Free Split and Segmental Latissimus Dorsi Muscle Transfer in One Stage for Facial Reanimation

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The authors report the experience in facial reanimation using free innervated split and segmental latissimus dorsi muscle flap one-stage transfer in 86 patients with longstanding facial palsy. The segmental latissimus dorsi was taken from the distal part of the muscle so that the muscle flap had an ultra-long neurovascular pedicle of 13 to 17.5 cm in length. The muscle flap was made thinner by splitting the segmental muscle. The split segmental muscle flap was transferred to the paralyzed side of the face with its ultra-long neurovascular pedicle passing through a tunnel in the upper lip to the normal side of the face. The neurovascular pedicle of the muscle flap was anastomosed with the facial nerve, artery, and veins, respectively, on the normal side of the face. The operation was designed without the cross-facial nerve graft stage. From 1986 to October of 1997, 86 patients with longstanding facial paralysis were treated in our department. The duration of facial palsy in this series ranged from 1.5 to 51 years. A satisfactory result was obtained in 80 cases, evaluated at 8 months to 2 years postoperatively. The expression movement of the soft tissues of the face can be seen not only over transferred muscle but also on the paralyzed muscle covered by the splitting muscle flap. It is supposed that this is the result of muscle-muscle neurolization. Study of 66 specimens of latissimus dorsi muscle in the cadavers is discussed. (*Plast. Reconstr. Surg.* 103: 473, 1999.)

Facial paralysis results in the inability to wrinkle the forehead, close the eye, or raise the eyebrow or corner of the mouth, owing to a lost nasolobial fold. Facial asymmetry occurs during both rest and function. Emotional facial expression, blinking, eating, and speaking are all adversely affected. In addition to considerable facial impairment, failure to close the eye may result in exposure to keratitis, threatening vision.

Techniques described initially for the management of facial paralysis included static suspension of eyelids, cheek, and corner of the mouth using fascia lata strips[1] or anastomosing the accessory or hypoglossal nerves to the facial nerve.[2,3] More recently, techniques have been used to introduce muscle to replenish the atrophied facial asymmetry at rest; however, a normal smile is usually not restored. Autogenous free on-lay muscle grafts, for example extensor digitorum brevis, have also been used.[4] Extending the transplanted muscle across from the paralyzed to the unparalyzed side facilitates neurolization.

Although significant challenges remain in the management of facial paralysis, considerable advances have been made over the last few decades. Facial paralysis was first treated by free neurovascular muscle transfer using the gracilis muscle.[5] In these cases, the nerve supplying the gracilis muscle was anastomosed to the nerve to the temporalis muscle, and thus the activity of the transplanted muscle was controlled by the trigeminal nucleus. The control of the muscles of facial expression and transplanted muscle by the facial nerve is a prerequisite for restoration of a synchronous natural smile. After 1980, the treatment of facial paralysis has been developed by many authors, such as O'Brien,[6,7] Terzis,[8] Buncke et al.,[9] Harii et al.,[5] and Dellon and Mackinnon.[10] The procedure is divided into two stages. The first stage involves the cross-facial nerve graft. The second stage of the operation, which is

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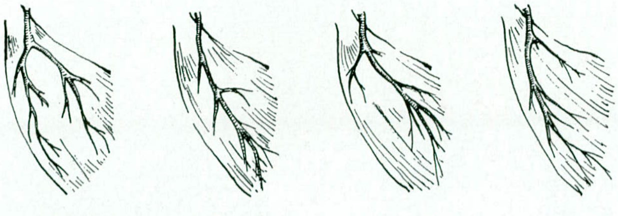

FIG. 1. Segmental arterial blood supply types of latissimus dorsi muscle. Type I, homogenous 50%; type II, feather 6%; type III, inner feeder 17%; and type IV, outer feeder 27%.

