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Facial nerve repair: the impact of technical variations on the final outcome

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Abstract

Objectives To analyze the outcome of facial nerve (FN) reconstruction, the impact of technical variations in different conditions and locations, and the importance of additional techniques in case of suboptimal results.
Study design Retrospective study.
Setting University-based tertiary referral center.
Patients Between 2001 and 2017, reconstruction of the FN was performed on 36 patients with varying underlying diseases.
Interventions FN repair was performed by direct coaptation ($n=3$) or graft interposition ($n=33$). Microsurgical sutures were used in 17 patients (47%) and fibrin glue was used in all cases. Additional reinnervation techniques (hypoglossal–facial or masseter–facial transfers) were performed in five patients with poor results after initial reconstruction.
Main outcome measures FN function was evaluated using the House–Brackmann (HB) and the electronic clinician-graded facial function (eFACE) grading systems. Minimum follow-up was 12 months.
Results FN reconstruction yielded improvement in 83% of patients, 21 patients (58.3%) achieving a HB grade III. The eFACE median composite, static, dynamic and synkinesis scores were 69.1, 78, 53.2, and 88.2 respectively. A tendency towards better outcome with the use of sutures was found, the difference not being significant. All patients undergoing an additional reinnervation procedure achieved a HB grade III, eFACE score being 74.8.
Conclusions FN reconstruction offers acceptable functional results in most cases. No significant differences are expected with technical variations, different locations or conditions. In patients with poor initial results, additional reinnervation techniques should be always considered. The eFACE adds substantial information to the most used HB scale.

Keywords Facial nerve repair · CPA tumors · Nerve graft · Suture anastomosis

Introduction

Facial nerve (FN) paralysis is a devastating complication of the natural history or the treatment of cerebellopontine angle (CPA), temporal bone, and parotid disorders. It leads to patients suffering from serious functional, cosmetic, and psychological problems [1].

Management of FN injuries continues to be one of the most difficult issues faced by the otologic and head and neck surgeons. It follows a complicated algorithm depending on the mechanism and the location of the injury, the time course of the paralysis, the medical condition and prognosis of the patient.

Although many techniques have been developed to rehabilitate patients with facial paralysis (FP), the outcome of all of these procedures lacks the symmetry or spontaneity

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of an intact FN function [2]. Three options exist for nerve reconstruction: (1) primary tension-free coaptation of the nerve segments (best option when feasible); (2) cable grafting between the proximal and distal nerve stumps, when the length of the defect prevents primary coaptation, and (3) nerve transfer, which is indicated when the proximal segment of the FN is not accessible [3].

Reconstruction of the FN, with or without a cable graft, is a well-known procedure. Used within a prudent time after the nerve injury, it usually provides very acceptable results. However, due to different reasons, reinnervation may be poor or even not occur. In these cases, it is imperative to offer patients additional techniques to achieve better functional and cosmetic results.

The aims of this study were to:

(a) Determine the outcome of FN reconstruction with or without graft interposition in different conditions and locations including CPA, temporal bone and parotid.
(b) Analyze the impact of technical variations on the facial function outcome.
(c) Study the importance of performing additional techniques in case of suboptimal results.

Material and methods

Inclusion and exclusion criteria

A retrospective study of patients undergoing FN repair between January 2001 and May 2017 within the Facial Paralysis Unit at La Paz University Hospital was performed. All patients had reconstruction of the FN with or without graft interposition. A minimum follow-up of 1 year was required. Patients treated with facial nerve decompression and those undergoing reanimation techniques (e.g. hypoglossal–facial or masseter–facial transfer) as the main initial procedure were excluded. Cases of end-to-side facial nerve reinforcement [4] were also excluded.

