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Multivector functioning muscle transfer using superficial subslips of the serratus anterior muscle for longstanding facial paralysis

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Summary Various donor muscles have been identified for restoring facial function due to longstanding facial paralysis. Donor muscles such as the gracilis and latissimus dorsi are frequently used and often produce one or two reliable vectors of force. However, there are drawbacks of using these muscles, including the instability of separating multivector functioning muscle units and limited amount of muscle contraction. Serratus anterior muscle transfer has the advantages of multiple independently functioning motor units that can be created with a single neurovascular pedicle. This article describes multivector muscle transfer using two or three superficial subslips of the serratus anterior muscle on a single neurovascular pedicle to produce an esthetic smile that is customized to imitate the function of the contralateral mimetic muscles. Twelve patients who had longstanding unilateral facial paralysis underwent muscle transfer consisting of multivector superficial subslips of the serratus anterior muscle innervated by the ipsilateral masseteric nerve. The procedure had an uneventful postoperative course, and patients obtained excellent results, with sufficient upper lip excursion, mouth angle, and lower lip working simultaneously. Functioning muscle transfer using multivector

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superficial subslips of the serratus anterior muscle is effective for treating longstanding facial paralysis. This technique avoids postoperative bulkiness of the cheek muscle and achieves a more natural and symmetrical smile.

Introduction

The gracilis[1] and latissimus dorsi muscles[2] are frequently used as donor muscles to restore lost mimetic function due to longstanding facial paralysis. Positioning the transferred muscle is overly simplistic, even though facial mimetic muscles are synchronized in a complex arrangement to produce intricate and coordinated expressions that cannot be sufficiently reconstructed with a single muscle vector. The serratus anterior muscle on a single neurovascular pedicle has potential for facial reanimation. The innate ability of this muscle to separate force vectors has evident advantages compared to other muscles for facial reanimation. However, multiple muscle transfer often needs to be debulked.

We developed a method for functional facial reanimation using thinned and multivector neurovascularized serratus anterior muscle slips to achieve more natural and synchronous smile activity.

Here, we provide a detailed description of our technique and its clinical results.

Patients and methods

From 2006 to 2014, 12 patients (four men and eight women) with longstanding, irreversible facial paralysis underwent muscle transfer using two or three superficial subslips of the serratus anterior muscle as a one-stage procedure. At the time of muscle transfer, patients' ages ranged from 21 to 55 (mean, 36.2) years. The etiology of facial paralysis for the 12 patients is summarized in Table 1.

To plan a functional smile reconstruction that mimics the normal side as closely as possible, the unaffected side must be carefully assessed. For patients with complete facial paralysis, three subslips are usually used with differences in the direction of movement. However, when facial dimension is narrow, or loss of mimetic muscle function is partial, two subslips are generally selected. In this study, postoperative clinical examinations were performed at least 12 months postoperatively according to Terzis' functional and esthetic grading system for smile[3].

Clinical anatomy

The serratus anterior muscle arises from the first through the ninth or tenth ribs medial to the anterior axillary line and inserts into the ventral vertebral border of the scapula, thereby forming the medial axillary wall.[4,5] The upper two-thirds of the muscle forms a flat sheet, hence attaching the first five ribs to the superior aspect of the medial scapular border and stabilizing the scapula to allow the arm to lift above the shoulder.[6,7] The lower one-third of the muscle forms four to five muscle slips from the sixth to the ninth ribs, inserting into the lower scapular angle; these lower three to four almost-independent slips can be isolated for free transfer, which allow the remaining muscle to stabilize the scapula and prevent scapular winging.[8] The serratus anterior muscle is a type III muscle[9] that is perfused predominantly by the serratus branch of the thoracodorsal artery, which runs along the superficial surface of the muscle, entering at the juncture of the middle and posterior thirds.

The serratus anterior muscle is innervated by the long thoracic nerve (C5–C7), which descends along the junction of the middle and posterior thirds in the fascia of the lower

Table 1 Patients' summary.

