



Cross-facial nerve grafting

Ryan M. Collar, MD, Patrick J. Byrne, MD, Kofi D. Boahene, MD

From the Department of Otolaryngology, Head and Neck Surgery, Division of Facial Plastic and Reconstructive Surgery, Johns Hopkins School of Medicine, Baltimore, Maryland.

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Cross facial nerve grafting may be utilized in the treatment algorithm of both reversible paralysis, wherein axonal input to existing mimetic muscles will elicit movement, or in irreversible paralysis, wherein cross facial axons are used to motor a free muscle transfer. This article reviews the indications, operative technique, post-operative care, and potential complications of this technique.

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Facial paralysis is a devastating diagnosis. It carries with it a myriad of functional, psychological, and social challenges for those afflicted. For most patients, the greatest of these is the inability to smile, and the attendant isolating struggles with communicating and expressing emotion.

As elucidated in this series, many approaches to managing facial paralysis exist. Symmetric and spontaneous facial reanimation remains an elusive surgical goal; however, the advent of microsurgery has led to a more sophisticated armamentarium for paralysis treatment. Among these approaches is the cross-facial nerve graft (CFNG), the operative technique which will be described in detail herein. Successful CFNG allows for coordinated and volitional mimetic movement through rerouting facial nerve axons from the unaffected side to the paralyzed side through a donor nerve conduit.

Indications

Within the authors' practice, CFNG is used primarily as the first stage before free muscle transfer, or in conjunction with hypoglossal transfer.¹

CFNG plus free muscle transfer is indicated for patients with complete irreversible paralysis whose electromyography (EMG) demonstrates silent motor end plates not amenable to reinnervation.² The advantages and disadvantages of this sur-

gical approach are often deliberated against those of the temporalis tendon transfer for this patient population.^{3,4}

CFNG with hypoglossal transfer is used for patients with complete reversible paralysis, whose motor end plates are likely to respond to new axonal ingrowth.⁷ In the author's practice, CFNG for complete reversible paralysis is most commonly used for patients with an unfavorable outcome following Bell palsy, or those status-post resection of cerebellopontine angle tumors where the nerve is believed to be intact. The timing of nerve transfer procedures is controversial for this population because of competing interests: allowing sufficient time for all possible facial nerve recovery, and surgically delivering axons to paralyzed muscles before end plate atrophy, ie, the paralysis becomes irreversible. Key factors predictive of recovery include the time between insult and initial recovery, and the rate of recovery thereafter.^{5,6} Our institution may offer CFNG plus hypoglossal transfer to these patients 6 months after facial nerve injury if they remain House Brackman VI, and EMG shows no volitional potentials. In this situation, the CFNG is placed in conjunction with hypoglossal transfer wherein the facial nerve is anastomosed end-to-side with the hypoglossal nerve (with intentional hypoglossal axonal injury). The hypoglossal transfer provides axonal input to the denervated motor end plates, and confers excellent facial tone at rest. In many patients, hypoglossal-facial crossover also yields some level of commissural excursion that is activated by tongue movement. In a second procedure, the CFNG is used to "supercharge" those branches of the facial nerve responsible for excursion, allowing for spontaneous volitional smile.⁷

Address reprint requests and correspondence: Ryan M. Collar, MD, Johns Hopkins School of Medicine, 601 North Caroline Street, 6th Floor, Baltimore, MD 21287.

E-mail address: ryanmcollar@gmail.com.

Technique

Nerve selection and harvest

Because of its ease of access, modest secondary morbidity, and favorable length (25-35 cm), the most commonly used donor nerve is the sural nerve. Other options include the medial or lateral antebrachial cutaneous nerves. The medial antebrachial cutaneous nerve typically has much more branching than the sural nerve, making it ideal for immediate reconstruction of the main facial nerve trunk and pes anserinus after their excision for oncological reasons. However, it is shorter and thinner than the sural nerve making it less optimal for CFNG.

The sural nerve courses with the short saphenous vein along the posterolateral aspect of the leg superficial to the deep fascia. Anticipated morbidity is predicted by its sensory innervation to the lateral posterior third of the leg, and the lateral posterior aspect of the foot and heel.

Several harvest techniques may be used. These include an extended linear incision, stair step incisions, or endoscopic approaches.⁸ The author finds the stair step incision to be most favorable: it is efficient, accounts for anatomic variability of the nerve, and creates only modest scar morbidity (Figure 1).

