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Evolution of Patients With Immediate Complete Facial Paralysis Secondary to Acoustic Neuroma Surgery

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Abstract

Objective: To study the evolution of patients with immediate complete facial paralysis after acoustic neuroma surgery in different scenarios and assess different facial reanimations techniques.

Methods: This study included 50 patients with complete facial paralysis immediately after acoustic neuroma surgery. Data were analyzed into 4 groups according to the need and type of reconstruction of the facial nerve, either none, immediate, or on a deferred basis. All patients had intraoperative facial nerve monitoring, and facial nerve function was evaluated according the House-Brackmann (HB) scale.

Results: Of all patients with immediate total paralysis, no patients achieved totally normal facial function (grade I), and only 5 (10%) recovered to a grade II. For all groups included, the majority of patients (82%) achieved an acceptable final facial function (grade III HB). In this series, only 2 patients remained with a grade VI facial function.

Conclusions: The possibility of recovering near normal facial function after a grade VI facial paralysis is very low. Procedures like the immediate repair of the facial nerve with an interposed donor graft may provide better facial function in patients with partially injured facial nerve. Even in cases of total section, there are other procedures that can improve the results.

Keywords

vestibular schwannoma, facial reinnervation, hypoglosal-facial anastomosis

Introduction

Acoustic neuroma (AN) surgery carries the risk of facial nerve damage. In the past years, anatomic facial nerve preservation has significantly improved to around 90% to 98% of all cases.[1,2] However, worse facial preservation rates between 52% and 78% have also been reported, especially in cases of large tumors.[3,4]

The occurrence of an immediate total facial paralysis following AN surgery may reflect different physiopathological situations, including: total section of the nerve, partial section of the nerve, or anatomically preserved nerve with neurapraxia or axonotmesis. Each situation may lead to different outcomes.

When the nerve is completely sectioned, immediate repair by means of either an end-to-end anastomosis or a nerve graft may be attempted with acceptable outcomes in the long term in the majority of the patients. If no proximal stump is available, the resulting facial paralysis can be treated by a subsequent hypoglossal-facial anastomosis.[5-7]

If the nerve is partially damaged and no electrical stimulation is obtained at the end of the procedure, an end-to-side interposed donor grafting can be placed as a facial nerve reinforcement, providing better and faster facial function at the long term.[2,8]

If the nerve is anatomically intact, electrical stimulation at the end of the surgery will play an important role. Several publications have found a strong correlation between the electrophysiological response and facial outcome. About 50% of the patients with an absent response will have poor

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facial function over the long term. However, if the facial nerve remains intact, any attempt of reinnervation is usually delayed for at least 1 year after surgery.[6,9]

The aim of this study is to evaluate the evolution of patients with immediate complete facial paralysis after AN surgery in different scenarios and assess the efficiency of procedures like intraoperative reconstruction of a facial nerve section, reinforcement technique with end-to-side interposed donor grafting for partial nerve injury, or XII-VII anastomosis.

Material and Methods

A retrospective cohort study of all patients with complete facial paralysis after acoustic neurinoma removal in our department between 2001 and 2011 was performed. This constitutes 23% of all AN cases operated in that period. In all patients, intraoperative facial nerve monitoring was performed with threshold measurement at the end of the intervention. Facial nerve function was evaluated using the House-Brackmann (HB) grading system on the first postoperative day, the day of discharge (average 7 days), and 24 months after surgery.

Patients with an HB grade I, II, III, and IV were excluded from the study, as were those with a delayed total facial paralysis (2 cases) starting 7 days or more after surgery.

In the immediate postoperative period, all our patients received topical treatment with artificial tears, epitelizant cream, and eyelid occlusion until the need for temporary or permanent eyelid surgical treatment was decided. The eyelid procedures included lateral tarsorrhaphy in 3 cases (6%) and eyelid weights in 20 patients (39%).

Patients were classified into 4 study groups as described in the following.

