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Microvascular decompression for glossopharyngeal neuralgia using intraoperative neurophysiological monitoring: Technical case report

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Abstract

Background: Glossopharyngeal neuralgia (GN) is a rare functional disorder representing around 1% of cases of trigeminal neuralgia. Lancinating throat and ear pain while swallowing are the typical manifestations, and are initially treated using anticonvulsants such as carbamazepine. Medically refractory GN is treated surgically. Microvascular decompression (MVD) is reportedly effective against GN, superseding rhizotomy and tractotomy.

Methods: We encountered three patients with medically refractory GN who underwent MVD using intraoperative neurophysiological monitoring (IONM). The offending vessels were the posterior inferior cerebellar arteries, which were confirmed intraoperatively via a transcondylar fossa approach to be affecting the root exit zones of the glossopharyngeal and vagus nerves. As IONM, facial motor-evoked potentials (MEPs) and brainstem auditory-evoked potentials were monitored during microsurgery in all three patients. Pharyngeal and vagal MEPs were added for two patients to avoid postoperative dysphagia.

Results: GN disappeared immediately after surgery with complete preservation of hearing acuity and facial nerve function. Transient mild swallowing disturbance was observed in 1 patient without pharyngeal or vagal MEPs, whereas the remaining two patients with pharyngeal and vagal MEPs demonstrated no postoperative dysphagia.

Conclusion: Although control of severe pain is expected in surgical intervention for GN, lower cranial nerves are easily damaged because of their fragility, even in MVD. IONM including pharyngeal and vagal MEPs appears very useful for avoiding postoperative sequelae during MVD for GN.

Key Words: Glossopharyngeal neuralgia, intraoperative neurophysiological monitoring, lower cranial nerves, microvascular decompression

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INTRODUCTION

Glossopharyngeal neuralgia (GN) consists of paroxysmal, transient, severe, sharp pain in the back of the throat, base of the tongue, tonsillar fossa, depth of the ear canal, and area beneath the angle of the jaw, all of which are territories innervated by the glossopharyngeal nerve and the pharyngeal branches of the vagus nerve. GN is therefore also called vagoglossopharyngeal neuralgia. Episodes usually last seconds to minutes and are often precipitated by chewing, coughing, yawning, talking, or swallowing.[27] GN may also be associated with cardiovascular manifestations, and because of the association with cardiac dysrhythmia, some cases prove fatal.[4] Although the incidence is low (about 0.7/100,000 people),[17] this pathology often causes great suffering to the patient, such as an inability to swallow during attacks. First-line treatment for GN involves anticonvulsants such as carbamazepine (CBZ), gabapentine (GPT), and lamotrigine.[3,8,18] Surgery is reserved for those patients in whom pain continues despite medical treatment or who experience significant side effects. Lesioning techniques including rhizotomy and percutaneous radiofrequency thermocoagulation have been performed with apparent effectiveness for pain relief, but inevitably produce motor deficits causing dysphagia and hoarseness.[10] Microvascular decompression (MVD) for GN was initiated by Laha and Jannetta in 1977,[20] and the effectiveness of this method in achieving pain relief has increased with the development of high-resolution magnetic resonance imaging (MRI) providing high sensitivity and specificity in identifying the offending vessels compressing the cranial nerves.[21] Even though the rate of pain relief appears very high, the frequency of complications varies significantly. Major complications, including hoarseness, dysphagia, and cough, can be caused by injury to the glossopharyngeal and vagal nerves, as can hearing loss and facial palsy.[2] The cause of such cranial nerve injury is usually mechanical stress to the nerve, such as retraction, compression by prosthesis, or ischemia due to perforator injury. Depending on the level of experience of the surgeon, correct and appropriate evaluation of the integrity of nerve functions can be difficult. Intraoperative neurophysiological monitoring (IONM) is commonly used in tumor surgeries for the lower cranial nerves to facilitate maximal preservation of function and reduce complications,[7,15] but its use during MVD for GN surgery has rarely been reported, especially in evaluating the integrity of lower cranial nerve functions.[11] We reviewed the cases of three patients with primary GN who underwent MVD using IONM in our institution from 2013 to 2014. As IONM, brainstem auditory-evoked potentials (BAEPs) for assessing cochlear nerve function and compound muscle action potentials (CMAPs) of the orbicularis oculi and orbicularis oris muscles stimulated by transcranial electrical stimulation for facial nerve function were applied with MVD for GN in all three patients. In two of the three patients, the stylopharyngeal muscle and false vocal cord were used for transcranial monitoring of muscle-evoked potentials (MEPs) to ascertain glossopharyngeal and vagus nerve functions, respectively. To the best of our knowledge, pharyngeal and vagal MEPs during MVD for GN have not been reported previously. We describe herein our experience with MVD for vagoglossopharyngeal neuralgia, focusing on the utility of IONM in avoiding postoperative complications.

