Paparella: Volume IV: Plastic and Reconstructive Surgery and Interrelated Disciplines

Section 1: Plastic and Reconstructive Surgery

Chapter 13: Extratemporal Facial Reanimation

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In our affluent society in which personal appearance plays an important role in everyday life, a patient with a facial paralysis suffers a high degree of functional, emotional, and social handicaps. Before 1895, there was no recorded attempt to "treat" facial palsy by surgical methods. Today, almost every case of facial paralysis can be improved through the use of surgery or a combination of surgical procedures. These advances are directly related to a more accurate assessment of the etiology, the degree of paralysis, the site of the paretic factors, and their effects on the physiologic status of the afflicted nerves and muscles. Ideally, the goals of rehabilitation of the paralyzed face should be to achieve (1) normal appearance at rest; (2) symmetry with voluntary movement; (3) restoration of oral, nasal, and ocular sphincter control; (4) symmetry with involuntary motion and reflex facial expression; and (5) no deficit of other significant functions. At present, there is no simple procedure ideally suited for rehabilitation of the paralyzed face and no surgical technique that can accomplish all these goals. Some procedures are controversial and some are still being evolved and developed. The head and neck surgeon must employ a number of concepts, depending on the cause, the time interval, the wound characteristics, and the availability and necessity of neuromuscular substitution.

Careful preoperative selection of patients based on realistic expectation and limitation of surgical procedure is paramount to a successful operation and a satisfied patient. Among the many techniques available to reanimate the paralyzed face, the more commonly employed include direct facial to facial nerve anastomosis, interpositional cable grafts, nerve crossovers, dynamic and static musculofacial transposition, and facial plastic procedures. Dynamic reconstruction with neural reconstitution is preferable to static methods unless the circumstances of the case preclude their use. No single technique and no single concept can satisfy the needs of the various types of paralysis, and it is not unusual for a multiple or combined surgical approach to be required for optimal results. It is important for both surgeon and patient to recognize that any rehabilitative procedure never restores normality and that the afflicted side will manifest some degree of mass movement, weakness, and dyskinesia.

Etiology

Congenital Paralysis

This condition is extremely rare, is usually recognized at birth or shortly thereafter, and may be complete or partial. The well-recognized entity of the Möbius syndrome probably results from agenesis of some portion of the neuromuscular system. With this condition, facial tone in the position of repose may be quite good but there is rarely any improvement in the movement of the face.

Inflammation

Inflammation, the most common cause of facial paralysis, is usually associated with Bell's palsy. It is postulated that this may be viral in origin, but other theories such as heredity, autoimmune disease, and vascular spasm have not been definitely established. Bell's palsy may present as a partial or complete paralysis, and 85 per cent of patients recover with minimal residual paresis. However, 15 per cent have a significant deficit with manifest weakness, spasm, and dyskinesia.

Trauma

Otologic disease and its associated surgery may produce facial paralysis. Cholesteatoma has decreased in incidence and thus is a less common cause of facial palsy. On the other hand, temporal bone fractures secondary to motor vehicle accidents, industrial accidents, and warfare with resultant stretching, crushing, or total avulsion of the nerve are on the increase.

Neoplasia

The principal cause of facial paralysis from neoplasia is associated with malignant tumors in the parotid gland, ear canal, and middle ear, with a decreasing incidence in tumors adjacent to the facial nerve and those involving the nerve itself, such as a schwannoma. The tumor may directly invade the nerve, as in adenoid cystic adenocarcinoma, or compress it from adjacent tumor expansion. The paresis associated with neoplasia is subtle, segmental, and gradually progressive, in contrast to Bell's palsy, which is sudden in onset.

Site of Lesion

The site of involvement in the facial nerve is important for treatment and prognosis. The level of primary involvement may be immediately apparent from the history and physical examination. When it is obscure, MR imaging, CT scanning, audiolabyrinthine tests, and tests of tearing, taste, salivary production, and stapedial function may be helpful. Generally, the more peripheral the lesions, the more favorable is the prognosis. This phenomenon is explained by the fact that central pathology affects the total nerve trunk, whereas peripheral pathology may be selective; peripheral interconnections may also assist in collateral budding.

