# Predictive Value of Intraoperative Facial Motor Evoked Potentials in Vestibular Schwannoma Surgery Under 2 Anesthesia Protocols

*Miao Ling[1], Xiaorong Tao[1], Siyuan Ma[1], Xiaocui Yang[1], Li Liu[1], Xing Fan[1], Guijun Jia[2], Hui Qiao[1]*

■ OBJECTIVE: **We sought to validate the feasibility of facial motor evoked potential (FMEP) in facial nerve (FN) monitoring during vestibular schwannoma (VS) surgery under 2 anesthesia protocols and to examine its value for postoperative prognosis.**

■ METHODS: **This prospective study included 106 patients with VS who underwent microsurgical excision between May 2014 and November 2016 at the Beijing Tiantan Hospital, Capital Medical University, China. All patients were investigated for FMEP elicited by transcranial electrical stimulation in the contralateral facial motor cortex. The patients randomly received total intravenous anesthesia or combined intravenous—inhalation anesthesia. Postoperative FN function was evaluated 7—10 days after surgery (short-term) and at the last follow-up (long-term) using the House-Brackmann (HB) grading system. HB grades 1 and 2 were deemed satisfactory, whereas HB grades 3—6 were deemed unsatisfactory. The value of the final-to-start FMEP ratio for predicting short-term and long-term postoperative FN functions was examined.**

■ RESULTS: **Valid FMEPs were obtained in 97 patients, which were recorded from the mentalis muscle. The FMEP amplitude ratio was significantly correlated with short-term and long-term postoperative FN functions. Receiver operating characteristic curve analysis showed that the FMEP ratio cut-off values of 77.4% (area under the curve = 0.797) and 56.9% (area under the curve = 0.900) predicted satisfactory FN function 7—10 days after surgery and at the last follow-up, respectively. No statistically significant difference was found in FMEP quantitative parameters between the 2 anesthesia protocols.**

■ CONCLUSION: **The FMEP amplitude ratio is a valuable predictor for postoperative FN function. FMEP ratio ≥57% is predictive of satisfactory long-term FN function.**

## INTRODUCTION

Given the close anatomic relationship between facial nerve (FN) and vestibular nerve, vestibular schwannoma (VS) surgery carries a high risk to the FN.[1] With the development of microsurgery and intraoperative neurophysiologic monitoring, the incidence of nerve injury has significantly decreased.[2,3] In 1898, intraoperative neurophysiologic monitoring of the FN was introduced by Dr. Fedor Krause. Traditional FN monitoring methods during VS surgery include continuous electromyography (EMG) and intermittent direct electrical stimulation (DES).[4] In 1979 Delgado et al[5] highlighted the advantages of using continuous EMG to identify FN and facilitate tumor resection during VS surgery. Continuous EMG monitoring of FN was used

**Key words**
- Facial motor evoked potential
- Facial nerve
- Final-to-start ratio
- Predictive factor
- Vestibular schwannoma

**Abbreviations and Acronyms**
**AUC**: Area under the curve
**CI**: Confidence interval
**CIVIA**: Combined intravenous—inhalation anesthesia
**CMAP**: Compound muscle action potentials
**DES**: Direct electrical stimulation
**EMG**: Electromyography
**FMEP**: Facial motor evoked potential
**FN**: Facial nerve
**HB**: House-Brackmann
**ISI**: Interstimulus interval
**MAC**: Minimum alveolar concentration
**MEP**: Motor evoked potential
**ROC**: Receiver operating characteristics
**SD**: Standard deviation
**TES**: Transcranial electrical stimulation
**TIVA**: Total intravenous anesthesia
**VS**: Vestibular schwannoma

*From [1]Beijing Neurosurgical Institute and [2]Beijing Tiantan Hospital, Capital Medical University, Beijing, China*

*To whom correspondence should be addressed: Hui Qiao, M.D.; Guijun Jia, M.D. [E-mail: jiaguijun@cssc.net.cn; hqiao1215@sina.com]*

*Citation: World Neurosurg. (2017). https://doi.org/10.1016/j.wneu.2017.12.029*

*Journal homepage: www.WORLDNEUROSURGERY.org*

*Available online: www.sciencedirect.com*

to detect neurotonic discharge caused by FN mechanical or metabolic irritation during tumor resection. One exclusive pattern of discharge, the "A train," presented as sudden-onset, symmetric sequence and was proven to be an indicator of increasing risk on FN and was highly correlated with FN dysfunction.[6] However, the association between the extent of nerve injury and the presence of neurotonic discharge remains unknown. Moreover, mechanical irritations of the distal nerve stump may provoke EMG activities in sharp transected FN.[7] Triggered EMG, another FN monitoring technique, detects compound muscle action potentials (CMAP) evoked by DES along the FN through recording electrodes inserted in the ipsilateral facial muscles. It is an effective assessment method for FN functional status and correlated with postoperative FN outcomes.[8,9] Nevertheless, triggered CMAP can only be stimulated intermittently by the surgeon after visualization of the nerve at the root exit zone, which is extremely difficult in patients with distorted brainstem and displaced nerve due to large tumors. Moreover, visualization of the proximal FN may not be possible in the early steps of surgery.

