

Split hypoglossal-facial nerve neurotomy for treatment of the paralyzed face^{☆,☆☆,★}

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Abstract

Background: Several methods of neural rehabilitation for facial paralysis using 12-7 transfers have been described. The purpose of this study is to report on a series for dynamic reinnervation of the paralyzed face by using a split 12-7 nerve transposition. The goals of this procedure are to minimize tongue morbidity and to provide good facial reinnervation.

Methods: Prospective case series. Melolabial crease discursion, overall facial movement, and degree of tongue atrophy and mobility were recorded.

Results: Thirteen patients underwent facial reanimation using a split hypoglossal-facial nerve transfer with postoperative follow-up to 58 months (range, 6–58 months). All patients achieved excellent rest symmetry and facial tone. Of 13 patients, 10 had measurable coordinated movement and discursion of their melolabial crease. Of 13 patients, 12 had mild to moderate ipsilateral tongue atrophy. The mean time to onset of visible reinnervation was 3 months.

Conclusion: Split hypoglossal-facial nerve transposition provides good rehabilitation of facial nerve paralysis with reduced lingual morbidity. Long-term rest symmetry and potential learned movement can be achieved. This technique may provide a favorable alternative to the traditional method of complete hypoglossal sacrifice or jump grafting.

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1. Introduction

Neural rehabilitation of facial paralysis typically involves epineural neurotomy from a donor motor nerve. The most popular of the potential options has been the ipsilateral hypoglossal nerve. The landmark work done by Conley et al [1] describing their 30-year experience highlights the utility and success rate of this operation. Although this procedure is effective in establishing facial tone, rest symmetry, and some

movement, it can be associated with significant tongue dysfunction. This results from both the lack of movement and the progressive atrophy seen with denervation of the ipsilateral tongue. Many patients seeking facial rehabilitation do so to avoid the psychological stigmata of appearing to have “had a stroke.” Unfortunately, traditional hypoglossal-facial nerve transfers can lead to patients trading one functional deficit for another. The dysphagia and dysarthria associated with the unilateral sacrifice of the hypoglossal nerve can also appear to be the consequence of a stroke, thereby defeating one of the primary purposes of the operation.

This fundamental limitation of sacrificing one motor nerve for another during hypoglossal-facial nerve transfer has led to the development of numerous adjunctive methods of facial paralysis rehabilitation. Static techniques as well as muscle transfers have been used [2,3]. Although these provide suspension of the oral commissure and good rest symmetry, they are all means of masking the primary problem of neural loss and motor endplate atrophy. Although

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useful in the setting of long-standing paralysis, patients who are managed earlier can potentially achieve more natural rest symmetry with neural rehabilitation. The ideal procedure would use a motor nerve that would not result in significant morbidity. The concept of jump grafting has been advocated to achieve this goal [4]. Although there have been reports of success with this procedure, reducing the number of neurotaphies from 2 to 1 may provide a theoretical regenerative advantage [4–7]. Our potential solution to this has been the use of a split hypoglossal-facial nerve neurotaphy. Although this technique has been described in several texts, there is a paucity of literature supporting its use [7–9]. Excepting several case reports, only one clinical series has been reported in the setting of known facial nerve transections, raising some doubts about its applicability in patients with delayed presentations [10]. We report on our series of 13 patients who underwent delayed split hypoglossal-facial nerve neurotaphy procedures. This study represents the largest clinical series of this procedure and illustrates its utility for achieving good facial outcomes with acceptable tongue morbidity.

2. Materials and methods

This study is a retrospective review of clinical experience from 2002 to 2008. All patients who underwent a split hypoglossal-facial nerve neurotaphy for complete facial nerve paralysis are included. Most (11/13) were followed for a minimum of 6 months before neural rehabilitation procedures were undertaken because the status of the facial nerve and its integrity were uncertain. Preoperative electromyographic studies were done to document the presence of fibrillation potentials and the absence of any polyphasic action potentials, suggesting potential delayed recovery. Postoperatively, patients were followed every 3 months for 2 years, then annually. Follow-up findings of both facial nerve motion and tongue function were noted at each office visit. The facial nerve function was graded using both the House-Brackmann and May grading classifications [9]. This study was approved by the institutional review board (no. 08-220).

