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Cross-Face Nerve Grafting with Infraorbital Nerve Pathway Protection: Anatomic and Histomorphometric Feasibility Study

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Smiling is an important aspect of emotional expression and social interaction, leaving facial palsy patients with impaired social functioning and decreased overall quality of life. Although there are several techniques available for facial reanimation, staged facial reanimation using donor nerve branches from the contralateral, functioning facial nerve connected to a cross-face nerve graft (CFNG) is the only technique that can reliably reproduce an emotionally spontaneous smile. Although CFNGs provide spontaneity, they typically produce less smile excursion than when the subsequent free functioning muscle flap is innervated with the motor nerve to the masseter muscle. This may be explained in part by the larger number of donor motor axons when using the masseter nerve, as studies have shown that only 20% to 50% of facial nerve donor axons successfully cross the nerve graft to innervate their targets. As demonstrated in our animal studies, increasing the number of donor axons that grow into and traverse the CFNG to innervate the free muscle transfer increases muscle movement, and this phenomenon may provide patients with the benefit of improved smile excursion. We have previously shown in animal studies that sensory nerves, when coapted to a nerve graft, improve axonal growth through the nerve graft and improve muscle excursion. Here, we describe the feasibility of and our experience in translating these results clinically by coapting the distal portion of the CFNG to branches of the infraorbital nerve. *(Plast Reconstr Surg Glob Open 2016;4:e1037; doi: 10.1097/GOX.0000000000001037; Published online 23 September 2016.)*

Patients with unilateral facial palsy have difficulties eating and speaking and have diminished social functioning, with decreased overall quality of life.[1–3] Staged facial reanimation with cross-face nerve grafts (CFNGs) using the sural nerve and contralateral facial nerve as donors is a well-established surgical treatment for severe facial palsy.[4–8] The 2-staged procedure uses CFNGs placed in the first stage to guide donor axons from a branch of the contralateral facial nerve through the sural nerve graft to innervate and animate the free functioning muscle transfer placed in the second stage. Although several techniques exist for facial reanimation, CFNGs represent the only facial reanimation technique that can produce an emotionally spontaneous smile.[9]

Other nerves have been used, such as use of the motor nerve to the masseter muscle, to reinnervate free muscle flaps, and the motor nerve to masseter muscle produces greater smile excursion than CFNGs.[10] This may be because the masseter nerve provides a greater number of donor axons, and only 20% to 50% of donor axons from the contralateral facial nerve successfully cross the CFNG to innervate target tissue.[10–12] The greatest unsolved problem in facial reanimation presently is retaining true emotional spontaneity while improving muscle power. The challenge of improving axonal growth across CFNGs must be overcome to improve power.

It can take several months for axons to regenerate through the CFNG, which can be up to 15 cm long.[13] Pro-

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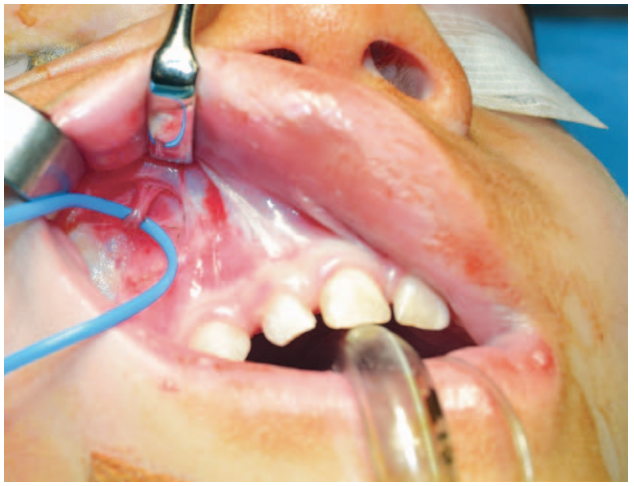


Fig. 1. A small branch of the infraorbital nerve (shown with a nerve loop) can be identified through the same superior buccal incision used for the sural nerve graft.

