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Revisiting the sternocleidomastoid flap as a reconstructive option in head and neck surgery

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Review Article

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Abstract

Background. The sternocleidomastoid can be used as a pedicled flap in head and neck reconstruction. It has previously been associated with high complication rates, likely due in part to the variable nature of its blood supply.
Objective. To provide clinicians with an up-to-date review of clinical outcomes of sternocleidomastoid flap surgery in head and neck reconstruction, integrated with a review of vascular anatomical studies of the sternocleidomastoid.
Methods. A literature search of the Medline and Web of Science databases was conducted. Complications were analysed for each study. The trend in success rates was analysed by date of the study.
Results. Reported complication rates have improved over time. The preservation of two vascular pedicles rather than one may have contributed to improved outcomes.
Conclusion. The sternocleidomastoid flap is a versatile option for patients where prolonged free flap surgery is inappropriate. Modern vascular imaging techniques could optimise pre-operative planning.

Introduction

The sternocleidomastoid regional pedicled flap can be used as a myocutaneous, myofascial, myoperiosteal or osteomuscular flap.[1,2] The first sternocleidomastoid flap operation was reported in 1908. Surgical outcomes have been variable, largely a result of the variable blood supply to the muscle.[1,3–5] The main advantages are that it requires a shorter operating time compared to free flaps,[6] it has reduced muscle bulk, it is associated with reduced morbidity, and it is a convenient, versatile and hairless tissue.[4,7]

Free flaps are increasingly used, as a result of advances in microvascular surgery. However, they are unsuitable when prolonged general anaesthetic cannot be tolerated or when no microvascular team is available.[8,9] It also exposes an additional donor site to the risk of post-operative complications.[8]

Regional pedicled flaps avoid the need for microvascular anastomosis. The pectoralis major is a commonly used reconstructive flap, but often requires incisions outside of the primary operating field.[10,11] It can be too voluminous for some reconstructions, and there can be excessive adipose tissue, especially in females.[8,12] Therefore, a sternocleidomastoid flap may be preferable for some patients.

There is great variety in usage of the sternocleidomastoid flap in the literature, and there have been many new reports since the most recent general review in 2001.[1] As the use of free flaps is not without flaws, and a pectoralis major flap is not always an option,[8] a reliable alternative for reconstruction needs to be explored. Use of the sternocleidomastoid reconstructive flap should therefore be reviewed, taking into account the literature from the past 15 years.

Methods

A literature search of the Medline and Web of Science databases was conducted to identify all articles, published from 1946 to 2016, that reported the use of sternocleidomastoid flaps. The keywords used were as follows: 'sterno*mastoid', 'flap', 'limitation*', 'blood supply', 'vascula*', 'vessel*', 'repair' and 'reconstruct*' (where the asterisk represented a wildcard symbol). The search was conducted in March 2016 and updated in August 2018. Exclusion criteria included case series with a small number of flaps used (less than 12) and studies that were not performed on humans.

The articles were split into case series, anatomical or radiological studies, and surgical methodology studies. Articles were then sorted by date to ensure the latest surgical techniques were well represented in the literature review.

The analysis of success and complication rates only included studies published from 1980 onwards. Complications were split into five categories based on the complications reported in the literature, and rates were analysed for each study. The trend in success rates was analysed by date of the study.

Arterial supply of sternocleidomastoid

Superior pedicle

The superior pedicle is the sternocleidomastoid branch of the occipital artery (Figure 1a and b). This is the major blood supply to the superior third of the sternocleidomastoid, if not the entire muscle,[10,13] and is the pedicle on which the flap has been based most frequently.[1] Fróes *et al.*[14] studied 30 cadaveric specimens, and found that the thin sternocleidomastoid branch of the occipital artery entered at the base of the muscle's superior third, along with the accessory nerve. From here it supplies the superior third consistently, and can branch longitudinally below this level or form one main branch.[5,14–16]

As the superior pedicle almost never reaches the inferior pole of sternocleidomastoid, a flap based on this alone is unlikely to be well vascularised at its distal end, which could lead to ischaemic complications.[16] This may have caused necrosis and flap failure in previous studies that utilised the superior pedicle only.[13,17]