3. Surgical technique

A modified Blair incision is used to allow identification and isolation of the facial nerve. The inferior limb of the incision is extended anteriorly to allow for dissection of the hypoglossal nerve in the same surgical field. A standard superficial parotidectomy approach is then performed to identify the facial nerve trunk. The lateral lobe of the parotid gland is not removed but retracted anteriorly. The hypoglossal nerve is initially dissected in its path at the point anterior to the posterior belly of the digastric muscle, and then traced both anteriorly and posteriorly. Using an

operating microscope, the epineurium of the hypoglossal nerve is then divided linearly along its course parallel to the direction of the fibers using an 11-blade edge to create a short linear neurotomy. Microdissection scissors are used to complete the split procedure. Care is taken to divide the fibers equally. Finally, the anterior release of the superior nerve bundle is performed with microscissors. These fibers are then rotated superiorly to meet the facial nerve stump. An epineural neurotaphy is then performed using 9-0 monofilament nonabsorbable sutures. The technique is illustrated in Fig. 1A to D. Fig. 2A and Fig. 2B are representative intraoperative photographs.

4. Results

Postoperative outcomes are shown in Table 1. The surgery was successfully performed in all 13 patients with no immediate postoperative complications. The range of time from onset of paralysis to surgery was 3 weeks to 30 months. All of the patients in the series were able to achieve rest symmetry of their oral commissure in long-term follow-up. One representative patient, postoperatively, is shown in Figs. 3A to 4B. All patients achieved a postoperative House-Brackmann score of III to IV and a May classification score of excellent or good (II or III) except for one patient. The mean time to onset of visible neural reinnervation was 3 months with tone returning before dynamic movement. Patients continued to show improvement over a 6-month period to achieve their final outcomes. Of 13 patients, 10 had notable volitional facial movement measured by melolabial crease discursion ranging from 3 to 12 mm. Morbidity to the tongue was assessed by examination of lateral movement and degree of atrophy (classified as none, minimal, moderate, and severe). Of 13 patients, 8 had minimal atrophy, 5 had moderate, and 1 had severe. All patients except the one with severe atrophy had bilateral tongue mobility.

5. Discussion

Hypoglossal-facial nerve neurotaphy is an accepted and widely used technique for neural rehabilitation of facial nerve paralysis [1]. The procedure can reliably provide excellent rest symmetry and, in many cases, coordinated facial movement. The rest symmetry achieved by these techniques results from tone returning to the muscles of facial expression. In essence, this represents a physiologic reversal of the denervation process of the facial nerve. In this regard, it may potentially provide a more natural appearance than the numerous static sling and muscle transfer procedures that fundamentally reposition the anatomical structures of the face. Unfortunately, the movement that is achieved, however, is not volitional and often requires significant patient “relearning” to coordinate directed tongue