Group 1

Group 1 consisted of 36 patients (72%) with intact facial nerve at the end of surgery in whom observation was recommended.

Group 2

Group 2 included patients (n = 4) (8%) with partial nerve injury at the end of surgery and end-to-side interposed donor graft as a facial nerve reinforcement technique. Partial injury to the facial nerve implies that the nerve is not disrupted but shows an irregular anatomic area with no electrical stimulation proximal to this area. The facial nerve was reinforced by an interposed donor graft based on the surgical technique described by Samii et al.[2,8]

Group 3

Group 3 included patients (n = 7) (14%) with section of the facial nerve and intraoperative reconstruction either end-to-end anastomosis or nerve grafting.

Table 1. Outcomes of Group 1: Immediate Complete Facial Paralysis With Anatomically Preserved Facial Nerve (n= 36).

Final Facial Function	II	III-IV	V-VI
No procedure, n (%)	6 (16)	24 (66)	1 (2.7)
XII-VII anastomosis, n (%)	—	4 (11)	1 (2.7)

Group 4

Finally, patients (n = 3) (6%) in group 4 had facial nerve section and early reconstruction with XII-VII anastomosis.

The statistical analyses were described by frequency (percentage), and a multivariate logistic regression analysis was used to test the statistical significance of association between a favorable final outcome (HB II-IV) and each possible predictor of facial nerve function.

Results

Demographics

Of the 50 patients included, 33 (66%) were female. The average age at the time of surgery was 48 years (18-75 years). The size of the tumor (defined as the maximum diameter measured on MRI) varied from 0.8 to 6 cm (median, 2.19 cm). Surgical approaches were as follows: 28 patients retrosigmoid approach, 17 patients translabyrinthine approach, and 5 patients middle cranial fossa approach.

Facial Nerve Function According to the Study Group

Group 1: Intact Facial Nerve, n = 36 (72%). Thirty-one patients in this group (86%) underwent no further procedures. Only 6 (16%) of the 31 achieved a facial function (HB grade II) at the last follow-up. The majority of the patients in this group (69%) achieved acceptable facial function (HB grades III or IV). Only 1 patient (2%) remained with poor facial function (HB grade VI) and rejected further treatment (Table 1).

Five patients in this group (13%) were treated with a XII-VII anastomosis after 12 months of observation without improvement in facial function. Four patients achieved acceptable facial function; 2 (5%) grade III and the other 2 (5%) grade IV HB. The remaining patient had neurofibromatosis type 2 (NF2). She underwent facial reconstruction surgery 1 year after the resection of her right tumor. One year later, she suffered a postoperative fatal hemorrhage during the fourth postoperative day after surgery for the left tumor. At this time, her EMG showed signs of reinervation on the right side.

In this study group, 22 patients (61%) generated response to electrical stimulation at the end of surgery, 10 patients (27%) had no response, and 4 patients (11%) were not tested

Table 2. Outcome of Facial Function in Patients With Anatomically Preserved Nerve and Complete Immediate Facial Paralysis According to the Stimulation Threshold at the End of the Surgery.

Stimulation Threshold	n	II	III	IV	V	VI
≤ 0.05 mA	12	5	7	—	—	—
0.06-1 mA	5	1	4	—	—	—
≥ 2 mA	5	—	3	2	—	—
No response	10	—	5	3	—	2

(see facial nerve outcome in Table 2). Eight of the 10 patients in which no response was obtained by electrical stimulation did not require any other procedure. The other 2 (20%) underwent a XII-VII anastomosis. One reached a final HB grade III function, and 1 remained with a grade VI (NF2).

Group 2: Partially Injured Facial Nerve With no Electrical Stimulation Proximal to This Area (n = 4). All 4 patients underwent a standard translabyrinthine approach. At the end of the resection, electrical stimulation testing was performed. As no electrical response was elicited, a donor graft was harvested. The ipsilateral great auricular nerve (n = 1), superior vestibular nerve (n = 1), or sural nerve (n = 2) were used. All of these patients achieved an acceptable final facial function, 3 HB grade III and the remaining an HB grade IV.