Degree of Paralysis

The degree of paralysis often determines the treatment and prognosis. Obviously, partial paresis indicates that a portion of the facial nerve system is intact and functioning. The integrity of this portion of the nerve may assist in the regeneration of the weakened segments. This is particularly true in the midportion of the face where there are many neural interconnections. Complete paralysis may represent either axonal block in an intact nerve or disruption of the nerve. In the first instance, there is hope for some type of return of movement; in the latter instance, return of movement is unlikely and can come only from aberrant nerve pathways or axonal regrowth from adjacent muscles. The degree of paralysis is directly proportional to the degree and nature of axonal interference and the capacity for spontaneous recovery.

Time Interval Before Rehabilitation

There is a relative correlation between the time elapsed since the initiation of the paralysis and the possibility of "spontaneous" return of movement or the attainment of rehabilitation by surgical intervention. Any paralysis that can be rehabilitated immediately offers the best chance of success. In paralyses that have existed for up to 2 years, nerve nuclei, axons, and muscular elements are lost, but there is always a sufficient residuum of these elements to effect some return of movement with a corrective procedure. Although the face maintains its muscular structural composition longer than other regions of the body, there an attritional loss of mimetic muscle after 2 years. The end stage of this process is severe muscle fibrosis that is irreversible and requires some type of muscle substitution in the rehabilitation program.

Physiologic Status of Facial Nerve and Mimetic Muscles

The basic physiologic status of the facial nerve and the mimetic muscles dictates the rehabilitative concepts and the prognosis. The facial nerve undergoes wallerian degeneration in the peripheral segment in all instances of lysis of the nerve. When this is immediately treated by nerve grafting or nerve crossover, there is a partial regrowth of the nerve elements. If grafting is delayed for over 2 years, there is a progressive atrophy of the nerve and mimetic muscles. A unique feature of this degenerating nerve is the persistence of a small number of residual neurilemmal and axonal structures even 30 to 40 years after the primary insult. It is obvious that not all the axons are obliterated in the nerves of the face and that this depleted residual neural network facilitates the potential for nerve rehabilitation. There is a prolonged and unexpected facility for this subliminal system to regenerate if fresh axons are introduced into it.

Muscle atrophy is a much more severe problem to deal with. Islands of certain muscles persist and respond to electric stimulation in most cases of facial paralysis. These muscles may be near the midline of the face, or may be innervated from the contralateral side by axonal ingrowth from masticatory muscles or collateral budding through multiple nerve connections in the face. This obviously facilitates rehabilitation, because the atrophic process extends over a period of decades before end-stage muscle fibrosis is established. When this occurs, however, muscle substitution is necessary for rehabilitation.

Availability of Tissue for Repair

The most favorable situation for rehabilitation is an intact anatomy, since this permits the use of regional tissues in repair. In most of these patients there are sufficient intact nerves and muscles to carry out a rehabilitative technique. In many patients, however, there is radical ablation with large deficiencies in nerve and muscle tissue. Some problems are associated with severe trauma and heavy scarring. These circumstances may obviate the possibility of using regional tissue for nerve and muscle repair, and require that substitutes be procured from distant sites and transplanted in the wound under optimal conditions for survival and function. In these patients, free muscle transplantation with microneurovascular anastomosis using various distant muscles, including the gracilis, pectoralis minor, serratus anterior, extensor digitorum brevis, and others, is the technique of choice in this modern era.