Middle pedicle

The middle pedicle of the sternocleidomastoid is either a branch of the superior thyroid artery (80 per cent), a branch directly from the external carotid artery (20 per cent)[18,19] or it branches from both.[5] These branches can display variety in origin, and travel superficially to the carotid sheath en route to the sternocleidomastoid.[19]

Yugueros and Woods[13] suggested that the superior thyroid artery most likely supplies the entire muscle, though they based their flaps on only the superior pedicle. Wei *et al.*[20] proposed that the branch from the superior thyroid artery is the main blood supply to the sternocleidomastoid. Their view was supported by Khazaeni and colleagues' successful results,[21] basing their flaps on only the middle pedicle. Other reports suggest that the branch from the superior thyroid artery splits to supply the sternal and clavicular heads separately, thus allowing the muscle to be divided and one head to be taken as a flap.[22] The area supplied by the superior thyroid artery branch remains controversial, and there is a need for robust anatomical studies to confirm the area this vessel supplies.

Inferior pedicle

The inferior pedicle is the most disputed.[5] It is now thought to originate from a branch of the suprascapular artery (Figure 2).[5,16] More rarely, the inferior pedicle is a branch of the superior thyroid artery or transverse cervical artery.[5] These variations are important in surgery, as branches from the transverse cervical artery will appear more cranially than the usual inferior pedicle.[5] The inferior pedicle cannot be relied on to perfuse the entire muscle, as demonstrated with the injection of neoprene-latex, which only reached the superior third in 13 per cent of 15 specimens.[16]

Venous drainage

Venous drainage usually reflects the arterial supply.[13] In the published literature, it is mentioned considerably less than arterial supply, although its importance is well-recognised.[4,8,17,23] Chen and Chang[8] quantified veins left to drain each flap, which other studies invariably failed to do. They concluded that the maximum number of veins should be left, to aid venous drainage. They also suggested conserving the superior part of the external jugular vein for another channel of venous flow.

Other studies proposed venous insufficiency as a major reason for flap failure.[17,23] Veins are particularly susceptible to intra-operative injury, so care must be taken not to exert excessive tension.[17]

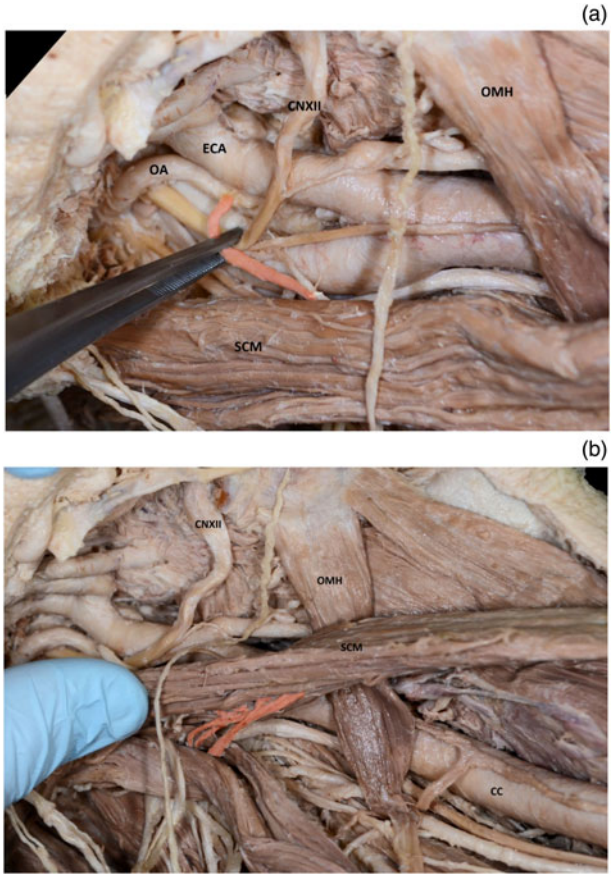

Fig. 1. (a & b) Cadaveric dissection images demonstrating the blood supply to the superior pedicle of the sternocleidomastoid (the red coloured branch is the sternocleidomastoid branch of the occipital artery). OA = occipital artery; ECA = external carotid artery; CNXII = 12th cranial (hypoglossal) nerve; OMH = omohyoid; SCM = sternocleidomastoid; CC = common carotid

