Our first clinical success in microneurovascular free muscle transplantation for treatment of long-standing facial paralysis was in 1973. The author introduces his recent technical refinements of this clinical procedure and the results obtained.

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REFINED MICRONEUROVASCULAR FREE MUSCLE TRANSPLANTATION FOR REANIMATION OF PARALYZED FACE

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Neurovascular free muscle transplantation has proved its versatility in reconstruction of the paralyzed face in which mimetic muscles have already become severely degenerative or atrophied. This report describes the purpose of this operation, recent technical refinements, and clinical results.

PURPOSE OF OPERATION

As reported in our previous papers, the primary goal of the operation is to obtain synchronous and symmetrical facial animation and spontaneity of emotional facial movements (especially upon smiling), a matter hardly accomplished by conventional local muscle transposition methods. For this purpose, the transplanted muscle is placed subcutaneously between the nasolabial region and the zygomatic region in the expectation of elevation of the paralyzed cheek and nasolabial fold with smiling. If required, certain conventional procedures, such as the temporalis muscle sling, canthoplasty, eyebrow-lift, and digastric muscle transfer, etc., can be used additionally for correction of paralyzed eyelids, forehead and eyebrow, and lower lip.

SELECTION OF DONOR MUSCLE

Of 116 muscles transplanted in our present series, the gracilis muscle accounted for an absolute majority (106 muscles). The latissimus dorsi muscle was only used in five cases in which a long vascular pedicle was required, because either the superficial temporal vessels or the facial vessels usually utilized as recipient vessels were not available. In two cases, dual transfer of segments of the latissimus dorsi and serratus anterior muscles nourished by a common nutrient pedicle of the thoracodorsal vessels was achieved to simultaneously correct a paralyzed cheek and lower lip, but the results were not significant. The extensor digitorum brevis muscle was utilized in two of our early cases, but further use was relinquished because excursion sufficient for elevation of the paralyzed cheek with smiling could not be obtained with such a small muscle. Part of a rectus abdominis muscle with a pedicle of the inferior epigastric vessels and the intercostal nerve was used in one case in which recipient vessels were distantly located.

Early in our series, a relatively large part of a muscle would be transplanted, but this procedure frequently required secondary excision of excess muscle volume, even though spontaneous atrophy had reduced the original volume by one-third to one-half. At present, an adequate portion (average, 3-cm wide, 8-cm long) of the proximal segment of the muscle belly centering on its neurovascular hilus is used to avoid conspicuous bulkiness.

SELECTION OF A MOTOR NERVE IN THE RECIPIENT BED

The important factor in obtaining satisfactory results with this method is not the selection of a donor muscle, but that of suitable motor nerve stump in the recepient bed which can innervate the transplanted muscle smoothly and adequately. The three major procedures outlined here are categorized in accordance with the motor nerve selected in the recipient bed.

Method I

A stump of the facial nerve is available for use.

I-A. A healthy or a fresh stump of the facial nerve in the paralyzed side is used.

I-B. A stump of the affected facial nerve in the paralyzed side is used.

Method II

A nerve branch other than that of the facial nerve is used.