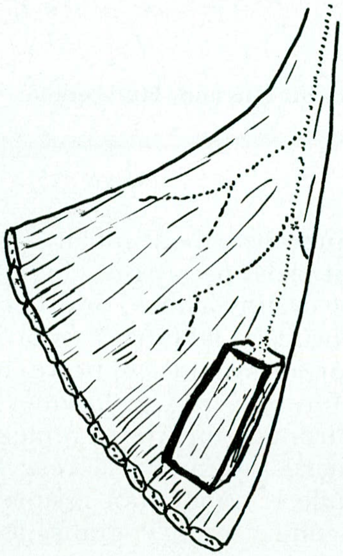

FIG. 2. Dissection of segmental latissimus dorsi muscle flap.

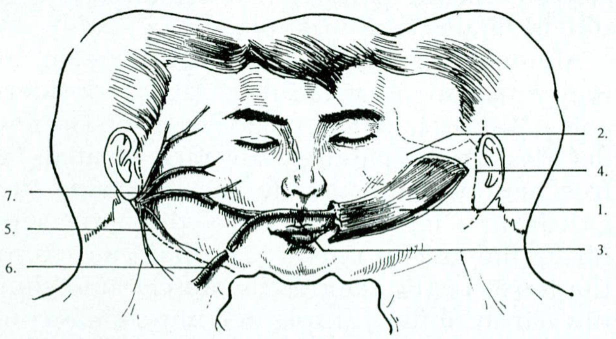

FIG. 3. Design of one-stage free transfer of split and segmental latissimus dorsi flap with an ultra-long neurovascular pedicle. 1, muscle flap; 2, body of zygoma; 3, neurovascular pedicle; 4, incision on the paralyzed side; 5, the incision on the normal side; 6, the facial artery and vein; and 7, buccal branches.

performed 8 to 12 months following the first stage, involves neurovascularized muscle transfer. The result of this sort of operation is always good.

The purpose of this paper is to describe the technique and results of 86 cases of facial paralysis treated, using latissimus dorsi muscle transfer in a new way: a single stage, individualized, neurovascular transfer of split segmental muscle flap with an ultra-long pedicle.[11–13]

MICROANATOMY

Microanatomy is the key to latissimus dorsi segmental muscle flap preparation and has been previously described by us in a detailed cadaver study of 66 specimens.[14]

The thoracodorsal artery measures 1.6 to 2.7 mm in diameter. It runs on the deep surface of the latissimus dorsi muscle before dividing into medial and lateral branches that enter the muscle. They arise 18.5 mm superior to the level of the inferior angle of the scapula, 21.5 mm medial to the anterior border of this muscle, and 53.3 mm lateral to the vertical line passing through the inferior angle of the scapula. The medial and lateral branches further divide into segmental arteries, of which there are generally four (and up to six) patterns of distribution (Fig. 1). There are generally two venae comitantes accompanying each segmental artery.

The relationship between artery (A), vein (V), and nerve (N) of the medial segments of latissimus dorsi muscle for types I through IV is NVAV (100 percent), of lateral segments for types I and II is NVAV (51.6 percent), and of types III and IV is VAVN (42.5 percent) (Fig. 1).

OPERATIVE TECHNIQUE

The technique involves a single operation with two teams operating simultaneously. One team prepares the latissimus dorsi segmental muscle flap for transfer while the other prepares the recipient site.

The patient is positioned supine with the donor latissimus dorsi muscle side 30 degrees upward and over its anterior border, and the skin flaps are raised anteriorly and posteriorly to expose the muscle. Dimensions of the latissimus dorsi segmental muscle flap required for the individual case are marked, usually 2.0 to 4.0 cm wide and 7 to 9 cm long. The anterior border of the muscle is mobilized, and by careful inspection and palpation the lateral branch of the thoracodorsal artery is identified. Raising segmental flaps 3 or 4 cm gives a longer pedicle (8 to 12 cm) than the usual 5 to 8 cm. Dissection proximally along the lateral branch through the muscle leads to the thoracodorsal artery itself. The latter is mobilized proximal to the branch to the inferior omohyoid muscle,

