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ANATOMIC BASES OF MEDICAL, RADIOLOGICAL AND SURGICAL TECHNIQUES

Surgical anatomy of the platysma motor branch as a donor for transfer in brachial plexus repair

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Abstract
Object Nerve transfers have become a major weapon in the battle against brachial plexus lesions. Recently, a case involving the successful use of the platysma motor branch to re-innervate the pectoralis major muscle was reported. The present anatomical study was conducted to clarify the surgical anatomy of the platysma motor nerve, in view of its potential use as a donor for transfer.
Methods Microsurgical dissections of the facial nerve and its terminal branches were performed bilaterally in five formaldehyde-fixed cadavers, thereby yielding ten samples for study. The relationships between the platysma motor branch and adjacent structures were studied and measurements performed. Specimens were removed and histologically studied.
Results The platysma branch of the facial nerve was found to arise from the cervicofacial trunk. In five instances, one main nerve innervated the platysma muscle, and there was a smaller accessory nerve; in four cases, there was just a single branch to the muscle; and in one case, there was a main branch and two accessory branches. The distance between the gonion and the platysma motor branch averaged 0.8 cm (range 0.4–1.1 cm). The platysma branch received thin anastomotic rami from the transverse superficial cervical plexus. The neural surface of the platysma motor branch, on average, was 76% the surface area of the medial pectoral nerve.
Conclusion The anatomy of the platysma motor branch is predictable. Contraction of the platysma muscle is under voluntary control, which is an important quality for a donor

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nerve selected for transfer. The clinical usefulness of platysma motor branch transfer still must be elucidated.

Keywords Brachial plexus · Nerve grafting · Nerve transfer · Neurotization · Facial nerve

Introduction

When a proximal nerve stump is not available for reconstruction, as in cervical root avulsion from the spinal cord, nerve transfer is employed. Nerve transfer, also called "neurotization", consists of sectioning a normal nerve and connecting its proximal stump to the distal stump of an injured nerve. This involves loss of function in the donor nerve, which is compensated by the recovery of function in the receptor nerve. For this to be worthwhile, the receptor nerve must be functionally more important than the nerve to be sacrificed.

In brachial plexus surgery, two types of neurotization can be performed: [1] intraplexual nerve transfer, wherein the donor stump comes from a nerve branch originating in the brachial plexus itself; and [2] extraplexual nerve transfer, wherein the donor stump comes from a nerve which is not part of the brachial plexus.

Different nerves have been utilized for extraplexual neurotization (hypoglossal, occipital, intercostal, phrenic, and contralateral pectoral nerves) and well as cervical motor rami, and C4 or C7 radicular branches [2, 7, 12]. A new type of extraplexual nerve transfer has been described recently, one which uses a branch of the facial nerve (platysma branch) to reinnervate the pectoralis [5]. It is this recent report that has prompted us to study the surgical anatomy of this nerve.

In terms of anatomy, classic textbooks provide basic and thorough descriptions of the platysma motor branch [8, 16, 17, 19, 20]. As far as we know, however, measurements relevant to its surgical dissection—such as its length, diameter, and landmarks—are not available in the literature. The present study was conducted to clarify these parameters, all of which are important if planning to use the platysma motor branch as a donor for transfer.

Materials and methods

Ten facial nerves were obtained from five human cadavers perfused with formaldehyde fixative. The cadaveric material was processed, and dissections were performed in the Laboratory of Anatomy at the University of Buenos Aires School of Medicine. Bilateral microsurgical exposures were made under an operating microscope, using 6×–25× magnification. The facial nerve was dissected from the parotid region to its terminal branches. The superficial cervical plexus was also dissected, especially its transverse branch, and anastomotic rami to the platysma branch were studied. A caliper (accuracy, 0.02 mm; Draper, Japan) was used for measurements, and high-definition photographs were obtained from the specimens.