Group 3: Sectioned Facial Nerve With Intraoperative Reconstruction (n = 7). The 2 types of reinnervation techniques included primary end-to-end facial nerve anastomosis (n = 3) and end-to-end facial nerve anastomosis with sural nerve (n = 2) or greater auricular nerve (n = 1) or vestibular nerve (n = 1) interposition graft.

All patients in this group achieved an acceptable final facial function. Six patients achieved an HB grade III and 1 patient a grade IV.

Group 4: Facial Nerve Section and Early Reconstruction With XII-VII Anastomosis (n = 3). Patients in this group had an anatomically interrupted facial nerve. Reconstruction was not performed at the same time due to the lack of a proximal nerve stump or due to medical or anesthetical reasons that led to end of the operation. As in the previous groups, the majority of the patients in this group achieved an acceptable final facial function (HB grade III). See facial function outcome for groups 2, 3 and 4 in table 3.

The average time to onset of reinervation in each study group is shown in Table 4. The mean number of months to show signs of reinnervation was 7 months. It is noteworthy that despite the wide ranges in groups 2, 3, and 4, some patients showed earlier signs of reinnervation when compared to group 1, which includes patients with intact nerve.

Table 3. Outcomes of Facial Function In Groups 2, 3 and 4.

Final Facial Function	I-II	III	IV	V-VI
Group 2, n (%)	—	3 (75)	1 (25)	—
Group 3, n (%)	—	6 (85)	1 (15)	—
Group 4, n (%)	—	3 (100)	—	—

Table 4. Time to Start Showing Reinervation Signs.

Study Group	Median (mo)	Intervals
Group 1	6	5-16
Group 2	8	6-12
Group 3	8	6-19
Group 4	9	6-20

Prognostic Factors

Considering all the patients in this study (50), only 5 patients (10%) achieved an HB grade II at the last follow-up, and none of the patients improved to normal function. Given the limited number of patients, it was not possible to establish statistical significance in any of the variables (Table 5).

Hypoglossal Facial Procedures

The XII-VII anastomosis was performed in 8 patients (16%), 5 in group 1 and 3 in group 4. A classic surgical technique (end-to-end anastomosis) was performed in 4 patients, and a hemiend-to-end hypoglossal-facial anastomosis was performed in the other 4 patients.

Physical Therapy

All patients were referred to rehabilitation. Thirty-four patients (68%) received facial neuromuscular reeducation. In association with this, 19 patients (38%) received botulinum toxin to facilitate individualization of movement patterns and to control synkinesis.

Discussion

Tumor Size and Facial Nerve Function

Many studies have shown that facial function after surgery is worse in bulkier tumors.[10,11] Good facial nerve function (HB grades I or II) is reported in only 27% to 58% of patients with large AN. On the other hand, it has also been demonstrated that long-term facial nerve function outcome is significantly related to the degree of tumor adhesion to the facial nerve.[12] Seo and et al[13] found that this was the most significant predictable factor influencing late facial outcome. In this study, all tumors were less than 20 mm in

Table 5. Multivariate Logistic Regression Analysis.

Variable	Odds Ratio	$P > \|z\|$	95% Confidence Interval
Sex	0.6	.638	0.07-4.7
Age	0.9	.065	0.8-1.0
Side	1.2	.822	0.19-8.0
Reason for consultation	0.6	.274	0.26-1.45
Facial function before surgery	1	.263	0.70-3.6
Size	0.9	.765	0.75-1.2
Approach	0.5	.472	0.09-2.9
Origin	1.2	.470	0.65-2.4
Facial integrity	3.1	.306	0.35-27.4
Electric stimulation	2.1	.096	0.87-5.3

size,[13] suggesting that this factor could explain worse facial results in some small tumors.

