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Intra-operative facial nerve monitoring. Its predictive value after skull base surgery

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Abstract

Purpose: Facial nerve monitoring can be used to predict post-operative facial function after skull base surgery. In this study three methods of prediction of facial function were compared. These methods utilize various parameters of the evoked electromyographic monitoring.

Material and methods: Twenty-three patients who underwent surgery for skull base diseases were retrospectively reviewed. Amplitude of ongoing electromyographic activity, stimulation current thresholds and amplitude of evoked response were analysed. The predictive value of the three methods was correlated with post-operative facial nerve function.

Results: The method that used only the stimulation thresholds predicted the final post-operative facial function in 86.9 per cent of the patients. The second employed a mathematical ratio which combined the amplitude of evoked response and the stimulation current thresholds and confirmed the prediction of the facial function in 91.3 per cent of the patients. The last method does not consider the stimulation thresholds greater than 0.05 mA and failed to predict the final VIIth nerve function in patients in whom the stimulation was greater than 0.05 mA.

Conclusion: Analysis of prognostic value demonstrates that the first two methods had the smaller degree of variation showing the better sensitivity.

Key words: Facial nerve; Monitoring, physiological; Skull base, surgery

Introduction

Intra-operative facial nerve monitoring provides a significant contribution towards the preservation of post-operative facial function following cerebello-pontine angle surgery (Delgado *et al.*, 1979; Lye *et al.*, 1982; Moller and Jannetta, 1984; Kartush *et al.*, 1985; Prass and Luders, 1986; Benecke *et al.*, 1987; Prass *et al.*, 1987; Harner *et al.*, 1988; Silverstein *et al.*, 1988; Kartush *et al.*, 1991; Magliulo *et al.*, 1994a). This system is used also to predict neural integrity at the end of the operation. Only a few papers have reported on this topic (Beck *et al.*, 1991; Kirkpatrick *et al.*, 1991; Berges *et al.*, 1993; Silverstein *et al.*, 1994). Kirkpatrick *et al.* (1991) predicted the final post-operative facial function in a group of small acoustic neuromas. However, no attempt was made to correlate the post-operative facial outcomes with the intra-operative monitoring parameters and the prediction failed in the large tumour group. Beck *et al.* (1991) produced excellent immediate facial results studying the electromyographic (EMG) response amplitude to a 0.05 mA stimulation and the magnitude of ongoing EMG activity. They observed a certain degree of variability in the distribution of the cases. Berges *et al.* (1993) were able to assign a predictive ability to a mathematical ratio including the stimulation thresholds and the amplitudes of EMG response measured at the brainstem and the internal auditory canal. Silverstein *et al.* (1994) determined the lowest current thresholds to elicit facial muscle response in an effort to evaluate their potential predictive value.

To our knowledge, these methods were not applied to predict the immediate and final post-operative facial function following skull base lesion resection.

The purpose of this report is to compare the sensitivity of the methods suggested by Beck *et al.* (1991), Berges *et al.* (1993) and Silverstein *et al.* (1994) in predicting the facial function after surgery of skull base diseases. This study reviews 23 patients focusing upon guidelines to improve their accuracy.

Materials and methods

The cases of 23 patients who underwent surgery for lesions in the lateral skull base between 1990 and 1994 at the Second and Fourth ENT Clinics, University 'La Sapienza' Rome, were retrospectively reviewed. The group analysed consisted of 14 women and nine men ranging in age from 21 to 71 years (mean age 45.3 years).

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TABLE I
DISTRIBUTION OF THE POST-OPERATIVE FACIAL FUNCTION ACCORDING TO THE HOUSE-BRACKMANN CLASSIFICATION

	Post-operative facial function	
	Acute (10 days)	Final (1 year)
House-Brackmann Grades		
I	7 (30.4%)	10 (43.5%)
II	8 (34.7%)	7 (30.5%)
III	3 (13%)	3 (13%)
IV	5 (21.7%)	3 (13%)
V	—	—
VI	—	—

The patients had lesions located in various regions of the lateral skull base and were operated on with anterior transposition of the facial nerve (infratemporal approach types A and B).

All of the patients benefited from the use of electomyographic (EMG) facial nerve monitoring (NIM-2). This two-channel device assesses simultaneously the EMG activity of the orbital orbicularis muscle and oral orbicularis muscle. The equipment includes a loudspeaker to allow the surgeon ongoing feedback and circuitry to reject cautery artifacts. A monopolar flush-tipped stimulator that delivered a constant current stimulus between 0.05 and 1 mA was used.

During general anaesthesia, muscle relaxant agents were administered only at intubation. The patients received no other paralytic medication afterwards in order not to alter evoked motor activity and to monitor the facial nerve reliably.