Patient	Sex	Age (years)	Type	Etiology	Number of muscle subslips	Terzis and Noah score	Follow-up (months)
1	M	37	Complete	Mebius syndrome	7th, 8th, 9th	Excellent	34
2	M	37	Complete	Bell's palsy	7th, 8th, 9th	Excellent	92
3	M	29	Complete	Trauma	6th, 7th, 8th	Excellent	97
4	F	38	Complete	Ramsay Hunt syndrome	6th, 7th, 8th	Excellent	69
5	F	47	Complete	Acoustic neuroma	7th, 8th, 9th	Good	23
6	F	27	Incomplete	Bell's palsy	6th, 7th, 8th	Excellent	60
7	F	21	Incomplete	Congenital	6th, 7th, 8th	Excellent	33
8	F	45	Complete	Acoustic neuroma	6th, 7th, 8th	Good	54
9	M	26	Incomplete	Ramsay Hunt syndrome	6th, 7th	Good	18
10	F	55	Complete	Ramsay Hunt syndrome	7th, 8th, 9th	Good	12
11	F	38	Complete	Ramsay Hunt syndrome	7th, 8th	Excellent	36
12	F	34	Incomplete	Ramsay Hunt syndrome	6th, 7th, 8th	Good	32
Average		36.2					46.7

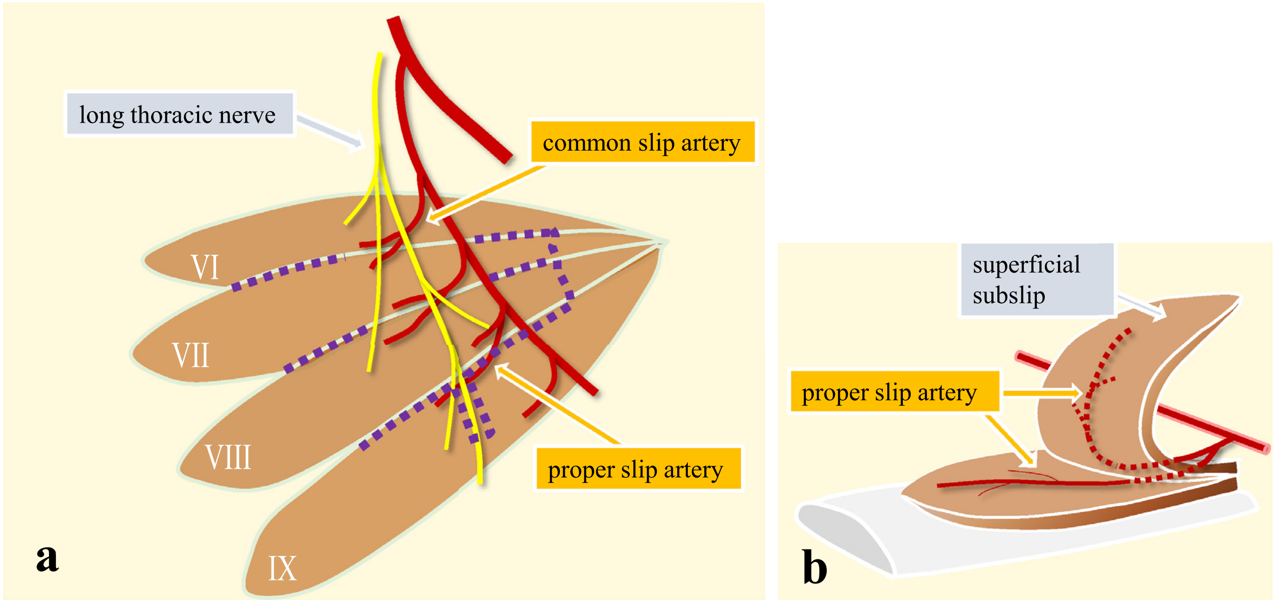

Figure 1 Schema of the lower serratus anterior muscle. (a) Neurovascular anatomy of the lower serratus anterior muscle. Each muscle slip can be safely divided up to the common artery without compromising vascularity (Dotted line), and (b) Harvest of the superficial subslip.

