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Original Article

Facial nerve electrical motor evoked potential in cerebellopontine angle tumors for its anatomical and functional preservation

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ABSTRACT

Background: Among the technical measures to preserve facial nerve (FN) function, intraoperative neuromonitoring has become mandatory and is constantly being scrutinized. Hence, to determine the efficacy of FN motor evoked potentials (FNMEPs) in predicting long-term motor FN function following cerebellopontine angle (CPA) tumor surgery, an analysis of cases was done.

Methods: In 37 patients who underwent CPA surgery, FNMEPs through corkscrew electrodes positioned at C5-C6 and C6-C5 (C is the central line of the brain as per 10–20 EEG electrode placement) were used to deliver short train stimuli and recorded from the orbicularis oculi, oris, and mentalis muscles.

Results: In 58 patients, triggered electromyography (EMG) was able to identify the FN during resection of tumor, but 8 out of these (4.64%) patients developed new facial weakness, whereas 3 out of 38 (1.11%) patients who had intact FN function MEP (decrement of FN target muscles – CMAPs amplitude peak to peak >50–60%), developed new facial weakness (House and Brackmann grade II to III).

Conclusion: The FNMEP has significant superiority over triggered EMG when tumor is giant and envelops the FN.

Keywords: Cerebellopontine angle tumors (CPA), Facial nerve motor evoked potential (MEP), Facial nerve preservation, Intraoperative neuromonitoring

INTRODUCTION

Skull base micro neurosurgery, especially of the cerebellopontine angle (CPA), puts the cranial nerves at risk, especially the facial nerve (FN). Among the technical measures to preserve FN function, intraoperative neuromonitoring (IONM) has become mandatory and is constantly being advanced.[6,16,17,23] At present, there are two main FN monitoring methods during CPA surgery: electromyography (EMG) and motor evoked potential (MEP).[12] The former is helpful in localizing the FN as well as predicting postoperative functioning whereas the latter can

predict postoperative function.[4,18] Direct electrical stimulation (triggered EMG) of the FN is the conventional approach for intraoperative electrophysiological mapping.[11,15] However, it can monitor the nerve segment only between the stimulation site and the recording electrode, and that too, not continuously. In addition, direct electrical stimulation may not be possible when the tumor completely envelopes the nerve. FN motor-evoked potential, which is being used in CPA surgeries,[7,10,12,20] is a noninvasive monitoring technique in which scalp electrodes stimulate the FN corresponding motor cortex which triggers compound muscle action potential (CMAP) in downstream muscles. An unattenuated waveform in target muscles indicates intact FN function.

In this study, we present our experience in the use of FNMEP in predicting FN functional integrity following CPA surgery.

MATERIALS AND METHODS

In this retrospective single-center study, we included all age patients who underwent IONM-guided CPA tumor surgery from April 2014 to December 2020 at the Sakra World Hospital, Bengaluru, India. All patients underwent monitoring with triggered electromyogram and spontaneous electromyogram for FN, out of which 37 underwent corticobulbar tract transcranial electrical MEP (CBT and TCeMEP), CBT, TCeMEP were recorded from upper and lower facial muscles. Standard demographic and clinical data were collected from all the enrolled patients. The preoperative House-Brackmann Grading scale was used to grade facial weakness. Retromastoid suboccipital craniotomy was done for all patients.

Total intravenous anesthesia was given. Neuromuscular block agents were used for intubation and omitted after that. Inhalational agent and neuromuscular blockade were avoided after intubation.

IONM was conducted using a Neuro Monitoring System (Medtronic Xomed, Jacksonville, FL, USA) NIM ECLIPSE E4 Version. CBT and TCeMEP were recorded using corkscrews electrode (DME1001 24K 1.2M CORKSCR ROHS Medtronic), which were placed according to 10–20 system interhemispheric CBT and TCeMEP montage C5-Anode-C6-Cathode, C6-Cathode-C5-Anode. This new term we used to define the location of the stimulating electrode. This is 10% of T3-C3, T4-C4 of 10–20 electro encephalography (EEG) electrode placement. To elicit the responses, we used a short train 2–3 pulses interstimulus interval ISI 1.2 ms, 75 μs pulse duration. The least current required of 90–110 Volt after wearing off of muscle relaxant to avoid the volume conduction from surrounding and other motor pathways. MEP responses were recorded from orbicularis oculi, orbicularis oris, and mentalis at the surgical site. A minimum amplitude of >50 μV with appropriate response latency was considered a reliable MEP response through twisted subdermal twisted-pair non-insulated straight needle electrodes (DSN2280 12K 27G 2.0M DL ROHS Medtronic). The recording conditions included a band-pass filter at 30–1500 Hz, with a 50 Hz Notch filter, and a Sweep speed of 5 ms/division window of 50 ms with autosensitivity.