Clinical and surgical variables

Clinical data included age, sex, preoperative facial function, etiology of the paralysis (disease or surgery), time between FP and reconstruction surgery, and time to the first signs of facial reinnervation. Each case was discussed in the Facial Paralysis Unit monthly meeting to decide the best surgical option and subsequent concomitant treatments (physical therapy and eyelid procedures) required to optimize the final facial function. If a tension-free apposition of the stumps was possible, a direct end-to-end coaptation was performed. When needed, a donor graft was extracted, either a great auricular nerve (GAN) or a sural nerve. In both cases, the

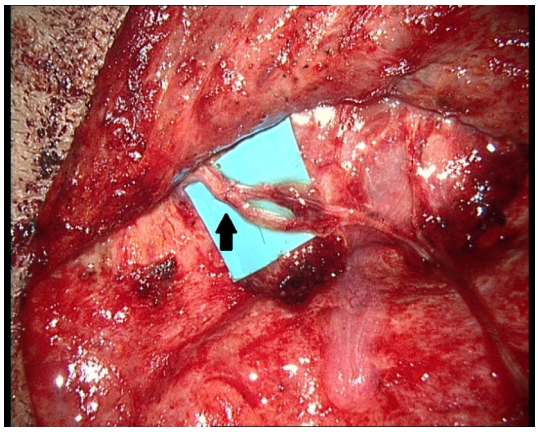

Fig. 1 Left side. Parotid approach showing a cable graft anastomosis with the great auricular nerve using microsurgical suture (arrow)

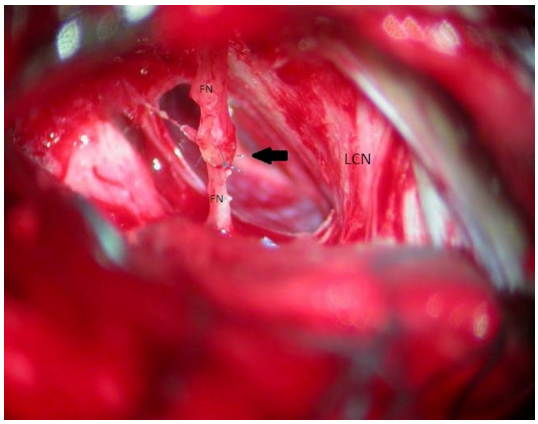

Fig. 2 Right side. Facial nerve (FN) reconstruction with suture (arrow) in the CPA by a retrosigmoid approach. *LCN* lower cranial nerves

fibers matched the direction of the FN axons. Fibrin glue was used in every case, irrespective of the use of sutures. Microsurgical sutures were used in cases of parotid reconstruction (Fig. 1) but also in three of eleven CPA reconstructions (two cases of FN end-to-end coaptation and one GAN graft interposition because of a larger FN defect) (Fig. 2). A standard method of nerve suture was carried out in these cases. The nerve ends were trimmed, the coaptation was performed with a 9-0 or 10-0 monofilament suture (usually three to five sutures through the epineurium and perineurium, respectively), and the coaptation was wrapped in fibrin glue. Coaptation without sutures was performed within the temporal bone, since preserving the bony canal of the horizontal and vertical segment of the FN allows stability of the nerve graft by itself. In cases of subtotal petrosectomy or translabyrinthine approaches, the FN reconstruction was also stabilized with abdominal fat. (Fig. 3) Additional

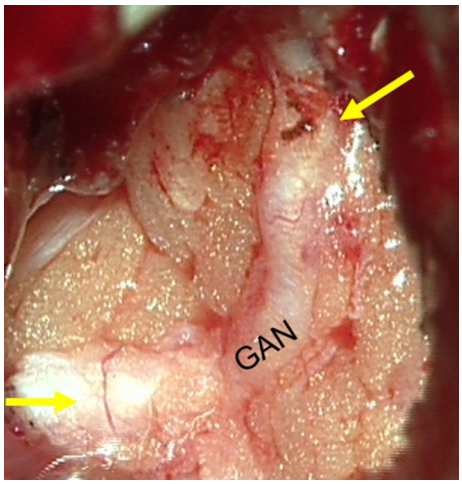

Fig. 3 Left side. FN reconstruction (arrows) in the CPA with a great auricular nerve (GAN) donor graft stabilized with abdominal fat. Translabyrinthine approach

reinnervation techniques were offered to patients with poorer results or to those willing to improve their outcome. The need for complementary curative treatment in case of malignant tumors was also noted.