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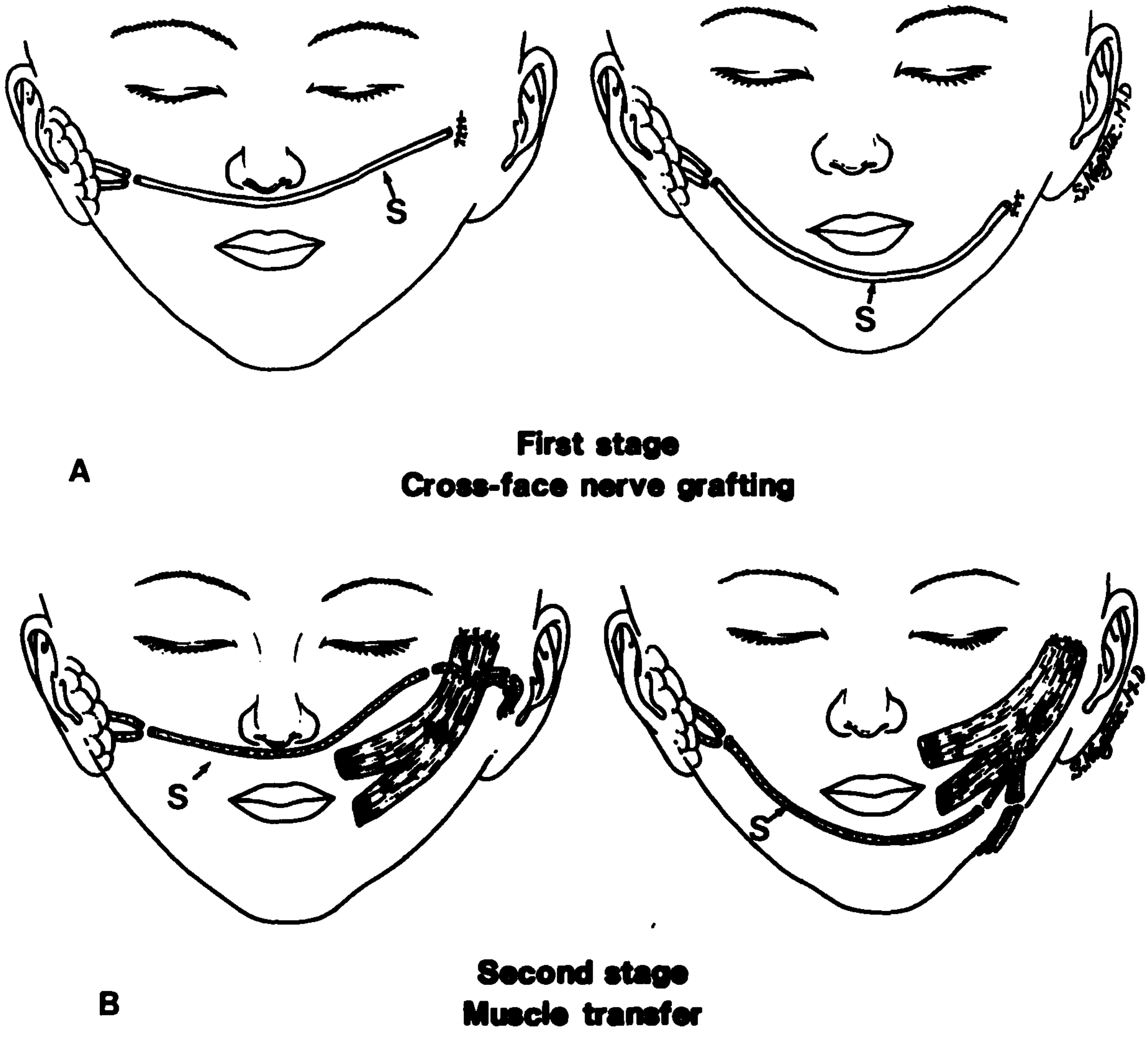

Figure 1. Schema of method-III operation. A: First stage, cross-face nerve grafting. B: Second stage, muscle transfer. S, cross-face sural nerve graft; M, free muscle transplantation.

II-A. The hypoglossal nerve is used.

II-B. The deep temporal nerve is used.

Method III

The stump of a cross-face nerve graft is used (Fig. 1).

When a fresh functioning stump of the facial nerve (e.g., for paralysis following wide resection of a large cavernous hemangioma or a malignant tumor involving the facial nerve and mimetic muscles) can be used, method I-A obtains the most natural contraction of the transplanted muscle. Since, however, such a stump is not available in most cases, method III, combining free muscle transplantation with a cross-face nerve graft, has wide application and can obtain the satisfactory result described below.

ESSENTIALS OF METHOD III OPERATION

A two-stage operation is required, each stage an average 10–12 months apart.

