# The Effects of Combined Intraoperative Monitoring of Abnormal Muscle Response and Z-L Response for Hemifacial Spasm

*Xin Zhang, Hua Zhao, Yin-Da Tang, Jin Zhu, Ping Zhou, Yan Yuan, Shi-Ting Li*

BACKGROUND: **Microvascular decompression (MVD) is the most effective treatment for hemifacial spasm (HFS). During MVD surgery, abnormal muscle response (AMR) is widely used. Z-L response (ZLR) is a new monitoring method for HFS. We compared the effectiveness of AMR plus ZLR and simple AMR.**

METHODS: **In a retrospective study of 1868 cases of HFS treated using intraoperative monitoring between January 2013 and December 2015, 896 patients underwent simple AMR monitoring and 972 underwent combined intraoperative monitoring of AMR and ZLR.**

RESULTS: **AMR waveforms were observed in 837 (93.42%) patients in the AMR group and in 898 (92.39%) patients in the AMR plus ZLR group ($P > 0.05$). During MVD, AMR waveforms disappeared in 772 patients in the AMR group and 854 patients in the AMR plus ZLR group ($P < 0.05$). The efficacy rate of MVD in the AMR plus ZLR group was higher compared with the AMR group when AMR was not detected or disappeared during the operation ($P < 0.05$). When AMR persisted during the operation, there was no significant difference between the 2 groups in efficacy of the operation ($P > 0.05$).**

CONCLUSIONS: **Regardless of whether the compression vessels of the facial nerve are simple or complicated, combined intraoperative monitoring of AMR plus ZLR monitoring provides more valuable neurosurgical guidance than simple AMR during MVD for HFS.**

## INTRODUCTION

Hemifacial spasm (HFS), a syndrome of unilateral facial nerve hyperactive dysfunction, is a benign, chronic, involuntary movement of 1 side of the face. Although benign, HFS is a severe and disabling condition that impairs patients in their daily life.[1] Over the past 3 decades, microvascular decompression (MVD) surgery has been shown to be an effective treatment of this condition. The operation can resolve spasms in >90% of cases.[1-3]

For patients with HFS, an abnormal muscle response (AMR) can be recorded preoperatively and intraoperatively in most patients. This response is useful for electrophysiologic diagnosis of HFS.[4] Many studies have demonstrated a positive correlation between intraoperative resolution of AMR and clinical outcome in patients undergoing MVD for HFS.[5-7] Although intraoperative AMR monitoring is very important and has been widely used, there are still many limitations of AMR. The common weaknesses of AMR are 1) typical intraoperative AMR waves are not present from the beginning of the MVD to the end, 2) the typical waves persist after MVD is completed, 3) intraoperative waveforms are unstable and susceptible to surgical interference, and 4) AMR could not identify which vessel was the major culprit when multiple compressing vessels were found during MVD.[7-9] As a new monitoring method for HFS, Z-L response (ZLR) is recorded from the facial muscles when the offending artery wall is electrically stimulated during the operation. ZLR has been reported to be useful for MVD.[8,9] However, to our knowledge, there has been no research on the effect of combined electrophysiology of AMR plus ZLR compared with AMR. We report the first study to compare the sensitivities and reliabilities of AMR and AMR plus ZLR.

**Key words**
- Abnormal muscle response
- AMR
- Hemifacial spasm
- MVD
- ZLR
- Z-L response

**Abbreviations and Acronyms**
AICA: Anterior inferior cerebellar artery
AMR: Abnormal muscle response
HFS: Hemifacial spasm
MVD: Microvascular decompression
PICA: Posterior inferior cerebellar artery
VA: Vertebral artery
ZLR: Z-L response

*From the Department of Neurosurgery, Xinhua Hospital, Shanghai Jiaotong University School of Medicine; and Center for Diagnosis and Treatment of Cranial Nerve Diseases, Shanghai Jiao Tong University, Shanghai, China*

*To whom correspondence should be addressed: Shi-Ting Li, M.D., Ph.D. [E-mail: lishiting@xinhuamed.com.cn]*
*Xin Zhang, Hua Zhao, Yin-Da Tang, and Jin Zhu are co–first authors.*

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## MATERIALS AND METHODS

### Patients

This study was approved by the Xin Hua Hospital Ethics Institutional Committee. Each patient involved in this study signed an informed consent. All methods were carried out in accordance with approved institutional guidelines and regulations. Between January 2013 and December 2015, 1868 patients underwent MVD for HFS at Xinhua Hospital. Simple AMR monitoring was performed in 896 patients from January 2013 to May 2014. AMR plus ZLR monitoring was performed in 972 patients from June 2014 to December 2015. Age, sex, and side of lesion were similar in the AMR group and the AMR plus ZLR group.