FN evaluation

FN function was evaluated using the House–Brackmann (HB) grading system [5] and the electronic, clinician-graded facial function scale (eFACE) at least 12 months after the surgical procedure. The eFACE is a 16-item instrument that provides zonal and overall facial function scores; it offers static, dynamic, and synkinesis scores, and produces an immediate graphic output for easy interpretation and tracking of progress [6].

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS; version 23). Statistical analysis was conducted by Fisher's two-tailed exact test with a level of $p < 0.05$ indicating a significant result.

This study was approved by the institutional ethics review board of La Paz University and was conducted according to the provisions of the Declaration of Helsinki and its amendments.

Results

Patients

Thirty-six patients underwent facial reconstruction. Twenty patients (55%) were female, and the mean age was 45 years (range 5–76 years). The mean follow-up was 31.4 months (range 20–126 months). The etiology of FP is shown in Table 1.

Surgical technique

End-to-end coaptation was performed in three patients (8.3%). Of the 33 patients undergoing a cable graft repair, the GAN was used in 31 patients (93.9%), the sural nerve in 1 case (3%) and the vestibular nerve in another case (3%). Microsurgical sutures were used in 17 patients (47.2%).

Preoperative and postoperative facial function

Table 2 shows initial facial function. 14 patients had normal function preoperatively. In patients with preoperative facial dysfunction, the median time between the onset of the paresis or paralysis and the reconstruction surgery was 7 months (range 1–42 months). All patients had complete FP (grade VI) in the immediate postoperative period. The median time between the surgical procedure and the first clinical signs of reinnervation was 9 months (range 6–14 months).

After a minimum 1-year follow-up, FN function improved in 83.3% of the patients: 21 patients (58.3%) had HB grade III, 9 (25%) had HB grade IV, and 6 patients (16.6%) showed no recovery. According to the eFACE grading system, the median composite, static, dynamic and synkinesis scores

Table 1 Conditions in the skull base and parotid gland for which facial nerve reconstruction was performed

Condition	No of cases (%)	Preoperative function House–Brackmann scale					
		I	II	III	IV	V	VI
Facial nerve tumor	9 (25)	1		1	2	2	3
Malignant parotid tumor	9 (25)	4	2				3
Vestibular schwannoma	8 (22.2)	7			1		
Petrous bone cholesteatoma	5 (13.8)				1		4
Benign parotid tumor	3 (8.3)	1					3
Arteriovenous malformation	1 (2.7)	1					
Traumatic case	1 (2.7)						1

Table 2 Comparison between preoperative and postoperative facial nerve function ($n=36$)

Facial function (HB)	Preoperative	Postoperative
I	14 (38.8%)	
II	2 (5.5%)	
III	1 (2.7%)	21 (58.3%)
IV	4 (11.11%)	9 (25%)
V	2 (5.5%)	0
VI	13 (36.1%)	6 (16.6)[a]

[a]An additional reinnervation technique was offered to all patients with no initial improvement

were 69.1, 78, 53.2, and 88.2, respectively. Variation of eFACE scores in each HB category is shown in Table 3.

Association between condition and postoperative facial function

The best results—cases with postoperative HB grades III–IV—were achieved in patients with benign parotid tumors and traumatic cases, and also in FN tumors (100%), with an eFACE mean composite score of 82, 84 and 69 respectively. The worst outcomes occurred in patients with PBCs (60% of postoperative HB grades III–IV) with an eFACE mean composite score of 63 ($p>0.05$).

No association was found between patient's age, sex, preoperative facial function, time between facial paralysis and reconstruction surgery, time to the first signs of facial reinnervation, radiation status and final facial outcome.

Surgical variables

The three patients that underwent direct coaptation reached a HB grade III and an eFACE mean composite score of 76. On the other hand, cases with graft interposition achieved HB grade III in 54.5% of cases (eFACE mean composite score of 67.8) ($p=0.561$).

When the impact of sutures was analyzed, a tendency towards better outcome with the use of sutures was found, the difference not being significant. 94.1% of the cases with sutures reached HB grades III–IV compared with 73.6% achieving this outcome with fibrin glue only ($p=0.069$). Outcomes with the eFACE grading system showed similar results, both in the composite score (with sutures, median = 77.5, fibrin glue only, median = 64) and in most of the subgroups (dynamic score: suture median = 65.5, fibrin glue median = 53; synkinesis score: suture median = 98, fibrin glue median = 91) ($p>0.05$).

