Operative Techniques in Otolaryngology 30 (2019) 138–144

Operative Techniques in Otolaryngology

The sternocleidomastoid flap

Bhavishya S. Clark, MD, Sona Shah, BA, Tamara Brown Chambers, MD

From the Department of Otolaryngology – Head and Neck Surgery, University of Southern California, Los Angeles, California

KEYWORDS
Sternocleidomastoid Flap;
Head and neck reconstruction;
Hypopharyngeal repair;
Oral cavity repair;
Fcial defect;
Parotidectomy defect

The sternocleidomastoid muscle has long been used for local reconstruction in the head and neck. It remains an incredibly versatile flap by providing bulk, an area of hairless skin with excellent color match for the face, and opportunity to transpose periosteum or bone for correcting head and neck defects. In this paper, we discuss the anatomy of designing a sternocleidomastoid flap, highlight operative techniques to ensure success and minimize complications, and briefly review its commonly described uses.

Introduction

The sternocleidomastoid (SCM) flap was first described in the early 20th century to provide a method to dynamically reanimate the paralyzed face with its motor nerve and vascular supplies intact. The first reported musculocutaneous flap based on the SCM was done by Owens in 1955 who used it for reconstruction of the cheek after surgery for carcinoma.[1] In 1967, Littlewood described the use of the SCM for maxillectomy reconstruction.[2] Since then, various uses for this flap have been described. SCM flaps have been used for 1 stage reconstruction in patients with benign and malignant pathologies. A flap can be designed to be muscle only, myocutaneous, myoperiosteal, or osseomyocutaneous with resection of the clavicle. The muscle carries the cutaneous paddle, periosteum, and/or bone graft directly. When chosen correctly, common uses for the SCM flap include facial reanimation, protection of major vessels, oral cavity defect repair, prevention of Frey syndrome after parotidectomy, oro- and hypopharyngeal wall repair, and facial defect repair to name a few. Successful use of the SCM flap relies on careful preoperative planning and a thorough understanding of head and neck anatomy.

Anatomy

The SCM muscle originates from the manubrium and the medial aspect of the clavicle. It is a 2-headed muscle that runs obliquely in the neck to insert into the mastoid process of the temporal bone and the superior nuchal line. It is rounder and thicker superiorly near the mastoid. Inferiorly, there is a small gap between the clavicular and sternal heads. The superficial layer of the deep cervical fascia covers the muscle. Innervation is from the spinal accessory nerve (SAN) and branches of the cervical plexus, C1 and C2. Unilateral contraction of the SCM muscle flexes the neck anterolaterally and rotates the head opposite to the side of contraction.

The SCM is a type II muscle according to the Mathes-Nahai classification of muscle flaps, having 1 dominant pedicle and other minor pedicles.[3] Blood supply to the SCM varies along the length of the muscle. It is sup-

Address reprint requests and correspondence: Tamara Brown Chambers, MD, USC Tina and Rick Caruso Department of Otolaryngology – Head and Neck Surgery, 1540 Alcazar Street, Suite 204, Los Angeles, CA 90033.

E-mail address: tamara.brown@med.usc.edu

http://doi.org/10.1016/j.otot.2019.04.009
1043-1810/

plied by the occipital artery superiorly, the superior thyroid artery at its mid-portion, and the transverse cervical artery inferiorly (Figure 1). The occipital artery arises posteriorly off of the external carotid artery opposite the facial artery to nourish both heads of the SCM indiscriminately. It can easily be seen during dissection entering through the inner surface of the muscle. The superior thyroid artery originates from the anterior surface of the external carotid artery at the level of the greater cornu of hyoid bone. It gives rise to the sternomastoid branch that enters the anterior belly of the SCM and traverses in a posterolateral course to feed the sternal and clavicular heads separately. Though the occipital artery was initially considered the dominant pedicle of the SCM, newer studies highlight the greater importance of the superior thyroid artery in creating this flap.[4] Cadaveric studies show wide variation of the transverse cervical artery supplying the inferior one-third of the muscle and flaps are not based off of this artery as a result.[5] This unique tripartite blood supply with a rich anastomosis amongst the supplying vessels allows for superiorly or inferiorly based flaps.