First-Stage Operation (Cross-Face Nerve Grafting)

A long, ~ 20-cm, sural nerve graft is subcutaneously passed, through either the upper lip or the chin, from the intact side to the paralyzed cheek. Under magnification, several fascicles selected from the zygomatic and buccal branches of the intact facial nerve are sutured to the fascicles in the distal stump of the grafted sural nerve. Originally, the facial nerve branches in the intact side were exposed through a preauricular face-lift incision, but now these branches are exposed through a small, less than 2-cm-long, incision at

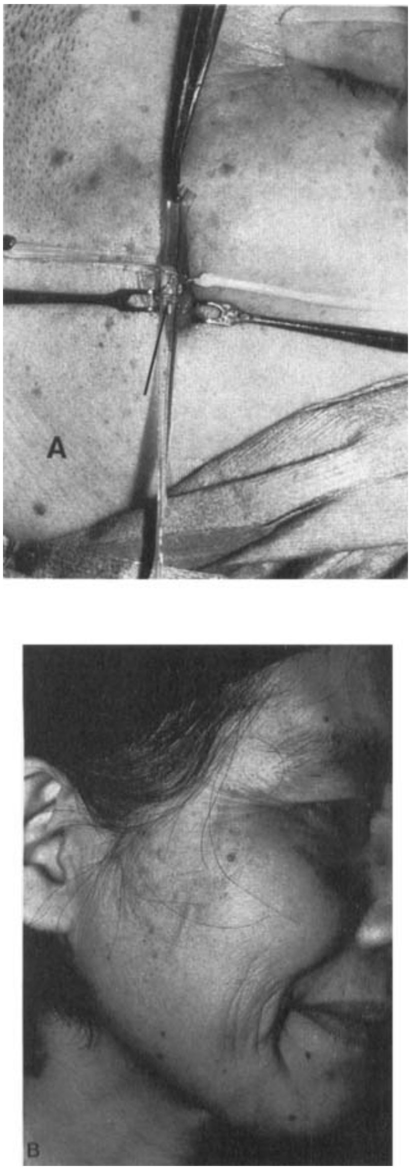

Figure 2. ***A:*** *Exposure of facial nerve branches (arrow) on intact (nonparalyzed) side through a small skin incision along the anterior margin of the parotid gland. S, sural nerve graft.* ***B:*** *Invisible scar of skin incision of same patient.*

the anterior margin of the parotid gland. A sufficient number of zygomatic and buccal branches can be exposed through such a small incision, leaving a minimal and invisible scar (Fig. 2).

It is important to select some of the facial nerve branches that innervate the levator muscles of the upper lip and the nasolabial fold, because the subsequent muscle transplant will be positioned to elevate the upper lip and the nasolabial fold with smiling.

Second-Stage Operation (Free Muscle Transplantation)

The progress of axon regeneration through the sural nerve graft is monitored by the advance of the referred Tinel's sign, which on the average reaches the other stump of the nerve graft anchored beneath the skin in the paralyzed cheek in 6 to 8 months after the first operation. The second-stage operation, however, will not take place until several months after Tinel's sign has advanced to the nerve stump in expectation of maturation of the regenerated axons by that time.

The cheek skin on the paralyzed side is undermined through a preauricular face-lift incision. The sural nerve graft stump and suitable recipient vessels (either the superficial temporal vessels or the facial vessels) are carefully exposed. Wide undermining of the cheek skin proceeds toward the nasolabial fold to create a cheek pocket, which subsequently will accept the transplanted muscle. A new

Figure 3. ***A:*** *Through a preauricular face-lift incision, a nasolabial groove can be created by pulling on the remnant of the zygomatic major attachment to the orbicularis oris muscle. TM, temporalis muscle transposition for correction of paralyzed eyelids.* ***B:*** *A small part of the soft tissues over the zygoma is excised (arrow).*

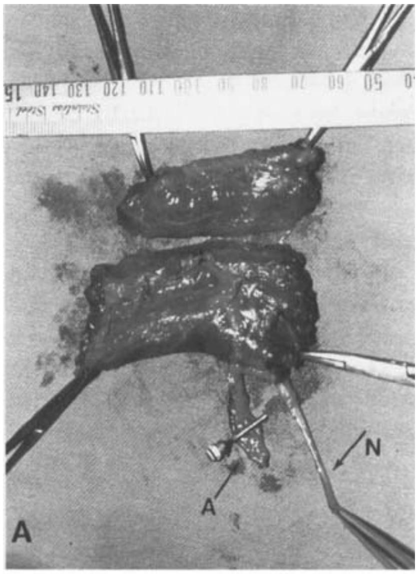

Figure 4. A. A gracilis muscle harvested in accordance with required volume. A, nutrient vessels; N, motor nerve. B: Immediately after operation.

nasolabial groove can be created by pulling traction stay sutures, inserted into the atrophied zygomatic major muscle at the site of its attachment to the orbicularis oris muscle, toward the zygoma. At this point, the site of fixation of the distal portion of the muscle is determined. We prefer not to incise the nasolabial region to anchor the muscle, because patients may complain of a visible postoperative scar. A portion of the subcutaneous tissue overlying the zygoma is excised to accommodate the bulk of the muscle attachment (Fig. 3).