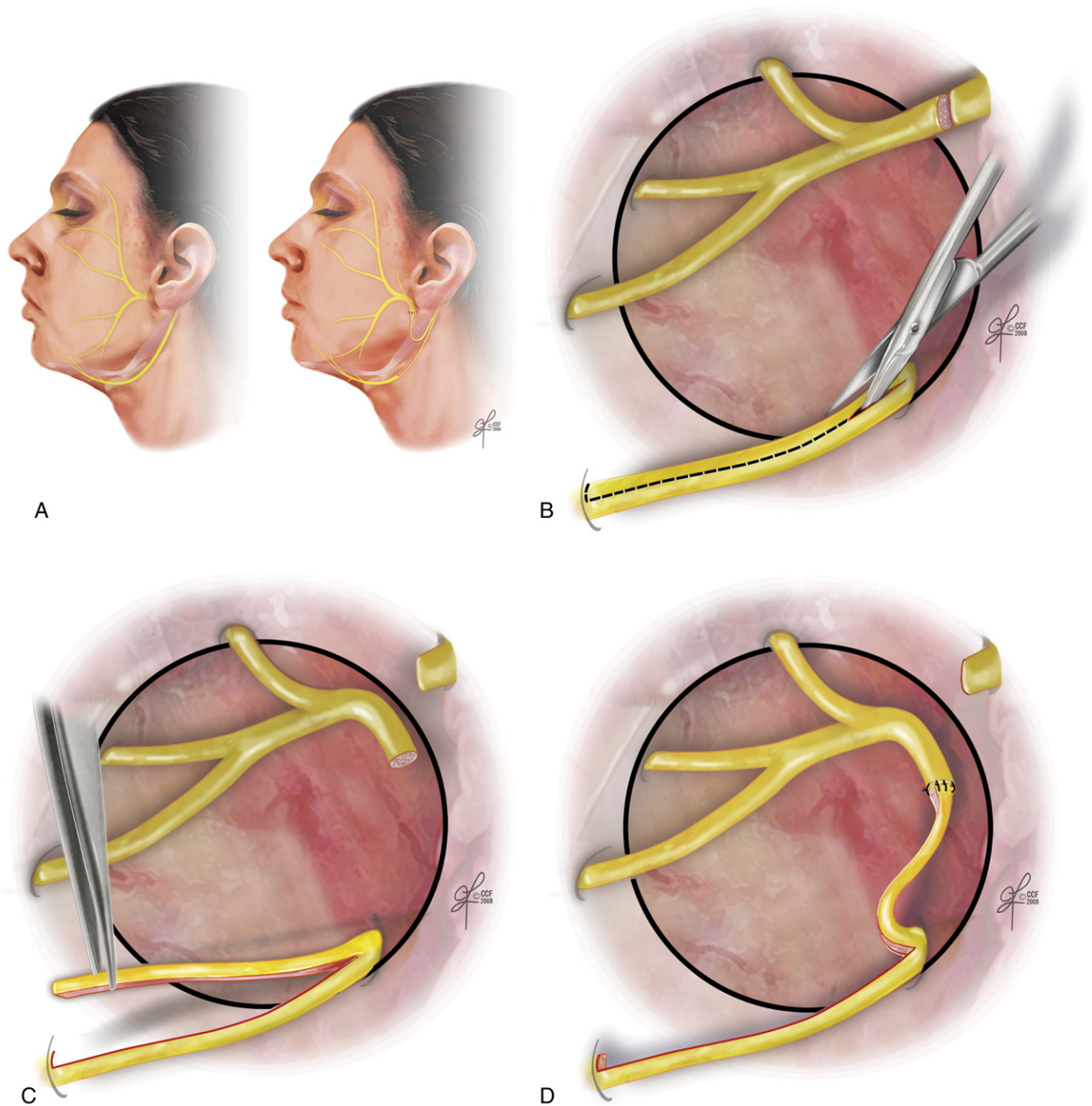


Fig. 1. (A) Pre- and postoperative illustrations depicting split 12-7 nerve transposition. (B) Anterior cut of XII using microdissection scissors. (C) Superior division of XII brought superiorly to proximal VII. (D) Superior division of XII anastomosed to proximal VII.

movements with desired facial expressions. Even when movement is present, however, mastering coordinated facial expression presents a challenge compounded with the presence of potential synkinesis.

This problem could potentially be avoided by use of the patient's functional contralateral facial nerve as a donor nerve. Unfortunately, several drawbacks exist with this procedure including potential for facial weakness on the

donor side as well as unpredictable results [11,12]. This is likely due to the extensive length of nerve grafting required as well as the minimal axonal contribution found in the distal donor nerves that are used in this operation. When all of these factors are taken into account, the hypoglossal-facial nerve neurotomy seems favorable compared to cross-facial techniques and serves as the "gold standard" for facial nerve reinnervation [7,9].