The patient is positioned supine with the knee bent at 45 degrees and the hip medially rotated. A measurement is made from tragus to tragus along the upper lip to estimate the required donor nerve length. A vertical 2-cm incision is designed 2 cm posterior and superior to the lateral malleolus. Blunt dissection allows easy identification of the nerve that lies just anterior to the saphenous vein. Further dissection proceeds posterosuperiorly along the nerve's course. A nerve stripper and long malleables are useful in dissecting. A second incision precisely along the course of the nerve is then made several centimeters proximally. The nerve is identified and dissection ensues again proximally along the nerve's course. To achieve 25-35 cm of length, 3 to 4 incisions are generally required (Figure 2). Once the required length is obtained, the nerve is delivered through one of the stair step incisions, and the inferior nerve end is marked for orientation.

Identification of donor facial nerve

The critical component of the surgery is the selection of the donor facial nerve on the nonparalyzed side. The key is to select the facial nerve branch that will (a) accurately simulate natural smile excursion alone, (b) will supply a sufficient axonal load to the paralyzed face, and (c) will do so without deforming the intact side of the face.

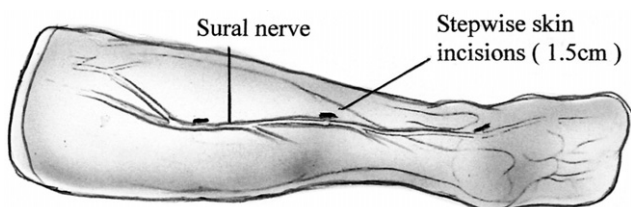


Figure 1 Illustration of sural nerve harvest using stair-step incision technique.

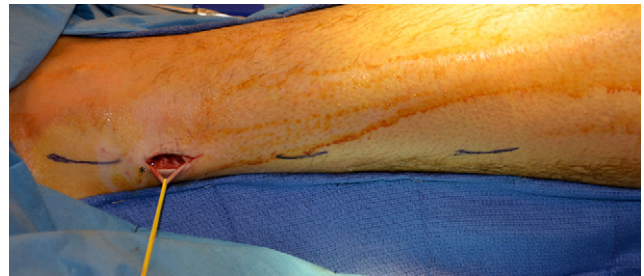


Figure 2 Sural nerve harvest, intraoperative photograph. Left leg with anticipated stair step incisions marked, and sural nerve isolated distally as tagged with a vessel loop (*). (Color version of figure is available online.)

Before surgery, the vector of natural smile excursion on the intact side is indicated on the paralyzed side with a surgical marker. Long acting paralytics are avoided, as intraoperative facial nerve stimulation is essential. A retrotragal facelift incision is designed on the intact nonparalyzed side. Similar to a facelift, a subcutaneous flap is elevated to the anterior aspect of the parotid gland. A sub-superficial muscular aponeurotic system (SMAS) elevation is then meticulously performed with blunt scissors. The zygomatic nerves of interest are generally at the midpoint of a line between the tragus and the oral commissure or 2 cm below the zygoma.⁹ At this location anterior to the parotid gland, the facial nerve has arborized into 8-12 total branches that lie superficial to the masseter muscle and just deep to the SMAS.¹⁰ Using the EMG probe, nerves in this vicinity are stimulated to ascertain their target innervation.

The ideal nerve activates the zygomatic muscle complex, thus elevating the commissure and defining the nasolabial crease, while preserving 2 additional branches that also innervate the zygomatic muscle complex. The number of axons present in the donor facial nerve has been demonstrated to ultimately predict the outcome on the paralyzed side, with greater than 900 axons being a favorable count.¹¹ This requires a robust nerve proximal to the smallest terminal branches, considering that the entire facial nerve contains approximately 7000 axons.¹² Once carefully selected, the nerve is traced anteriorly approximately 2 cm, and tagged with a vessel loop (Figure 3) for eventual neuroorrhaphy.

Next, a subcutaneous tunnel is extended from the selected buccal branch on the intact side to the pretragal region on the contralateral paralyzed face. A short retrotragal incision is made on the paralyzed side. The tunnel is generally created with facelift or Metzenbaum scissors. A short intraoral horizontal labial mucosal incision near the gingivolabial sulcus may be used to help completely connect the 2 sides.

Neuroorrhaphy

The sural nerve is then transferred into the face (Figure 4). The inferior marked end is to be coapted to the donor facial nerve on the nonparalyzed side. A long suture secured to one end of the sural nerve is used to guide it through the subcutaneous tunnel from tragus to tragus. On the paralyzed side, the nerve is tagged with large colored permanent



Figure 3 Identification of donor facial nerve branch, intraoperative photograph. Superior is to right, and anterior is to the top of the image. View is beneath the sub-SMAS flap via the retrotragal facelift incision. The zygomatic branch to be microcoapted to the sural graft (*) is marked with a vessel loop. A second branch is also in view which provided commissural excursion (small arrow); it was left undisturbed. (Color version of figure is available online.)

suture and/or a tympanostomy tube for identification at the second stage.