Summary of reported complications

Necrosis of the sternocleidomastoid flap is relatively high, although this is mainly accounted for by partial epithelial necrosis of the myocutaneous flap (Table 1).[3,6,8–10,20,24–26] Partial epithelial necrosis is difficult to prevent, with no conclusive evidence that preserving two or more pedicles to the flap prevents this.[4,9,17] Nor does the technique of suturing the skin to underlying muscle, to decrease the shearing of skin perforators, seem to prevent partial epithelial necrosis.[7,13,20] However, as partial epithelial necrosis can nearly always be relied upon to heal with conservative management alone, many authors discount the importance of partial epithelial necrosis.[1,8,10] Disregarding partial epithelial necrosis would decrease the complication rate of the sternocleidomastoid flap to a more acceptable figure.

Interestingly, all of the studies that reported fistula development have based the sternocleidomastoid flap upon one pedicle.[2,3,6,13,24] Authors who have preserved two vascular pedicles have not reported fistulae. Basing the sternocleidomastoid on only one vascular pedicle may lead to greater risk of fistulae.

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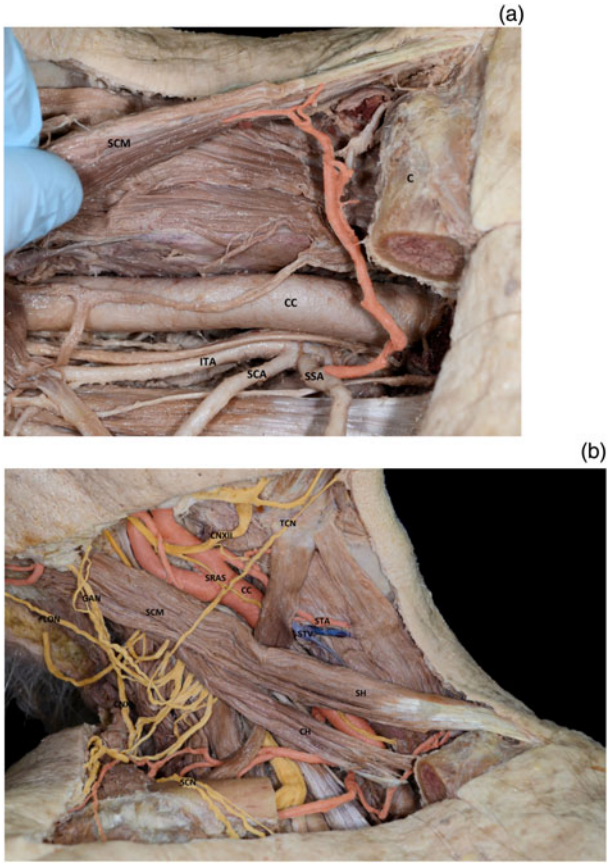

Fig. 2. Cadaveric dissection images demonstrating (a) the blood supply to the inferior pedicle of the sternocleidomastoid (the red coloured branch is the sternocleidomastoid branch of the suprascapular artery), and (b) the anatomical relationship of the sternocleidomastoid to the nerves and vessels of the neck. Yellow = nerves, red = arteries and blue = veins. SCM = sternocleidomastoid; C = clavicle; CC = common carotid; ITA = inferior thyroid artery; SCA = superficial cervical artery; SSA = suprascapular artery; LON = lesser occipital nerve; GAN = great auricular nerve; CNXII = 12th cranial (hypoglossal) nerve; TCN = transverse cervical nerve; SRAS = superior root ansa cervicalis; STA = superior thyroid artery; STV = superior thyroid vein; CNXI = 11th cranial (accessory) nerve; SH = sternal head; CH = clavicular head; SCN = supraclavicular nerves

Muscle necrosis has been reported, although very rarely.[1] Cho *et al.*,[23] Gołcabek and Kondratowicz,[17] and Marx and Mcdonald,[4] all experienced muscle necrosis in their studies. The number of pedicles does not seem to impact muscle necrosis, as Marx and Mcdonald[4] preserved two, whilst Gołcabek and Kondratowicz,[17] and Cho *et al.*,[23] only preserved one pedicle.