longed loss of contact between neurons and Schwann cells in the distal nerve graft during this time causes Schwann cell atrophy and loss of neurotrophic support, limiting axon regrowth through the graft.[14,15] This loss of contact may be ameliorated by "protecting" the distal stump with additional donor axons, allowing Schwann cells to migrate into the distal nerve stump and provide endogenous trophic support,[14,16–20] maintaining a growth-permissive state and preventing the deleterious effects of chronic denervation.[16,21,22]

Sensory nerves have been used previously to enhance recovery by preventing atrophy of denervated muscle while axons regrow from the site of nerve repair.[23,24] Providing regenerating axons with a distal target by coapting the CFNG distally to either the hypoglossal nerve or facial nerve stumps has also demonstrated increased axon regeneration through CFNGs.[25,26] In our laboratory studies, we demonstrated that donor sensory nerves coapted to the distal end of CFNGs can also markedly increase axonal regrowth across CFNGs and improve outcomes in a rat model.[27] In 5 patients to date, we have coapted branches of the infraorbital nerve to the distal CFNG during the first stage of the procedure to promote axon regeneration across the CFNG. These patients are presently awaiting the second stage of the operation. Here, we describe the anatomic feasibility of the procedure and describe the morbidity associated with the use of the branches of the infraorbital nerve.

SURGICAL PROCEDURE

The zygomaticobuccal branches of the facial nerve on the functioning side are exposed through a preauricular incision, and the branch to the zygomaticus major is identified using electrical stimulation.[6–8] A superior buccal incision is made above the contralateral canine root to tunnel the cross-face sural nerve graft to the contralateral side of the face. The infraorbital nerve branches are then exposed on the paralyzed side through the superior buccal incision using cephalad dissection. This maneuver provides visualization of the infraorbital nerve branches distally, which may then be traced proximally to identify the nerve at the infraorbital foramen as needed (Fig. 1). The protection phenomenon does not require large numbers of donor axons[28]; therefore, we use a small branch of the infraorbital nerve as a donor.

The graft is first tunneled along the superior buccal sulcus to the contralateral side of the face. Once the graft is in an appropriate position, it is sutured to the donor infraorbital nerve branch in an end-to-end fashion using the operating microscope and 10-0 nylon sutures. In 1 method (Fig. 2), a terminal branch of the infraorbital nerve can be transected and coapted end to end to the distal segment of the sural nerve graft using 10-0 nylon sutures. This method is our current preferred technique. An alternate method would involve coapting the side of the donor infraorbital nerve to the end of the donor sural nerve graft, but this maneuver requires more extensive dissection. Free muscle transfer is performed 9 to 12 months later.

RESULTS

Our modification of the CFNG technique for unilateral facial paralysis intends to translate the results of our laboratory investigations and use them to inform our clinical practice.[14,23,27] Exposure of the infraorbital nerve is easily achieved adding minimal morbidity and complexity to the procedure. All the 5 patients to date had congenital facial nerve palsy and normal infraorbital sensation preoperatively. No patient has demonstrated subjective or objective sensory dysfunction in the donor infraorbital nerve distribution postoperatively with facial sensory testing using the Weinstein enhanced sensory test D monofilaments (Fig. 3).

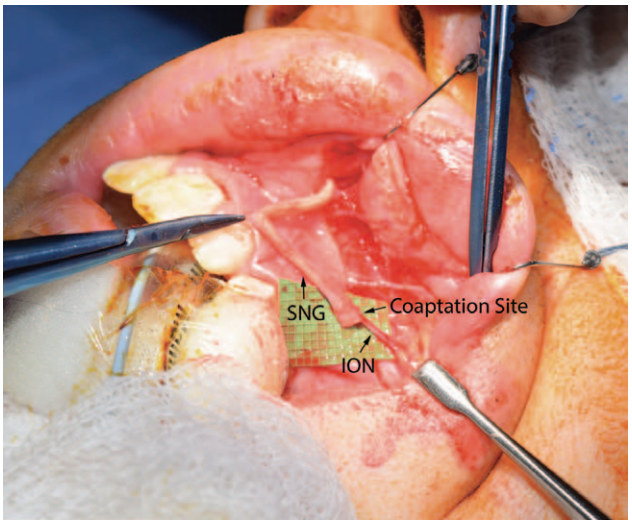
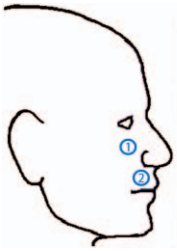


Fig. 2. The sural nerve graft (SNG) has been tunneled across the face, and a distal branch of the infraorbital nerve (ION) has been coapted to the distal end of the SNG using 10-0 nylon sutures.