Blood supply to the skin overlying the SCM is worth a mention as well because the platysma muscle overlies the SCM. Platysma muscle fibers are oriented obliquely across the neck, arising from the muscular fascia of pectoralis major to their attachment onto the body of the mandible. The platysma muscle runs at an angle opposite to the SCM such that the caudal portion of the SCM is covered by the platysma and the cephalad portion is not. This is of importance because myocutaneous perforators from the superior thyroid artery have to traverse the width of the SCM and platysma in order to supply the skin inferiorly. As a result, due to the absence of the platysma in the cephalad region, superiorly placed skin paddles are more robust than inferiorly located ones.[6]

Key structures near the SCM should be identified early to minimize risk of iatrogenic injury to them. The external jugular vein crosses vertically in the neck over the SCM. The carotid sheath and its contents lie deep and medial to the SCM, separated by a fibrous sheath. To minimize functional deficits after surgery, the SAN should be preserved. Landmarks to aid in the detection of the SAN have been extensively described. The SAN most commonly crosses the internal jugular vein anteriorly in the upper neck giving a branch to the SCM and trapezius muscles. Some argue for its identification in the posterior triangle near its insertion into the trapezius muscle, 3–5 cm above the clavicle.[7] Another noted landmark to aid dissection is Erb's point (punctum nervosum), where sensory branches of the cervical plexus merge dorsal to the SCM.[7] It is located 2 fingerbreadths above the clavicle and 1 fingerbreadth lateral to the posterior border of the SCM.[8] The SAN exits at Erb's point in the posterior neck triangle. When creating a SCM flap, to reduce risk of injury to the vascular pedicle, dissection in the anterior triangle of the neck is recommended to identify the SAN. Fortunately, the greater auricular point, located in the anterior triangle, is considered the most reliable guide for identification of the SAN.[9] It is the point where the greater auricular nerve crosses the anterior border of the SCM. In most cases, the SAN is found within a centimeter of the greater auricular point, just superior and deep to it.[9]

Technique

Four types of SCM flaps have been described: muscle-only flaps, myocutaneous flaps, myoperisoteal flaps, and osseomyocutaneous flaps. When considering an SCM flap, defects should be carefully measured. Single-headed SCM flaps can repair soft tissue defects up to 8 cm × 6 cm. If bone is needed, an SCM flap with a clavicular bone graft can fix mandibular defects up to 6 m long.[4] If a skin paddle is needed, the maximum arc of rotation can be obtained by planning a skin paddle over the most distal portion of muscle.

A skin incision should be made parallel to the muscle from the angle of the mandible, overlying the belly of the muscle, for optimal exposure of the occipital and superior thyroid arteries. If the flap is being used for reconstruction immediately following oncologic surgery, the muscle may be accessed using the neck dissection skin incision. Next, skin-platysma flaps are raised anterior and posterior to the SCM. Once exposed fully, muscle should be raised with its investing fascia to minimize injury to deeper structures. The SCM can be separated from its superior or inferior bony attachments with a combination of blunt and sharp dissection. Due to wide variation in the arterial supply by the transverse cervical artery to the inferior one-third of the muscle, pedicles for the SCM should be based on the superior thyroid artery with or without the occipital artery preserved intact. Dissection usually proceeds in an inferior to superior direction with ligation of inferiorly located vessels. Great care should be taken when dissecting the mid-portion of the SCM where the superior thyroid artery lies. In contrast to previous reports, newer studies show that maintenance of the occipital artery is not needed for SCM flap survival. Preserving the superior thyroid arteriovenous system however is critical for the survival of the SCM flap.[10] As dissection continues, the SAN should be identified and preserved using the aforementioned landmarks. Dissection continues along the length of the muscle to obtain the necessary arc of rotation while minimizing undue tension or torsion on the superior thyroid artery or SAN.

Myocutaneous perforators supply the skin paddle. As such, the size of the skin paddle should not extend significantly beyond the borders of the muscle. Maintaining the cranial portion of the external jugular vein will improve venous return of the skin paddle.[11] Once raised and before insetting the flap, capillary refill of the paddle should be confirmed by stroking the skin of the paddle.