Overall failure rate, comparison of techniques and other flaps

The overall complication rate of the sternocleidomastoid flap varies significantly between studies (Table 1). The majority of studies, especially more recent ones, have complication rates between 10 and 30 per cent. As shown in Figure 3, there is a general trend of decreasing complication rates with the more recent studies.[2–4,6,8–10,13,17,20,23–29] The complication rates reported in Table 1 were calculated per complication reported, and so may differ from studies that calculated it per flap (there were multiple complications per flap).[9,23]

The flap failure rate concerns those flaps that did not recover with conservative management.[1] The overall failure rate of the myocutaneous sternocleidomastoid flap, as reported in Kierner and colleagues' 2001 meta-analysis,[1] was 7 per cent,

Table 1. Complications of sternocleidomastoid flap since 2001*

Study	Year	Type of flaps used	Site of reconstruction	Total cases (*n*)	Complication type (*n*)					Complication rate (%)
					Partial epithelial necrosis	Total epithelial necrosis	Fistula	Total flap loss	Other	
Zhao *et al.*[25]	2001	Myocutaneous	Oral	47	3	0	0	2	0	11
Tanaka *et al.*[10]	2003	Myocutaneous	Oral, oropharynx	40	8	0	0	0	0	20
Laccourreye *et al.*[6]	2006	Myofascial	Oropharynx	73	0	0	8	0	22 partial necrosis	41
Zhao *et al.*[26]	2009	Myocutaneous	Cheek	12	0	0	0	0	0	0
Kumar *et al.*[9]	2009	Myocutaneous	Oral, pharynx	32	5	3	0	2	0	31
Wei *et al.*[20]	2013	Myocutaneous, osteomuscular	Oral, pharynx	65	5	0	0	0	2 flap dehiscence	11
Chen & Chang[8]	2015	Myocutaneous	Oral, anterior neck	19	2	0	0	0	0	11
Ellabban[3]	2016	Muscle	Hypopharynx	12	0	0	1	0	0	8

*Table based on the design of Ariyan (1997; page 69).[24]

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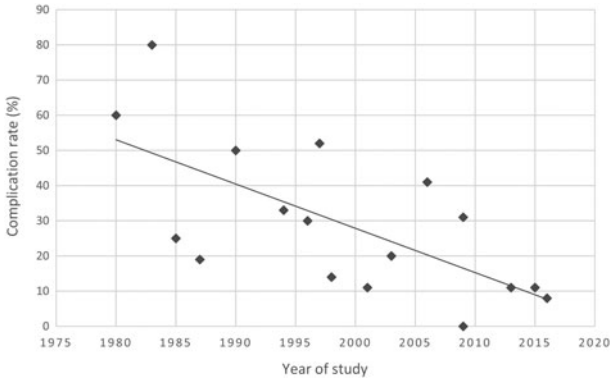

Fig. 3. Reported complication rates of the sternocleidomastoid flap by year of study, based on data from: Sasaki (1980),[27] Cho *et al.* (1983),[23] Marx and Mcdonald (1985),[4] Charles *et al.* (1987),[28] Gołcabek and Kondratowicz (1990),[17] Alvi and Stegnjajic (1994),[2] Yugueros and Woods (1996),[13] Ariyan (1997),[24] Ross and Klenzner (1998),[29] Zhao *et al.* (2001),[25] Tanaka *et al.* (2003),[10] Laccourreye *et al.* (2006),[6] Zhao *et al.* (2009),[26] Kumar *et al.* (2009),[9] Wei *et al.* (2013),[20] Chen and Chang (2015),[8] and Ellabban (2016).[3]

whereas the overall complication rate was 21 per cent. This indicates that many complications were minor and healed without surgical intervention, as supported by the literature.[10,30] Of the post-2001 studies, only 4 total myocutaneous flap losses were reported out of 215 in total, giving a failure rate of 1.9 per cent (Table 1).