Facial Nerve Function Following Total Facial Paralysis

In our entire series, only 5 patients (10%) achieved an HB grade II at the last follow-up, and the majority (68%) reached a facial function grade III of HB. These results are comparable to those reported in the literature.[1,5,14]

Our results confirm that postoperative immediate HB grade VI function only rarely recovers to grade I or II, with the majority of cases recovering to grade III and IV. Kunihiro et al[7] studied 107 patients with a complete facial paralysis after AN surgery with preserved nerve continuity and reported that 72% of these patients had spontaneous recovery, only 20% achieving an HB grade I-II. Similar conclusions were obtained in the study published by Coca et al[1] in 2008 in which only 5 of the 30 patients with total facial paralysis (16.6%) recovered to HB grade I; most patients (33.3%) reached an HB grade III and (26.6%) an HB grade IV.

Many studies have demonstrated that a stimulation threshold (ST) below .05 mA at the proximal part of the nerve is the best indicator of a long-term good facial function.[15,16] Most patients with electrical response to less than this threshold will achieve good function (HB grades I-II) 1 year after tumor resection.[9] However, "false-positives" have been defined as a poor facial nerve (FN) outcome even though having favorable intraoperative data. Neff et al[17] reported 5 of 74 patients, and Mandpe et al[18] reported 10 of 38 patients with ST ≤ .05 with an HB grade III to VI at 1 year postoperatively. In our study, 7 of 12 patients with ST ≤ .05 achieved HB grade III and could be considered as "false-positives," but none of these cases reached worse results (V-VI). This discrepancy could be explained by the fact that only a subset of neuronal fibers needs to be functionally intact to provide a low threshold. In principle, only a single intact FN axon could produce a measurable EMG response at a low stimulation threshold but clearly would not mediate normal FN function.[18] The fact that our series includes only patients with immediate complete FP may also influence the number of "false-positives."

Facial Nerve Function Following Different Reconstruction Procedures

"Any facial nerve reconstruction procedure leads to maximum grade III." This affirmation was stated by the Gruppo Otologico, in Piacenza, Italy, who described 39 patients with FN interruption, followed by reconstruction during the original procedure. Two methods were adopted: 11 cases were reconstructed using end-to-end anastomosis and 28 cases by using graft interposition with sural nerve. Among the 11 cases of end-to-end anastomosis, 9 had final HB grade III function, and 2 had grade IV function. Considering the patients who underwent graft interposition, 19 had HB grade III function, 4 had grade IV, 2 had grade V, and 3 had grade VI. In 6 of the 9 patients, a hypoglossal-facial anastomosis was performed. Of these 6 patients, 2 recovered to HB grade III function and 4 to grade IV function.[5] King et al[19] showed similar results. They reviewed 18 nerves repaired in 17 patients (1 patient underwent bilateral repair). Six of the 18 nerve repairs were performed by end-to-end anastomosis; the other 12 nerves were repaired by grafts. No recovery occurred in 4 cases. Of 14 nerves showing recovery, 11 reached HB grades III or IV.[19] Our results are comparable to these publications; all patients included achieved a maximum HB grade III.

Techniques such as end-to-side donor graft interposition have proved to be effective and do not cause further damage to the facial nerve. They may avoid a second surgical procedure in patients who have a partial anatomic lesion and absence of electrical stimulation of the facial nerve after resection of tumors in the cerebellopontine angle. Celis-Aguilar et al[2] published in 2013 their experience at performing this technique in 4 patients. All patients achieved a good result after facial nerve reinforcement by 1 year of follow-up.

