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LONG-TERM RESULTS OF FACIAL NERVE FUNCTION AFTER ACOUSTIC NEUROMA SURGERY -CLINICAL BENEFIT OF INTRAOPERATIVE FACIAL NERVE MONITORING-

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KEY WORDS

intraoperative monitoring; acoustic neuroma; facial nerve function

ABSTRACT

The goals in acoustic neuroma surgery should be the total removal of tumor and preservation of facial nerve function. The aim of this study is to establish the benefit of intraoperative monitoring for the total removal of tumor and the long-term result of facial nerve function after surgery. Thirty-two patients, who were operated on between 1985 and 1995, were divided into two groups: an unmonitored (n=14) and a monitored (n=18) group. Postoperative facial nerve function was followed by a modified House-Brackmann grading (H&B) immediately (initial), and at 1 week, 1 month, 6 months and 1 year (final) after surgery. A final H&B grade of I/II was taken as the preservation of facial nerve function. Facial nerves were preserved anatomically in all cases. A total tumor removal was accomplished in 21% of unmonitored group and in 72% of monitored group patients. Final H&B (I/II) was achieved in 36% of unmonitored group and in 83% of monitored group patients. All 9 patients with initial H&B (I/II) had final H&B (I/II). None of 5 patients with initial H&B (V/VI) had final H&B (I/II). However, 3 patients showed late-recovery of facial weakness at 6 months after surgery. Eighteen patients with initial H&B (III/IV) had various degrees of final facial weakness. Among them, 12 patients showed early-recovery at 1 month after surgery. In conclusion, facial

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nerve monitoring during acoustic neuroma surgery is useful to improve the rates of total removal of tumor and functional preservation of facial nerve. We can expect final degrees of facial weakness by initial degrees in conjunction with sequential changes in postoperative facial weakness.

INTRODUCTION

Recent advances in skull base surgery have resulted in good outcome for the patient with acoustic neuroma. [2,3,13,16] The treatment goals in acoustic neuroma surgery should be the total removal of tumor and the preservation of facial nerve function. Intraoperative facial nerve monitoring is an essential tool not only for the mapping of facial nerve course but also for the assessment of intraoperative facial nerve function in acoustic neuroma surgery. [1,4,5,6,8,11,12,17,21,22,23] The appropriate surgical strategy for the individual patient must be scheduled to accomplish these goals. The main aim of this study is to establish the clinical benefit of intraoperative monitoring for the completeness of the tumor removal and the long-term result of facial nerve function after surgery by comparing groups of monitored and unmonitored patients.

CLINICAL MATERIALS AND METHODS

Patient population

We reviewed a series of 32 patients who underwent surgery at the Kobe University Hospital between 1985 and 1995. These patients included 18 men and 14 women. The age range was 30 to 76 years (mean, 53 years). The tumors were located on the left side in 19 and on the right side in 13 patients. The size of the 32 tumors was determined by measuring the maximum tumor diameter on preoperative MRI. All patients received preoperative CT and MRI with gadolinium enhancement. The 32 patients were treated with the two different surgical approaches (retrosigmoid or posterior transpetrosal) since 1985. The patients were divided into two groups: the unmonitored (14 cases) and monitored (18 cases) groups. The facial nerve function after surgery was sequentially followed by a modified House-Brackmann grading scale [7] (H&B) immediately (initial), and at 1 week, 1 month, 6 months and 1 year (final) after surgery. A final H&B grade of I/II was taken as the preservation of facial nerve function.