FIG. 4. Postoperative complication of right acoustic neuroma for 2 years. This 42-year-old woman was treated by one-stage neurovascular muscle transfer. (*Above, left*) At rest; (*above, right*) laughing. (*Below*) One year postoperation of segmental and split latissimus dorsi muscle transfer at rest (*left*) and smiling (*right*).

increasing the length of the pedicle to 10 to 14 cm. Further dissection of the segmental artery through the muscle yields a 13- to 17.5-cm, ultra-long pedicle to the segmental muscle flap. A thinner latissimus dorsi muscle flap is about 0.4 to 0.6 cm. The neurovascular pedicle must be protected in the muscle while one is splitting.

The face is approached through preauricular incisions on both sides. On the normal, nonparalyzed side, the facial artery and vein are prepared for microvascular anastomosis, and a 1-mm diameter of branch from the buccal plexus of the facial nerve is selected, in preference to a larger main buccal branch (1.5 mm), for anastomosis to the nerve supplying the latissimus dorsi muscle.

A subcutaneous tunnel in the upper lip is created. The ultra-long pedicle of the latissimus dorsi split and segmental muscle flap is delivered from the paralyzed to the normal side through the subcutaneous tunnel. Microa-

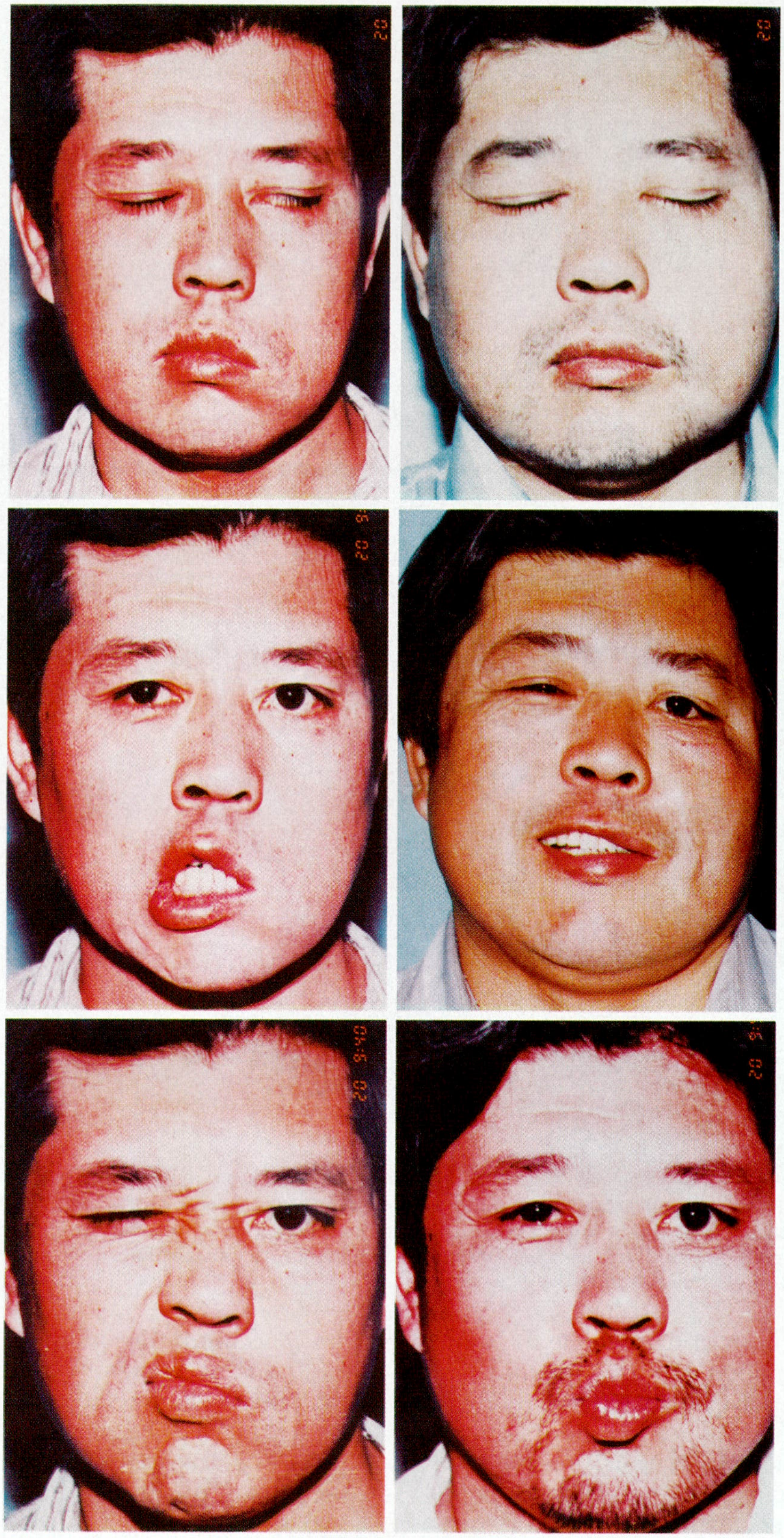

FIG. 5. A 43-year-old man with left facial paralysis 4 years after a left acoustic neuroma previously removed was treated by segmental and split latissimus dorsi muscle transfer. (*Above, left*) At rest before treatment; (*above, right*) 8 months after latissimus dorsi muscle flap transfer, at rest. (*Center*) Smiling before treatment (*left*) and 8 months after latissimus dorsi muscle flap transfer (*right*). (*Below*) Whistling before treatment (*left*) and 8 months after latissimus dorsi muscle flap transfer (*right*).

nastomosis of the thoracodorsal artery, vein, and nerve to the prepared facial artery, vein, and branch of the buccal plexus of the facial nerve is performed, respectively.