Neurophysiological monitoring

Facial, pharyngeal, and vagal MEPs

Following the induction of anesthesia with a short-acting agent for neuromuscular blockade, neuroanesthesia was maintained by intravenous infusion of propofol and remifentanil. Constant current stimuli consisting of four rectangular pulses with a 1.5-ms interstimulus interval were generated using a neuromaster MS-120B system (Nihon Kohden, Tokyo, Japan). Corkscrew electrodes were placed at positions C3 and C4 to stimulate transcranial MEPs for evaluation of not only the pyramidal tract but also the corticobulbar tract. The electrode placed on the other side of the target was used for anodal stimulation, because the cortex under the anode is preferentially stimulated. Facial MEPs were recorded from the orbicularis oculi and orbicularis oris muscles through paired stainless-steel needle electrodes inserted subdermally using a Neuromaster MEE-1000 system (Nihon Kohden). To obtain pharyngeal MEPs, paired stainless-steel needle electrodes were inserted directly after induction of anesthesia and intubation of an endotracheal tube into the stylopharyngeal muscle located in the posterior wall of the pharynx. Vagal MEPs were recorded from the false vocal cord using a surface electrode mounted on the endotracheal tube. To avoid large and overwriting stimulus artifacts, the band-pass filter was set at 100–3000 Hz. The amplitude of MEPs from the muscles innervated by the facial, glossopharyngeal, and vagus nerves was defined as the range between maximum positive and negative peaks of the polyphasic waveform. Basically, stimulation intensity was gradually increased until the amplitude of the target muscles could be elicited for the 1st time, which was defined as the threshold intensity of transcranial MEPs. Pharyngeal and vagal MEPs can be elicited by stimulation of either side due to the bilateral distribution of the corticobulbar tracts of the glossopharyngeal and vagus nerves. The intensity of stimulation for pharyngeal and vagus nerves was increased gradually until at least 10 μV of significant waveform with latency of approximately 10 ms was elicited; this point was defined as a threshold. The control amplitude was obtained by stimulation at an intensity of 20% above the threshold, representing supra-minimal stimulation.[24] In our patients, the intensity during microscopic procedures providing significant amplitude ranged from 40 to 80 mA. Those MEPs were usually recorded every 5 min. If, during microscopic procedures around the target, MEP amplitude decreased to ≤50% in comparison to the control amplitude, the surgeon assumed that the procedure would damage the relevant cranial nerves and temporarily abandoned the procedure or manipulated another site distant from the relevant nerves.