serratus slips to join the thoracodorsal vascular pedicle at the level of the fifth rib.[10]

In a cadaveric study, Godat et al.[11] described the detailed neurovascular anatomy of the serratus anterior muscle in which the nerve consistently branches proximally and deep to the artery. The serratus artery gives rise to common slip arteries, which each supply the adjacent muscle slips. Lifchez et al.[12] demonstrated that the serratus anterior muscle slips contain a loose areolar plane, which allows the separation of each slip into both a superficial and a deep subslip. Independent branches of common slip arteries maintain the vascularity of both subslips and communicate through multiple intraslip anastomoses. Individual superficial subslips of the serratus anterior muscle measure 12–15 cm in length, and mean superficial subslip thickness at the serratus artery was 4 mm and at the origin of the slip was 3 mm. On the basis of their cadaveric studies, we demonstrated that only superficial subslips can be harvested and that each subslip can be safely divided up to the common artery and transferred without compromising vascularity (Figure 1(a) and (b)).

Surgical technique

Harvesting of donor muscle

During the procedure, the patient is placed in the half-lateral or supine position, with the arm draped free to allow for intraoperative position changes. The ipsilateral lower slips of the serratus anterior muscle and its overlying neurovascular pedicle are identified by retraction of the latissimus dorsi muscle through a mid-axillary lazy-S incision with axillary extension. The sixth to eighth superficial subslips (or seventh to ninth) are separated from the deep subslips between the loose areolar plane from the ribs to scapular insertion, and the superficial subslips are harvested to include the thoracodorsal vessels and preserve the upper branches of the long thoracic nerve to prevent scapular winging postoperatively. The motor nerve measures 4–6 cm in length and is harvested from just after the branching point of the upper slips to the insertion point into the lower slips and can be split off the proximal trunk to preserve the fascicles using the operating microscope.

Muscle preparation and positioning

A preauricular incision extending to the submandibular area is made, and the facial flap is elevated as in a subcutaneous plane reaching the orbicularis oris muscle of the upper and lower lips. The ipsilateral masseter motor nerve is dissected in the recipient site.

Two or three harvested muscle subslips are placed into the cheek pocket, in which neurovascular bundles are oriented on the inner side leaving potential for further thinning. Close to the neurovascular pedicle, the scapular origin of the muscle slips is placed on the oral commissure side to provide more complex multiple force vectors. The muscle subslips are separated from each other at both the medial and lateral margins, preserving the proper slip vessels and nerves. Vascular anastomosis and nerve coaptation between the ipsilateral masseteric nerve and the long thoracic nerve are performed under an operating microscope after securing the scapular origin of the superficial slips to the middle third muscle of the upper lip, modiolus, and outer third of the lower lip. Finally, the other side of the muscle subslips is fixed to the deep temporal and periauricular fascia. Each muscle subslip is oriented at different vectors imitating the perioral movement of the unaffected side. For patients with complete facial paralysis, the upper (sixth) subslip is oriented at approximately 50–60°, the middle (seventh) slip

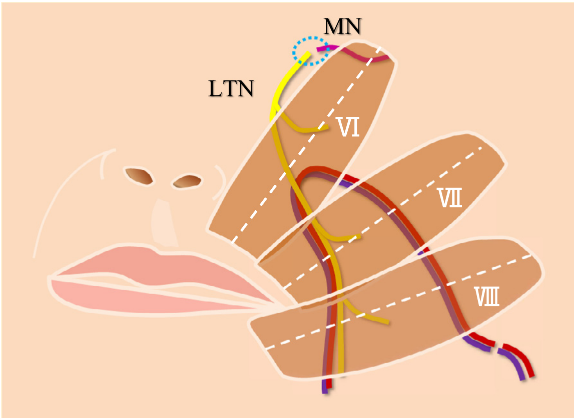

Figure 2 Setting of three multivector superficial subslips of the serratus anterior muscle that are innervated by the ipsilateral masseteric nerve (end-to-end neurorrhaphy). LTN: Long thoracic nerve MN: Masseteric nerve.

at approximately 30–45°, and the lower (eighth) slips at approximately 0–10°to the horizontal plane (Figure 2).