Surgical strategy

The surgical strategy for the individual patient with acoustic neuroma should be scheduled only when the advantages and limitations of various surgical approaches, as well as the tumor size and preoperative useful hearing, have been well considered. For the patients whose preoperative hearing is still good and whose tumors are less than 4 cm in size, a retrosigmoid approach can be selected with the goal of preserving hearing. For the patients with tumors larger than 4 cm in size, posterior transpetrosal approach should be selected irrespective of hearing status. In most cases of large tumors (> 3 cm), facial nerve becomes ribboned or splayed on the tumor surface during the facial nerve's course. A more careful and sharp dissection technique around the facial nerve is required to reduce surgical trauma because of the difficulty in separating the tumor from the facial nerve due to tumoral infiltration or reaction fibrosis. The lateral end of internal auditory meatus cannot be directly visualized through the retrosigmoid approach. A posterior transpetrosal approach is better than a retrosigmoid approach in such cases for reason of (1) the shorter access to the tumor from the lateral route, (2) identification of the facial nerve at the early stage of operation, and (3) the requirement of addressing the tumor in a wide and shallow operative field.

Intraoperative monitoring

Intraoperative facial nerve monitoring was performed in 18 patients by means of facial electromyographic evoked potentials (Fa-EMG) (Signal Processor 1100; NEC Co., Japan) and a mechanical pressure pick-up sensor with a loudspeaker. [9, 14, 19] The needle electrodes were placed into the orbicularis oris and oculi muscles prior to anesthesia. No muscle relaxants were administered during surgery. Two channels were used to separately record the lower and upper facial muscle activities. The train activity, which indicated the nerve impairment, was also followed by spontaneous Fa-EMG monitoring during surgery (Fig. 1). For electrical stimulation of facial nerve, a surgical bipolar forceps was used with a constant-current stimulation threshold between 0.5 and 2 mA. The forceps could be used alternatively as a coagulater or an electrostimulater of facial nerve under the control of a single foot switch connected to an original bipolar device including two electrical relays (Fig. 2). After the total tumor removal, we measured the amplitudes of the proximal compound muscle action potential (CMAP) of the facial nerve in the brainstem and of the distal CMAP in the internal auditory meatus (IAM) in 6 patients to estimate the precise individual postoperative facial nerve function.

Statistical analysis

Statistical analysis was tested by paired t test, with statistical significance set at the level of $p < 0.05$.

RESULTS

Total tumor removal

A total tumor removal was accomplished in 3 (21%) of 14 cases in the unmonitored group and in 13 (72%) of 18 cases in the monitored group (Table I). In all

Fig. 1. Intraoperative spontaneous EMG recording showing the train activity of facial nerve and indicating nerve impairment.

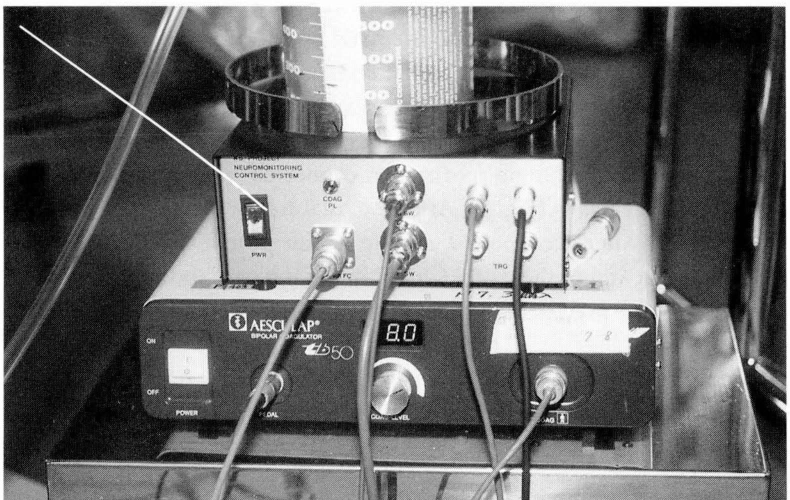

Fig. 2. A photograph of a original bipolar device including two electrical relays which can alternately be used as a bipolar coagulater or an electrostimulater under the control of a single foot switch.

cases, facial nerves were preserved anatomically after tumor removal. The total removal rate of the monitored group was significantly higher than that of the unmonitored group ($p<0.01$). Intraoperative facial nerve monitoring was helpful to identify the facial nerve course in the cerebellopontine angle during surgery. Therefore, a high rate of complete tumor removal could be accomplished using intraoperative monitoring.