Facial Rehabilitation

Direct Nerve Repair and Grafting

When the facial nerve is lysed or resected, the most effective method of rehabilitating the paralyzed face is by direct nerve repair or autogenous nerve grafting. This method requires an available proximal and distal segment of the residual facial nerve, and that mimetic muscles are functioning adequately. Ideally, the neural pathway should be reestablished immediately. If delay in repair is necessary, an interval of up to 1 year usually poses no additional problem, and good results have obtained after a delay of as long as 2 to 3 years. Direct repair is preferred if reapproximation without tension is possible. When there is a significant loss of the main trunk of the facial nerve, eg, after ablative cancer surgery, an interpositional cable graft becomes necessary. The graft should lie in a healthy, well-vascularized area that is free of scar tissue, and because of slight shrinkage it should be 20 per cent longer than the defect to avoid undue tension.

The most commonly used grafts are of cervical plexus at the C3 and C4 levels either from the ipsilateral or the contralateral side. These provide the greatest convenience and adaptability. Usually a 9- to 12-cm graft can be obtained from the main trunk with four or five branches of good physical match to accommodate the corresponding nerve branches in the face. Alternatively, sural or lateral femoral cutaneous nerves may be used. The main trunk is approximated with three or four nontraumatic No. 10-0 monofilament sutures in the epineurium, and the fine peripheral segments with one suture through the shaft of the nerve. The use of an operating microscope is mandatory to facilitate accurate approximation of the nerve ends. Although sutureless methods employing micropore adhesive or different glues have been popularized in Europe, their use in North America is still viewed by many surgeons with skepticism, mainly because of previously reported evidence of foreign body reaction, increased fibrosis, and slightly inferior results in comparison with suture techniques.

Factors influencing the success of repair include the time interval from primary injury, tension at the site of anastomosis, the character of the wound, the presence of scar tissue, the length of the graft, and the patient's general condition including age, nutritional status, and any metabolic derangement, eg, diabetes mellitus. The effects of postoperative radiation therapy on facial nerve graft function have been a subject of great controversy among head and neck surgeons. Gullane and Havas (1987) demonstrated good dynamic and mimetic function after primary cable grafting despite irradiation, and recommended a delay of 6 weeks before initiation of radiation with a maximal dose of 5000 rad in 4 weeks. Some return of function can be expected in up to 95 per cent of properly selected patient groups; this may take 6 to 24 months depending on the length of nerve graft. If the repair is successful, one may expect initial improvement in facial tone, followed by gradual return of facial movement, although there is always associated mass motion, weakness, dyskinesia, and deficit in emotional expression.

Nerve Crossover

Nerve crossover is one of the most effective methods of reestablishing kinetic activity to the paralyzed face when the proximal end of facial nerve is not available but the peripheral neuromuscular system remains intact. The hypoglossal, spinal accessory, glossopharyngeal, and phrenic nerves have been used for this purpose. This procedure is simple, involving only a single suture line, and the motor nerve selected provides a powerful source of reinnervation. However, there are always associated and uncoordinated movements, and loss of function of the donor nerve.

The spinal accessory is a good match for anastomosis with the facial nerve, but has the disadvantages of shoulder drop, lack of dynamic movement in the face, and little facial activity except upon intention or command. The face is static when eating, talking, and swallowing. On occasion, both the 11th and 12th nerves have to be sacrificed after tumor ablation and the phrenic nerve may then be used for rehabilitation. This nerve is also a good match for the facial nerve but has many disadvantages, including resting facial twitches and diaphragmatic palsy.

The hypoglossal nerve, on the other hand, is a powerful nerve and causes movement of the face upon chewing, talking, and swallowing. It is these movements that are effective in producing movement of the face. The technique consists of crossing the proximal portion of the hypoglossal nerve to the distal segment of the facial nerve and an anastomosis, using three or four 10-0 monofilament sutures. Facial movement is usually apparent within 4 to 6 months; it is mass movement and associated with all the natural physiologic movements of the tongue. Facial tone is usually excellent with normal appearance at rest and good protection of the eye. The tongue is rarely a source of problems; as cited by Conley and Baker in their series of 135 patients with hypoglossal-facial crossovers, only 3 per cent persistently complained about chewing, 2 per cent about swallowing, and 2 per cent about speech. Overall, the deficit in the tongue has not been a major source of complaint. This procedure is simple and, with few failures, complications are rare and most results are good to excellent.