Brainstem auditory-evoked potentials

During surgery, potentials were recorded continuously by stimulation of the ear ipsilateral to the affected side with alternating rarefaction and condensation clicks. A stimulus rate of 17.1 Hz was used for optimal resolution of the collected peaks. A click intensity of at least a 110-dB sound pressure level was implemented, and white noise at an intensity of a 40-dB sound pressure level was used to mask activity in the contralateral ear. Five hundred trials were averaged over each 12-ms observation interval to obtain interpretable BAEP data. Three channels were used for recording. Channels 1 (Cz/A1) and 2 (Cz/A2) were formed between the vertex and mastoid process of the left and right ears, respectively. Channel 3 (Cz/Cv2) was spanned from the vertex to cervical vertebra C2. Wave V, the largest component of the BAEP waveform, was analyzed in real-time during the procedure. Significant changes in wave V were recorded and reported to the surgeon to monitor brainstem function, detect ischemia, and identify perturbations as indicators of hearing function. Two components of wave V were monitored and compared with baseline responses during the course of surgery: Amplitude and latency. Significant changes in each variable were recorded and reported to the surgeon. A significant change in amplitude took place when wave V decreased to 50% of the baseline value, and a significant change in latency occurred when wave V shifted at least 0.5 ms away from the baseline. In addition, the specified differences in latency or amplitude were required to occur during at least two consecutive trials in order to be considered significant and to prevent technical issues from interfering with data collection.

CASE ILLUSTRATIONS

Case 1

A 79-year-old man presented with a 5-year history of lancinating tongue, deep pharyngeal, and ear pain in the distribution of the glossopharyngeal nerve on the left side. Episodes of pain were triggered by talking, coughing, and especially swallowing, and interfered with his quality of life. GN was diagnosed and initially treated using CBZ, which achieved relief of severe throat pain. However, the efficacy of CBZ gradually decreased and severe throat pain recurred regardless of the maximum dose of medication. Other agents such as GPT, pregabalin (PGB), and diazepam (DZP) were tried, but provided no relief. The patient experienced debilitating generalized weakness and syncopal episodes with dose escalations. He was therefore referred to our department from neurology for consideration of surgical intervention after hospitalization for exacerbation of pain and symptoms related to the escalating doses of DZP and PGB. MVD was considered because MRI demonstrated an offending vessel compressing the root exit zone (REZ) of the glossopharyngeal nerve on the affected side. Surgery was performed via a transcondylar fossa approach using BAEPs and facial MEPs during the microsurgical procedure as IONM to minimize postoperative sequelae. The oribicularis oris and oculi muscles were used for recording transcranial MEPs for monitoring facial nerve function. The patient was placed in a park bench position while keeping the head slightly above the level of the heart to avoid venous engorgement. The head was rotated slightly to the right side, angled 30° toward the right shoulder. A unilateral hockey stick incision was performed. The skin together with the muscle was detached from the suboccipital surface. Lateral suboccipital craniotomy extending to the condylar fossa was performed and the dura mater was opened. The lateral medullary cistern was opened to expose the lower cranial nerves entering the jugular foramen. Arachnoid dissection and retraction of the cerebellum exposed the REZ on the ventral surface of the medulla oblongata. The offending vessel was confirmed to be a loop of the posterior inferior cerebellar artery (PICA) compressing the proximal sites of the glossopharyngeal and vagus nerves, which were also recognized under microscopy [Figure 1a]. The arachnoid membrane surrounding the lower cranial nerves was dissected to mobilize the PICA. As a prosthesis, a piece of shredded Teflon was inserted into the space between the bundles of the glossopharyngeal and vagus nerves and the PICA [Figure 1b and c]. Postoperatively, the patient was completely free of pain, and no recurrence has been

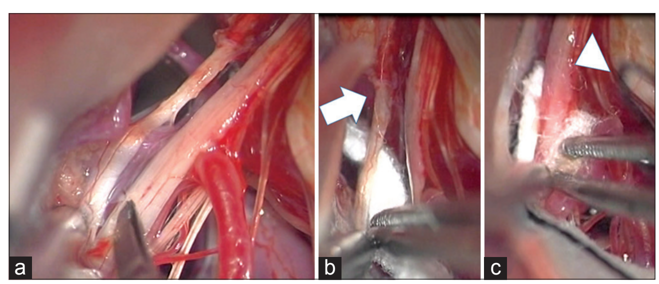

Figure 1: (a) Intraoperative view showing the posterior inferior cerebellar artery compressing the root exit zones of the glossopharyngeal and vagus nerves. (b) A piece of shredded Teflon is interposed between the root exit zone of IX nerve (arrow) and posterior inferior cerebellar artery. (c) Another piece of Teflon ball is inserted between the root exit zone of X nerve (arrow head) and posterior inferior cerebellar artery. IX: Glossopharyngeal nerve, X: Vagus nerve

seen after 18 months of follow-up. No hearing loss or facial paresis was observed. Mild dysphagia and hoarseness occurred postoperatively, but resolved completely within 2 months.