During the cheek operation, a second team harvests the gracilis muscle. An average 3 × 8–10-cm section of the gracilis muscle belly close to the neurovascular hilus is isolated and transferred to the cheek subcutaneous pocket. The distal portion of the muscle is split and anchored tightly at the site of the traction stay sutures, creating a nasolabial fold. Neurovascular anastomoses are then accomplished under an operating microscope. Finally, the proximal portion of the muscle belly is fixed, under appropriate tension, to the periosteum of the zygoma exposed by excising the subcutaneous tissue (Fig. 4).

CLINICAL RESULTS OF METHOD III

Of 115 cases (115 muscle transfers) operated on between September, 1973 and December, 1985, 85 cases (85 muscle transplantation) were achieved by method III. These consisted of 52 cases of complete paralysis and 33 cases of incomplete or partial paralysis. The durations of paralysis were an average 12.4 years (shortest, 18 months; longest, 68 years). Use of part of the gracilis muscle was preferred, except in three cases in which segments of the latissimus dorsi and serratus anterior muscles were used.

The cases were followed up for more than 1 year prior to evaluation, but this could not be accomplished in nine cases, and they were not considered. Therefore, 76 of 85 cases treated by method III are analyzed in this paper. Results were evaluated on the basis of observation of patients' facial animations and electromyography. Overall evaluations were classified as good, satisfactory, fair, and poor. Good signifies symmetric balance and good facial tone at rest, sufficient voluntary contraction of the transplanted muscle, synchronous or natural expression upon emotional

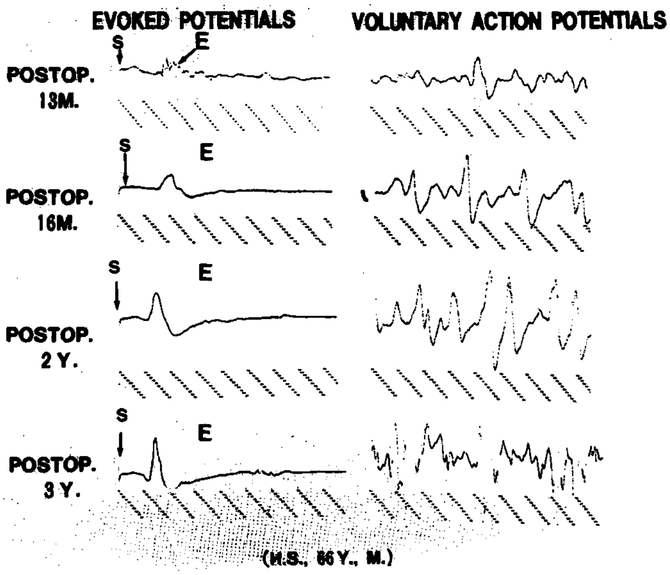

Figure 5. Representative periodical EMG findings show gradual increases of voluntary action potentials and evoked potentials. Normal interference patterns are noticed. Distal latency of the evoked potentials shortens along the postoperative course. E, evoked potentials; S, stimulation.

Figure 6. Case 1. A 57-year-old woman with right complete paralysis after resection of an acoustic tumor. ***A, B:*** *Preoperative views.* ***C:*** *Recipient vessels (A) and stump of cross-face nerve graft (N) exposed in the recipient bed.* ***D:*** *A nasolabial groove created by subcutaneous traction.* ***E, F:*** *A part of the gracilis muscle belly (A, nutrient vessels; N, motor nerve), and the muscle set in place (A, vascular anastomosis, N, nerve suture).* ***G, H, I:*** *One and a half years postoperatively.*