On the nonparalyzed side, the end-to-end coaptation of the sural nerve to the donor sural nerve is performed with the operative microscope. After transection, the donor facial nerve is reflected posteriorly. A biopsy of the donor facial nerve is obtained for axonal count, and 2-3 epineurial 9-0 nylon sutures are used to complete the neuroorrhaphy. The coapted nerve is wrapped in a dura regeneration matrix (Durepair, Medtronic, Minneapolis, MN) and secured with a fibrin sealant (Duraseal, Covidien, Mansfield, MA). This thwarts loss of axons into surrounding tissues, and prevents direct neurotization of nearby muscles, such as the adjacent masseter muscle.

Second stage

After 6-12 months, axonal regeneration will have occurred across the sural nerve graft. Progress is assessed with the Tinel sign during serial office evaluations.

During the second surgery, intraoperative facial nerve EMG is again required. A retrotragal facelift incision is made on the paralyzed side, and the sural nerve with active cross-facial axons is identified in the pretragal subcutaneous region, as previously marked with a suture or tympanostomy tube. A biopsy is taken for axonal count.

At this point, in the case of irreversible complete paralysis, free muscle transfer is indicated wherein the motor nerve to the muscle graft is coapted end-to-end to the active CFNG. The details of this procedure are discussed in a separate article in this issue.

For those patients undergoing CFNG alone or in combination with hypoglossal transfer, the active CFNG will be anastomosed to an ipsilateral facial nerve branch. A subcutaneous flap is developed to the anterior aspect of the parotid on the paralyzed side. The SMAS is elevated bluntly, and the ipsilateral zygomatic branches are isolated as discussed earlier in the

text. The zygomatic branch that confers robust isolated excursion with definition of the nasolabial crease akin to a natural smile is selected.

In patients with reversible paralysis status after hypoglossal transfer at the first stage, stimulation of facial nerve branches with EMG probe should incite mimetic movement. Using nerve stimulation to identify the optimal buccal branch without previous hypoglossal transfer is more difficult because the facial nerve will contain few if any functioning axons, and, hence, will not stimulate muscle contraction. In this scenario, a large branch traced to the zygomatic musculature is selected.

Microneural anastomosis is then performed between the CFNG and the selected zygomatic facial nerve branch on the paralyzed side in either an end-to-end or end-to-side manner (Figure 5). The latter technique may be desired if the patient has developed excellent excursion with tongue movement after hypoglossal transfer, or if there is a dominant zygomatic branch that if fully severed may downgrade the level of tone. This stated, a recent review of this literature¹³ concluded that the degree of motor nerve sprouting after end-to-side grafting depends on the degree of motor nerve injury (after intentional partial axotomy in the donor nerve). In view of this, the decision for neuroorrhaphy technique is case-specific and requires careful perioperative consideration.

Some authors, notably Terzis,⁷ have performed up to 4 simultaneous CFNGs, usually with hypoglossal-facial jump grafting, to provide tone and volitional reanimation to the frontalis, orbicularis oculi, and/or lip depressors in addition to the midface lip elevators. The basic technique is identical to that described earlier in the text, except that nerve stimulation and CFNGs are used to identify and connect branches on the intact and paralyzed sides that provide brow elevation, eye closure, and lip depression. Also, multiple cross-facial tunnels are required, often with 1-2 CFNGs passing through both the upper and lower lips. Using >3 CFNGs may require harvesting sural nerve from both legs to obtain adequate grafting material.

Postoperative care

Managing patient expectations is critical in the immediate postoperative period. The time between initial surgery and the development of volitional smile is typically 18-24 months. A



Figure 4 Anticipated subcutaneous course of the sural nerve graft (*). (Color version of figure is available online.)

Figure 5 Illustration of cross-facial nerve graft from a buccal branch of the patient's non-paralyzed left side coapted in an end-to-end fashion to a buccal branch on the patient's paralyzed right side.

key factor in rehabilitation is dedicated regular work with an occupational or physical therapist experienced in facial paralysis.⁴

Complications

We have not experienced significant complications related to this surgical approach. Theoretic issues include injury to a main nerve trunk on the intact side, selection of a branch that worsens mimetic function on the intact side during the first stage, and failure to achieve meaningful improvement in commissural excursion if too few axons are transferred to the paralyzed side.

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