Comparison of final facial nerve function between the monitored and unmonitored groups

In the unmonitored group, final H&B (I/II) was achieved in 5 (36%) of 14 patients. In monitored group, final H&B (I/II) was achieved in 15 (83%) of 18 patients (Table I). Intraoperative facial nerve monitoring can thus improve the preservation of facial nerve function ($p<0.01$).

Table I. Comparison of tumor size, total tumor removal, and preservation of facial nerve function.

	monitored (n=18)	unmonitored (n=14)
tumor size (cm)	3.1	2.5
total tumor removal (%)	72	21
preservation of facial nerve function (%)	83	36

Table II. Overall outcome of postoperative facial nerve function in 32 patients.

	Final function (H&B)		
Initial function (H&B)	I+II	III+IV	V+VI
I+II (n=9)	9	0	0
III+IV (n=18)	11	4	3
V+VI (n=5)	0	3	2

Facial nerve function was evaluated by House-Brackmann grading scales.
Initial function (H&B); 1 day after surgery, Final function (H&B); 1 year after surgery

Sequential changes of postoperative facial nerve function

The sequential change of postoperative facial nerve function was followed in each of the 32 patients. All of the 9 patients with initial H&B (I/II) had final H&B (I/II). None of the 5 patients with initial H&B (V/VI) had final H&B (I/II). However, 3 of 5 patients with initial H&B (V/VI) showed the late-recovery of facial nerve function at 6 months after surgery and had final H&B (III/IV). The 18 patients with initial H&B (III/IV) had various degrees of final postoperative facial nerve function; 11 patients had at final H&B (I/II), 4 (22%) patients remained final H&B (III/IV), and 3 (17%) patients had final H&B (V/VI). In the monitored group, 7 (78%) of 9 patients with initial H&B (III/IV) had final H&B (I/II). These results indicated that intraoperative facial nerve monitoring improved the recovery rate of facial nerve palsy. Twelve of 18 patients with initial H&B (III/IV) showed early-recovery of facial nerve function at 1 month after surgery and had final H&B (I/II) (Table II) (Fig. 3).