Results

The length of the long thoracic nerve ranged from 4 to 6 cm, and all cases were sutured to the branch of the ipsilateral masseter motor nerve without interpositional nerve graft. Transferred superficial subslip thickness ranged from 5 to 7 mm, and two muscle subslips were inserted into the cheek pocket. None of the patients suffered vascular complications or muscle necrosis, and no donor site problems including scapular winging were noted.

All patients recovered voluntary smiling function with sufficient excursion of the upper lip, mouth angle, and lower lip simultaneously. Postoperative muscle bulkiness of the cheek with multiple subslips was not noticeable. According to the Terzis' functional and esthetic grading system for smile, seven patients had excellent outcomes and five had good outcomes >12 months after surgery (Table 1).

Case 1

A 38-year-old female presented with longstanding, complete facial paralysis since childhood (Figure 3). One-stage muscle transfer was performed using three superficial subslips of the serratus anterior muscle innervated by the ipsilateral masseteric nerve.

The ipsilateral seventh to ninth superficial subslips of the serratus anterior muscle were harvested, with muscle length of 10–12 cm and thickness of 5 mm (Figure 4(a)). The transferred subslips intersect each other at both the medial and lateral margins, preserving the proper slip vessels and nerves (Figure 4(b)). Vascular anastomosis and nerve coaptation were performed under an operating microscope after the scapular side of three superficial slips was secured to the middle third muscle of the upper lip, modiolus, and outer third muscle of the lower lip. Finally, the other side of the muscle slips was trimmed to a suitable length, with the upper, middle, and lower subslip measuring 8, 9, and 10 cm, respectively, and fixed to the deep temporal and periauricular fascia, with tension more than the original resting tension. The seventh slip was oriented at 60°, the eighth slip at 45°, and the seventh slip at 10° to the horizontal plane (Figure 4(c)).

Signs of voluntary contraction were observed at approximately 3 months, and a voluntary smile without biting was observed 10 months after the surgery. At 69 months postoperatively, the patient exhibited a symmetrical smile, with teeth showing at full contraction (excellent result) (Figure 5).

Figure 3 Case 1: Preoperative views. (a) At rest, and (b) On smiling.