RESULTS

The study conducted included a total of 95 patients, comprising 39 men and 56 women, with an average age of 45.75 years. These patients underwent surgery for CPA tumors between April 2014 and December 2020. The age range of the patients was quite diverse, spanning from 2 months to 77 years, reflecting the broad spectrum of individuals affected by such tumors.

During the surgical procedures, different monitoring techniques were employed to ensure the safety and integrity of the FN. In 37 patients, transcranial FNMEP (TcFNMEP) was utilized, whereas triggered EMG and other monitoring modalities were utilized in the remaining cases.

Among the 58 patients who had intact FN function, trigger EMG was performed on all individuals to identify the FN during tumor resection. However, it was noted that 8 out of these 58 patients (4.64%) developed new facial weakness postoperatively. Similarly, in the subset of 37 patients who underwent TcFNMEP monitoring, 3 patients (1.11%) experienced a decrement in FN target muscle compound muscle action potentials (CMAPs) amplitude peak to peak of more than 50–60%. Notably, this observation occurred despite using the same current range (110–150 V) during the intraoperative period.

Following the surgeries, all patients who experienced new facial weakness, regardless of the monitoring technique used, presented with weakness graded between II and III. However, encouragingly, all of these patients eventually recovered to their preoperative status within 6–8 months.

The demographic characteristics of the patients included in the study are detailed in Table 1, providing additional insight into the population under investigation. Furthermore, Table 2 summarizes the various types of surgeries performed where intraoperative neuromonitoring (IONM) was employed, highlighting the diversity of procedures and the importance of continuous monitoring to ensure optimal outcomes. Table 3 showing statistical analysis and type of anesthesia used during surgery.

Overall, the study underscores the significance of intraoperative monitoring techniques in safeguarding critical neural structures, such as the FN, during complex surgical procedures, ultimately contributing to improved patient outcomes and recovery.

Table 1: Demographic parameters.

Characteristic			Value		Percentage
Male			39		41.1
Female			56		58.9
			Age		
Valid	**Missing**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
95	0	45.75	15.840	2	77

Table 2: Types of lesion and procedure.

S. No.	Type of Lesion	Type of Procedure	Number of surgeries	Percent
1	CPA epidermoid	Retromastoid suboccipital craniotomy	1	1.1
2	Vestibular schwanomma	Retromastoid suboccipital craniotomy	61	64.2
3	Petroclival meningioma	Retromastoid suboccipitalcraniotomy	03	3.2
4	CPA and fourth ventricle ependymoma (WHO grade II)	Retromastoid suboccipital craniotomy	01	1.1
5	CPA abscess	Retromastoid suboccipital craniotomy	01	1.1
6	CPA meningioma	Retromastoid suboccipital craniotomy	13	13.7
7	CPA epidermoid	Retromastoid suboccipital craniotomy	08	8.4
8	Facial spasm	Retromastoid suboccipital craniotomy	03	3.2
9	CPA along trigeminal neuralgia	Retromastoid suboccipital craniotomy	02	2.1
10	Posterior fossa meningioma	Retromastoid suboccipital craniotomy	01	1.1
11	CPA SOL	Retromastoid suboccipital craniotomy	01	1.1
		Total	95	100.0

CPA: Cerebellopontine angle, SOL: Space occupying lesion

Statistical analysis

Table 3: Statistical analysis showing type of anesthesia used during surgery.

Anesthesia (1-GA, 2-Awake, 3-Local)		
Valid	**Frequency**	**Percentage**
01	95	100

DISCUSSION

Merton and Morton first reported an FNMEP elicited by transcranial electrical stimulation in 1980[13], and the FNMEP was applied in tumorectomy by Zhou *et al*. in 2001.[24]

This monitoring approach records the CMAP in the target muscle (orbicularis oculi, orbicularis oris, and mentalis) evoked by stimulating the FN motor cortex.[22] Transcranial electrical stimulation is less invasive than conventional direct electrical stimulation, and the FNMEP is considered to be closely associated with the postoperative FN function. In CPA tumorectomy, TcFNMEP can be applied for real-time evaluation of the FN function, facilitating the early identification of FN damage and promoting maximal safe resection of the CPA tumors with FN preservation.[1,24] The FNMEP has significant superiority when tumor is giant and envelops the FN.