Three methods of predicting the facial nerve outcome during acoustic neuroma surgery were evaluated and compared.

The first method utilized the intra-operative train pattern recorded for more than 30 seconds. Beck *et al.* (1991) considered only amplitudes greater and lesser than 500 microvolts. Another parameter evaluated was the EMG response amplitude (more or less than 500 microvolts) of the orbicularis oris muscle using a fixed stimulation intensity of 0.05 mA after tumour excision.

Berges *et al.* (1993) employed a mathematical ratio defined by the formula $R = R'/R''$. R' and R'' compare the stimulation intensity (I) and the amplitude (A) of evoked responses taken respectively at the level of the cerebellopontine angle (CPA) and internal auditory canal (IAC) ($R' = I$ (CPA/A (CPA); $R'' = I$ (IAC)/A (IAC)). In the present study this ratio was modified and R' and R'' are respectively measured at the proximal and distal uncovered facial nerve segments.

The third method (Silverstein *et al.*, 1994) examines the facial nerve stimulation current thresholds that produce a muscle contraction. Post-operative facial nerve function at 10 days and one year after surgery using the House-Brackmann classification (1985) was correlated with the findings obtained by these three predictive methods. Statistical significance was calculated with multiple Chi-squared tests.

Results

In Table I the post-operative facial nerve function at 10 days and one year after surgery is summarized.

Fifteen patients (65.1 per cent) of the acute facial nerve function group showed a Grade I or II facial nerve dysfunction compared with 17 (74 per cent) of the final facial nerve function group. Facial nerve dysfunction (Grade III or IV) was achieved respectively by 34.9 per cent and 26 per cent of the acute and final facial nerve function groups. No patients fell into the Grade V or Grade VI (poor or no function).

In Table II the prognostic value of the method devised by Beck *et al.* (1991) is compared with the post-operative facial function. The patients were

TABLE II
DISTRIBUTION OF THE ACUTE AND FINAL POST-OPERATIVE FACIAL FUNCTION ACCORDING TO THE METHOD OF BECK *ET AL.*

	Post-operative facial function Acute (10 days)			
Groups	A	B	C	D
House-Brackmann Grades				
I	5 (27.7%)	—	1 (5.5%)	—
II	5 (27.7%)	1 (5.5%)	1 (5.5%)	—
III	—	—	1 (5.5%)	—
IV	—	1 (5.5%)	1 (5.5%)	2 (11.1%)
V	—	—	—	—
VI	—	—	—	—
	Final (1 year)			
Grades				
I	7 (38.8%)	—	1 (5.5%)	—
II	3 (16.6%)	1 (5.5%)	1 (5.5%)	—
III	—	—	2 (11.1%)	1 (5.5%)
IV	—	1 (5.5%)	—	1 (5.5%)
V	—	—	—	—
VI	—	—	—	—

Group A: ongoing EMG activity <500 microvolts and contraction >500 microvolts. Group B: ongoing activity >500 microvolts and contraction >500 microvolts. Group C: ongoing activity <500 microvolts and contraction <500 microvolts. Group D: ongoing activity >500 microvolts and contraction <500 microvolts.

TABLE III

DISTRIBUTION OF THE ACUTE AND FINAL POST-OPERATIVE FACIAL FUNCTION ACCORDING TO THE METHOD OF BERGER *ET AL.*

	Post-operative facial function Acute (10 days)	
	R<2	R>2
House-Brackmann Grades		
I	7 (30.4%)	—
II	7 (30.4%)	1 (4.3%)
III	—	3 (13%)
IV	1 (4.3%)	4 (17.3%)
V	—	—
VI	—	—
	Final (1 year)	
Grades		
I	10 (43.4%)	—
II	6 (26%)	1 (4.3%)
III	1 (4.3%)	2 (8.6%)
IV	—	3 (13%)
V	—	—
VI	—	—

divided into four categories: A, B, C and D. In Class A the patients had an ongoing EMG activity less than 500 microvolts and a contraction more than 500 microvolts. Class B demonstrated an ongoing EMG activity more than 500 microvolts and a contraction greater than 500 microvolts. The patients of class C had less than 500 microvolts of ongoing activity associated with a contraction less than 500 microvolts, while class D differed from the latter by having an ongoing activity greater than 500 microvolts.

Eighteen patients could be evaluated with this method. The remainder were not included because the stimulation intensity capable of inducing their contraction response was greater than 0.05 mA. Class A always showed excellent VIIth nerve function. The other classes demonstrated variable findings. Each class exhibited patients with excellent or moderate facial function, failing to predict correctly the immediate and final facial function in some patients.

In the method of Berger *et al.* (1993) (Table III), the ratio predicted the post-operative facial function more accurately. Only two patients did not correlate with this behaviour. In one patient, the R ratio was more than two and showed an acute and final post-operative facial function near to normal (Grade II). The patient with the ratio R<2 had immediate Grade IV facial function and recovered only a final Grade III.