We measured (1) the distance between the facial nerve bifurcations into the cervicofacial and temporofacial trunks and the origin of the platysma branch, (2) the distance from the origin of the platysma branch to the gonion, (3) the distance from the platysma branch to the gonion, at that point where the former is closest to the latter, (4) the distance from the mastoid process of the temporal bone to the origin of the platysma branch, (5) the full length of the platysma branch, from its origin at the cervicofacial trunk to its terminal branching, and (6) the diameter of the platysma motor branch at the level of its origin. We also counted the number of terminal rami of the platysma motor branch. Special attention was paid to the path of the platysma motor branch, together with it branching pattern. The parameters measured during dissection of the platysma motor branch are depicted in Fig. 1.

For three dissections, the pectoral medial nerve also was dissected distal to the pectoral ansa in the infraclavicular region. In these three dissections, both the platysma motor and the pectoral medial branch were removed for histological study. Specimens were fixed in paraffin, sectioned, and then stained by means of Masson's trichrome method. Microphotographs of the cross-sectioned views were obtained. Images were studied using the public domain software ImajeJ 1.34 s. In each specimen, the area of neural tissue was determined, and the relative size of the paired medial pectoral nerves versus the platysma motor branch was estimated.

Results

The motor branch to the platysma muscle was found to arise from the cervicofacial division of the facial nerve. After its emergence, the platysma motor branch perforated the deep cervical fascia to lie immediately underneath the plastyma muscle. Along its path, vascular twigs were identified, that accompanied the platysma motor branch. The platysma motor branch remained superficial to the retromandibular and facial veins, and to the facial artery. The results of the various anatomical measurements depicted in Fig. 1 are presented in Table 1.

In five cases, there was one main nerve innervating the platysma muscle, and a smaller accessory nerve; in four cases, there was a single branch to the muscle; and, in one case, there was one main branch and two accessory branches (Figs. 2, 3). In two of the ten specimens,

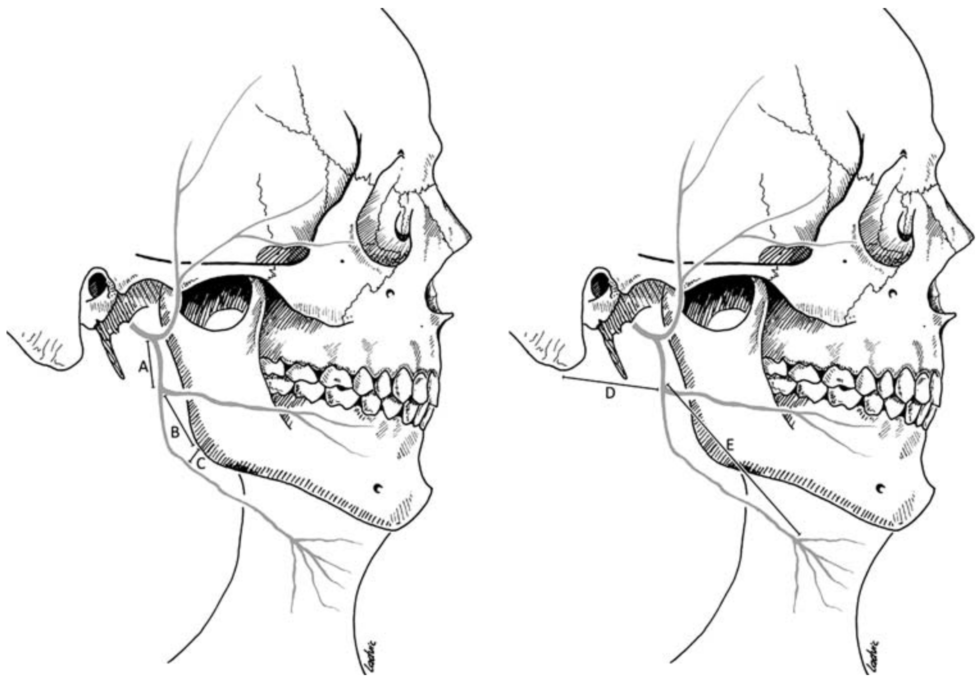

Fig. 1 Schematic representation of the measurements conducted in this study. **a** Distance from the facial nerve bifurcation into the temporofacial and cervicofacial trunks, to the origin of the platysma branch of the facial nerve. Where more than one branch was found, the superior and most proximal branch was selected as the distal limit to measure distance A. **b** Distance from the origin of the platysma branch to the gonion. **c** Distance from the closest part of the platysma branch of the facial nerve to the gonion. **d** Distance from the mastoid tip to the origin of the platysma branch of the facial nerve. **e** Length of the platysma branch from its origin to its distal branching