The split segmental muscle flap is placed in position over the zygomaticus major muscle. The superior end is anchored to the body of zygoma and to the fascia deep to the submuscular aponeurotic system; the inferior end is then separated into three leaves that are secured to the upper lip, oral commissure, and lower lip. At the time of preparing the segmental muscle flap, a leaf projecting from it can also be fashioned so that it can be inserted into the lower eyelid (Figs. 2 and 3).

Results

At our institution, 86 cases of facial paralysis were treated by the previously described technique between 1986 and October of 1997.

The etiology of the cases treated involved postoperative complication of acoustic neuroma (Figs. 4 and 5), Bell's palsy (Fig. 6), motor accidents, postoperative sequelae of facial hemangioma (Fig. 7), otitis media, congenital deformity, and others. Before surgery, the mean duration of facial paralysis was 13.6 years (range 1.5 to 52 years); the age range was 7 to 52 years.

Outcome was assessed by clinical examination and patient questionnaire for facial appearance at rest and during voluntary and involuntary movements and muscle tone.

Eighty cases showed recovery from facial paralysis, whereas 2 cases failed. Satisfactory results were obtained in 80 cases, evaluated at 8 months to 2 years after operations. The recovery of facial expression was not only the result of the movement of transferred muscle but also the paralyzed muscle covered by transferred muscle. The neuronization of the transferred muscle flap took place at 128 days after operation and the latest at 8 months. Recovery continued up to 2 years postoperatively. All cases investigated by electromyography showed activity, the earliest occurring postoperatively, and improved with time.

Discussion

Various muscles have been used for free neurovascular transfer for treatment of facial paralysis. They include gracilis, extensor digitorum brevis, latissimus dorsi, and pectoralis minor muscles. The criteria of selection of a suitable donor muscle for free neurovascular transfer are a single neurovascular pedicle, the similar shape and size, and no functional disability after operation.