Supplementary procedures

Twenty-five patients (69%) underwent adjuvant ocular procedures, including upper eyelid platinum or gold weight implantation (60%), tarsorrhaphy (3%), canthoplasty (3%), and tarsal strip (3%). 29 patients (80.5%) received rehabilitation treatment including neuromuscular reeducation and chemodenervation injections (Botox®).

Approach in patients with no spontaneous reinnervation

In the six patients who showed no clinical and electromyographic signs of recovery, an additional reinnervation procedure was offered 9–12 months after the initial reconstruction procedure (Table 4). Two patients underwent a hypoglossal–facial transfer and three patients a masseter–facial transfer (in two cases with an additional cross-face nerve graft). All these patients reached a postoperative HB grade III function and also had an improvement in the eFACE score (mean composite score from 43.6 to 74.8). The remaining patient (malignant parotid tumor) rejected any additional procedure. Therefore, considering the 36 patients entering this study, 35 had facial function improvement and one rejected further treatment.

Discussion

The best reanimation procedure for the paralyzed face depends on several factors. When possible, immediate reconstruction of the nerve continuity is the preferred option, but frequently, the nerve gap is too large to obtain a tension-free coaptation, so an intermediate graft needs to be interposed [7]. Regardless of the graft material used or the technique employed, the best possible postoperative outcome is a HB grade III. The frontal muscle function rarely recovers and a certain degree of synkinesis is unavoidable after grafting [8]. In spite of performing a correct surgical technique, reinnervation may not occur in some cases. In the present study, signs of reinnervation were found in 83.3% of patients. HB grades III and IV were obtained in 58.3% and 25% of our patients, respectively. Patients with no initial signs of

Table 3 Comparison between House–Brackmann grades and eFACE scores

Facial function grading scale	House–Brackmann grade		
	III	IV	VI
eFACE mean composite score	77 (range 61–94)	68 (range 48–86)	44 (38–49)

Table 4 Patients with no initial recovery following facial nerve reconstruction

Case	Age	Duration of the previous facial palsy/preoperative HB grade	Condition	Graft	Postoperative HB grade/eFACE[a]	Time until additional reinnervation technique	New FN reconstruction technique	Final HB grade/eFACE[a]
1	59	6 months/IV	Petrous bone cholesteatoma	GAN	VI/48	11 months	Masseter–facial and fascia lata suspension	III/61
2	51	No palsy	Vestibular schwannoma	GAN	VI/40	12 months	Masseter–facial and single cross-face sural graft	III/83
3	24	24 months/IV	Vestibular schwannoma	GAN	VI/38	10 months	Hypoglossal–facial[b]	III/81
4	53	8 months/VI	Petrous bone cholesteatoma	GAN	VI/49	9 months	Masseter–facial	III/72
5	50	No palsy	Vestibular schwannoma	GAN	VI/48	12 months	Hypoglossal–facial and double cross-face sural grafts	III/77
6	69	5 months/VI	Malignant parotid tumor	GAN	VI/39	Patient rejected any additional reconstruction technique		

[a]eFACE composite score

[b]A prophylactic cross-face anastomosis was performed 6 months before the tumor resection and the first reconstruction technique

HB House–Brackmann, *FN* facial nerve, *GAN* greater auricular nerve

recovery were offered an additional reinnervation procedure, which led to a final improvement in all the 36 patients of this series but one who rejected additional treatment.

Outcomes following FN repair

Prasad et al. [8] reported a large series of lateral skull base cases undergoing FN repair using sural nerve as an interposition cable graft. They reported 50.7% of HB grade III, 21.6% of HB grade IV, 8.9% of HB grade V and 18.8% HB grade VI. These results are very similar to those in the present series. No other facial grading scales were used in this study. Arriaga and Brackmann [9] studied 23 cases of FN repair after CPA tumor removal, and they reported 26% of HB grade III, 51,7% of HB grades IV–V, and 13% of graft failure, performing direct approximation (13 cases) or cable graft (8 cases), with no significant difference between the two techniques. HB grade III outcome rate was lower than in our series. In different series, the percentage of patients achieving a grade III is extremely variable, ranging from 5 to 86% (8). Most authors report HB Grade III in about 50–60% of their patients [1, 10–12]. The results of the present study were consistent with those in the literature, with 58.3% of patients obtaining HB grade III.

