Dual-innervated multivector muscle transfer using two superficial subslips of the serratus anterior muscle for long-standing facial paralysis

Hisashi Sakuma¹ ², Ichiro Tanaka¹, Masaki Yazawa³, Anna Oh³
¹Department of Plastic and Reconstructive Surgery, Ichikawa General Hospital, Tokyo Dental College, Ichikawa; ²Department of Plastic and Reconstructive Surgery, Yokohama Municipal Citizen’s Hospital, Yokohama; ³Department of Plastic and Reconstructive Surgery, Keio University School of Medicine, Tokyo, Japan

INTRODUCTION

Muscle transfer is used to reconstruct a natural, symmetrical smile in patients with long-standing facial paralysis. Although the transplanted muscle should ideally be reinnervated by the facial nerve to synchronize perioral movement with the healthy side, the healthy contralateral facial nerve alone sometimes does not obtain sufficient contraction of the transplanted muscle [1]. To solve this problem, the ipsilateral massteric nerve was used as a neural motor source to obtain strong voluntary contraction at an early stage [2]. However, it remained difficult to reproduce an involuntary spontaneous smile synchronized with the healthy side [3-5]. In recent years, many studies reported dual innervation using a combination of the massteric and contralateral facial nerves to compensate for this drawback. Watanabe et al. [6] first described dual innervation using the latissimus dorsi muscle innervated by the contralateral facial nerve by end-to-end neurorrhaphy and the massteric nerve via muscular

Keywords: Facial paralysis / Free tissue flap / Serratus anterior muscle

Correspondence: Hisashi Sakuma
Department of Plastic and Reconstructive Surgery, Ichikawa General Hospital, Tokyo Dental College, 5-11-13, Sugano, Ichikawa 272-8513, Japan
Tel: +81-47-322-0151
Fax: +81-47-325-4456
E-mail: prssakuma@gmail.com

This work was supported by JSPS KAKENHI (Grant No. JP 20K18443).
neurotization of the underlying masseter muscle. Biglioli et al.
[7] reported one-stage transfer of the gracilis muscle, innervated
by both the masseteric and contralateral facial nerves. It is possi-
bile to add the ability to smile for conveying emotions through
input from the contralateral facial nerve in an end-to-side fash-
ion, while guaranteeing adequate contraction of the transplant-
ed muscle by input from the masseteric nerve in an end-to-end
fashion. However, single muscle transfer has limitations in re-
producing a natural smile, since the multiple mimetic muscles
have different vectors and move in coordination when smiling
normally [8,9]. To overcome these problems, we developed a
natural smile reconstruction method involving the transfer of
two superficial subsips of the serratus anterior (SA) muscle,
which are dually innervated by the ipsilateral masseteric and
contralateral facial nerves.

CASE

A 67-year-old woman presented with complete facial paralysis
that had lasted for 2 years secondary to facial nerve schwanno-
ma resection (Fig. 1). In the first stage, through a preauricular
incision on the healthy side, cross-face nerve grafting (CFNG)
was performed. Two facial nerve buccal branches were identi-
fied and the thicker one was used as the recipient nerve. Six
months after the first stage, dual-innervated muscle transfer was
performed, using two superficial SA subsips. Through a midax-
illary lazy-S incision with extension into the axilla, the ipsilateral
lower SA subsips and its overlying neurovascular pedicle were
identified. The 5-mm-thick and 12-cm-long seventh and eighth
superficial subsips were harvested, including the thoracodorsal
vessels and long thoracic nerve, with preservation of the upper
branches to prevent postoperative scapular winging (Fig. 2).

The seventh and eighth subsips were placed into the cheek
pocket, with the neurovascular bundles oriented on the inner
side. The scapular origin of the muscle subsips was divided into
two portions and positioned on the oral commissure side. After
the thoracodorsal vessels were anastomosed with the facial ar-
tery and vein under a surgical microscope, the seventh subsip
was secured to the orbicularis oris of the upper lip and the
eighth subsip to the modiolus. The long thoracic nerve was su-
tured to the masseteric nerve branch in an end-to-end manner
and sutured to the distal stump of the CFNG in an end-to-side
manner (Fig. 3A). The opposite sides of the muscle subsip
were sufficiently separated from each other to differentiate the
force vector of each subsip, preserving the proper subsip ves-
sels and nerves. The upper seventh subsip (8 cm long) was ori-
ented to make an angle of 50° and the lower eighth subsip (10
cm long) was positioned to make an angle of 20° with the hori-
zontal plane and secured to the deep temporal and periauricular
fascia (Fig. 3B). Furthermore, through bilateral incisions along
the lower vermilion border, a horizontal fascia lata graft was
added between the orbicularis oris muscle of the lower lip and
the lower eighth subsip to prevent deformities, such as lower lip

Fig. 1. A woman presenting with complete facial paralysis. (A) Pre-
operative view at rest. (B) Preoperative view during smiling.

