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Topographic and anatomical analysis of sternohyoid muscle autograft in surgical treatment of facial paralysis lasting more than 18 months

© R.A. IZHAEV, A.R. DOLOVA, A.I. NEROBEYEV

Central Research Institute of Dentistry and Maxillofacial Surgery, Moscow, Russia

ABSTRACT

Objective. To study topographic and anatomic features of sternohyoid muscle, as well as the features of its blood supply and innervation as a neuromuscular graft in surgical treatment of facial paralysis lasting more than 18 months.

Material and methods. This topographic anatomical study included 25 cases of bilateral dissection of sternohyoid muscle (a total of 50 cases) on 25 fresh unfixed corpses. There were 14 female (56%) and 11 male (44%) corpses aged 69.76 years (range 49-84). In all cases, death was not caused by lesions of maxillofacial region and neck. We also excluded corpses with cervical scars. All people died within 3 previous days.

Results. We established all the main characteristics of sternohyoid muscle graft. In all cases, sternohyoid muscle graft had a stable centralized blood supply through superior thyroid artery. Venous outflow was carried out through superior thyroid vein in 86% of cases and middle thyroid vein in 14% of cases. In all cases, innervation of the muscle was ensured by superior root of the cervical loop arising from hyoid nerve.

Keywords: *facial nerve, paralysis of facial muscles, facial paralysis, free tissue transplantation, sternohyoid muscle flap.*

INFORMATION ABOUT THE AUTHORS:
Izhaev R.A. — https://orcid.org/0000-0002-4301-5953
Dolova A.R. — https://orcid.org/0000-0002-0478-9059
Nerobeyev A.I. — https://orcid.org/0000-0001-9882-016X
Corresponding author: Dolova A.R. — e-mail: albinadolova5594@mail.ru

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Introduction

Smiling is a fundamental component of social interactions due to expression of emotions and communication between people [1]. Patients with facial paralysis have significant functional, social, emotional and aesthetic problems due to the lack of communicative facial muscle movements [2–7]. Considering the role of this problem, clinicians are still looking for new methods of surgical treatment of mimic muscle paralysis and ways to improve modern methods [5–9].

Paralysis of mimic muscles is a polyetiological disease determined by congenital abnormalities or damage to the facial nerve during surgical interventions, various injuries, inflammatory processes, tumors, vascular diseases, etc. [10].

Modern methods of surgical correction of functional and cosmetic disorders in facial paralysis can be divided into static [11, 12] and dynamic ones [12, 14]. The ultimate goal of dynamic correction is recovery of synchronous, symmetrical and involuntary facial movements [14, 15].

Today, the “gold standard” in surgical treatment of mimic muscle paralysis lasting more than 1.5 years is free transplantation of skeletal muscle with a neurovascular bundle [16]. Autotransplantation of the gracilis muscle is the most common in these circumstances [17]. However, this technique has some disadvantages, namely, excess volume of the muscle relative to own mimic muscles. This necessitates splitting autograft for its thinning with higher risk of circulatory disorders [18].

The above-mentioned factors prompted clinicians to search for an alternative to gracilis muscle in surgical treatment of mimic muscle paralysis. We put forward a hypothesis that sternohyoid muscle could potentially be an ideal variant. Indeed, this muscle can provide better results due to anatomical and physiological features.

Material and methods

Topographic anatomical study included 25 cases of bilateral dissection of sternohyoid muscle (50 cases) on 25 unopened human cadavers (14 female and 11 male). We excluded cadavers with scars on the neck. We performed contrast enhancement of tissues using brilliant green to determine the type and volume of arterial blood supply to sternohyoid muscle. We injected brilliant green into catheterized arteries supplying the sternohyoid muscle.

Results

Design of the flap

Sternohyoid muscle looks like a long flat ribbon. Mean length of sternohyoid muscle flap is 9.2 cm, width — 1.7 cm **(Fig. 1)**.

