Simultaneous 'Dual System' Rehabilitation in the Treatment of Facial Paralysis

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• Simultaneous dual system rehabilitation of facial paralysis involves using two independent reanimation techniques to optimize facial movement in both a quantitative and qualitative manner. These techniques involve the use of nerve grafting or crossover procedures combined with a dynamic muscle transfer. A group of 37 patients who underwent five different combinations of reanimation was analyzed. The techniques were evaluated using a standard rating scheme for judging success of reanimation procedures. The combination of a masseter muscle transfer to the lower region of the face and a cable graft of the upper facial nerve division appeared to offer excellent results in terms of independent motion of the upper and lower regions of the face and good eye closure, while allowing spontaneous mimetic function in 50% of cases. The advantages and disadvantages of the other techniques are described. The clinical situations in which these techniques have advantage over single reanimation techniques are outlined.

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Rehabilitation of facial paralysis remains one of the most challenging reconstructive tasks facing the head and neck surgeon. Appropriate management requires a thorough understanding of the neurophysiologic mechanisms involved, an appreciation of the various causes of facial palsies and their natural histories, a working knowledge of the available techniques for reconstruction, and an ability to tailor the approach to each patient's unique situation. A wide variety of techniques have been developed over the years in an effort to reduce the devastating impact of this condition on the patient. Techniques may be static (eg, fascial and alloplastic strips), dynamic (eg, muscle transposition), or physiologic (eg, nerve grafting or crossover, or microneurovascular muscle transplantation).[1-6] Additional procedures such as face or brow lifting, tarsorrhaphy, eyelid springs, and lid weights provide the ability to "fine tune" the rehabilitation.

However, each procedure has its own indications and limitations. Not all procedures are suited to every patient or every clinical situation. One must approach each patient individually, appreciating not only the extent of the paralysis, but its cause, clinical course, and prognosis. Often more than one procedure may be required to obtain optimal results. This may require staging of the procedures, although some surgeons may elect to combine various techniques in one operation.

Combining rehabilitative options in a single-stage procedure offers several advantages to the patient when spontaneous recovery of nerve function is not possible. Nerve grafting techniques, although highly successful when properly employed, require from 6 to 12 months before results become apparent. Combining a dynamic muscle transfer, using the masseter or temporalis muscle, with a nerve graft or crossover procedure (Fig 1) provides function and mobility in the early postoperative period. This minimizes the patient's reinnervation of the mimetic musculature. Combining procedures also increases the chances that the patient will have useful function in the event that one system fails.[7]

One additional potential benefit of combining rehabilitative systems involves regionality of motion. When a single reanimation technique is relied on to rehabilitate the entire face, there is a potential for mass motion or synkinesis. Dividing the face into regions, each served individually by a separate reanimation system, has at least the theoretical advantage of separating the cortical control governing the motion of the face, thereby reducing the likelihood of mass motion. Numerous interconnections between cranial nerve systems are known to exist from

Fig 1.—Intraoperative view of masseter transfer (large arrows) combined with a cable graft of the upper facial division (small arrows).

the most peripheral of sites to the most central. This would include the brain stem as well as higher centers.

This article outlines our experience with "dual system" rehabilitation in facial paralysis. By way of definition, *dual simultaneous* rehabilitation refers to the use of two separate neural or muscular mechanisms brought together in a single-stage procedure to reanimate a paralyzed face. These techniques use various combinations of interposition cable grafting, nerve crossover procedures, and masticatory muscle transfers.

PATIENTS AND METHODS

Thirty-seven patients who underwent a total of five different forms of simultaneous combination reanimation were analyzed. The various surgical combinations used are listed in Table 1. A masticatory muscle transfer in conjunction with a nerve grafting or crossover procedure was the most common combination used.

Techniques were employed when spontaneous return of facial function was not likely to occur. The cause of the paralysis is listed in Table 2. Long-standing Bell's palsy, iatrogenic facial nerve sacrifice from tumor surgery, and trauma constituted the majority of cases. In cases of preoperative paralysis, appropriate neurophysiologic testing was performed. In cases where the patient was rehabilitated primarily during radical parotidectomy, such testing obviously was not performed.