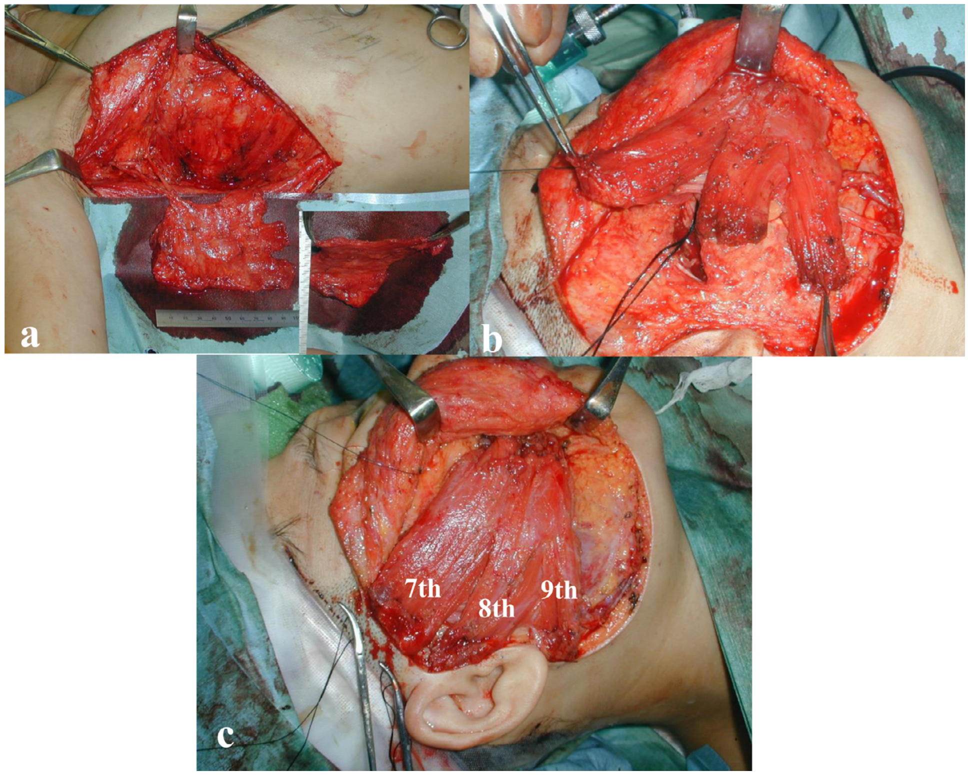

Figure 4 Intraoperative views. (a) Harvest of three superficial subslips with the long thoracic nerve and thoracodorsal vessels. (b) Separating three subslips from each other at both the medial and lateral margins, preserving the proper slip vessels and nerves. (c) Setting of three multivector superficial subslips on the cheek. The 7th slip was oriented at 60°, the 8th slip at 45°, and 9th slip at 10° to the horizontal plane.

Figure 5 Postoperative views at 69 months after surgery. (a) At rest, and (b) Open-lip smile.

Figure 6 Case 1: Preoperative views. (a) At rest, and (b) On smiling.

Case 2

A 27-year-old male presented with incomplete facial paralysis due to Ramsay Hunt syndrome (Figure 6). One-stage muscle transfer using two multivector superficial subslips of the serratus anterior muscle innervated by the ipsilateral masseteric nerve was performed.

The ipsilateral sixth and seventh superficial subslips of the serratus anterior muscle were harvested; the muscle length was 10–13 cm and thickness was 5–7 mm. After the scapular side of the sixth and seventh superficial slips was secured to the middle third of the upper lip, modiolus, and outer third of the lower lip, end-to-end vascular anastomosis and nerve coaptation were performed under an operating microscope. Finally, the other side of the muscle slips was trimmed to suitable length, with the upper subslip and the lower subslip measuring 7 cm and 10 cm, respectively, and fixed to the deep temporal and periauricular fascia, with tension more than the original resting tension. The sixth slip was oriented at 50° and the seventh at 15° to the horizontal plane (Figure 7).

Signs of voluntary contraction were observed at approximately 3 months, and smile symmetry with nearly full contraction (good result) was noted at 12 months postoperatively (Figure 8).

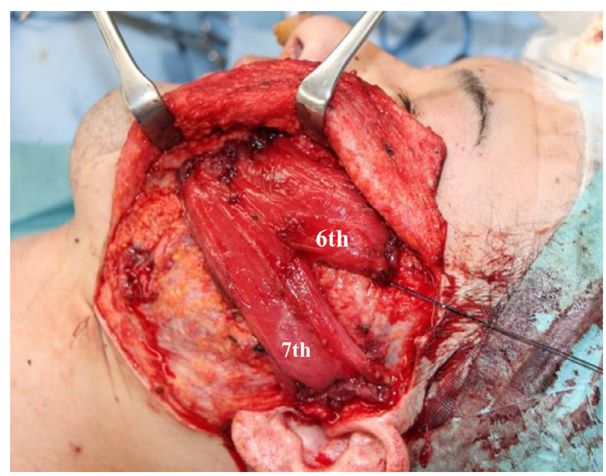

Figure 7 Intraoperative view. Setting of two subslips on the cheek. The 6th slip was oriented at 50° and the 7th slip at 15° to the horizontal plane.

Discussion

Reconstruction of longstanding facial paralysis is challenging for plastic surgeons. The goal of facial reanimation surgery is to reestablish facial expression symmetry to be as natural as possible. Understanding the anatomy of the facial expression based on the components of the perioral region, including not only the movement of the upper lip, oral commissure, and lower lip but also the form of the nasolabial fold, is imperative when performing facial reanimation.