If bone is needed, an SCM flap with a clavicular bone graft can repair mandibular defects up to 6 cm long.[4] There are risks associated with full- and partial-thickness bone grafts. Full-thickness clavicular grafts affect the stability of

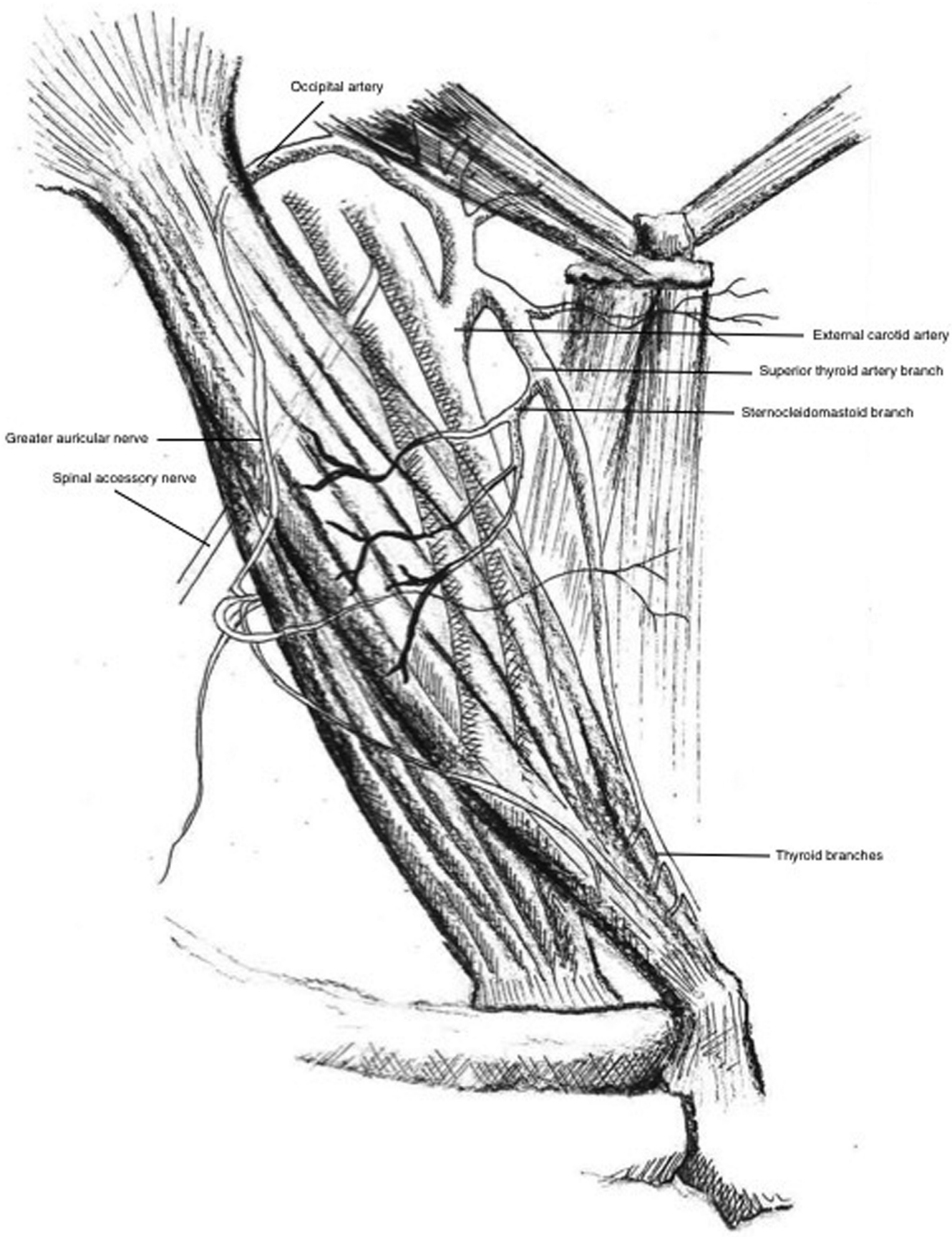

Figure 1 Blood supply to the sternocleidomastoid muscle and its relation to surrounding structures.