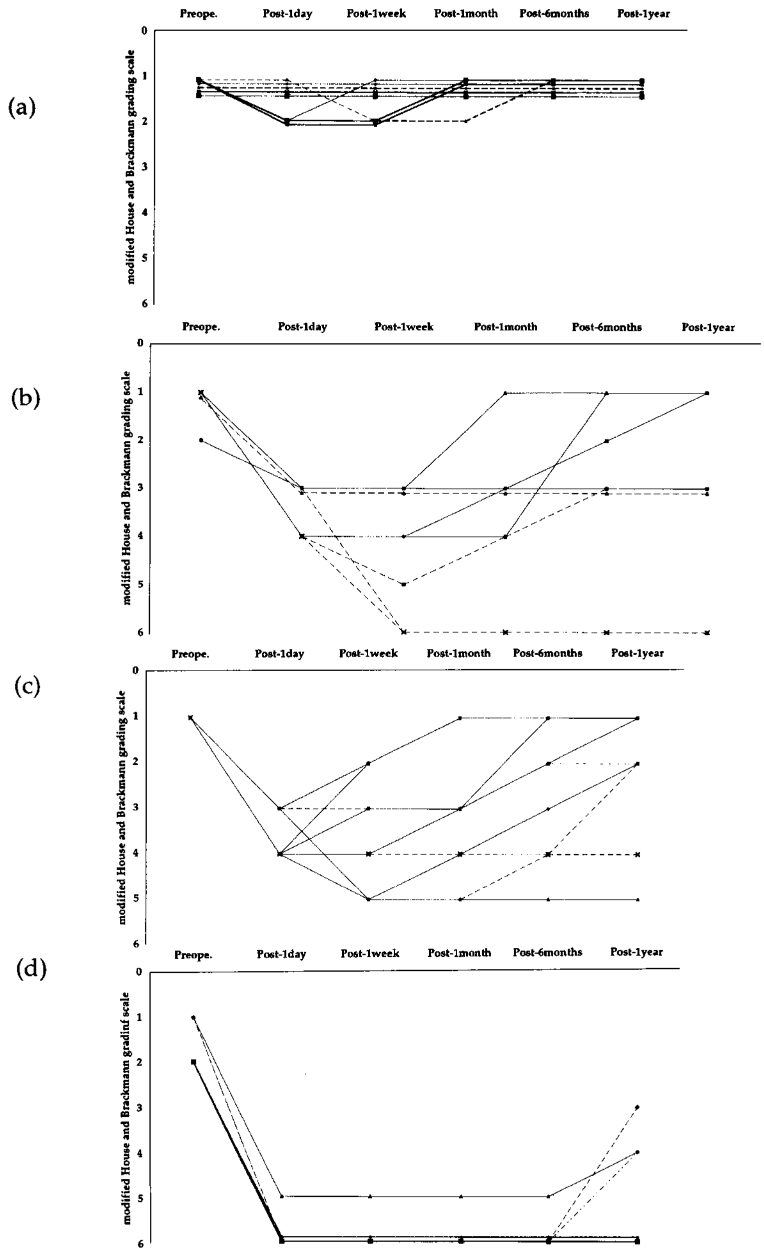

Fig. 3. The sequential changes of postoperative facial nerve function in 32 patients with initial postoperative facial nerve function: (a) H&B (I/II); (b) H&B (III/IV) without facial nerve monitoring; (c) H&B (III/IV) with facial nerve monitoring; and (d) H&B (V/VI).

Proximal-to-distal amplitude ratios of CMAP

Of the 6 tested patients, the proximal-to-distal amplitude ratios of CMAP were greater than 2:3 in 3 patients, between 1:3 and 2:3 in 3 patients, and less than 1:3 in no patients. The 3 patients with ratios greater than 2:3 had final H&B (I/II). Of the 3 patients with ratios between 1:3 and 2:3, 2 patients had final H&B (I/II) and one patient had final H&B (III/IV) (Table III) (Fig. 4).

Table III. Relationship between proximal-to-distal amplitude ratios and final facial nerve function in 6 patients.

Proximal-to-distal amplitude ratios	Final function (H&B)		
	I+II	III+IV	V+VI
>2:3	3	0	0
1:3~2:3	2	1	0
<1:3	0	0	0

Facial nerve function was evaluated by House-Brackmann grading scales.
Final function (H&B); 1 year after surgery