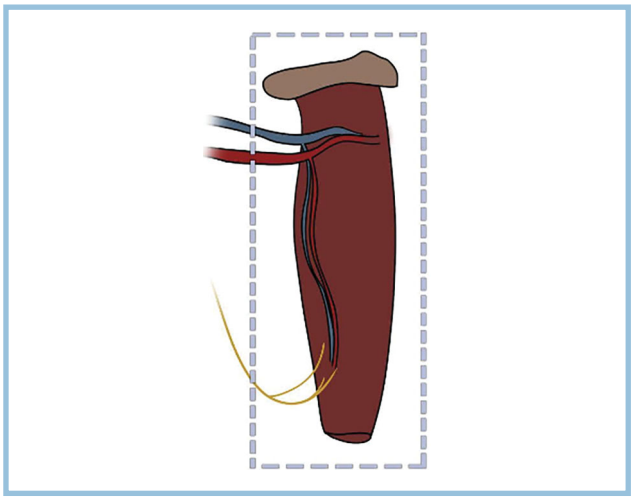


Fig. 1. **Flap design.**

We concluded that it is advisable to include the fibers of thyrohyoid and/or sternothyroid muscles into the flap. Indeed, the main vessels give branches to these muscles. Moreover, vessels pass inside sternothyroid muscle in some cases. Sternohyoid muscle flap is harvested together with a fragment of hyoid bone to provide rigid fixation at the stage of flap transplantation to the face.

Arteries

The muscle was supplied through superior thyroid artery in all cases **(Fig. 2)**. We found certain variability in location of orifice of this artery:

1) superior thyroid artery arose from external carotid artery immediately after bifurcation in 88% of cases;

2) superior thyroid artery arose from common carotid artery before bifurcation in 12% of cases.

Further, superior thyroid artery has some branches (a large artery to the thyroid gland, arteries to the nearby muscles, artery to sternohyoid muscle arising from superior thyroid artery in medial direction). In our opinion, flap harvesting along with the fibers of thyrohyoid muscle is expedient and safer. Indeed, the artery to sternohyoid muscle passes through thyrohyoid muscle in 16% of cases. Moreover, there are the arteries to thyroid and sternothyroid muscles arising from superior thyroid artery. Thus, sternohyoid muscle detachment from the underlying thyrohyoid and sternothyroid muscles increases the risk of damage to vascular pedicle.

Veins

We found adequate venous vessels in all cases **(Fig. 3)**. However, we noted some variability:

1) in 86% of cases, superior thyroid vein provided venous outflow from sternohyoid muscle; this vein merges with internal jugular vein at the level of orifice of superior thyroid artery;

2) in 14% of cases, venous outflow from sternohyoid muscle was carried out through the middle thyroid vein; the last one merges with internal jugular vein at the level of thyroid cartilage;

3) branching of venous vessel of the autograft is observed after arising from internal jugular vein.

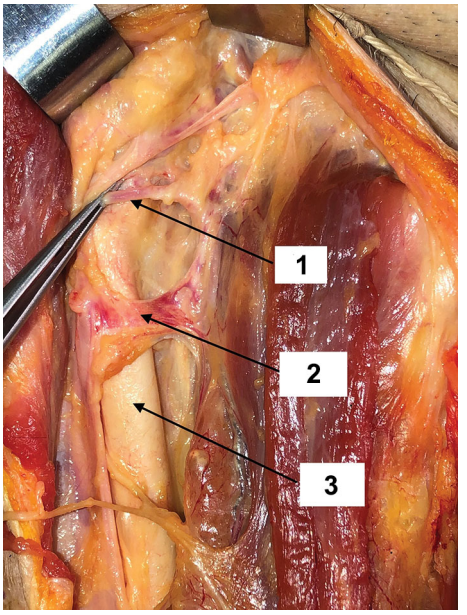


Fig. 2. **1 — superior thyroid artery; 2 — superior thyroid vein; 3 — common carotid artery.**

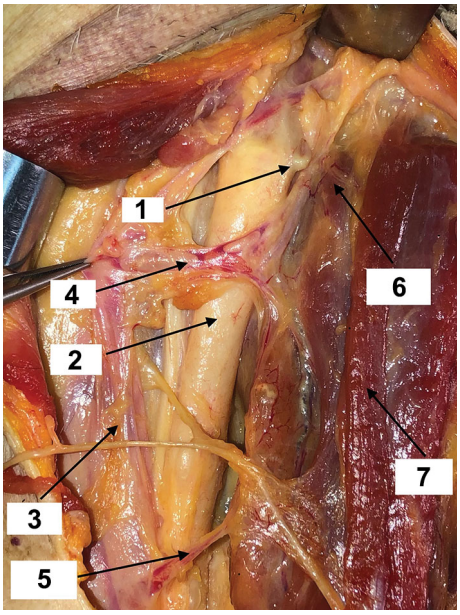


Fig. 3. **1 — superior thyroid artery; 2 — common carotid artery; 3 — internal jugular vein; 4 — superior thyroid vein; 5 — middle thyroid vein; 6 — venous network of sternohyoid muscle; 7 — sternohyoid muscle.**