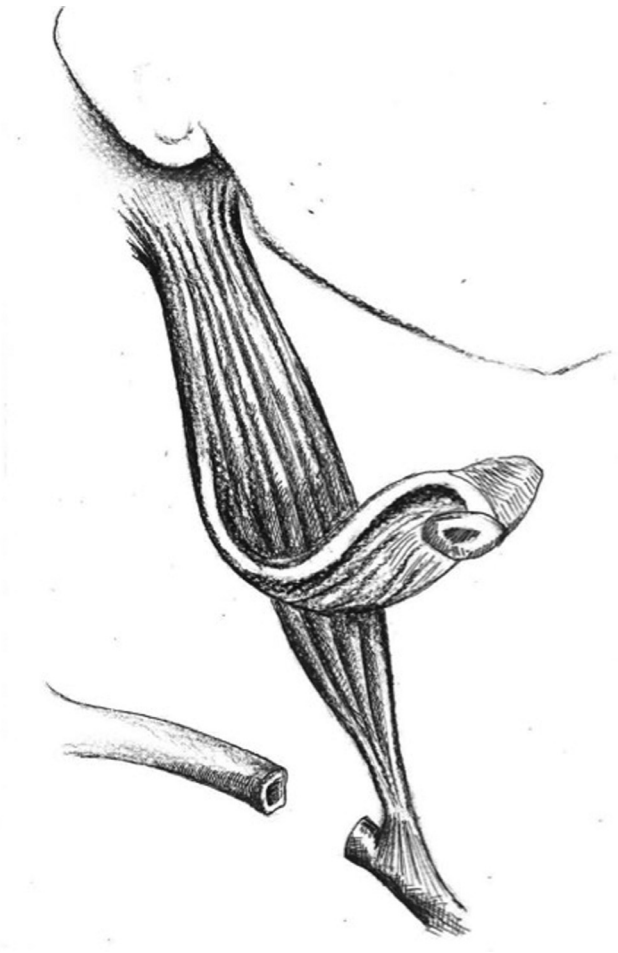

Figure 2 Full-thickness clavicular bone graft.

the sternoclavicular joint while partial-thickness clavicular grafts carry higher risk of a clavicle fracture during and after harvest.[12] Literature supports the use of either type of bone graft. The clavicular bone graft should be taken from the medial segment of clavicle with the SCM muscle attachment maintained intact (Figure 2); the blood supply to the bone and periosteum is provided by muscle perforators supplied by the superior thyroid artery. Titanium plate and screws can be used to secure the bone graft in place in the mandible. Dental implants can be inserted into the grafted bone in an immediate or delayed fashion.[4] A similar technique can be used to raise a myoperisoteal flap.

Depending on the location of the defect, the flap can be tunneled under the mandible. To minimize risk of injury to the pedicle coursing through the muscle, deep sutures should be placed in the periphery of the muscle during flap inset. If a skin paddle is used, dermal and skin surface sutures should be placed in a tension-free manner.

To minimize bulk, the SCM can be split and only one head may be transposed to fill defects. Care should be taken if detaching the sternal head; a branch of the superior thyroid artery can be encountered during dissection. Flaps may be based on the sternal or clavicular head because the sternomastoid branch of the superior thyroid artery supplies the two heads of the SCM separately.[13,14] The sternal head of the SCM can be split from the clavicular head until the first pedicle arising from the superior thyroid artery is encountered, approximately through two thirds of the muscle length.[5] The location of the skin paddle generally dictates which head is selected.

Once the SCM flap is raised with its superior thyroid arteriovenous system successfully identified and preserved, selective or functional neck dissection, including level II lymph nodes, can be carried out without fear of injury to flap viability in oncological surgery. Donor sites can be closed in a layered fashion by undermining and locally advancing surrounding skin. Skin grafts are rarely needed to cover the donor site.