Table 1.—Reanimation Combinations

Procedures	No. of Patients in Category
VII cable graft plus masseter transfer	20
XII-VII crossover plus temporalis transfer	8
XII-VII crossover plus masseter transfer	5
VII cable graft plus temporalis transfer	2
VII cable graft plus XII-VII crossover	2
Total	**37**

Table 2.—Cause of Paralysis

Cause	No. of Patients
Radical parotidectomy	25
Surgical trauma	5
Temporal bone trauma	2
Inflammatory	5
Total	**37**

Twenty-five patients (68.6%) underwent immediate or primary rehabilitation following ablative cancer surgery. The remaining 12 patients (32.4%) underwent rehabilitation as a secondary procedure, often several years after the onset of their facial paralysis.

Combination procedures were used in instances where a single technique had failed to achieve adequate reanimation or in situations where surgical and anatomic limitations made the use of a single rehabilitative procedure inadequate or impractical. A common example of the latter was patients who underwent radical parotidectomy with facial nerve sacrifice. Often, obtaining adequate margins involved transecting the facial nerve in such a way that there were many distal branches separated from the main trunk by several centimeters. Cable grafting alone in such a situation can be unreliable. One may find nerve grafts with branches that can be anastomosed with more than one peripheral branch, or one may use several cable grafts that are all sutured into the main trunk proximally. The diameter of the main trunk limits the amount of cable grafts that may be sutured into it. Additionally, one may not always be able to harvest nerve grafts with branches in them. Patients rehabilitated with cable grafting alone under this situation often have either synkinesis or have facial regions that lack adequate mobility postoperatively. This is when dual system reanimation techniques offer advantages.

Table 3.—Rehabilitation Rating System (After May)

Grade	Result	Definition
1	Superb	Some mimetic movement; no mass movement; complete eyelid closure and smile; some asymmetry with maximal effort
2	Excellent	No mimetic movement; otherwise same as grade 1
3	Good	Mass movement present; otherwise same as grade 2
4	Fair	Incomplete eye closure and/or poor mouth movement
5	Poor	Symmetry and tone only, no movement
6	Failure	Flaccid, no tone

Table 4.—Reanimation Results

Procedures	Average Score (n)
VII cable graft plus masseter	1.9 (20)
XII-VII crossover plus temporalis	2.6 (8)
XII-VII crossover plus masseter	1.4 (5)
VII cable graft plus temporalis	2.0 (2)
VII cable graft plus XII-VII crossover	1.0 (2)

Another indication for dual system reanimation exists when a previous reanimation attempt has failed to achieve adequate mobility. Often by this time, years have elapsed. This can lead to muscle degeneration and fibrosis. Neurophysiologic testing may, however, reveal regions in the face where action potentials may still be elicited. Fresh neural input, in the form of a cable graft or a XII-VII cranial nerve crossover, directed into such regions may allow reconstitution of purposeful motion. Areas where the muscles have shown signs of degeneration may be better rehabilitated with a dynamic muscle transfer.

The physiologic basis for dual system reanimation comes from the work of Miehlke and Stennert[8,9] on neural interconnections. The concept of muscle regeneration and neurotization was reviewed by Conley.[10] Dual reanimation techniques are not intended to replace single reanimation techniques in appropriate settings.

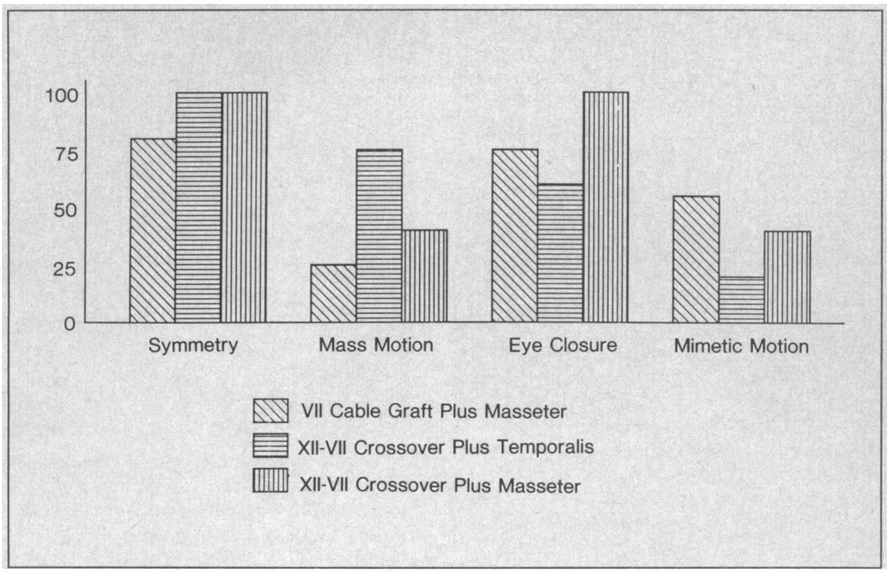

Fig 2.—Comparison of reanimation characteristics.