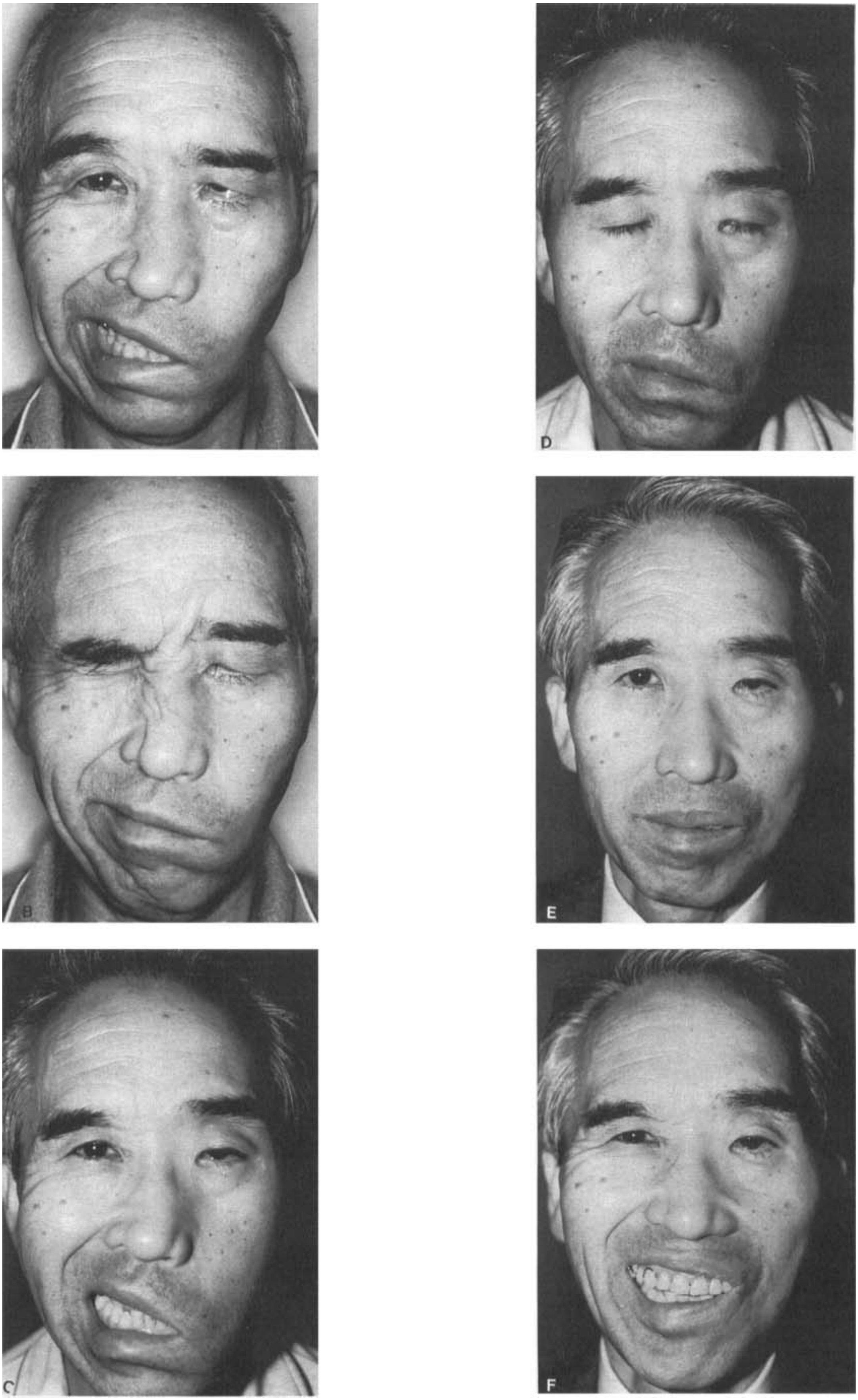

Figure 7. Figure 7G and legend on facing page

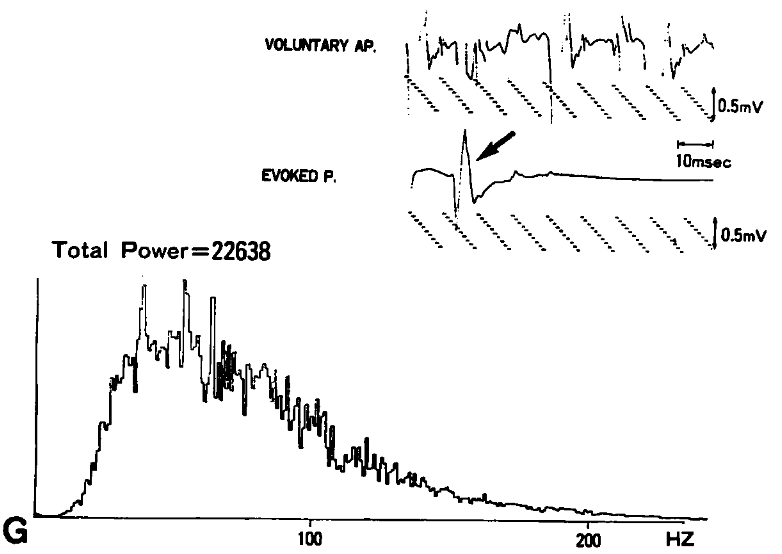

Figure 7. Case 2. A 57-year-old man with left complete paralysis after resection of an acoustic tumor. A, B: Preoperative views. C, D: Views before the second-stage operation. A cross-face nerve graft, temporal muscle transfer to eyelids, and eyebrow lift were achieved in the first-stage operation. E, F: Three years postoperatively. G: Electromyography and power spectrum at 18th postoperative month. (Partly reproduced from Harii K: J Jpn Plast Reconstr Surg 7:347–372, 1987, with permission of the publisher.)

movements (especially upon smiling), and good evoked potentials with stimulation of the intact facial nerve trunk. Satisfactory stands for symmetric balance and good facial tone at rest and active, but not sufficiently synchronous (too strong or weak) contraction of the muscle. Also, patient accepts the result. Fair signifies symmetric balance at rest but insufficient contraction of the muscle upon emotional movements. Poor means no correction. Of 76 cases evaluated, 52 cases (68.4%) were evaluated as good, 16 cases (21.1%) as satisfactory, and five cases (6.6%) as fair. Only three cases (3.9%) were declared poor.

Electromyographic investigations of the transplanted muscles revealed that denervation potentials, which serve as a good indicator of muscle viability, appeared from the 10th to 14th postoperative days and completely disappeared in the 9th postoperative month, while low-amplitude voluntary action potentials were noticed earliest in the 4th postoperative month. On the average, reinnervation began in the 9th postoperative month. The amplitude of action potentials gradually increased after the initial recording and reached a maximum level after 5 months. Giant spikes and polyphasic potentials were often observed in the early postoperative periods.