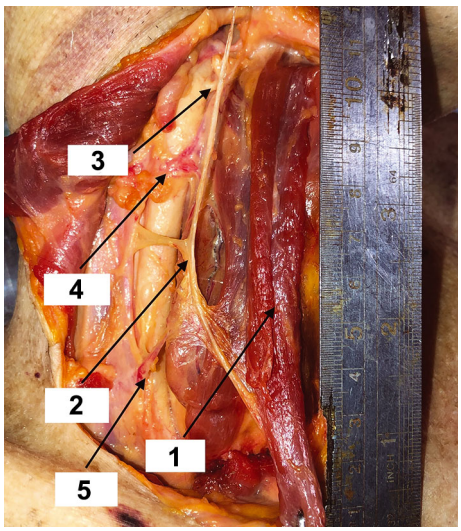


Fig. 4. **1 — sternohyoid muscle; 2 — ansa cervicalis; 3 — superior thyroid artery; 4 — superior thyroid vein; 5 — middle thyroid vein.**

We found 2 types of branching: 1) truncal type (57%); 2) diffuse type (43%). Therefore, we consider that autograft harvesting without exposure of vascular pedicle (together with fascial sheath) is expedient to avoid injury. Mean length of the vascular pedicle after graft harvesting was 5.5 cm.

Nerves

In all cases, innervation of sternohyoid muscle was carried out through a branch from cervical loop **(Fig. 4)**. This nerve arises from hypoglossal nerve, goes down along the cervical neurovascular bundle giving branches to sternohyoid, omohyoid and sternothyroid muscles.

The branches to sternohyoid muscle enter the muscle at two levels (inferior edge of thyroid cartilage and 2 cm above the sternum). Dominance of certain nerve can only be determined using intraoperative neuronavigation. Mean length of the autograft nerve after harvesting was 9.6 cm.

Discussion

Considering all the above-mentioned features of blood supply and innervation of sternohyoid muscle, we developed the most optimal technique for harvesting the sternohyoid muscle neuromuscular autograft **(Fig. 5, 6)**.

An access was made through a 7-cm skin incision along the anterior edge of the sternocleidomastoid muscle. We dissected platysma muscle, exposed the anterior edge of the sternocleidomastoid muscle and displaced it back to visualize great vessels and cervical loop. To facilitate surgical access, we dissected the fibers of the omohyoid muscle in the area of tendon insert. After dissection of tendon insert, we found cervical loop giving some branches at this level to omohyoid, sternothyroid and sternohyoid muscles. We mobilized cervical loop throughout the entire length from the hypoglossal nerve to sternohyoid muscle.

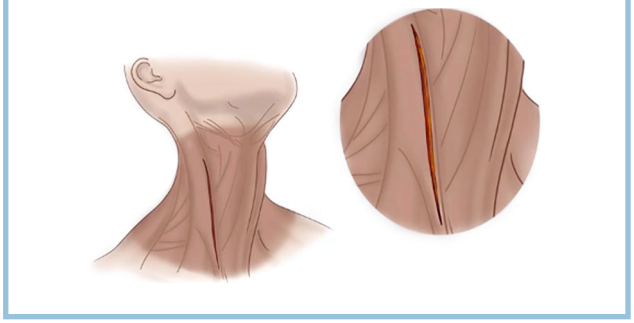


Fig. 5. **Approach along anterior edge of sternocleidomastoid muscle.**

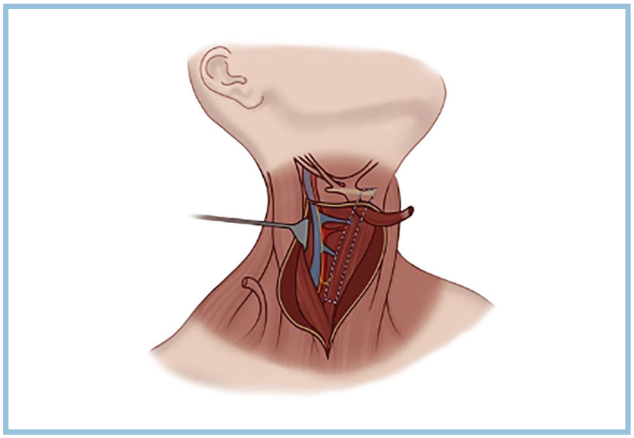


Fig. 6. **Great vessels and ansa cervicalis. Omohyoid muscle is dissected within the tendon segment.**

Next, we mobilized external carotid artery near its bifurcation to determine the orifice of superior thyroid artery. After discovery of superior thyroid artery, we mobilized it distally preserving the adjacent vein. The artery to sternohyoid muscle arises from superior thyroid artery in medial direction.