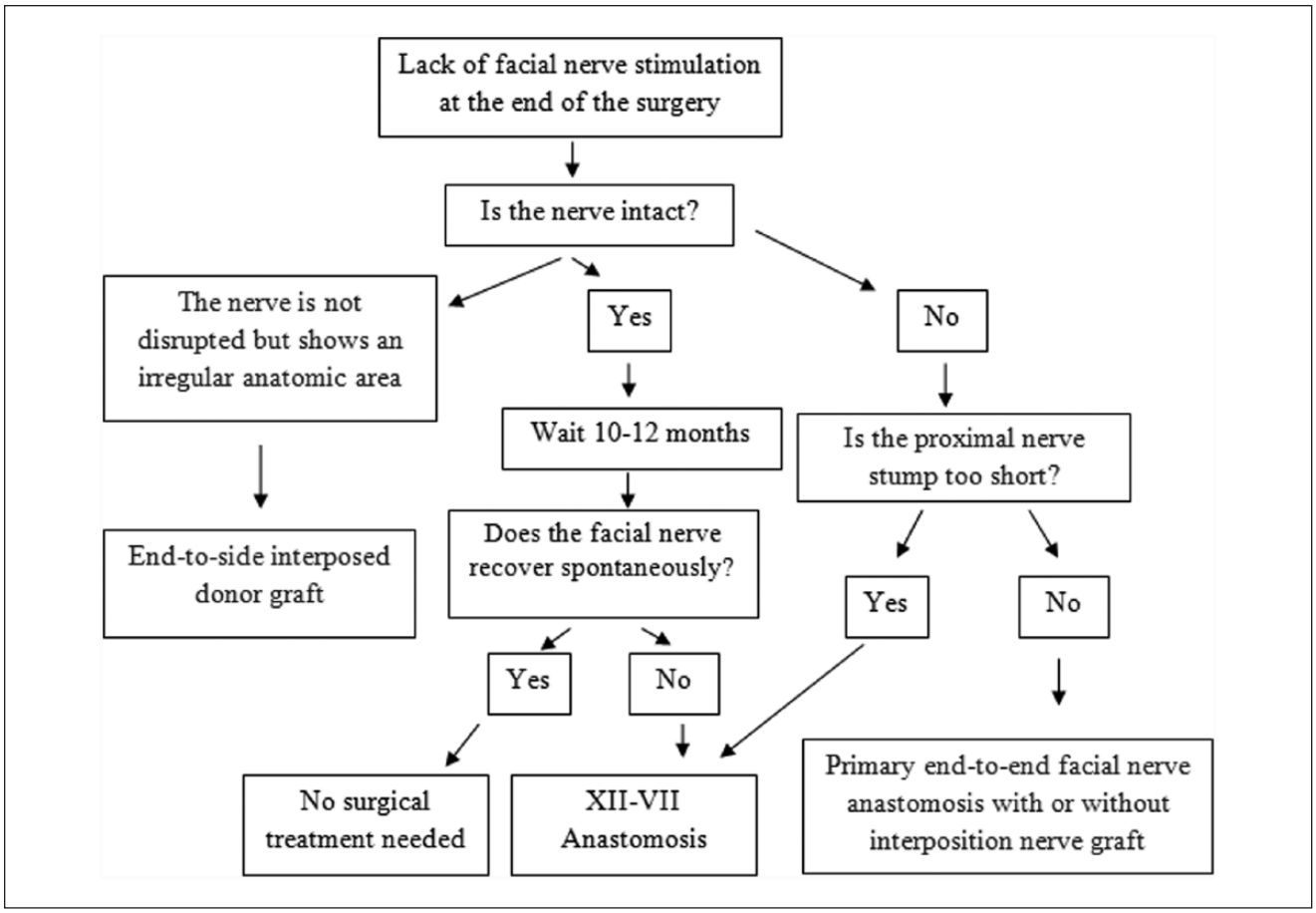

Figure 1. Decision-making algorithm.