Table 1 Measurements for the Platysmal Branch of the Facial Nerve (see Fig. 1 for a depiction of distances a–e)

Measurement	Mean (mm)	Range (mm)
Distance A	13	9–17
Distance B	18.5	12–23
Distance C	8	4–11
Distance D	58	51–78
Distance E	82	67–103
Diameter at origin	1.6	1.4–2.6

Results for measurements depicted in Fig. 1

we identified a branch originating from the platysma nerve, which had an ascending course, crossed the border of the mandible, and innervated the muscles that depress the lower lip. The diameter of the platysma branch ranged from 1.4 to 2.6 mm, with a mean of 1.6 mm. The number of branches into which the platysma nerve divided before entering the muscle averaged 9 (range 5–11), each one smaller than 0.3 mm in diameter (Fig. 4).

The cervical plexus anastomosed with the platysma motor branch via fine branches, which were less than 0.3 mm in diameter. We found a mean of 5 (range 3–9) anastomic branches of the cervical superficial plexus with the platytsma motor branch (Figs. 4, 5).

In the three specimens removed for histological analysis, the surface area of the platysma motor branch was equal to 68, 72, and 90% that of the medial pectoral nerve.

Discussion

Anatomical findings

In all ten dissections, we identified a major branch of the facial nerve to the platysma muscle. In six cases, two or three smaller accessory branches also were found. Importantly, in two cases, a branch to the lower lip muscles was identified. This finding explains the weakness experienced in the lower lip depressor muscles after accidental section of the branch to the platysma muscle during facial lift surgery. The functional deficit is transitory and usually resolves within 3–4 weeks [9]. This pseudo palsy should not be confused with true injury to the mandibular marginal ramus of the facial nerve, which results in a more persistent deficit of lower lip depression [18]. In a few cases, sectioning the platysma motor branch for transfer may produce a transient and mild deficit in lower lip function. This can be avoided by sectioning the platysma motor branch distal to the emergence of the branch to the lower lip. During surgery, identification of the platysma motor branch and the branch to the lower lip can be confirmed by means of electrical stimulation. It is of special interest that, in an anatomical study of the marginal branch of the facial nerve [22], this nerve was found in 10% of cases running below the lower border of the mandible, when considered anterior to the facial artery. In line with our findings, it was established that the anatomical variability of the lower branches of the facial nerve is very high [10, 18, 22, 24]. In our study, we approached the platysma branch of the facial nerve below the angle of the mandible, a place where it can be mistaken