Uses

SCM flaps are extremely versatile. They are best suited for repairing defects below the level of the zygomatic arch due to their maximum arc of rotation. Soft tissue defects exceeding 8 cm × 6 cm or mandibular defects greater than 6 cm are not suitable for repair with a SCM flap. A flap can be superiorly or inferiorly based, single or double headed, and have skin, periosteum, and/or bone elevated with muscle. If using a split muscle flap, a longitudinal split of the heads of the SCM can be carried up to two-thirds of the length of the muscle, until the sternomastoid branches of the superior thyroid artery are encountered.[5]

One commonly described application for a SCM flap is for defect repair after superficial or total parotidectomy. A superiorly based SCM flap can be sutured to the parotid fascia to fill the depression deformity and restore facial asymmetry after surgery[15,16] (Figure 3a and b). Additionally, the use of a SCM flap after parotidectomy has been show to decrease the incidence of Frey Syndrome.[17,18] Frey syndrome, also known as gustatory sweating, is a common occurrence after parotidectomy. Reported incidences range widely between 2% and 100%.[19] The etiology of Frey syndrome involves aberrant regeneration of postganglionic parasympathetic fibers to cutaneous sweat glands resulting in increased sweat secretion during eating. The syndrome usually develops within the first year after surgery, though can be delayed up to eight years after surgery.[20] Surgical and medical treatments for this condition have been described. A proven preventative measure at time of resection is to use an interpositional barrier between the skin flap and exposed parotid bed to discourage aberrant innervation. A SCM muscular flap works in such a way.[16]

A muscle-only flap can also be used to repair cervical esophageal perforations after trauma or iatrogenic injury in nononcologic patients.[21-23] The muscle may also be transposed over to cover and protect major vessels or suture lines in the neck. A SCM myocutaneous flap is well suited for closure of oro- or pharyngocutaneous fistulae due its close proximity to the defect and minimal bulk when compared to a pectoralis major, lattismus dorsi, or trapezius muscle flap.[24] The laryngotracheal complex can