Human mimetic activity typically causes a subtle interaction within the complex neuromuscular system consisting of 13 distinct muscles composed of four layers.[13] The main upper lip retractors include the zygomaticus major/minor, the levator anguli oris, and the levator labii superioris, a complex arrangement that works together to produce intricate and coordinated expressions.[13] Elevation of the oral commissure is controlled by two primary muscles: the zygomaticus major and the levator anguli oris.[14-16] The vector of the zygomaticus major is directed superolaterally and posteriorly, and the additional contraction of the levator anguli

Figure 8 Postoperative views at 12 months after surgery. (a) At rest, and (b) On smiling.

oris directs the overall vector superiorly.[17] Pessa et al.[18] described the independent effect of the contraction of various facial mimetic muscles on the nasolabial fold through their study of cadaver dissections and classified them into three zones. They found that the most common pattern of facial muscles inserting into the nasolabial fold was the combination of the levator alaeque nasi, the levator labii superioris, and the zygomaticus major muscle. The levator alaeque nasi and levator labii superioris defined the action of the medial and middle nasolabial folds (zones 1 and 2), the zygomaticus major minimally accentuated the lateral nasolabial fold (zone 3), and the levator anguli oris had no discernible effect on the fold. Paletz[19] demonstrated the vector analysis of perioral reference points during normal smiling. Average vector of the mid-lateral upper lip, oral commissure, and mid-lateral lower lip was 43°, 40°, and −3° above the horizontal. The movement of the mid-lateral portion of the upper lip was slightly more vertical than the oral commissure. Although the mid-lateral lower lip vectors and ranges vary greatly, during spontaneous smile, it is more often oriented above the horizontal plane than below it. Rubin[15] categorized smiles into three basic types: (1) the "Mona Lisa" smile, in which the corners of the mouth are pulled up and outward primarily by the zygomaticus major muscles, is the most common; (2) the "canine" smile, in which the levator labii superioris muscles are dominant in raising the upper lip; and (3) the "full denture" smile, which exposes the upper and lower teeth as a result of simultaneously contracting the elevators of the upper lip and corners of the mouth as well as the depressors of the lower lip.

These findings confirm that one muscle slip procedure is inefficient in providing complex vectors of mimetic muscles and that two or three muscle slips should be placed at different vectors to resemble the movement of the healthy side and nasolabial fold form. In addition, the variation in fixation point and tension of multiple muscle subslips enable to make a customized smile depending on the dominant smile type of the healthy side.

In the past, several attempts have been made to make one muscle fit into all the separate facial functions. O'Brien et al.[20] in 1980 and Frey and Giovanoli[21] in 2002 split the gracilis muscle parallel to its fiber direction into functional units to cover the diverse functions of the upper, middle, and lower faces. They achieved acceptable results but could not obtain clearly independent muscle activity of the muscle slips. Dellon and Mackinnon[22] split the latissimus dorsi muscle into three segments on the basis of fascicular stimulation, but they did not quantify the size of these muscles. The pectoralis major,[23] pectoralis minor,[24,25] and serratus anterior muscles[26-28] fundamentally differ with regard to their ability to divide into their individual slips with a well-defined neurovascular supply. Terzis[24] used the pectoralis minor muscle and its three or four slips for developmental facial paralysis in children. The pectoralis minor has sufficient bulk to produce adequate excursion and a dual nerve supply to allow for independent movements of its upper and lower portions. Despite this possibility, the apparent variability in the dominant vascular supply and difficultly in dissecting the neurovascular pedicle discouraged its routine use among most surgeons. In addition, the vectors of pull for three slips were directed to the same point, and there was no directional difference among the slips.