Fig 3.—A patient with masseter transfer and upper cable grafting shows a spontaneous mimetic smile (without biting). Patient was 5 years postoperative.

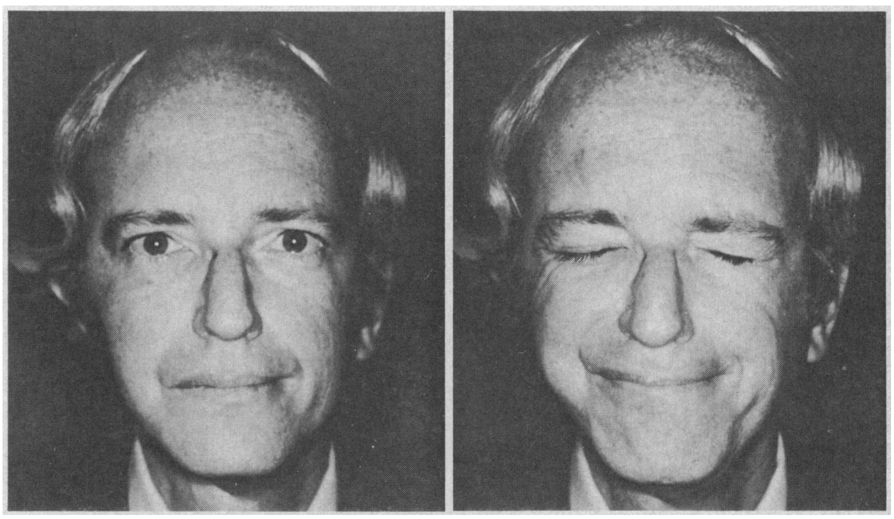

Fig 4.—Excellent result from a hypoglossal-to-facial crossover to the upper division and a masseter transfer to the lower region of the face 8 years previously. The patient stated after biofeedback that he could move his face without concentrating on it. Improvement with biofeedback may be obtained for 2 years or more after operation.

For rehabilitative purposes, the face may be divided into an upper and lower region. A separate type of reanimation was directed into each region. The eye is the most important aspect of the upper region. The eye may be rehabilitated through cable nerve grafting of the distal upper division of the facial nerve or through a hypoglossal crossover directed into the upper division or to the zygomatic branch alone. A tarsorrhaphy may be required during the time it takes for successful reinnervation. If neurotization is not possible because of anatomic or physiologic restraints imposed by the clinical situation, one may choose from a variety of other reanimation techniques including temporalis sling closure procedures, an eyelid spring, or gold weights placed in the upper lid. Ectropion may be corrected by lid-shortening procedures, or by implantation of auricular cartilage in the lower lid for support.

The mouth is the major component of the lower facial region. Symmetry at rest, sphincteric competence, and mimetic participation in facial gesturing are all goals of rehabilitation. These are rarely achieved with static sling procedures and instead require a dynamic form of rehabilitation. Masticatory muscle transfers are ideally suited for this purpose if nerve grafting or crossover are not possible. Results are enhanced through the use of biofeedback techniques.

Standard microsurgical neural anastomoses were used for grafting and crossover procedures. Muscle rotations were accomplished using previously reported techniques.[10]

All patients were followed up for at least 2 years. The results of reanimation were analyzed using a rating scheme adopted from May[11] (Table 3). Each patient was assigned a numerical score corresponding to the level of reanimation achieved.

RESULTS

Results for the most common combinations were tabulated and then averaged (Table 4). A significant difference between techniques was not appreciated using this method. Analysis of specific characteristics of reanimation more clearly demonstrated differences between techniques (Fig 2). The three most common techniques were usually successful in achieving symmetry at rest. Interposition grafting plus masseter transfer showed less mass motion, and reasonable mimetic

Fig 5.—This patient had a hypoglossal-facial crossover with a masseter, but shows mass motion on induced smile 2 years postoperatively.