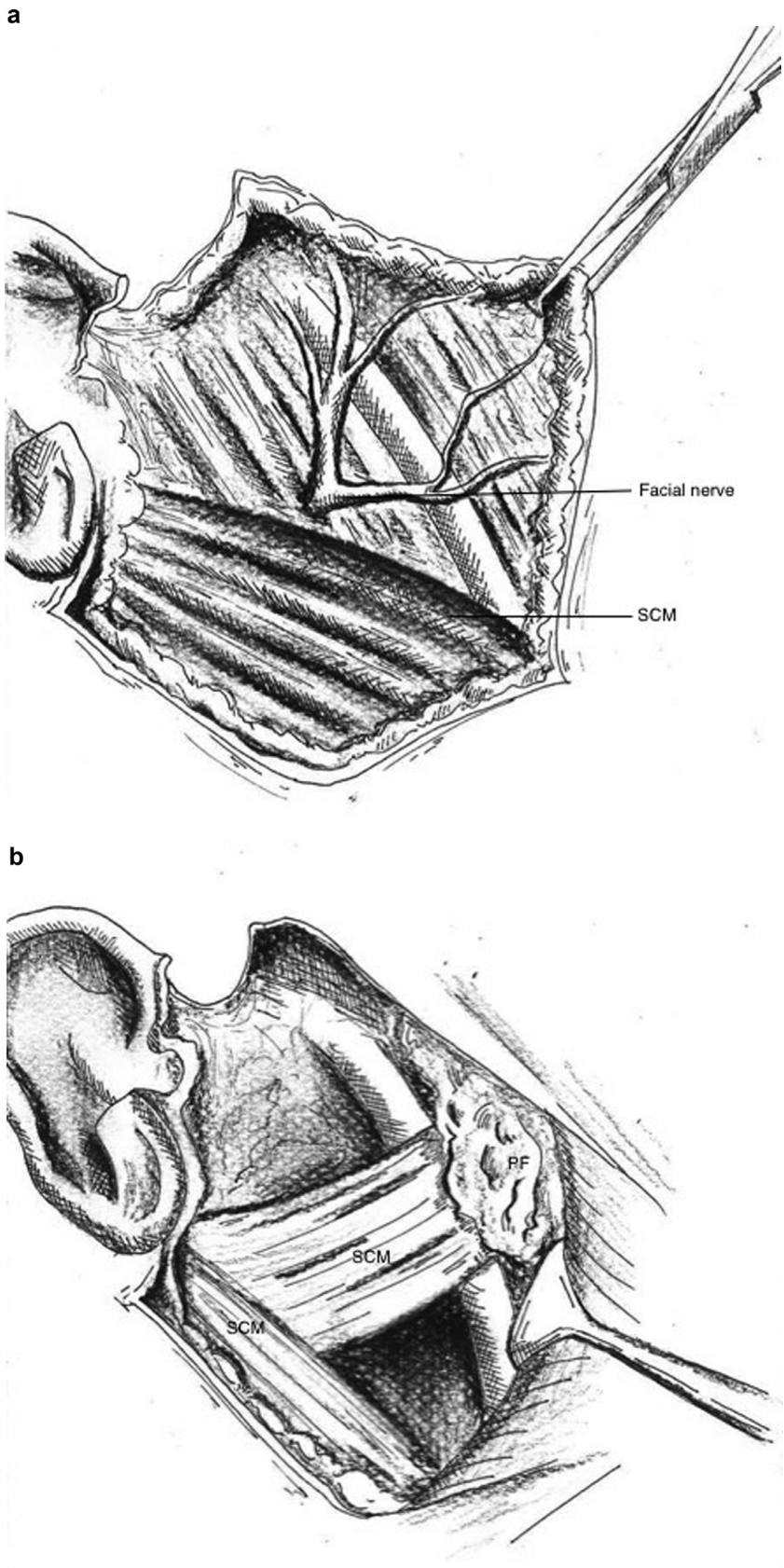

Figure 3 (a) Parotid bed after total parotidectomy showing exposed facial nerve and its branches. (b) The parotid bed applying a superiorly based SCM muscle flap. The flap is sutured to the parotid fascia. It covers and protects the facial nerve and restore facial contour.

be repaired with a SCM myoperiosteal flap.[25] Other described uses include repair of depressed post-tracheostomy scars,[26] repair of dead space after supraomohyoid neck dissection,[27] intraoral reconstruction,[28] and mandibular reconstruction.[29]

Obstacles

The popularity and use of the SCM flap has fluctuated over time for various reasons. Commonly cited criticisms of the flap include varying morbidity rate reports, the limited arc of rotation that can be obtained from the SCM's pedicle, the risk of damage to deeper structures during dissection, its questioned safety in oncologic surgery, and the resultant "flat neck deformity" it leaves behind.[30]

Morbidity reports of the SCM flap have been as low as 7.3% and as high as 52%.[28,31,32] As with other flaps, flap failure is mostly commonly due to compromised blood supply due to strain on the pedicle. Full flap failure is rare due to its rich vascular anastomosis but partial necrosis of the most distal portion of the flap and its skin paddle is well documented. Skin paddles centered over inferiorly based flaps have higher failure rates. Myocutaneous perforators to the skin paddle are more robust superiorly than inferiorly because the cephalad portion of the SCM is not covered by intervening platysma. Additionally, the blood supply to the skin over the inferior portion is the most unreliable along the length of the SCM. To minimize rates of flap morbidity, whenever possible, identification and preservation of both occipital and superior thyroid arteries is recommended. Traction, tension, and damage of the myocutaneous perforators, which feed the skin paddle, periosteum, and clavicular bone graft, can be minimized through judicious suture placement during inset. Sutures should be placed directly in the periphery of the muscle. Skin should be closed in a layered fashion. If encountered, partial necrosis or dehiscence of the skin paddle can be addressed with local wound care to promote re-epithelialization. Full failure of the skin paddle may require coverage with a skin graft. Complete flap failure is rarely encountered, affecting approximately 4%-7% of patients.[10]

The length of the pedicle rising from the superior thyroid artery dictates the arc of rotation of the SCM flap. The SAN further limits rotation superiorly. Widely dissecting along the length of the artery and nerve will increase the arc of rotation.