In 1982, Buncke et al.[27] first reported the utility of the serratus anterior muscle in facial reanimation. In two patients with longstanding facial paralysis, Yoleri et al.[28] used the lower three slips of the serratus anterior muscle, harvesting the slips with gradually decreasing lengths and transplanting the creation of different vectors and tension to the face. Although both patients had good results with symmetric open- and closed-lip smiles and sufficient excursion of the corner of the mouth, bulkiness due to three full-thickness muscle slips was observed.

Our technique has several advantages. Thinning of the superficial subslips and muscle length resembles facial mimetic muscle without the bulkiness observed with conventional full-layered serratus anterior muscle or other potential donor muscles. In addition, the muscle subslips can be separated from each other at both the medial and lateral margins, and placing the scapular origin of the muscle slips near the neurovascular pedicle to the oral commissure side provides more complex multiple force vectors. The consistent intramuscular neurovascular anatomy may be possible to split the individual slips and subslips, and multivector functioning motor units can be created with a single vascular anastomosis and single neurorrhaphy. As the superficial surface of subslips, on which the neurovascular pedicle runs, is placed on the deep surface of the cheek pocket, further muscle thinning can easily be performed without compromising the dominant neurovascular pedicle. When attempting transfer of the three superficial subslips of the serratus anterior muscle, the upper superficial subslip (sixth subslip) elevates the upper lip and helps form the medial and middle nasolabial folds to reveal the maxillary teeth (canine smile) and imitate the levator labii superioris, zygomaticus minor, and levator alaeque nasi. The function of the middle superficial subslip (seventh subslip) is to elevate the oral commissure ("Mona Lisa" smile) and to imitate the zygomaticus major. The function of the lower superficial subslip (eighth subslip) is to retract the oral commissure and to compress the cheek against teeth and gums, thereby imitating the buccinator. A single, common nerve innervating two or three independent muscle subslips can produce a coordinated and customized smile. Another advantage is its parallel fiber orientation, which enables the generation of contractile force in the mimetic muscles as well as lower donor site morbidity. Upper extremity dysfunction due to scapular winging is uncommon, as the upper subslips are not sacrificed. The major disadvantages of this technique in comparison with those of techniques using other donor muscles are that the length of the long thoracic nerve is relatively short and the selection of recipient nerve is often restricted in a one-stage procedure.

In this study, it is indicated that the superficial subslip of the serratus anterior muscle has latent flexibility with regard to its length, thickness, and vectors. Further studies are warranted to confirm that the choice of recipient motor nerve, such as the ipsilateral masseteric nerve, contralateral facial nerve with cross-facial nerve graft, or both as a dual innervation method, is superior for reconstructing more esthetic smiles.

Conflict of interest

The authors have no financial interests or personal relationships with other people or organizations that may have inappropriately influenced their work.