To determine the point of origin of superior thyroid vein from internal jugular vein, we mobilized internal jugular vein over a distance of 4–6 cm. We found that the second potential venous outflow can be organized within the upper pole of ipsilateral lobe of thyroid gland (through the middle thyroid vein).

We have established two types of venous branching in the flap. Therefore, it is advisable to distinguish two directions for mobilizing the vascular pedicle of the flap:

1) harvesting of the vascular pedicle distally up to the muscle is advisable in truncal type of venous branching;

2) in case of diffuse branching, it is necessary to mobilize sternohyoid muscle, find the vascular pedicle entry zone on its lower surface and continue dissection in proximal direction to avoid damage to venous network.

Sternohyoid muscle is exposed and displaced back in posterolateral direction to cut off thyrohyoid and sternothyroid muscles at the points of attachment to thyroid cartilage. The flap includes a part of hyoid bone. Indeed, harvesting of the flap implies resection of hyoid bone at the upper border after previous displacement of suprahyoid muscles.

Cutting off the lower edge of the flap was performed below the level where the branches of the cervical loop enter the muscle.

When transplanting the flap to the face, we use superficial temporal artery and vein as recipient vessels. Reinnervation of the flap is provided by buccal branch of the facial nerve on the intact side and masticatory branch of the trigeminal nerve on the affected side **(Fig. 7)**. The need for additional neural autograft can be determined intraoperatively depending on the length of the nerve.

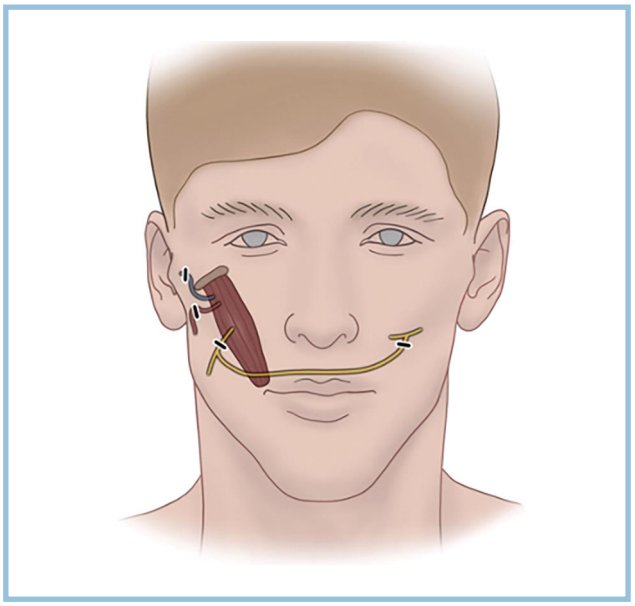


Fig. 7. **Transplantation of sternohyoid muscle flap on the face, revascularization and reinnervation.**

Conclusion

1. In all cases, sternohyoid muscle flap has a stable centralized blood supply through superior thyroid artery. The last one arises from external carotid artery in 88% of cases and common carotid artery in 12% of cases. Venous outflow is carried out through superior thyroid vein in 86% of cases and middle thyroid vein in 14% of cases. Considering mean length of the vascular pedicle, revascularization is possible using superficial temporal artery and vein.

2. Mean length of the autograft nerve was 9.6 cm that allows reinnervation of the graft using buccal branch of the facial nerve of the intact side without nerve insert. The advantages of this method are synchronous movements of the middle zone of the face with those on the intact side and earlier rehabilitation.

3. Small volume and thickness of the graft allow the most satisfactory aesthetic result without intraoperative splitting of the graft that reduces the risk of circulatory disorders.

4. We were convinced of technical feasibility of sternohyoid muscle flap harvesting, since stable neurovascular pedicle of adequate length meeting our requirements was found in all cases.

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No conflict of interests to declare.

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