### Surgery

All patients underwent MVD of the facial nerve in the lateral decubitus position via a standard retrosigmoid craniotomy and an infraflocculus approach. Zones I–V of the facial nerve were fully exposed to explore any offending vessels. The offending vessel was shifted off the facial nerve by inserting small pieces of shredded polytetrafluoroethylene (Teflon) felt between the vessels and the brainstem or the flocculus. To prevent the occurrence of adhesion after the operation, small pieces of moist gelatin sponge were placed between the Teflon and the brainstem or the flocculus.

### AMR Monitoring

AMR was recorded by electrical stimulation of the marginal mandibular branch of the facial nerve. Paired needle electrodes for stimulation were placed 5 mm apart along the marginal mandibular branch of the facial nerve, and paired needle electrodes for recording were placed in the orbicularis oculi muscles. AMR was recorded using 50 summations employing amplifiers with a frequency band of 5 Hz to 3 kHz. Stimulation (0.1 ms, rectangular wave, 2 Hz) was adjusted to supramaximal strength.[4] AMR was continuously recorded and printed out at 1-minute intervals (Figure 1). If the AMR disappeared completely or the amplitude decreased to <50% of the baseline level, the response was considered to be positive. When no other offending vessels were identified by additional investigation, further manipulation was avoided even if the AMR persisted.

### ZLR Recording

To record ZLR, the needle reference electrodes were inserted into the frontal muscle, and the needle recording electrodes were inserted into the orbicularis oculi, orbicularis oris, and mentalis muscles. The stimulating electrode was a noninvasive concentric electrode, which was used intracranially. It can be considered the bipolar mode. Before detaching the offending artery from the facial nerve, the stimulating electrode was placed on the offending artery wall near the compression site (within 5 mm), a square impulse (2 mA × 0.2 ms) was delivered, and the facial muscle response was recorded with the Medtronic Keypoint 4 system (Medtronic A/S, Skovlunde, Denmark) using the "F-Response" mode. This recording procedure was repeated in the same way for every offending vessel, 1 at a time, until the facial nerve was completely decompressed with Teflon sponges.[8,9]

### Combined Intraoperative Monitoring

In this study, AMR and ZLR were recorded simultaneously to identify the offending vessels. During the operation, after the full course of the facial nerve was explored, all the vessels that were in contact with the facial nerve were taken into account. To identify the real offending vessel, ZLR recording was used on each compression vessel, 1 at a time, before and after the offending vessel was decompressed. AMR recording was simultaneously monitored during the operation, until all offending vessels were transposed with Teflon sponges and the facial nerve was decompressed (Figure 1).

### Evaluation and Statistical Analysis

Follow-up information was obtained through phone interviews and a review of the medical records from clinic visits. A comprehensive analysis of the surgical outcomes, including complications, was performed at 1 day, 7 days, 1 month, 3 months, and 1 year after surgery, based on the analysis described by Kondo et al.[10] The efficacy of MVD was categorized as excellent (complete disappearance of spasm), good (occasional slight spasm), fair (moderate spasm, apparently persisting), or poor (no improvement). Effective operations were defined as "excellent" and "good." Statistical analyses were performed using SAS version 9.1.3 (SAS Institute Inc, Cary, North Carolina, USA). Continuous variables were presented as mean ± SD, and categorical variables were presented as frequency (%). Age, sex, side of lesion, and surgical outcomes were compared across groups using $\chi^2$ tests or unpaired $t$ tests (Table 1). A $P$ value $< 0.05$ was considered to indicate significant between-group differences.

## RESULTS

In the AMR group, AMR waves were not detected in 59 of 896 patients. At the time points 1 day, 7 days, 1 month, 3 months, and 1 year after surgery, the operation was effective in 48, 48, 46 (2 patients were lost to follow-up), 43 (4 patients were lost to follow-up), and 39 (8 patients were lost to follow-up) cases. Typical AMR waves were detected in 837 cases in the AMR group, and the waves disappeared in 772 cases during MVD. At the time points 1 day, 7 days, 1 month, 3 months, and 1 year after surgery, the operation was effective in 735, 736, 731 (6 patients were lost to follow-up), 714 (25 patients were lost to follow-up), and 702 (39 patients were lost to follow-up) cases. Typical AMR waves were persistent in 65 cases. At 1 day, 7 days, 1 month, 3 months, and 1 year after surgery, the operation was effective in 49, 49, 48 (1 patient was lost to follow-up), 45 (4 patients were lost to follow-up), and 41 (7 patients were lost to follow-up) cases (Figure 2).

In the AMR plus ZLR group, AMR waves were not detected in 74 of 972 patients. At the time points 1 day, 7 days, 1 month, 3 months, and 1 year after surgery, the operation was effective in 70, 70, 68 (3 patients were lost to follow-up), 64 (7 patients were lost to follow-up), and 58 (11 patients were lost to follow-up) cases. In the AMR plus ZLR group, typical AMR waves were detected in 898 cases, and the waves disappeared in 854 cases during the operation. At the time points 1 day, 7 days, 1 month, 3 months, and 1 year after surgery, the operation was effective in 836, 839, 828 (10 patients were lost to follow-up), 814 (32 patients were lost to