References

1. Harii K, Ohmori K, Torii S. Free gracilis muscle transplantation, with microneurovascular anastomoses for the treatment of facial paralysis. A preliminary report. *Plast Reconstr Surg* 1976;**57**:133-43.
2. Harii K, Asato H, Yoshimura K, Sugawara Y, Nakatsuka T, Ueda K. One-stage transfer of the lattisimus dorsi muscle for reanimation of a paralyzed face: a new alternative. *Plast Reconstr Surg* 1998;**102**:941-51.
3. Terzis JK, Noah ME. Analysis of 100 cases of free-muscle transplantation for facial paralysis. *Plast Reconstr Surg* 1997;**99**:1905-21.
4. Healey JE. *Synopsis of clinical anatomy*. Philadelphia: Saunders; 1969. p. 42-5.
5. Bharihoke V, Gupta M. Musclular attachments along the medial border of the scapula. *Surg Radiat Anat* 1986;**8**:71-3.
6. Fitchet SM. Injury to the serratus magnus (anterior) muscle. *N Engl J Med* 1930;**203**:818-23.
7. Hurwitz MT, Tocantins LM. Isolated paralysis of the serratus anerior (magnus) muscle. *J Bone Joint Surg* 1938;**20**:720.
8. Takayanagi S, Ohtsuka M, Tsukie T. Use of the latissimus dorsi and the serratus muscles as a combined flap. *Ann Plast Surg* 1988;**20**:333-9.
9. Mathes SJ, Nahai F. *Reconstructive surgery: principles, anatomy and technique*. New York: Churchill Livingstone; 1997. p. 31.
10. Clemente CD, editor *Gray's anatomy*. 30th Ed. Philadelphia: Lea & Febiger; 1985. 712-714 p. 520-1.
11. Godat DM, Sanger JR, Lifchez SD, et al. Detailed neurovascular anatomy of the serratus anterior muscle: implications for a functional muscle flap with multiple independent force vectors. *Plast Reconstr Surg* 2004;**114**:21-9.
12. Lifchez SD, Sanger JR, Godat DM, Recinos RF, LoGiudice JA, Yan JG. The serratus anterior subslip: anatomy and implications for facial and hand reanimation. *Plast Reconstr Surg* 2004;**114**:1068-76.
13. Freilinger G, Gruber H, Happak W, Pechmann U. Surgical anatomy of the mimic muscle system and the facial nerve: importance for reconstructive and aesthetic surgery. *Plast Reconstr Surg* 1987;**80**:686-90.
14. Lightoller GHS. The modiolus and muscles surrounding the rima oris with some remarks about the panniculus adiposis. *J Anat* 1925;**60**:1-85.
15. Rubin LR. The anatomy of a smile: its importance in the treatment of facial paralysis. *Plast Reconstr Surg* 1974;**53**:384-7.
16. Nairn RI. The circumoral musculature structure and function. *Br Dent J* 1975;**38**:49-56.
17. Ewart CJ, Jaworski NB, Rekito AJ, Gamboa MG. Levator anguli oris: a cadaver study implicating its role in perioral rejuvenation. *Ann Plast Surg* 2005;**54**:260-3.
18. Pessa JE, Zadoo VP, Adrian EK Jr, Yuan CH, Aydelotte J, Garza JR. Variability of the midfacial muscles: analysis of 50 hemifacial cadaver dissections. *Plast Reconstr Surg* 1998;**102**:1888-93.
19. Paletz JL, Manktelow RT, Chaban R. The shape of a normal smile: implications for facial paralysis reconstruction. *Plast Reconstr Surg* 1994;**93**:784-9.
20. O'Brien BM, Franklin JD, Morrision WA. Cross-facial nerve grafts and microneurovascular free-muscle transfer for long established facial palsy. *Br J Plast Surg* 1980;**33**:202-15.
21. Frey M, Giovanoli P. The three-stage concept to optimize the results of the microsurgical reanimation of the paralyzed face. *Clin Plast Surg* 2002;**29**:461-82.
22. Dellon AL, Mackinnon SE. Segmentally innervated latissimus dorsi muscle: microsurgical transfer for facial reanimation. *J Reconstr Microsurg* 1985;**2**:7-12.
23. Milroy BC, Korula P. Vascularized innervated transfer of the clavicular head of the pectoralis major muscle in established facial paralysis. *Ann Plast Surg* 1988;**20**:75-81.
24. Terzis JK. Pectoralis minor: a unique muscle for correction of facial palsy. *Plast Reconstr Surg* 1989;**83**:767-76.

25. Harrison DH. Current trends in the treatment of established unilateral facial palsy. *Ann R Coll Surg Engl* 1990;**72**:94–8.
26. Buncke H, Alpert B, Gordon L. Microvascular serratus anterior transplantation. In: Proceedings of the 51st annual convention of the American society of plastic and reconstructive surgeons, plastic surgery education foundation, and American society of maxillofacial surgeons, *Honolulu, Hawaii*; 1982. October 10-15.
27. Buncke HJ, Alpert BS, Evans HB. Free serratus anterior static and dynamic muscle transplants: presented at the American association of plastic surgeons meeting. Colorado Springs. CO. Philadelphia: Lea & Febiger; 1982.
28. Yoleri L. Modification of tension on muscle insertion improves smile in free-muscle transplantation. *Ann Plast Surg* 2006;**57**:295–9.