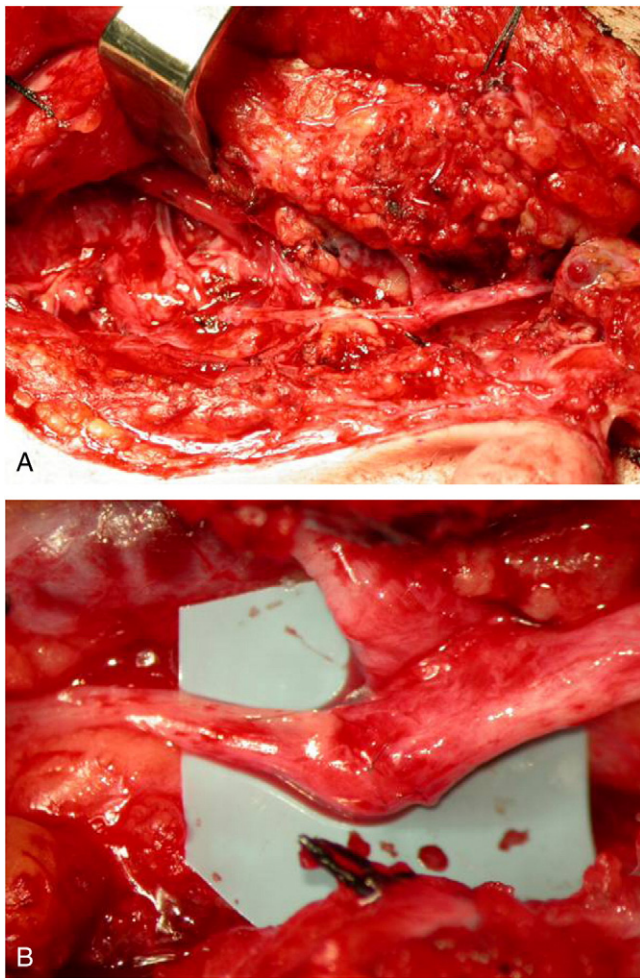


Fig. 2. (A) Intraoperative photograph showing superior division of XII anastomosed to proximal VII. Parotid gland retracted superiorly. (B) Closeup intraoperative view of nerve anastomosis. 9 o'clock indicates superior division of XII; 12 o'clock, inferior division of VII; 3 o'clock, superior division of VII.

While the hypoglossal-facial nerve neurotomy has become a reliable procedure for neural rehabilitation, it is associated with often significant tongue morbidity due to

immobility and atrophy of the ipsilateral side. This has been clinically significant in many patients. Efforts to reduce this complication led to the use of jump graft techniques where the hypoglossal nerve is not sacrificed [4]. Although hypoglossal preservation is achieved, reliable return of facial tone and rest symmetry has been variable [13]. One can question how reliably axonal migration should occur down the new neural tract through 2 nerve neurotomy provided by the jump graft compared with one using other techniques [7].

In an effort to balance the functional outcomes of both the tongue and the face, we have opted to use the technique of split hypoglossal-facial nerve transfers. Excepting isolated case reports and one case series, the data supporting its use are limited [10,14]. Prior reported surgeries were performed for known facial nerve transections in the immediate postoperative period. A major criticism of these reports, therefore, is whether the outcomes are translatable to delayed rehabilitation. We report the results of our series of 13 patients, 11 of whom underwent split hypoglossal-facial nerve neurotomy primarily in a delayed fashion (>6 months after injury). This represents the largest study describing this technique and the first focused on delayed reinnervations.

The facial outcomes of this study were comparable to those seen in studies of complete hypoglossal nerve sacrifice [1]. All patients achieved rest symmetry and most were able to achieve coordinated dynamic facial movement. A known and obvious limitation of hypoglossal-facial transfer procedures is the lack of involuntary emotional expression. Patients are encouraged after reinnervation occurs to practice directed tongue movements in conjunction with facial expression to coordinate some directed and balanced facial movement. Our patients undergo physical therapy and exercises to improve function. The success of this has been variable and depends more on the motivation of the patient than the outcome of the surgery. This is the fundamental limitation of all motor nerve neurotomy procedures.