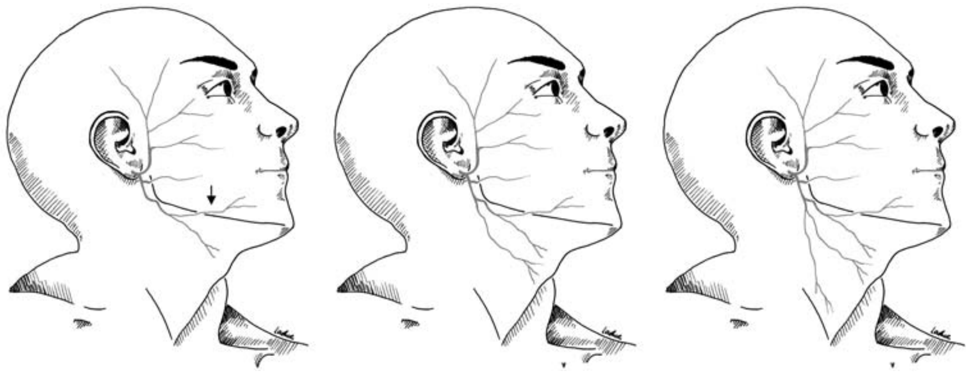

Fig. 2 Schematic drawings of the platysma motor branch and its variations. *Left*, A single branch originating from the cervicofacial trunk innervated the platysma muscle in four out of ten dissections. Notice that a branch (*arrow*) crosses the mandible and innervates the lip depressor muscles. *Center*, two branches innervated the platysma muscle in five out of ten dissections. *Right*, three branches innervated the platysma muscle in one dissection

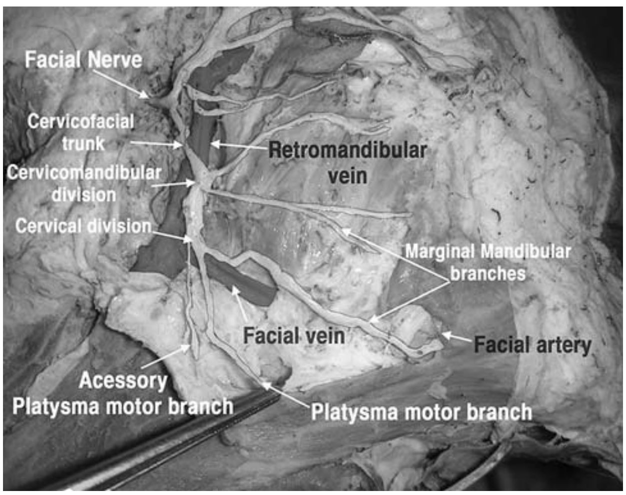

Fig. 3 Photographic view of the lower face and right neck. The parotid gland was removed to expose the facial nerve and its branches. In this dissection, the platysma is innervated by two branches, one running anteriorly under the mandible, and another smaller branch (accessory platysma motor branch) descending towards the lower part of the muscle. The platysma motor branch ran superficial to the retromandibular and facial vein and to the facial artery

for an anomalously positioned mandibular branch. As described by Ziarah [24], the distance that separates the mandibular branch and the platysma branch can be very small at the angle, or it might not even exist for a certain distance, well anterior of the angle of the mandible [10]. Special care should be given to differentiate the two branches intra-operatively, by means of electrical stimulation.

In our study dissections, the platysma motor branch was found to lie superficial to the major vessels of the lower face (the facial artery and the retromandibular and facial veins), a finding that agrees with another study that analyzed the mandibular rami of the facial nerve [22] and demonstrated that the lower branches of the facial nerve lie superficial to the vessels.

In agreement with previous classical work [8, 16, 17, 20, 23], we observed an anastomosis between the platysma motor branch and the cervical plexus at the level of the anterior border of the sternocleidomastoid muscle. It is possible that this anastomosis is motor in nature. For instance, the platysma muscle has been described as dually innervated by the motor nucleus of the facial nerve and a higher cervical motor nucleus [6]; indeed, unilateral platysmal palsy has been reported in a patient with a C3 spinal injury [15].

Using the platysma motor branch as a donor for transfer

The surface neural area of the platysma motor nerve was approximately 76% that of the medial pectoral nerve. This is in line with the relative size documented in other common successful nerve transfers for brachial plexus repair. For example, the accessory nerve has 1,200 fibers, whereas the musculocutaneous nerve has 3,000 fibers. This represents a ratio of 1:2.5, which is similar to the two intercostal nerves transferred to the musculocutaneus nerve described by Narakas [12]. But a worse relationship exists if we consider the study performed by Asfazadourian [1], where the author concluded that only 17.1–26.7% (a ratio roughly between 1:6 and 1:4, respectively) of the area of the musculocutaneous nerve can be accommodated using three intercostal nerves. Not surprisingly, the results of elbow flexion reconstruction are better when the accessory nerve is employed [21]. One of the most successful nerve transfer techniques ever described, with a success rate of 90%, is the Oberlin I technique, which involves the transfer of ulnar nerve fascicles to the biceps branch of the musculocutaneous nerve, a procedure that has a mean donor to recipient nerve ratio of 1:1 [14]. On the other hand, Narakas [12] stressed that useful recovery could be obtained even with a ratio of 1:6. We believe that full voluntary and synergic control of the transferred nerve, as exists with the platysma motor branch, is instrumental to the success of repair.