Timing of Facial Nerve Repair

Decision making for treatment of complete facial paralysis secondary to acoustic neuroma resection depends on the degree of the nerve injury. If there is evidence of complete anatomic disruption of the nerve, reconstruction should be performed as soon as possible. In 1990, Sunderland[20] summarized 40 years of clinical experience in nerve repair demonstrating that early repairs are better than late ones. Grinsell and Keating[21] also demonstrated that early nerve repair results in improved functional outcome. There is an accepted window period of 12 to 18 months for muscle reinervation before irreversible motor end plate degeneration occurs. Jonsson et al[22] demonstrated that one of the main limiting factors to target reinnervation and recovery after delayed repair is the degeneration of the distal stump leading to the death of Schwann cells and fibrosis. We propose a decision-making algorithm in Figure 1.

Poor Results Justify New Early Procedures

Given the psychological and quality-of-life implications of patients with complete facial paralysis in the context of the AN surgery and based on our results, we believe that patients with complete facial paralysis should be counseled about early reinervation techniques. One of these is the association between the hemi-hypoglossal-facial technique and the cross-face nerve grafting, which is a reconstructing procedure to obtain emotional controlled smile. The increased tone, improved symmetry, and possibility for purposeful movement of the face are incentives for using this method as demonstrated in cases published using this technique.[23-27]

Conclusions

In this study, we have reported the long-term facial function of a series of 50 cases of AN surgery with an immediate postoperative complete paralysis in 4 different scenarios. We conclude that these cases do not return to HB grade I and only infrequently obtain HB grade II. The most common outcome of these patients is an HB grade III or IV, and any facial nerve reconstructions leads to maximum HB grade III.

Despite the acceptable functional results, we need further techniques that allow the patient to reach facial symmetry. Due to the complexity of the pathology and the quality-of-life implications of these patients, the best way to make an integral management is through multidisciplinary facial paralysis units.