The characteristic distribution of vessels and nerves in latissimus dorsi previously described

FIG. 6. A 44 year-old man, who suffered from Bell's palsy for more than 10 years, was treated by segmental and split latissimus dorsi muscle transfer and is shown smiling before treatment (*left*) and after treatment (1 year after latissimus dorsi muscle flap transfer) (*right*).

FIG. 7. A 17-year-old girl suffered from left facial hemangioma; when 2 years old, she had left facial palsy after the hemangioma was removed. (*Above*) Smiling (*left*) and laughing (*right*) before operation. (*Below*) Two years after segmental and split muscle transfer shown smiling and exposing teeth (*left*) and laughing (*right*).

enables well defined "segmental muscle flaps" to be raised. Each segmental muscle flap behaves as a single and independent functional unit, enabling treatment to be designed for individual cases. Thus, the dimensions of the free-muscle transfer selected should produce the correct amount of bulk, power, and range of motion appropriate to different parts of the face. This needs to take into account that about 50 percent of the muscle transplanted can become atrophied up to 3 months after transfer and that the maximum working capacity is only one-fourth of what is normal.

The site for insertion of the muscle transfer is also important. It should be placed in position of the zygomaticus major muscle to raise the corner of the mouth, 30 to 40 degrees to the horizontal, and produce a symmetric smile.

A two-stage operation for facial reanimation has been widely used; cross-facial sural nerve grafting at the first stage is followed 6 to 8 months later, after the appearance of Tinel's sign at the distal end of the nerve graft, by the second stage that involves the free neurovascular transfer of gracilis or pectoralis minor muscles. The single stage surgical technique that we describe with an ultra-long pedicle avoids the need for preliminary cross-facial sural nerve grafting, the delay and possible complications of a second operation, and sural nerve donor-site morbidity. Unlike the pectoralis minor muscle, which is too close to the face, selection of the latissimus dorsi muscle enables surgery at the recipient and donor sites to be undertaken simultaneously, thus reducing the operative time.

There is early return of good facial movement with this technique at about the fourth month postoperatively. Improvement in facial movement continued for up to 1 or 2 years after surgery and is in agreement with other studies.

Recovery of function of a paralyzed muscle following a single stage free neurovascular transfer also has been studied in an animal model and clinically.[11,12,15] These studies showed that based on muscle tension, electromyography, and histologic findings, recovery from paralysis was significantly better when a neurovascular pedicle with attached muscle was implanted into the paralyzed muscle (group A) than when only a nerve was implanted (group B). The former group showed rich regeneration of motor end plates and blood vessels with significantly better electromyography activity and muscle tension than the latter group. Furthermore, the recovery was also significantly better in a subgroup of group A, in which the muscle was paralyzed for 12 weeks before the implantation (as opposed to there being no delay). The delay probably allows the Schwann cells to regenerate and produce a high concentration of chemotactic factors directing reinnervation of the paralyzed muscle, and the increase in space between the atrophied muscle fibers may also favor reinnervation.

In the one case in which there was no recovery from facial paralysis, this was presumably because of thrombosis of the vascular anastomoses.

The technique described was followed by good neurolization of the orbicularis oris muscle as indicated by patients being able to purse their lips. This process is favored by splitting the segmental muscle flap, encouraging the widespread formation of motor endplates (muscle-to-muscle neurolization). In our experiment and in clinical studies[12,13,15] and Dellon's experimental model,[16] it was demonstrated that reinnervation of paralyzed muscle was achieved not only by covering split muscle flap but also by implanting muscle bundles with neurovascular pedicle or adjacent normal muscles. The split muscle flaps were used as a group of implanting muscle bundles to cover the paralyzed muscle, demonstrating that denervated muscle can be reinnevated.

Another advantage of the distally located segmental muscle flaps is that it is thin, reducing the likelihood of secondary debulking procedures. Only two of our cases required such a procedure.

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