This decrease in failure rate may be a result of improvements in the technique of raising the sternocleidomastoid flap. Many recent studies described preventing excessive tension on the sternocleidomastoid flap by suturing the skin to the muscle before rotation of the flap, to prevent the loss of the delicate perforators to the skin.[9,10,20,25] Wei *et al.*[20] implemented checking for a good blood supply to the skin by rubbing the skin to see the refill rate. Preservation of the sternocleidomastoid branch of the superior thyroid artery may also play a role in the decreased failure rates. More recent studies have documented this alteration[8,9,20] since the anatomical investigations by Kierner *et al.*[5] It is difficult to identify which of these techniques, if any, are useful given the differences between the study and flap designs.

Free flaps have a much greater success rate than sternocleidomastoid flaps, cited in the literature as over 95 per cent.[31] Compared to other regional flaps, the sternocleidomastoid flap also has a lower success rate. Cho *et al.*[23] experienced a 60 per cent failure rate of sternocleidomastoid flaps, whereas pectoralis flaps had a lower rate of 21 per cent. However, a higher number of pectoralis flaps were tested. Zhao *et al.*[25] also found that the sternocleidomastoid flap had a lower success rate (around 90 per cent) compared to other regional flaps. The difference was much smaller between the different types, at about 2 per cent. Nevertheless, many authors still advocate the use of the sternocleidomastoid flap, especially in circumstances where the use of other flaps is not practicable.[1,2,8]

Discussion

The controversy regarding the use of the sternocleidomastoid flap has centred on the high rate of ischaemic complications.[1] Complication rates vary considerably, although they have apparently decreased in recent years (Figure 3). As it is difficult to compare studies, because of the differing techniques, flap types and defects described, the techniques that decrease complications are hard to elucidate. More studies that are similarly matched in terms of area and flap type need to be carried out, to examine the different techniques used and their success rates.

Preserving both the occipital artery and superior thyroid artery branches may ensure that blood supply reaches the entirety of the muscle.[20] Attempts to preserve the venous network of the sternocleidomastoid should also be made, so as to avoid excessive venous congestion.[8]

Knowledge of the blood supply is essential in flap planning.[16] If pre-operative computed tomography angiograms were performed to identify arterial variations, the sternocleidomastoid flap could be based on the appropriate pedicle for each patient, as has been successful for free flaps.[32] Increased knowledge of the blood supply has led to technique alteration, most notably the preservation of two or more pedicles.[9,20] Although the sternocleidomastoid flap has a higher failure rate compared to other regional flaps,[9] studies that preserved two or more pedicles to supply the sternocleidomastoid have reported greater success.[4,20,27] Although two pedicles can limit flap rotation,[18] Khazaeni *et al.*[21] overcame this by dissecting the middle pedicle to its maximal length. Noland *et al.*[7] reported that the sternocleidomastoid can be strongly depended upon as a flap if two or more pedicles are preserved.

Conclusion

The studies analysed in this review demonstrate the great variety of reconstructive options provided by a sternocleidomastoid flap. These include: complex osteomuscular flaps taken with partial thickness clavicular bone for mandibular reconstruction; myocutaneous flaps for oral defects; split flaps that take only the sternal or clavicular head to avoid excess bulk; and conventional myofascial flaps to reinforce jejunal free flap anastomoses following laryngectomy, or cover the carotid in malnourished patients undergoing modified radical neck dissection.[7,8,10,17,20,33,34]

The sternocleidomastoid remains an easy-to-use flap, in a convenient location, with a shorter operating time required.[3,9] The sternocleidomastoid should be considered as an alternative when: the patient cannot tolerate a long operating period, other flap sites are unsuitable or there is a lack of microvascular facilities.[8,9] Under certain conditions, the sternocleidomastoid flap could provide an option for those patients with very few other options for reconstruction available to them.

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Competing interests.. None declared

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