Silverstein *et al.* (1994) studied the prognostic value of the minimal stimulation intensity necessary to induce EMG response analysing four ranges of thresholds (Group 1 0–0.1 mA; Group 2 0.11–0.2 mA; Group 3 0.21–0.3 mA; Group 4 >0.3 mA). The analysis of our series showed an acute and final normal or near normal (Grade I or II) facial function in the majority of the patients with an intensity of stimulation within 0.1 mA. The thresholds more than 0.2 mA was observed essentially in the moderate (Grade III or IV) post-operative VIIth nerve function. The opposite trend was noted in only three patients. In one case, the threshold was within 0.1 mA, but the patient had a Grade IV facial function. The other two cases with intensity greater than 0.2 mA presented with a final Grade II.

Statistical analysis showed a significant difference ($p<0.05$) between final facial function and the four ranges of stimulation thresholds identified by Silverstein *et al.* (1994). This finding ($p<0.05$) was confirmed comparing the two ratios (R<2 and R>2) used by Berges *et al.* (1993) and the final post-operative facial function. The comparison between these two prognostic methods did not reach a significant difference.

TABLE IV

DISTRIBUTION OF THE ACUTE AND FINAL POST-OPERATIVE FACIAL FUNCTION ACCORDING TO THE METHOD OF SILVERSTEIN

	Post-operative facial function Acute (10 days)			
	1	2	3	4
House-Brackmann Grades				
I	7 (30.4%)	—	—	—
II	7 (30.4%)	1 (4.3%)	—	—
III	—	—	2 (8.6%)	1 (4.3%)
IV	1 (4.3%)	—	1 (4.3%)	3 (13%)
V	—	—	—	—
VI	—	—	—	—
	Final (1 year)			
Grades				
I	10 (43.4%)	—	—	—
II	4 (17.3%)	1 (4.3%)	1 (4.3%)	1 (4.3%)
III	—	—	1 (4.3%)	2 (8.6%)
IV	1 (4.3%)	—	1 (4.3%)	1 (4.3%)
V	—	—	—	—
VI	—	—	—	—

Stimulation thresholds: Group 1: 0–0.10 mA; Group 2: 0.11–0.2 mA; Group 3: 0.21–0.3 mA; Group 4: >0.3 mA.

Discussion

The prognostic utility of intra-operative facial nerve monitoring during neurotological, neurosurgical and skull base procedures has been suggested by numerous articles in the world literature (Delgado *et al.*, 1979; Lye *et al.*, 1982; Moller and Jannetta, 1984; Kartush *et al.*, 1985; Prass and Luders, 1986; Prass *et al.*, 1987; Harner *et al.*, 1988; Silverstein *et al.*, 1988; Benecke *et al.*, 1991; Kartush *et al.*, 1991; Magliulo *et al.*, 1994a). Adjunctive information is available on its potentially useful ability in predicting the facial nerve function at the end of acoustic tumour removal (Beck *et al.*, 1991; Kirkpatrick *et al.*, 1991; Berges *et al.*, 1993; Silverstein *et al.*, 1994). Various methods utilizing different parameters of the electromyographic activity have been described (Beck *et al.*, 1991; Berges *et al.*, 1993; Silverstein *et al.*, 1994).

Our study attempted to analyse the EMG predictive value in skull base diseases. It is well known that surgical techniques to remove these lesions require re-routing of the VIIth nerve with a further risk for the neural integrity and a possible post-operative dysfunction of various degrees. Leonetti *et al.* (1989) demonstrated that the EMG monitoring system increased the chances of preserving the facial function thus reducing the incidence and severity of post-operative facial nerve deficits. Magliulo *et al.* (1994b) confirmed these observations.

In the present study, we compared three methods of predicting facial nerve function following skull base tumour resection using intra-operative facial nerve monitoring. Specifically, we evaluated the methods proposed by Beck *et al.* (1991), Berges *et al.* (1993) and Silverstein *et al.* (1994).

Although the limited numbers of our series do not allow definitive conclusions, comparison between the three methods shows that the mathematical ratio of Berges *et al.* (1993) and stimulation-current thresholds of Silverstein *et al.* (1994) can significantly anticipate the final outcome of facial function. We give a slight preference to the method of Berges *et al.* (1993) for its smaller incidence of variation in each group (even if not statistically significant).

It is undoubtable that a larger series could provide more detailed and valid information on this particular topic. Evaluation of the macroscopic appearance of the facial nerve according to Berges' experience could increase the sensitivity of this electrophysiological test. We believe that this information could also be obtained by determining the ongoing intra-operative EMG activity. Further analysis is under way to investigate this possibility.

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