Fig 6.—This patient demonstrates the sharply demarcated mandibular angle and bulging of the buccal fat pad occasionally associated with rotation of the masseter muscle.

function, while achieving a high percentage of complete eye closure. Hypoglossal-to-facial crossover to the lower region of the face combined with a temporalis transfer to the upper region of the face achieved good symmetry, but was worst in the other categories.

It was generally believed that superior results were obtained when the combination techniques were performed in association with the primary ablative procedure, as opposed to being used secondarily. This was somewhat borne out in analysis of grading of the two situations. When performed primarily, overall assessment of reanimation averaged a grade of 1.88, while delayed procedures averaged 2.2. Although not statistically significant, there was a trend that was in agreement with the clinical impression. This concept was further analyzed with respect to region. The same trend was seen in reanimation results in the upper region, with primary reconstruction averaging 1.84, and delayed techniques yielding an average of 2.27. A statistically significant difference was seen in the results of rehabilitation of the lower region of the face, with primary reconstruction averaging 1.84, and delayed combination reanimation averaging 2.20 ($P = .05$).

Combination reanimation techniques involving muscle transfers were associated with good mobility in the early postoperative period. In fact, in patients who underwent masseter transfer to the lower region of the face, and cable grafting of facial nerve remnants in the upper region of the face, good purposeful mobility was appreciated in the lower region of the face in an average of 2.8 months, while it took an average of 10.3 months to achieve adequate purposeful motion in the periorbital region.

The effect of the cause of the paralysis on the reanimation results was examined. In general, the cause of the paralysis did not impact on the results as much as the length of time that the face was paralyzed. Rehabilitative techniques that were performed in association with the primary ablative procedure were usually superior to those that were delayed. However, good and bad results were not confined to one technique.

Illustrative cases are shown in Figs 3 through 5.

COMMENT

There are several advantages to the use of simultaneous dual reanimation procedures. Mass motion or synkinesis is reduced, since facial regions are individually served by two different systems. Interdigitation of masticatory and mimetic musculature results in collateral budding of axonal elements. Theories of reeducation of central mechanisms may be supported by the fact that many patients are able to spontaneously move individual regions of the face without concentrating on intentional movement (eg, without biting to produce motion in areas served by masticatory muscle transfers). Most of these patients have had some degree of biofeedback.

Dual system reanimation allows the surgeon a measure of flexibility in adapting to a variety of clinical presentations. Early facial mobility is obtained through the use of muscle transfers, with good purposeful motion appreciated in most cases within 3 months.

The use of two simultaneous systems has the additional advantage of increasing the likelihood that the patient will have purposeful facial motion, since each system serves as a backup for the other.

It appears that better results are obtained when these techniques are used as primary rehabilitative procedures rather than when they are relied on to reanimate the face secondarily. This is in keeping with well-documented principles of facial reanimation, since degeneration of the neuromuscular end plate and fibrotic changes in denervated muscle fibers increases when the face remains paralyzed after 1 or 2 years.

The disadvantages of dual system reanimation appear to be few, but merit discussion. Patients who have had a muscle rotation may be bothered by the sharp demarcation in the region of the mandibular angle, by the bulge of the buccal fat pad when a masseter is brought through the area (Fig 6), or by a temporal depression when the temporalis muscle is transferred. A 12th to seventh nerve crossover procedure runs the risk of tongue atrophy and speech disturbance. None of these procedures have been associated with debilitating sequelae, however, and patients are generally pleased with the results. Using two forms of reanimation at the same time theoretically exposes the patient to increased operative risk from bleeding and anesthetic exposure, but this has not been a problem.

The buccal fat pad may be removed at the time of masseter rotation to alleviate some of the distortion caused by rotating the muscle into the perioral region.[12] We are investigating implantation of the excised buccal fat pad into the region of the mandibular angle to camouflage the sharp mandibular outline left after masseter rotation.

In spite of these potential drawbacks, the use of these techniques, particularly the masseter transfer plus cable grafting, appears useful. Better results are achieved when the upper region of the face receives the neural input, either via a cable graft or crossover. The final result is enhanced by a multitude of factors relating to crossinnervation, cortical adaptation, and other mechanisms that remain either unknown or poorly understood. Certainly biofeedback is beneficial in appropriately motivated patients.

It is clear that facial paralysis is a complex disorder that is not remedied by a single approach or technique. Each surgeon will have good and bad results. Flexibility and judicious use of appropriate techniques will insure that the patient receives the maximal benefit from what is known and from what is available.

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