There is considerable debate on the oncological safety of using a SCM flap in patients without an N0 neck.[30,32,33] Newer reports however show use of a SCM flap following functional or selective neck dissection does not significantly affect disease recurrence.[28,34] Use of the SCM flap is generally discouraged if tumor directly invades the muscle or if performance of a thorough neck dissection is hindered by the location of the pedicle.[4] History of radiation to the head and neck is a not an absolute contraindication to use.[10,34] Level II neck dissection commonly results in damage to the SCM branch of the occipital artery. As mentioned previously, however, the superior thyroid arteriovenous system should be selected over the occipital artery as the dominant blood supply to the SCM flap. So long as this supply is preserved after a neck dissection, the SCM can be considered a reconstruction option following ablative surgery.

Transposition of the entire SCM muscle can create a "flat neck deformity," another criticism of this type of flap. If bulk is not required to fill a defect, performing a split muscle SCM flap can prevent a concave neck deformity.[35] The sternal and clavicular heads of the SCM have independent blood supplies and either head can be used for reconstruction.[5] Leaving the unused head at its superior and inferior attachments will minimize neck deformity.

Conclusions

SCM flaps are a reliable, convenient, and technically easy reconstruction option with wide application in the head and neck region due to their many unique qualities. When appropriately chosen, based on defect size and location, advantages of a SCM flap over a distant free flap include shorter duration of operation, good skin match, and minimal donor site morbidity. It is an oncologically safe option for reconstruction in patients with regional nodal metastases so long as the SCM muscle itself is free of disease and a thorough neck dissection to remove nodal disease is performed.[11] Complications can be reduced with careful understanding of the anatomy of the neck and proper surgical technique.

Disclosure

The authors of this paper do not have any conflicts of interests, financial, material, or personal, that relate to the research described in this paper.

References

1. Owens N: A compound neck pedicle designed for the repair of massive facial defects: Formation, development and application. Plast Reconstr Surg 15:369–389, 1955.
2. Littlewood M: Compound skin and sternomastoid flaps for repair in extensive carcinoma of the head and neck. Br J Plast Surg 20:403–419, 1967.
3. Mathes SJ, Nahai F. Clinical Atlas of Muscle and Musculocutaneous Flaps. St. Louis, Mo: Mosby, 1979.
4. Wei D, Liu JH, Zhao WQ, et al: Use of the versatile sternocleidomastoid flap in oral and maxillofacial surgery: Our experience. Br J Oral Maxillofac Surg 51:742–746, 2013.
5. Alagoz MS, Cagri Uysal A, Tuccar E, et al: How cranial could the sternocleidomastoid muscle be split? J Craniofac Surg 16:201–204, 2005.
6. Hurwitz DJ, Rabson JA, Futrell JW: The anatomic basis for the platysma skin flap. Plast Reconstr Surg 72:302–314, 1983.
7. Eisele DW, Weymuller EA Jr, Price JC: Spinal accessory nerve preservation during neck dissection. Laryngoscope 101:433–435, 1991.