Pathologic condition

Over the last 3 decades, several surgeons have reported FN reconstruction in various pathologic or traumatic situations [2]. In our study, we observed that slow-growing lesions, such as benign parotid tumors or FN tumors had favorable outcomes (HB grades III–IV in 100%, eFACE mean composite score: 82 and 69, respectively). This finding may be explained because FN fibers are stretched slowly over several months, eventually leading to kinking. On the other hand, the inflammatory insult to the FN caused by a cholesteatoma is very high, leading to interruption of the nerve by scarring [13]. In our patients with PBCs, 60% of the grafted nerves were associated with a postoperative HB grade III–IV (eFACE mean composite score 63). These results are similar in other series [8]. Also, malignancy did not appear to impair nerve reanimation in our cases. 66% of patients with malignant parotid tumors reached a HB grade III (eFACE mean composite score 68). These findings have been reported in other series as well [3, 14].

Surgical variables affecting FN outcome

Graft interposition or direct reconstruction

Although it is universally accepted that end-to-end neurorrhaphy generally yields the best results [15], grafting is necessary in most cases. In our study, the outcomes from both repair techniques showed no statistical difference, probably due to the small number of patients undergoing direct coaptation. Malik et al. [1] compared the results among end-to-end coaptation, cable graft interposition, and hypoglossal–facial transfer in 66 patients undergoing FN repair due to several causes. They found end-to-end coaptation as the best method of repair, reaching a HB grade III in 85% of cases

(56% and 25% in the cable graft interposition and hypoglossal–facial transfer groups, respectively).

Use of sutures

While extratemporal facial nerve reconstruction is usually performed with sutures, coaptation within the temporal bone and the CPA is usually performed without sutures. The theoretic advantages of a sutureless coaptation are: (1) less foreign body reaction and the potential effects of such reactions on regenerating axons, and (2) less direct trauma to the nerve from the suture. Several studies have supported this type of anastomosis [7, 16–18]. On the other hand, reconstruction with sutures may add stability to the coaptation, especially in unstable environments. In our study, no difference was found between both types of repair in terms of outcome, although cases with sutures showed slightly better results. Likewise, Arriaga and Brakmann compared the outcomes between nerve suture and microfibrillar collagen-assisted approximation (Avitene®) finding a slight but non-significant tendency for better results with the first technique [9]

The use of sutures in the CPA is controversial. Reconstruction or grafting in this location implies several difficulties when compared to the petrous bone or the parotid gland. A deep-seated brainstem, a pulsatile environment with cerebrospinal fluid (CSF) waves and an epineurium-deprived proximal end of the nerve are the main obstacles for efficient regrowth [7]. Prasad et al. [8] suggested that suturing should be reserved for extradural coaptation as the absence of a true fascicular organization until the geniculate ganglion makes it practically impossible to perform any kind of perineural suturing proximal to this location. In the present study, this type of reconstruction was performed using sutures in three cases, all of them achieving a HB grade III. Although it is a technically demanding procedure, the use of sutures provides additional stability in this unstable location and offers good facial function outcomes. Arriaga and Brackmann [9] used suture anastomosis in 23 CPA FN repair reaching acceptable (HB grade IV or better) postoperative facial motion in 47.8% of patients.