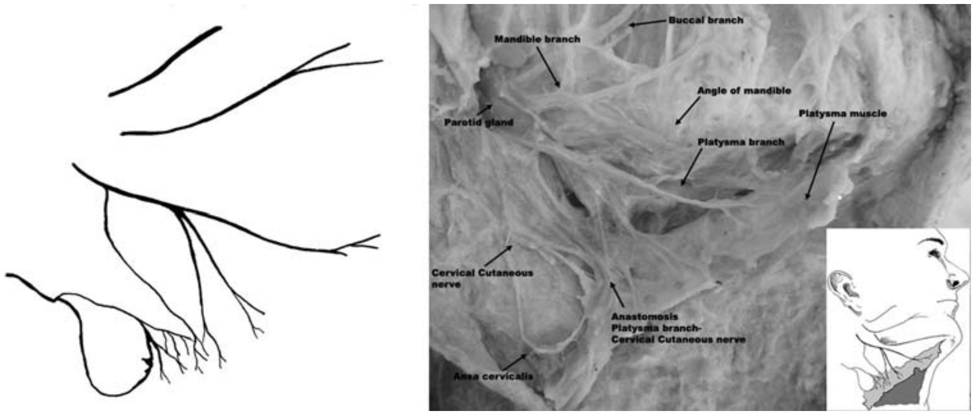

Fig. 4 **a** Platysma branch, *right* side. A single branch traverses the submaxilary region near the angle of the mandible, and is arborized to innervate the platysma muscle. Along its course, the platysma motor branch receives a variable number of very thin rami from the superficial cervical plexus. Note that the direction of these rami (predominantly from inferior to superior) differs from that of the platysma branch (mostly from posterior to anterior). **b** Same dissection, magnified. The ansa cervicalis (superficial cervical plexus) is clearly visualized (BB buccal branch of the facial nerve, MB mandibular branch of the facial nerve, *PB* platysma branch, PG parotid gland, PM platysma muscle, CCN cervical cutaneous nerve, AC ansa cervicalis, C anastomotic branches of the cervical plexus to the platysma branch, AM angle of mandible, MaP mastoid process, MP mental protuberance, MM muscles of mastication)