Case 2

A 71-year-old woman had been suffering from left paroxysmal transient throat and ear pain, precipitated by drinking and eating. She underwent surgical intervention because CBZ provided insufficient relief of pain after several years of treatment. MRI showed a loop of the left PICA conflicting with the REZ of the glossopharyngeal nerve. She underwent MVD via a left condylar fossa approach in a park bench position. During the microscopic procedure, the loop of PICA was confirmed to be compressing the glossopharyngeal and vagus nerve fibers exiting the medulla oblongata [Figure 2a]. The tortuous vessel impinging on those nerve roots was dissected carefully and displaced from the nerves by hanging the vessel using the sling technique with dura mater[19] [Figure 2b]. During the procedure, pharyngeal MEPs demonstrated a significant decrease in amplitude to <50% of the control level. The maneuver was therefore stopped temporarily and a self-retaining retractor was released until improvement of MEPs was obtained. After confirming improvement of MEPs to within normal limits, the microscopic procedure was resumed with careful attention to excessive retraction of the cerebellum and excessive stress on the glossopharyngeal and vagus nerves. Transposition of the offending vessel was finally accomplished within the normal range of IONM [Figure 3]. Postoperatively, the patient reported no facial pain or throat pain and has not shown any sequelae such as dysphagia or hoarseness.

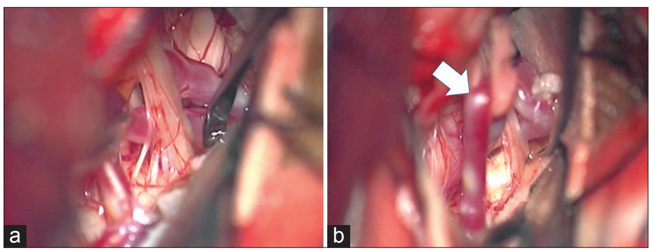

Figure 2: (a) Intraoperative view showing the posterior inferior cerebellar artery compressing and clinching the root exit zones of IX and X nerves. (b) The posterior inferior cerebellar artery is retracted and transposed with a sling made of divided dura mater (arrow)

Case 3

A 74-year-old man with a history of hypertension had started to feel intermittent serious throat pain in the left side while swallowing 4 years earlier. These symptoms had been treated using CBZ and PGN. Three years after initiation of medical therapy, recurrence of severe lancinating throat pain on the same side during swallowing proved refractory to CBZ pharmacotherapy. Other types of pharmacotherapy including DZP and trigeminal neuralgia were ineffective for the pain this