Declaration of Conflicting Interests

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References

1. Coca Pelaz A, Fernández LC, Gómez JR, Rodrigo JP, Llorente JL, Suárez C. [Complete facial palsy following surgery for acoustic nerve neurinoma: evolution and associated ophthalmological complications]. *Acta Otorrinolaringológica Esp*. 2008;59(5):223-227.
2. Celis-Aguilar E, Lassaletta L, Roda JM, Gavilán J. End-to-side interposed donor grafting as a facial nerve reinforcement technique after vestibular schwannoma surgery. *Ann Otol Rhinol Laryngol*. 2013;122(8):520-523.
3. Giordano AI, Domènech I, Torres A, et al. [Results in the surgical treatment of giant acoustic neuromas]. *Acta Otorrinolaringológica Esp*. 2012;63(3):194-199.
4. Mamikoglu B, Wiet RJ, Esquivel CR. Translabyrinthine approach for the management of large and giant vestibular schwannomas. *Otol Neurotol*. 2002;23(2):224-227.
5. Falcioni M, Fois P, Taibah A, Sanna M. Facial nerve function after vestibular schwannoma surgery. *J Neurosurg*. 2011;115(4):820-826.
6. Carlson ML, Van Abel KM, Schmitt WR, Driscoll CL, Neff BA, Link MJ. The anatomically intact but electrically unresponsive facial nerve in vestibular schwannoma surgery. *Neurosurgery*. 2012;71(6):1125-1130.
7. Kunihiro T, Kanzaki J, Shiobara R, Inoue Y, Kurashima K. Long-term prognosis of profound facial nerve paralysis secondary to acoustic neuroma resection. *ORL J Otorhinolaryngol Relat Spec*. 1999;61(2):98-102.
8. Samii M, Koerbel A, Safavi-Abbasi S, Di Rocco F, Samii A, Gharabaghi A. Using an end-to-side interposed sural nerve graft for facial nerve reinforcement after vestibular schwannoma resection. Technical note. *J Neurosurg*. 2006;105(6):920-923.
9. Marin P, Pouliot D, Fradet G. Facial nerve outcome with a peroperative stimulation threshold under 0.05 mA. *Laryngoscope*. 2011;121(11):2295-2298.
10. Lassaletta L, Gavilán J. [An update on the treatment of vestibular schwannoma]. *Acta Otorrinolaringológica Esp*. 2009;60(2):131-140.
11. Wang M, Jia D, Shen J, Zhang J, Li G. Facial nerve function after large cystic vestibular schwannomas surgery via the retrosigmoid approach. *Turk Neurosurg*. 2013;23(2):161-169.
12. Espahbodi M, Carlson ML, Fang T-Y, Thompson RC, Haynes DS. Small vestibular schwannomas presenting with facial nerve palsy. *Otol Neurotol*. 2014;35(5):895-898.
13. Seo J-H, Jun B-C, Jeon E-J, Chang K-H. Predictive factors influencing facial nerve outcomes in surgery for small-sized vestibular schwannoma. *Acta Otolaryngol (Stockh)*. 2013;133(7):722-727.
14. Jain Y, Falcioni M, Agarwal M, Taibah A, Sanna M. Total facial paralysis after vestibular schwannoma surgery: probability of regaining normal function. *Ann Otol Rhinol Laryngol*. 2004;113(9):706-710.
15. Axon PR, Ramsden RT. Intraoperative electromyography for predicting facial function in vestibular schwannoma surgery. *Laryngoscope*. 1999;109(6):922-926.
16. Grayeli AB, Guindi S, Kalamarides M, et al. Four-channel electromyography of the facial nerve in vestibular schwannoma surgery: sensitivity and prognostic value for short-term facial function outcome. *Otol Neurotol*. 2005;26(1):114-120.
17. Neff BA, Ting J, Dickinson SL, Welling DB. Facial nerve monitoring parameters as a predictor of postoperative facial nerve outcomes after vestibular schwannoma resection. *Otol Neurotol*. 2005;26(4):728-732.
18. Mandpe AH, Mikulec A, Jackler RK, Pitts LH, Yingling CD. Comparison of response amplitude versus stimulation threshold in predicting early postoperative facial nerve function after acoustic neuroma resection. *Am J Otol*. 1998;19(1):112-117.
19. King TT, Sparrow OC, Arias JM, O'Connor AF. Repair of facial nerve after removal of cerebellopontine angle tumors: a comparative study. *J Neurosurg*. 1993;78(5):720-725.
20. Sunderland S. The anatomy and physiology of nerve injury. *Muscle Nerve*. 1990;13(9):771-784.
21. Grinsell D, Keating CP. Peripheral nerve reconstruction after injury: a review of clinical and experimental therapies. *BioMed Res Int*. 2014;2014:698256.
22. Jonsson S, Wiberg R, McGrath AM, et al. Effect of delayed peripheral nerve repair on nerve regeneration, Schwann cell function and target muscle recovery. *PloS One*. 2013;8(2):e56484.
23. Yamamoto Y, Sasaki S, Sekido M, et al. Alternative approach using the combined technique of nerve crossover and cross-nerve grafting for reanimation of facial palsy. *Microsurgery*. 2003;23(3):251-256.
24. Yoleri L, Songür E, Mavioğlu H, Yoleri O. Cross-facial nerve grafting as an adjunct to hypoglossal-facial nerve crossover in reanimation of early facial paralysis: clinical and electrophysiological evaluation. *Ann Plast Surg*. 2001;46(3):301-307.
25. Lee EI, Hurvitz KA, Evans GRD, Wirth GA. Cross-facial nerve graft: past and present. *J Plast Reconstr Aesthetic Surg JPRAS*. 2008;61(3):250-256.
26. Endo T, Hata J, Nakayama Y. Variations on the "baby-sitter" procedure for reconstruction of facial paralysis. *J Reconstr Microsurg*. 2000;16(1):37-43.
27. Frey M, Giovanoli P, Michaelidou M. Functional upgrading of partially recovered facial palsy by cross-face nerve grafting with distal end-to-side neurorrhaphy. *Plast Reconstr Surg*. 2006;117(2):597-608.