Muscle motor evoked potential (MEP) was first proposed by Merton and Morton in 1980.[10] They elaborated a method for obtaining MEP from the limbs through transcranial electrical stimulation on the scalp of normal subjects. Currently, MEP is routinely applied in intraoperative monitoring. The existence of muscle MEP confirms the continuity of whole motor pathways including motor cortex, corticospinal tract, alpha motor neurons, peripheral nerve, and neuromuscular junction.[11] The technique of transcranial electric facial motor evoked potential (FMEP) was first proposed as a combination with EMG monitoring by Dong et al[12] in 2005, who illustrated the detailed protocol of FMEP including the stimulus and recording parameter settings. They also uniquely demonstrated the value of FMEP for predicting postoperative FN function. Similar studies were subsequently reported, and the usefulness of FMEP as an adjunct to traditional FN monitoring technique during VS surgery was validated.[13-15] FMEP monitors the function of facial motor pathways across the lesion and dissection site and assesses the FN functional status before its identification, which is independent of surgeons.

Despite these advantages, the utility of FMEP in FN monitoring remains undetermined. The objective of this study was to validate the feasibility of FMEP in FN monitoring during VS surgery and identify its prognostic value for FN functional outcome.

## PATIENTS AND METHODS

### Patients

This study was approved by the Medical Ethics Committee of the Beijing Tiantan Hospital, Capital Medical University, and written informed consent was obtained from all participants. A total of 106 patients with VS, American Society of Anesthesiologists physical statuses I–II, who were scheduled to undergo microsurgical excision via the retrosigmoid approach at the Beijing Tiantan Hospital, Capital Medical University between May 2014 and November 2016, were enrolled in this study. All the patients were treated by 1 surgical team. The removal extent was based on intraoperative judgment and postoperative magnetic resonance imaging. Data of these patients were prospectively collected.

The following criteria were used for patient selection:
Inclusion criteria:

- Consecutive patients with sporadic VS undergoing microsurgical excision via retrosigmoid approach by one team of surgeons.

Exclusion criteria:

- Patients who underwent another surgical approach
- Patients with a history of epilepsy
- Patients with implanted brain stimulation electrodes, stimulators, or pacemakers
- Patients with neurofibromatosis type II
- Previous radiotherapy
- Incomplete postoperative facial function data

### Anesthesia Management

Total intravenous anesthesia (TIVA) with propofol and opioids is frequently used for intraoperative monitoring. However, some anesthesiologists prefer to use low-dose halogenated anesthetics.[16] The use of an inhalational agent with intravenous anesthetics may be advantageous in patients with opioid tolerance because the halogenated agents work through synaptic mechanisms that differ from the opioids.[17] Some reports revealed that a low-concentration inhalational agent could be used in spinal cord surgery.[16,18] The use of TIVA versus combined intravenous–inhalation anesthesia (CIVIA) in FMEP monitoring has not yet been systematically studied.

The patients were randomized to receive either TIVA or CIVIA with sevoflurane. TIVA was induced with intravenous propofol, sufentanil, and rocuronium and maintained with remifentanil and propofol by a target-controlled infusion pump. CIVIA was induced with the same anesthetic agents as TIVA but additionally adopted sevoflurane inhalation. The concentration of inhaled drug was controlled at the minimum alveolar concentration (MAC) of 0.3–0.5,[19] and the MAC values of each patient were consistent throughout the surgery. Muscle relaxants were avoided after anesthesia induction and intubation in both anesthesia protocols.

### Intraoperative Monitoring

Standard monitoring techniques were continuously applied in all cases, such as brainstem auditory evoked potential, somatosensory evoked potential, and EMG. For EMG monitoring, the conventional setup for VS surgery consisted of trigeminal nerve and FN, which was recorded in ipsilateral masseter, orbicularis oris, orbicularis oculi, and mentalis muscles by 2 subdermally placed monopolar needle electrodes (NE-T-2000, Xi'an Friendship Medical Electronics Co., Ltd., Xi'an, China). These needle electrodes were also used for recording CMAP evoked by intermittent nerve DES for identifying the FN, assessing the functional status, and mapping the FN location during tumor resection. In the continuous EMG, the A-train, which presented as a sinusoidal pattern with the symmetrical sequence of mono to triphasic discharges (typical amplitudes 100–200 μV; frequency 100–200 Hz), was