Low amplitude, polyphasic, and short-duration evoked potentials with long distal latency were noticed in the early postoperative periods, but their amplitudes gradually increased. The distal latency became short in accordance with maturation of the innervated muscle (Fig. 5). The power spectrum showed a rapid increase in total power when muscle innervation proceeded smoothly.

AUXILIARY OPERATIONS AND SECONDARY CORRECTION OPERATIONS

Several additional operations were achieved for correction of paralyzed eyelids, drooping eyebrow, lower lip paralysis, etc. (temporal muscle sling transposition for correction of eyelid paralysis in 59 cases, eyebrow-lift by excision of a strip of skin in 30 cases, Kuhnt-Szymanowski operation or lateral canthoplasty in 11 cases, digastric muscle transposition for correction of paralyzed lower lip in 10 cases, and so on). In secondary correction operations, debulking of excess volume of a transplanted muscle was achieved in 25 cases (29.4%), and shortening of a transplanted muscle was achieved in 13 cases (15.3%). Scar revisions were required in six cases (7.1%), while suspension of a drooping lower lip with a fascia sling was achieved in three cases (3.5%).

SUMMARY

Neurovascular free muscle transplantation using microsurgical neurorrhaphy and vascular anastomoses has resulted in a new breakthrough in the treatment of longstanding facial paralysis. A newly transplanted skeletal muscle (the gracilis muscle usually preferred) can restore sufficient contraction power for reanimation of the paralyzed face. Its movements, however, are commanded by the motor nerve in the recipient bed, which is sutured to the motor nerve of the transplanted muscle. In most cases in which a facial nerve stump is not available in the recipient bed, the method-III operation, combining cross-face nerve graft with free muscle transplantation, obtained the most satisfactory

results (Figs. 6, 7). Frequently, several additional operations and secondary correction operations were required for total and satisfactory reanimation of a paralyzed face.

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