The alarm criteria of FNMEP have yet to be established. Some scholars recommend a >50% reduction in amplitude as an indicator for predicting FN damage [Figure 1].[2,8]

In general, FN dysfunction immediately after surgery gradually resolves over the long term if the FN is anatomically preserved intraoperatively.[3,18,19,21] Even if a patient has complete facial palsy immediately after surgery for vestibular schwannoma, some improvement may well be seen 1 year after the operation.[19]

Electromyographic activity occurs only at the time of direct irritation of the FN, while the absence of EMG activity may indicate a structurally and functionally intact nerve or a total loss of nerve function.[5]

EMG monitoring and triggered CMAP are not always satisfactory and not always predictive of FN function.[8,14] Stimulation through a millimeter of cerebral-spinal fluid or blood or identification of the exact location of stimulation (brainstem versus nerve root entry zone versus 1 mm distal on the nerve) is not readily reproducible, especially in large tumors where the nerve is significantly effaced. The trauma caused by probing for the FN with a nerve-stimulating probe may be counterproductive to FN preservation. Sequential use of facial MEP during different stages of cranial base surgery can detect damage to the nerve early, allowing separation of injury that may occur during the approach

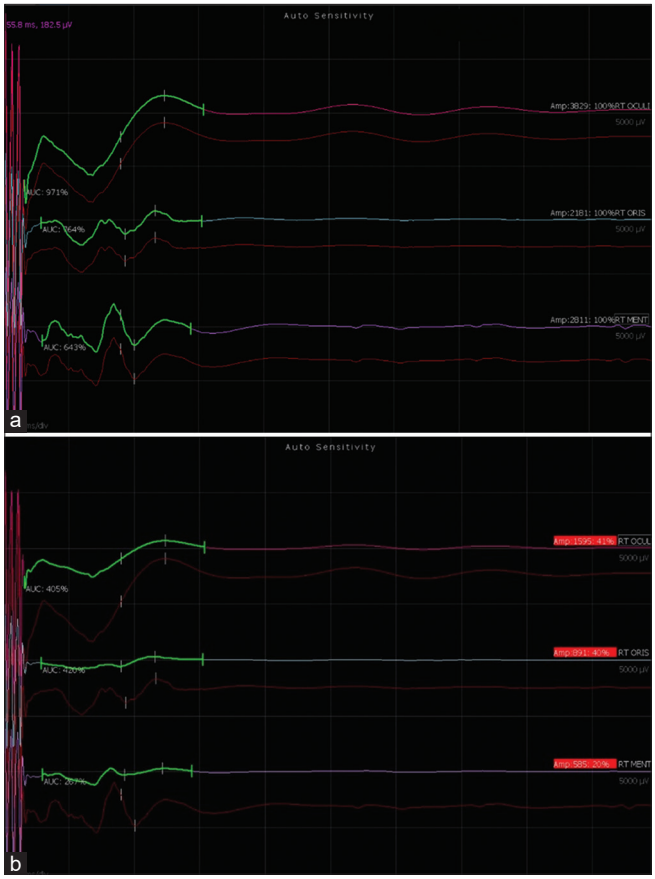

Figure 1: During the case of acoustic schwannoma amplitude of corticobulbar tract, transcranial electrical motor evoked potential dropped while resecting the tumor at cerebellopontine angle: (a) a baseline trace, (b) showed dropped cranial nerves compound muscle action potentials (CMAPs) amplitude >50%.

(i.e., drilling) versus intracranial dissection, assisting in self-evaluation and quality control during these procedures. A fall in MEP alerts the surgeon to change his plane of dissection and return to the original part once the MEP recovers.

In our center, we have used TcFNMEP as a complementary modality to direct nerve stimulation (triggered EMG) in our endeavor to preserve the FN during CPA tumor resection. Triggered EMG helps more in localizing the FN and predicting immediate nerve function, while FNMEP helps in monitoring the anatomical continuity of the nerve and also predicts long-term FN function.

In three of our patients, an intra-operative drop of more than 50% from baseline FNMEP was observed. Each of them developed House-Brackmann grade I-II facial weakness in the immediate postoperative period. However, at 6-month follow-up, all of them regained their preoperative FN functional status.

CONCLUSION

FN MEP is an emerging technique in the field of intra-operative neuromonitoring for CPA tumor surgery. When used judiciously in conjunction with triggered EMG, it can play a pivotal role in intra-operatively localizing the FN and predicting long-term FN function.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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