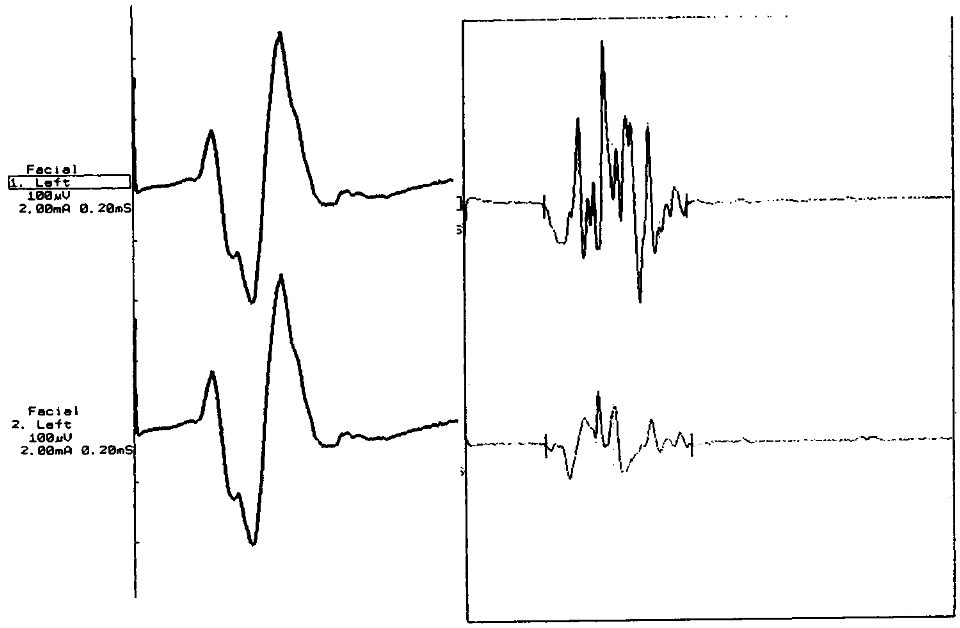

Fig. 4. Left, This patient with proximal-to-distal amplitude ratios greater than 2:3 elicited by facial nerve stimulation had final H&B (I). Right, This patient with proximal-to-distal amplitude ratios between 1:3 and 2:3 had final H&B (IV).

Comparison of the two surgical approaches in the monitored group

In the monitored group, final H&B (I/II) was achieved in 6 (75%) of the 8 patients who were treated by a retrosigmoid approach, and in 9 (90%) of the 10 patients treated by a posterior transpetrosal approach. There was no statistically significants difference between the two approaches in terms of preserving postoperative facial nerve function. However, the average tumor size resulting from the retrosigmoid approach was 20.3 mm and that resulting from the posterior transpetrosal approach was 40.6 mm (Table IV). These results indicate that satisfactory facial nerve function was obtained by a posterior transpetrosal approach in cases of large acoustic neuromas.

Table IV. Comparison of two surgical approaches in monitored group (n=18).

	posterior transpetrosal approach	retrosigmoid
tumor size (mm)	40.6	20.3
preservation of facial nerve function (%)	90	75

DISCUSSION

Total tumor removal and the preservation of facial nerve function should be the goal when dealing with acoustic neuroma, since long-term partial (H&B III/IV) or complete (H&B V/VI) facial nerve injury is a major impediment to the patient's quality of life. [2, 3, 13, 16, 18] Occasionally it can become extremely difficult to remove the last remaining tumor fragments from facial nerve. Because removal of such fragments can result in significant facial nerve injury, surgeons often hesitate to remove the tumor completely.

Clinical value of intraoperative monitoring

This comparative study establishes the clinical benefit of facial nerve monitoring during acoustic neuroma surgery, which improves the total tumor removal rate and the preservation rate of facial nerve function. Based on the present results, we conclude that intraoperative facial nerve monitoring should be used in acoustic neuroma surgery. There is a learning curve for the surgeon of acoustic neuroma surgery because the surgical technique has such a profound influence on the preservation of facial nerve function. Intraoperative facial nerve monitoring improves the learning curve. [3)] When unexpected facial nerve injury occurs during drilling of IAM and debulking of the tumor around the facial nerve, spontaneous Fa-EMG monitoring provides the surgeon with a real-time warning of facial nerve irritation, such that he or she may halt or change the surgical technique. [15)] The main purpose of intraoperative monitoring is to help surgeons confidently accomplish the treatment goals and avoid unexpected complications during surgery.

Overall outcome of final postoperative facial nerve function

In our series of 32 patients, 100% of patients with initial H&B (I/II) had final H&B (I/II); 61% of patients with H&B (III/IV) had final H&B (I/II), and no patient with initial H&B (V/VI) had final H&B (I/II). Certain tendencies were revealed in the recovery stage of facial nerve function, i.e., early-recovery in patients with initial H&B (III/IV) and late-recovery in patients with initial H&B (V/VI). By evaluating the initial facial nerve function and assessing the recovery stage of nerve function, we can confidently expect final postoperative facial nerve function.