8. Popovski V, Benedetti A, Popovic-Monevska D, et al: Spinal accessory nerve preservation in modified neck dissections: Surgical and functional outcomes. Acta Otorhinolaryngol Ital 37:368–374, 2017.
9. Hone SW, Ridha H, Rowley H, et al: Surgical landmarks of the spinal accessory nerve in modified radical neck dissection. Clin Otolaryngol Allied Sci 26:16–18, 2001.
10. Kierner AC, Zelenka I, Gstoettner W: The sternocleidomastoid flap—Its indications and limitations. Laryngoscope 111:2201–2204, 2001.
11. Chen HC, Chang HS: The sternocleidomastoid flap for oral cavity reconstruction: Extended indications and technical modifications. J Oral Maxillofac Surg 73:2429–2439, 2015.
12. Zhao W, Liu J, Wei D, et al: Pedicled partial thickness clavicular graft for oromandibular reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol 121:e1–e5, 2016.
13. Siemssen SO, Kirkby B, O'Connor TP: Immediate reconstruction of a resected segment of the lower jaw, using a compound flap of clavicle and sternomastoid muscle. Plast Reconstr Surg 61:724–735, 1978.
14. Tovi F, Gittot A: Sternocleidomastoid myoperiosteal flap for the repair of laryngeal and tracheal wall defects. Head Neck Surg 5:447–451, 1983.
15. Nofal AA, Mohamed M: Sternocleidomastoid muscle flap after parotidectomy. Int Arch Otorhinolaryngol 19:319–324, 2015.
16. Fee WE Jr, Tran LE: Functional outcome after total parotidectomy reconstruction. Laryngoscope 114:223–226, 2004.
17. Demirci U, Basut O, Noyan B, et al: The efficiacy of sternocleidomastoid muscle flap on Frey's syndrome via a novel test: Galvanic skin response. Indian J Otolaryngol Head Neck Surg 66(Suppl 1):291–298, 2014.
18. Casler JD, Conley J: Sternocleidomastoid muscle transfer and superficial musculoaponeurotic system plication in the prevention of Frey's syndrome. Laryngoscope 101:95–100, 1991.
19. Linder TE, Huber A, Schmid S: Frey's syndrome after parotidectomy: A retrospective and prospective analysis. Laryngoscope 107:1496–1501, 1997.
20. Malatskey S, Rabinovich I, Fradis M, et al: Frey syndrome-delayed clinical onset: A case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 94:338–340, 2002.
21. Richardson JD: Management of esophageal perforations: The value of aggressive surgical treatment. Am J Surg 190:161–165, 2005.
22. Navarro R, Javahery R, Eismont F, et al: The role of the sternocleidomastoid muscle flap for esophageal fistula repair in anterior cervical spine surgery. Spine 30:E617–E622, 2005.
23. Losken A, Rozycki GS, Feliciano DV: The use of the sternocleidomastoid muscle flap in combined injuries to the esophagus and carotid artery or trachea. J Trauma 49:815–817, 2000.
24. Marx RE, McDonald DK: The sternocleidomastoid muscle as a muscular or myocutaneous flap for oral and facial reconstruction. J Oral Maxillofac Surg 43:155–162, 1985.
25. Friedman M, Mayer AD: Laryngotracheal reconstruction in adults with the sternocleidomastoid myoperiosteal flap. Ann Otol Rhinol Laryngol 101:897–908, 1992.
26. Kurt Yazar S, Yuce E, Serin M, et al: A new technique in management of depressed posttracheostomy scars. Ann Plast Surg 81(3):311–315, 2018.
27. Li J, Han Z: Sternocleidomastoid muscle flap used for repairing the dead space after supraomohyoid neck dissection. Int J Clin Exp Med 8:1296–1300, 2015.
28. Tanaka N, Yamaguchi A, Ogi K, et al: Sternocleidomastoid myocutaneous flap for intraoral reconstruction after resection of oral squamous cell carcinoma. J Oral Maxillofac Surg 61:1179–1183, 2003.
29. Leclere FM, Vacher C, Benchaa T: Blood supply to the human sternocleidomastoid muscle and its clinical implications for mandible reconstruction. Laryngoscope 122:2402–2406, 2012.
30. Larson DL, Goepfert H: Limitations of the sternocleidomastoid musculocutaneous flap in head and neck cancer reconstruction. Plast Reconstr Surg 70:328–335, 1982.
31. Avery CM: The sternocleidomastoid perforator flap. Br J Oral Maxillofac Surg 49:573–575, 2011.
32. Sebastian P, Cherian T, Ahamed MI, et al: The sternomastoid island myocutaneous flap for oral cancer reconstruction. Arch Otolaryngol Head Neck Surg 120:629–632, 1994.
33. Tiwari R: Experiences with the sternocleidomastoid muscle and myocutaneous flaps. J Laryngol Otol 104:315–321, 1990.
34. Ross UH, Klenzner T: The myocutaneous sternocleidomastoid flap for reconstruction of the mouth cavity and pharynx. Laryngorhinootologie 77:168–171, 1998.
35. Alvarez GE, Escamilla JT, Carranza A: The split sternocleidomastoid myocutaneous flap. Br J Plaset Surg 36:183–186, 1983.