Crossface Nerve Grafting

Scaramella (1970), as cited by Conley and Baker, introduced the crossface sural nerve graft as an alternative to ipsilateral nerve repair when the proximal facial nerve segment is not available. This technique has been further developed by Fisch, Samii, and others. The paralyzed side is crossinnervated from the healthy side by means of sural nerve grafts that connect the distal segments of the paralyzed side to the corresponding reservoir of peripheral healthy facial nerve branches. The technique uses 25 to 30 cm of sural nerve graft sutured to the proximal end of the normal facial nerve, then tunneled across the face and approximated to the peripheral segment of the facial nerve on the paralyzed side.

The concept of this technique is ingenious and theoretically superior because reanimation is effected by means of specific facial nerve branch reinnervation. However, it has many disadvantages as cited by Conley and Baker:

1. The sural nerve has to be procured from the leg.

2. There is surgical intrusion of the normal as well as the paralyzed side of the face.

3. A longer interval is required for the return of function, and thus further muscle atrophy.

4. The procedure is still fraught with synkinesis and mass movement.

5. Prolonged surgical time is required.

The greatest disadvantage of this technique, as cited by Samii, is that only 50 per cent of all nerve fibers of the healthy facial nerve can be used, and these are joined to about 50 per cent on the paralyzed side, thereby limiting the amount of axonal input.

This technique is a current alternative to hypoglossal and accessory nerve crossover and muscle interdigitation. If direct repair or cable grafting of facial nerve is possible, there is no indication for this technique. Some potential applications of this procedure include combining it with masseter and temporalis muscle transposition or free muscle graft.

Regional Muscle Transfer

In long-standing facial nerve palsy, the use of regional muscle is indispensable when the mimetic muscles are atrophic and beyond the possibility of rehabilitation. Regional muscles are also valuable in cases of congenital paresis or regional weakness and atrophy in the presence of a partially intact facial nerve with moderate capability.

The basis of regional muscle transposition is to bring in new muscle innervated by a different cranial nerve that can furnish pull in various directions and thus accomplish more normal facial animation. These living muscle fibers bring with them axons that may grow into and support deficient areas in the mimetic muscle system. If islands of mimetic muscle have survived the paralysis, the introduction of a new dynamic muscle system may be helpful, with the possibility of myoneurotization. This technique is simple to perform. The transposed muscles provide a large volume of dynamic and living tissue that augments atrophic areas. There is no loss of other significant function and no interference with facial nerve function, thereby allowing the potential for future spontaneous regeneration of function.

The most popular muscles are the temporalis and masseter. The temporalis muscle can be adapted to the orbit, cheek, and oral regions. The masseter muscle is restricted to use in the oral and cheek regions. Since both temporalis and masseter muscles are controlled by the trigeminal nerve, the resultant facial movement is not physiologic or natural and often requires training. One method to correct this is to employ facial nerve graft with nerve implantation into the transposed muscle; if the proximal segment of facial nerve is not available, a crossface nerve graft can be used.