Measurement of individual proximal-to-distal amplitude of facial CMAP during surgery

To estimate the final facial nerve function more precisely at the end of surgery, we measured the amplitudes of CMAP elicited by facial nerve stimulation at the proximal and distal sites in 6 patients. Taha et al. [20)] reported the correlation of proximal-to-distal amplitude ratios with facial nerve outcome in detail. In their study of 20 patients, 100% of patients with ratios greater than 2:3 had H&B (III) or better initial postoperative facial nerve function and had H&B (I) final postoperative facial nerve function. Ninety percent of patients with ratios between 1:3 and 2:3 had H&B (III) or worse initial postoperative facial nerve function and all had H&B (III) or better final postoperative facial nerve function. All patients with ratios less than 1:3 had H&B (IV) or worse initial and final postoperative facial nerve function. Our results are compatible with their study. Final postoperative facial nerve function for the individual patient can be expected by measuring the amplitude ratios of CMAP during surgery.

Surgical approach

The postoperative facial nerve function in acoustic neuroma surgery is highly dependent on tumor size. [3, 8, 10, 21)] Even with intraoperative monitoring, it is more difficult to preserve the facial nerve function in cases of large tumors than in cases of small one because with large tumors (>3cm) the facial nerve becomes ribboned or splayed on the tumor surface during the facial nerve's course. In order for large acoustic neuroma surgery to succeed, the facial nerve must be identified in the early stage of operation at a site distant from the tumor. Two major approaches, retrosigmoid and translabyrinthine, have been commonly used for acoustic neuroma surgery. [2, 16] Advantages of the retrosigmoid approach include (1) preservation of hearing, (2) wide exposure of the tumor, and (3) anatomy that is familiar to neurosurgeons. Disadvantages of the retrosigmoid approach include (1) requirement of cerebellum and brainstem retraction, (2) difficulty of exposing the intracanalicular portion of the tumor, and (3) reduced chances of preserving facial nerve function in the case of large tumor (>3cm). Advantages of the translabyrinthine approach include (1) shorter distance between the surface and the tumor, (2) absence of cerebellum and brainstem retraction, and (3) identification of the facial nerve early in the procedure. Disadvantages of this approach include (1) sacrifice of hearing, (2) reduced exposure of the tumor, and (3) anatomy that is unfamiliar to neurosurgeons. However, a posterior transpetrosal approach has great advantages of (1) shorter access to the tumor and facial nerve due to the more lateral route, (2) reduced retraction of the cerebellum and brainstem, and (3) realization of a wider and shallower operative field compared with those of the retrosigmoid or translabyrinthine approach. In our series of large tumors in the monitored group, 6 (86%) of 7 patients treated via a posterior transpetrosal approach had final H&B (I/II). These results indicate that the choice of an appropriate surgical strategy on a case-specific basis can result in a good outcome of postoperative facial nerve function in all tumor size.

CONCLUSIONS

In this review, we compared the long-term results of facial nerve function after acoustic neuroma surgery between monitored and unmonitored patients. Intraoperative facial monitoring is helpful for mapping the facial nerve course during surgery and for improving the rates of total removal of tumor and functional preservation of facial nerve. We can expect the final facial nerve function by evaluating the initial postoperative facial nerve function and by assessing the recovering stage of the nerve function.

The choice of an appropriate surgical strategy on a case-specific basis can result in good outcomes of total tumor removal and postoperative facial nerve function in all tumor sizes. A retrosigmoid approach can be used for the patients with preoperative useful hearing and with tumors less than 4 cm in size for the aim of preserving hearing function. A posterior transpetrosal approach is best selected for the patients with tumors larger than 4 cm irrespective of preoperative hearing status in order to accomplish the surgical goals (total tumor removal and preservation of facial nerve function).

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