Fig. 2. Harvest of the lower serratus anterior (SA) muscle. (A) Sche-
ma of the surgical anatomy of the SA and its overlying neurovascu-
lar pedicle. (B) Two harvested superficial subsips of the SA.
Voluntary contraction was noted at approximately 4 months, and a spontaneous smile without biting was noted 8 months postoperatively. At 18 months after surgery, the patient simultaneously demonstrated a spontaneous symmetrical smile with sufficient excursion of the lower lip, upper lip, and oral commissure (Fig. 4). Postoperative cheek muscle bulkiness with the two subslips was not demonstrated at rest or while smiling.

DISCUSSION

In recent years, various double muscle transfer methods have been reported for long-standing facial paralysis, in which each muscle flap is reinnervated by two neural motor sources to reproduce complex perioral movements. Okazaki et al. [10] demonstrated dual latissimus dorsi muscle flap transfer with nerve suturing to the ipsilateral masseteric and contralateral facial nerves. Although this method using two muscle flaps mimics complex facial movements and guarantees reliable muscle contraction and voluntary smiling in one stage, it is difficult to produce a coordinated smile due to the independent innervation of each muscle flap. Matsumine et al. [11] reported a single-stage double muscle reconstruction technique using a latissimus dorsi muscle flap and SA flap, with dual innervation from the contralateral facial and masseteric nerves with neural interconnection via each distal nerve branch. This is an excellent technique in that coordinated natural smiles can be reconstructed by dually innervating each muscle flap. However, the two procedures mentioned above are somewhat complicated and tend to exhibit muscle bulkiness. Furthermore, it is feared that movement may be weakened by thinning of the originally thick latissimus dorsi muscle.

We focused on the SA muscle, whose muscle subslips are nourished and controlled by one neurovascular bundle. We previously reported a method of transferring two or three superficial subslips of the SA reinnervated by the masseteric nerve to the lower lip, upper lip, and oral commissure with different vectors [12]. However, due to the close proximity of the muscle subslips around the lips, a sufficient vector difference could not always be obtained, resulting in insufficient lip elevation or cheek bulkiness during muscle contraction. To address these issues, we developed a method in which only two muscle subslips were fixed to the upper lip and oral commissure, regardless of the state of paralysis and facial size, and the lower lip is pulled outward through a fascial graft. The superior muscle subslip to be transplanted is mainly aimed at raising the upper lip and
forming the nasolabial fold, with the inferior muscle subslip abducting the oral commissure and lower lip to the outside. As a result, by synchronously pulling the two muscle subslips controlled by one nerve with sufficiently different vectors, a more natural smile can be obtained. Combining this technique with a fascial graft also makes it possible to reconstruct more esthetic smiles and prevents muscle bulkiness. Furthermore, it is possible to simply reproduce a spontaneous symmetrical smile by adding additional input from the contralateral facial nerve via a CFNG to the proximal side of the long thoracic nerve with end-to-side neurorrhaphy, similar to Biglioli's procedure [7]. The disadvantages of this method are that it is a two-stage reconstruction requiring a sural nerve graft; it is expected that a spontaneous smile is unlikely to occur due to the instability of axonal regeneration from the ipsilateral facial nerve via an end-to-side anastomotic site; and excessive contraction of the transplanted muscle is likely to occur due to the inclusion of a large amount of axons from the masseteric nerve via an end-to-end anastomotic site [13].

As a result of this preliminary study, we believe that dual-innervated muscle transfer using two multivector superficial subslips of the SA muscle may be useful for the reanimation of long-standing facial paralysis because it can produce a voluntary and spontaneous smile without muscle bulkiness. Further study is necessary to confirm these findings.

NOTES

Conflict of interest
No potential conflict of interest relevant to this article was reported.

Ethical approval
The study was approved by the Institutional Review Board of the Yokohama Municipal Citizen's Hospital (IRB No. 20-11-02) and performed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained.

Patient consent
The patient provided written informed consent for the publication and the use of her images.

Author contribution
Conceptualization: H Sakuma. Methodology: H Sakuma, I Tanaka, A Oh. Writing - original draft: H Sakuma. Writing - review & editing: M Yazawa. Approval of final manuscript: all authors.
tation with the neural interconnection between the ipsilateral masseter and contralateral facial nerve for reanimating established facial paralysis: a report of 2 cases. Microsurgery 2019;39:457-62.

12. Sakuma H, Tanaka I, Yazawa M, et al. Multivector function- ing muscle transfer using superficial subslips of the serratus anterior muscle for longstanding facial paralysis. J Plast Reconstr Aesthet Surg 2019;72:964-72.

13. Tanaka I, Sakuma H, Yazawa M, et al. Examination of the long-term course of the free muscle grafting that assumed masseteric nerve singularity motor nerves for old facial paralysis. Facial Nerve Res Jpn 2018;38:58-60.