		Donor Infraorbital Region		Contralateral (Normal) Region	
	Age	Site 1	Site 2	Site 1	Site 2
Pt. 1	16	0.025	0.025	0.025	0.025
Pt. 2	16	0.025	0.025	0.025	0.025
Pt. 3	7	0.07	0.07	0.07	0.07
Pt. 4	9	0.025	0.025	0.025	0.025
Pt. 5	17	0.025	0.025	0.025	0.025

Fig. 3. Weinstein enhanced sensory test—D monofilaments, which contain a set of 5 Semmes Weinstein monofilaments designed to evaluate tactile sensitivity in the face, were used to assess sensitivity in 2 locations innervated by the infraorbital nerve. Using a distal branch of the infraorbital nerve for sensory protection resulted in no detectable loss of sensation in the tested distribution of the infraorbital nerve in comparison with the contralateral face.

DISCUSSION

In our series, we have either coapted the sural nerve graft to the side of the infraorbital nerve or transected a distal branch of the infraorbital nerve and coapted the transected end to the distal end of the graft. Using histomorphometric analysis, we have documented that the donor branches of the infraorbital nerve we have used contained 975 myelinated fibers (Fig. 4), which we expect to provide a sufficient number of donor axons to protect the sural nerve graft. Although coapting the sural nerve graft into the side of the infraorbital nerve root does not permit harvesting nerve samples for histomorphometry, end-to-side and side-to-side nerve repairs are known to result in robust regeneration of axons and migration of Schwann cells across the repair site into distal denervated stumps.[22] We have previously used end-to-side sensory nerve repairs in other clinical scenarios and found that they are sufficient to promote nerve regrowth through nerve grafts.[29–31]

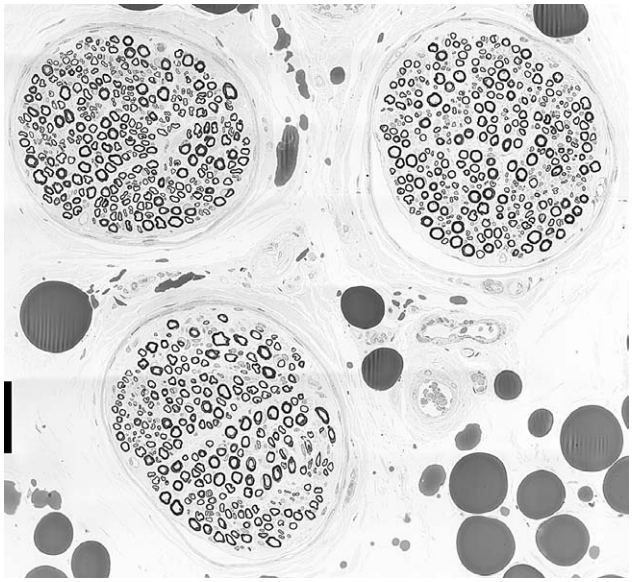


Fig. 4. Histomorphometric analysis of a transected infraorbital nerve branch used for sensory protection demonstrated 975 myelinated axons in the donor nerve. These donor axons and associated Schwann cells may prevent Schwann cell atrophy and loss of neurotrophic support in the distal sural nerve graft, improving axon regeneration across the CFNG.

This refinement to the first stage of facial reanimation may further improve functional outcomes. We are currently using this technique as part of a multimodal approach to improve axon regeneration through the CFNG and continue to document the functional outcomes in these patients.

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