Although the facial nerve outcomes of this technique are good, the primary advantage of this technique is not related to facial function alone. The most clinically significant benefit of this alternative approach is the reduced morbidity seen in

Table 1
Data of facial movement/tone and tongue status after 12-7 nerve transposition

Patient no.	Sex	Follow-up (mo)	May classification	House brackmann	Melolabial crease movement (mm)	Tongue atrophy	Tongue mobility
1	M	6	Excellent (II)	3	5	Moderate	Palsy
2	F	9	Excellent (II)	3	6	Minimal	Good
3	M	10	Fair (IV)	5	4	Severe	Paralysis
4	F	11	Excellent (II)	3	4	Minimal	Good
5	F	18	Excellent (II)	3	3	Moderate	Palsy
6	F	18	Good (III)	3	4	Moderate	Palsy
7	M	18	Excellent (II)	3	6	Minimal	Good
8	F	23	Good (III)	4	3	Minimal	Good
9	M	24	Excellent (II)	3	5	Minimal	Good
10	F	24	Good (III)	4	3	Minimal	Good
11	F	36	Good (III)	4	3	Moderate	Good
12	F	48	Excellent (II)	3	12	Minimal	Good
13	F	58	Excellent (II)	3	4	Minimal	Good



Fig. 3. (A) Anterior view of patient in repose 51 weeks after split 12-7 nerve transposition. (B) Anterior view of patient in A during animation.

the ipsilateral tongue. Most of the patients in this study were able to retain tone and have bilateral movement in their tongue. In the initial postoperative period, the tongue is often weak as the residual axonal fibers suffer from neuropraxia. By the first 3-month follow-up visit, however, the tongue recovers. Although some minor deficits may persist, they are markedly reduced when compared to total hypoglossal sacrifice, thereby allowing patient compensation to play a significant role in improved function. Sixty-two percent retained good to excellent tongue function, which is better than the outcomes seen in complete hypoglossal nerve transection [1].

A few patients experienced moderate tongue atrophy and one patient severe atrophy similar to that seen in complete hypoglossal nerve transection. A number of potential explanations for this exist. The simplest is technical error and accidental denervation of the tongue by excessive trimming of the preserved remnant of the hypoglossal nerve. The intraoperative course of the patient with severe tongue atrophy was unremarkable, and to all identifiable parameters, the nerve was divided equally. This patient did have good facial function.

Another potential explanation for this failure, in regard to tongue function, relates to the nature of interwoven axonal paths through the hypoglossal nerve. Unfortunately, the axons do not travel in strict linear paths through the epineurium. Sequential neuronal cross-sectional studies have shown variable and often twisting axonal paths through the nerve [15]. This has definite implications in the success of techniques such as this one. While in an ideal scenario, splitting the nerve would result in a 50/50 distribution of fibers along each resulting branch, this is likely not the reality. As May [9] describes: “Splitting the hypoglossal nerve in an effort to spare the tongue and reinnervate the face is a flawed concept.” As the nerve is split, many axons are likely transected in the process. The ideal 50/50 distribution may eventually become a 30/30/40 distribution where, hypothetically,

40% of the axons are lost. The exact amount of axonal loss is purely supposition as this information is not attainable without cross-sectional studies of the reinnervated nerve. Further animal studies may help elucidate this question.

Despite these recognized limitations of this technique, the clinical results have been promising. Our patients achieved good facial outcomes comparable to complete transection techniques with markedly reduced tongue morbidity. The goal in the conception of this approach is that sharing the hypoglossal axonal fibers between the facial and the hypoglossal nerve optimizes the function of both nerves. The outcomes of this study support previously reported findings by Arai et al suggesting that the reinnervation potential of a split nerve results in decreased tongue atrophy and comparable facial nerve function, even in a delayed setting [1,9,10].

6. Conclusions

Split hypoglossal-facial nerve neuroorrhaphy provides good rehabilitation of facial nerve paralysis with reduced lingual morbidity. Long-term rest symmetry and potential learned, coordinated movement can be achieved. This



Fig. 4. (A) Oblique view of patient in Fig. 3A during repose. Ruler indicating position of melolabial crease. (B) View of patient in A during animation showing 4 mm melolabial crease discursion.

technique may provide a favorable alternative to the traditional method of complete hypoglossal sacrifice or jump grafting. The outcomes of this study provide additional clinically applicable information regarding the use of split hypoglossal-facial nerve transfers and give new support for the use of this technique in the delayed setting.

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