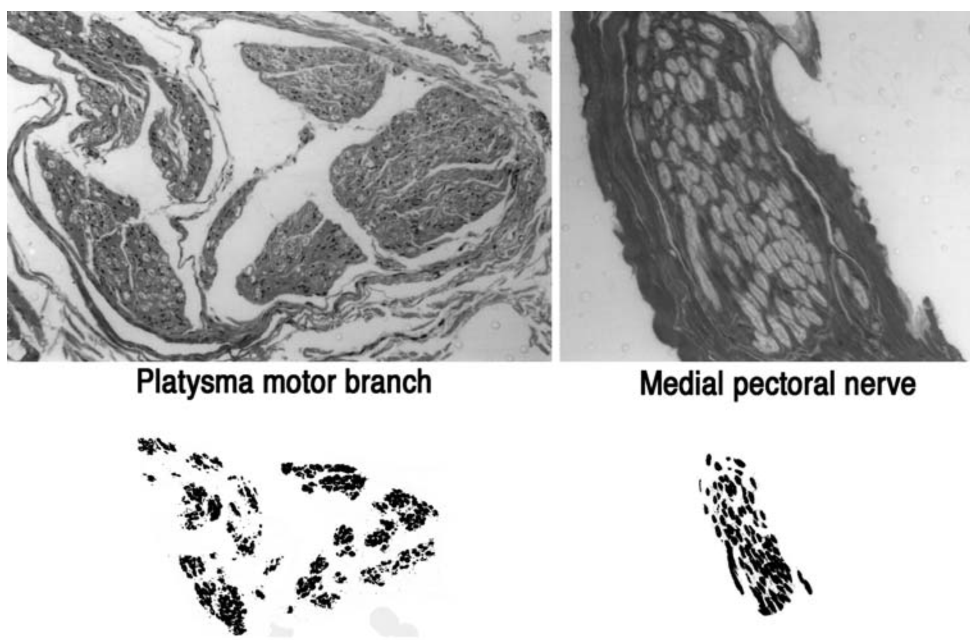

Fig. 5 Histological cross-section of the platysma motor branch and the medial pectoral nerve in the same subject. For comparison and analysis, images were transformed into a bitmap pattern and the non-neural tissue excluded. Note that the size of the black zone (neural tissue) is similar when the platysma and pectoral branches are compared. In this particular case, the surface area of the neural tissue in the platysma motor branch was 90% that of the medial pectoral nerve. Gomori's trichrome staining was used

One drawback in using the platysma motor branch is the need for long nerve grafts, if the target is the medial pectoral nerve. Experimentally, we have observed that misrouting occurs more frequently with long grafts [4]. On the other side, if we use a shorter graft to neurotize a proximal target, as could be the case with the medial cord or the anterior division of the upper trunk, fiber dispersion and simultaneous re-innervation of antagonist muscles probably will occur [13].

Therefore, to overcome this problem in our practice, when we use long grafts, we always target the repair to terminal motor branches. In line with this, we have demonstrated comparable results when the accessory nerve is attached to the musculocutaneous nerve with short grafts, as when it is attached to the biceps motor branch with long grafts [3].

With some lesions of the facial nerve, such as after acoustic neurinoma resection, the proximal stump of the facial nerve is not always available for grafting. In these cases, one potential treatment modality consists of transferring motor branches from the contralateral normal side to reconstruct the paralyzed face (i.e., cross-face grafts). In such instances, the platysma motor branch might be used to reinnervate the contralateral marginal mandibular branch. Moreover, in partial lesions of the facial nerve, the non-injured platysma motor branch may be transferred to a buccal branch of the involved facial nerve. Also, due to its proximity, the platysma motor branch might be used to reinnervate the hypoglossal nerve on the same or contralateral side. Additionally, with complete palsy of the brachial plexus, in conjunction with a lesion of the accessory nerve, using the platysma motor branch to restore function to the upper trapezius muscle might be considered. Not all the aforementioned procedures currently are performed in practice, and more experimental and clinical work must be done. We hope that the present work will provide future researchers with the anatomical basis to perform these studies.

Besides the medial pectoral nerve and the contralateral facial nerve discussed before, other targets of a size that is comparable to the platysma branch, like the motor branch of the triceps brachii [11] and the teres minor nerve [3], should be considered as axon recipients. In this instance, too, additional laboratory and clinical work are warranted to clarify the issue.

Finally, it is important to note that after sectioning the platysma motor branch for transfer, platysma muscle function might be preserved or later restored spontaneously, because of its multiple sources of innervation, which stem from either the facial nerve or the cervical plexus.

Surgical approach to the platysma motor branch

The platysma motor branch should be dissected one finger breadth distal to the gonion. At this level, the nerve is immediately deep to the platysma muscle, proximal to its terminal branching, proximal to its anastomosis with the cervical plexus, and an average distance of 1.8 cm from the angle of the mandible.

Conclusions

The platysma branch of the facial nerve is constant and its anatomy predictable. It has the anatomical potential to be used as a donor nerve for transfer. However, its clinical usefulness still must be elucidated.

Acknowledgments This study was performed in the Laboratory of Anatomy at the University of Buenos Aires School of Medicine, Buenos Aires, Argentina.

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