Evaluation of the FN following reconstruction

Various scoring systems have been devised for grading the severity of the FN impairment. The most universally accepted and used is the HB scale, because of its simplicity, reproducibility and low interobserver variability. For several decades, this six-point scale intended initially to describe recovery after VS resection has been applied to a wide range of other pathologic conditions that result in FP [6]. A deficiency of the HB scale is that several different facial motor functions and facial dysfunction are grouped under one heading. This shortcoming is most noticeable in the assessment of patients with differential function along the branches of the FN [19]. The best facial outcome following reconstruction is HB grade III (described as "moderate dysfunction" includes complete eye closure and motion of the forehead), but many of these patients should be better classified as HB grade IV because of mass motion and lack of forehead movement. The HB scale lacks sensitivity to subtle but important changes in facial nerve function over time, provides an insufficient classification of synkinesis, and is unable to capture fluctuating or zonal facial paralysis [20]. Thus, it may be best applied to a facial nerve that has intact nerve sheaths, whereas other grading systems should be used to evaluate recovery following FN reconstruction [1, 2].

In 2015, a group at the Massachusetts Eye and Ear Infirmary developed the eFACE scale [21]. In this study, the eFACE was used as an additional grading system to the HB scale, the scores showing a great variation for each HB category. This new instrument has been compared with other time-tested methods of facial grading. Gaudin et al. [20] established the correlation between the eFACE and the Sunnybrook Facial Grading System (FGS) scores among patients with FP and compared the reliability of the two scales. They found a moderately strong correlation between the Sunnybrook FGS and the eFACE in all four categories: composite, static, dynamic and synkinesis. The eFACE has the added benefit that is rapid to administer, offers sliding scale zonal detail and has been shown to demonstrate superior interrater reliability [21]. The eFACE has been used in facial paralysis of various etiologies, like Bell's palsy and infectious causes [22, 23], so this study would be the first to use it following reconstruction of the FN.

Patients with no spontaneous recovery

This study also focuses on those patients who showed no initial recovery following FN reconstruction. It is imperative to follow every patient very closely during the postoperative period, as an additional reinnervation procedure may only be useful before the facial muscles become irreversibly atrophied. Five patients underwent an additional procedure between 9 and 12 months following facial nerve reconstruction, all of them achieving a HB grade III (Table 4). It must be noted that the time to recovery following reconstruction may exceed 12 months [1, 24]. Therefore, some of these patients may still have improved spontaneously. However, we believe that if no clear signs of clinical reinnervation are shown after 8–9 months, an additional technique should be offered to the patient.

In our Facial Paralysis Unit, this approach (double innervation) is currently considered in three situations: (1) additional hypoglossal–facial or masseter–facial transfer in those cases that show no recovery 7–8 months after the

first reconstruction surgery, (2) masseter–facial transfer in patients with clinical signs of reinnervation who want to enhance the initial outcome, and (3) masseter–facial transfer combined with a cable nerve graft in the same surgery, when due to the graft length, the patients age, or the duration of the paralysis the expected prognosis is poor only with the nerve graft.

The combination of grafting and a reinnervation procedure such as a hypoglossal–facial transfer has been previously described after radical parotidectomy, using the hypoglossal nerve for innervation of the lower facial muscles with a cable graft for the upper facial muscles [25]. Using a separate neural input for innervation of the upper and lower facial muscle groups can prevent or decrease synkinesis. FN reconstruction with cable grafting and concurrent masseteric nerve transfer has also been reported [3], in this case the masseteric nerve is coapted to a peripheral buccal nerve branch and the nerve graft is interpositioned between the main trunk of the FN and the remaining peripheral nerve stumps. This combined approach offers several advantages compared with cable grafting alone. The masseteric nerve provides fast return of movement of the oral commissure, it provides neural input and reduces muscle fibrosis while waiting for neural input to regenerate through the cable graft ("babysitter" procedure) [26]. Cable grafting has a lower axonal count than the masseteric nerve, but produces a spontaneous smile. Combining the two options, the masseteric nerve augments the smile restored with the graft [3].

Conclusions

FN reconstruction with or without cable graft interposition is a convenient procedure for patients with a complete transection of the facial nerve. The functional results are satisfactory with 83% of our patients achieving HB grades III or IV. No significant difference was found when analyzing pathologic condition, location, or surgical details as the use of sutures. In patients not reaching an acceptable facial function, an additional reinnervation technique should always be offered. The eFACE is a valid instrument for the assessment of facial paralysis, which adds substantial information to the most used HB scale.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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