphovascular disease would place them at unreasonable risk. The body of literature at this time seemingly supports the use of the SIF for oral cavity malignancy in cases of clinically and radiographically negative nodal disease.[17-19] However, the use of nodal dissection vs observation vs postoperative radiation and its potential protective effect in high-risk patients (those with primary site lymphovascular occult metastasis risk >20%) is not clear. Meticulous skeletonization of the pedicle, inclusion of the anterior belly of the digastric with the SIF, and removal of fibrofatty tissue in level 1, have not been demonstrated to cause increased risk of cancer recurrence. In carefully selected patients, a series of 50 oral cavity malignancy cases with SIF reconstruction, there was an overall 10% rate of occult metastases and despite only 36% of patients receiving adjuvant chemoradiation there was no local recurrence associated with the SIF.[17]

The literature also suggests the pedicled SIF may be a cost-effective alternative to free tissue transfer. Although the true monetary savings are difficult to determine due to variation in free flap management (e.g. length of stay in intensive care units, hospital fees, supporting staff fees among others), it is reasonable to anticipate overall shorter operative time, shorter length of stay in intensive care units stay, and shorter hospital stay.[20,21]

Summary

The SIF is a valuable and versatile reconstructive option for the head and neck surgeon. Appropriate modifications allow reconstruction of the entire ipsilateral face and oral cavity with the possibility of bony reconstruction.

Disclosure

All authors involved have no conflict of interest to disclose.

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