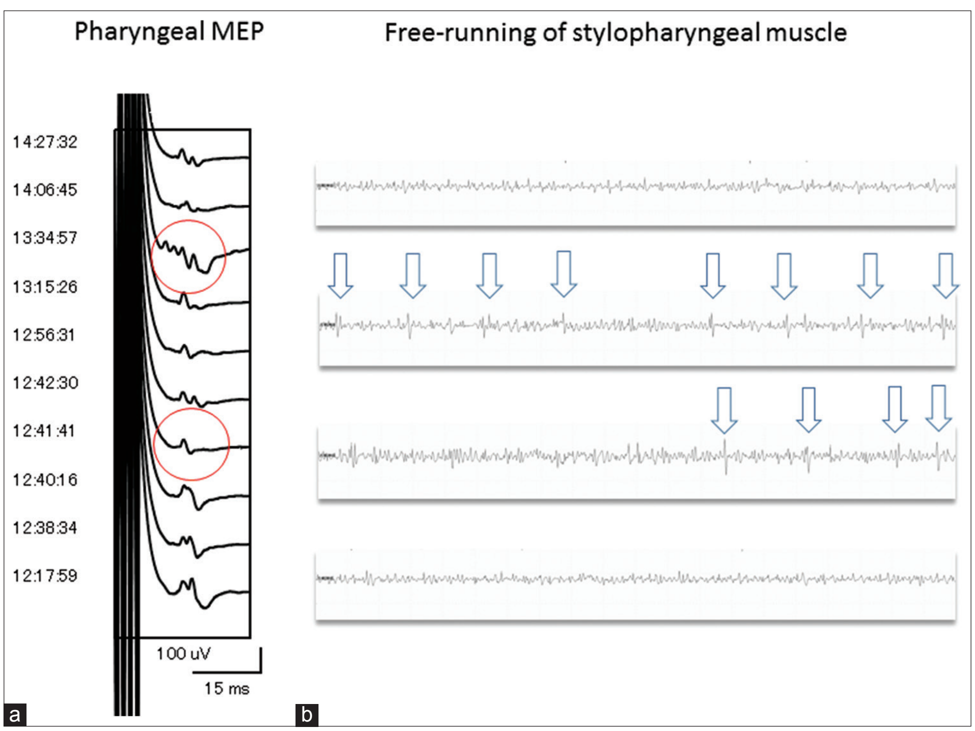

Figure 3: (a) Pharyngeal MEP elicited by transcranial electrical stimulation demonstrating transient reduction <50% of the amplitude of the control baseline and pleomorphic change (red-encircled) when free-running electromyography showed intermittent spike discharge sporadically. (b) Free-running electromyography of the stylopharyngeal muscle monitored continuously reveals intermittent spike discharges (white arrows) during direct procedure around the glossopharyngeal nerve

time. MRI demonstrated the left PICA compressing the ventral side of the proximal glossopharyngeal nerve. Surgical intervention was performed using a transcondylar fossa approach with IONM, including BAEPs and facial, pharyngeal, and vagal MEPs. Lateral suboccipital craniotomy extending to the right condylar fossa was performed to obtain the operative trajectory in the inferolateral direction. The arachnoid membrane was dissected carefully and gentle upward retraction of the cerebellum exposed the cerebellomedullary cistern, where the glossopharyngeal and vagus nerves originate from the ventral surface of the medulla oblongata. The PICA proximal to the loop was observed to compress the ventral aspect of the glossopharyngeal and vagus nerve roots in the REZ [Figure 4a]. The arachnoid membrane supporting and connecting the surrounding vasculature and nerve roots was dissected gently and the mobilized loop of PICA was moved away from the REZs of the glossopharyngeal and vagus nerves, and affixed to the jugular tubercle using fibrin-coated collagen fleece (Tachosil; Nycomed, Linz, Austria) [Figure 4b]. Slightly elongated latency of wave V was observed several times during retraction of the cerebellum, but recovered immediately with the release of retraction. Transcranial MEP did not reveal any evidence of significant reductions in facial, pharyngeal, or vagal MEPs, even while manipulating around the glossopharyngeal and vagus nerves [Figure 5]. Postoperatively, severe throat and ear pain were completely absent. The patient was able to eat and drink without pain and showed no difficulty in swallowing.

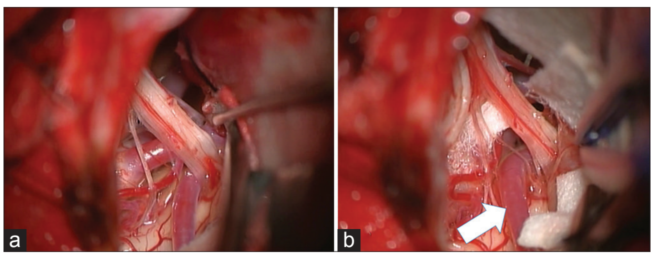

Figure 4: (a) Intraoperative view shows the caudal loop of posterior inferior cerebellar artery compressing the root exit zones of the IX and X nerves. (b) The offending vessel is dissected and adhered to the dura mater in the jugular tuberculum to maintain separation from the root exit zone (arrow)