Free Muscle Grafts

Thompson (1974) described this relatively new concept of using tendon of the palmaris longus muscle. He attached the tendon to the zygomatic arch of the paralyzed side and sutured the muscle belly to the oral commissure, allowing it to interact with the raw surface of the orbicularis muscle of the mouth. Reinnervation of the graft is said to occur from the orbicularis muscle fibers of the nonparalyzed side. Hakelius (1979) reported transplanting the extensor digitorum brevis muscle of the second toe to the paralyzed eyelid. The muscle graft is placed through a bony tunnel in the nasal pyramid so that a portion of the muscle contacts the normal contralateral orbicularis muscle. Both authors reported high success rates and satisfactory results, stating that return of movement is controlled by the normal side of the face. However, most of the transplanted muscle undergoes degeneration and collagen replacement because of limited vascularization with subsequent loss of support and lift. Harii (1979) modified this method using the gracilis muscle with immediate revascularization via microvascular anastomosis. With this improvement, complete survival of the transplant muscle is possible. Subsequent workers including O'Brien and colleagues (1980), Harrison (1984), and Manktelow (1984) further improved this technique with immediate microneurovascular anastomosis. Other muscles that have been used successfully include the pectoralis minor, latissimus dorsi, and serratus anterior. The resultant function of the transplanted muscle, and hence the return of facial function, depend on the amount of muscle transplanted, the adequacy of reinnervation, and the position and tension in which the muscle is inserted into the face. Harrison reported a series of ten patients in whom satisfactory facial movement was achieved in eight by means of a two-stage procedure. A crossfacial nerve graft was performed in the first stage. After confirmation of the success of neurotization in about 6 months, microneurovascular pectoralis minor muscle transplantation was performed in the second stage. In this manner, muscle atrophy secondary to delay for neurotization is eliminated and postoperative results are more reliable. Employing a similar technique, Manktelow (1984) was successful in transplanting the gracilis muscle with excellent results. Although this technique has not yet achieved unanimous support from reconstructive surgeons, it holds tremendous potential for future development.

Muscle Interdigitation

This technique is valuable after extensive ablative surgery about the face and cheek when nerve grafting and nerve crossover are impractical. The masseter muscle is ideal for this maneuver in that its proximity permits it to be spliced directly into the cut mimetic muscles, thus permitting axons to grow directly into the denervated muscle. This produces immediate support and movement within 3 months. The same concept may be used in ablations, including that of the ascending ramus of the mandible, by transposing the internal pterygoid muscles. The temporalis muscle may also be interdigitated into the face and about the orbit by an overlapping technique, or may be connected into the face with its inverted temporal fascia. Although the movement obtained by these techniques is impressive, there is usually some sag about the oral commissure that may require elevation by fascial stripping at a later date.

Nerve Implantation

This technique has limited application in rehabilitation of the paralyzed face because of the availability and adequacy of other procedures. There is, however, the occasional problem of identification of degenerated peripheral nerve segments several years after an ablative operation has healed. The search for the peripheral branches may reveal scarred atrophic remnants of the degenerated nerves or no peripheral branches at all. The central stump may be readily identified in the fallopian canal. A nerve graft with implantation at the presumed site of the peripheral branches or directly into the surviving muscles may restore some movement in the face. In this uncontrolled operation there is risk of failure or only minimal return of movement, yet if a transposed muscle is prepared by denervation, some of the invading axons will make connections with the muscle group. The technique is single staged and uncomplicated and may be complemented subsequently if unsuccessful.

Facial Stripping

This technique is reserved for support of a sagging face when other dynamic methods of reanimation are impossible. It may be effective as a complementary method in regional areas of weakness about the oral commissure, lips, cheeks, and orbit. Balance and symmetry in response achieved by this method of lifting may permit any residual minimal neuromuscular function to become more effective.

Myotomy, Neurectomy, and Local Excision

These local regional techniques are used to gain symmetry and balance in repose. Their purpose is to weaken the normal side regionally or to tighten and support the paralyzed side; their effects are subtle, minimal, and unrelated to the rehabilitation of the neuromuscular system except as an ancillary procedure. These local balancing techniques may ameliorate some of the conspicuous deficits that may remain after maximal effect has been obtained from other dynamic rehabilitative procedures.

"Spontaneous Return"

"Spontaneous return" without nerve grafting usually is the result of direct axonal ingrowth from a cut masticatory muscle into the cut mimetic muscles. It therefore is most commonly found in radical ablations near the parotid gland and mandible. This principle of axonal ingrowth is now used routinely with the intention of interdigitating these muscles when nerve grafting is not carried out. There may be axonal regrowth from the opposite side of the face, but this is limited to the central bilateral muscles around the lips and root of the nose. It is not known why this process of neurotization from the opposite side is not more extensive. Aberrant nerve pathways (of the great superficial petrosal and trigeminal nerves) have contributed to this phenomenon. The possibility of "spontaneous return" should never be considered as a hopeful substitute for a planned and specific method of facial rehabilitation.