RESULTS

Three patients with medically refractory GN were treated using MVD after MRI depicted the PICA offending lower cranial nerves. The PICA impinged on not only the glossopharyngeal nerve but also the vagus nerve, as confirmed intraoperatively and released by surgical devices. All three patients underwent surgery using a transcondylar fossa approach and neuralgia disappeared completely without any medical treatment postoperatively. One patient undergoing MVD without pharyngeal or vagal MEPs experienced mild, transient dysphagia postoperatively. The other two patients with lower cranial nerve monitoring did not demonstrate any sequelae after surgery, including dysphagia or dysphonia.

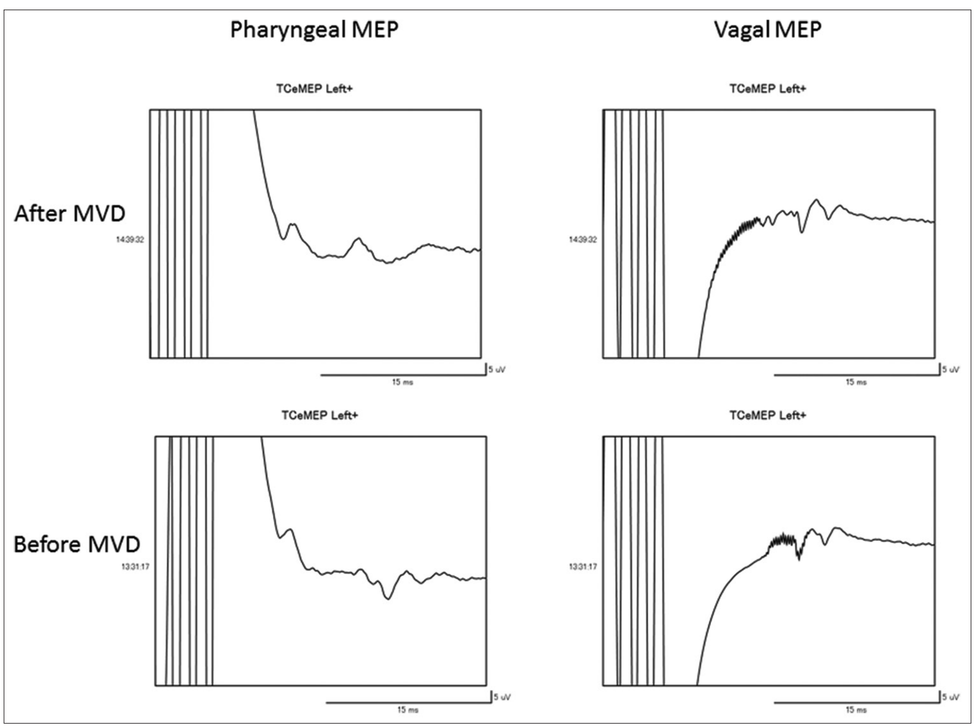

Figure 5: Pharyngeal and vagal MEPs demonstrate no significant changes between before and after microvascular decompression

DISCUSSION

Among the surgical treatments for GN, MVD has been reported to be associated with a high success rate of long-term pain relief and a low rate of recurrence.[2,5] Postoperative glossopharyngeal and vagus nerve dysfunction remain possible, even though MVD is a safer procedure than other surgical treatments for GN, such as rhizotomy or tractotomy of the trigeminal nerve. Complications after MVD for GN have been reported in 0–33.3% of cases, including hearing loss, facial paresis, dysphonia, dysphagia, hoarseness, and decreased palatal and gag reflexes.[4,5,9,16,19,22,23,25,28,31,32] Sensorineural hearing loss has a reported incidence of 1.5–4.2% after MVD performed for GN.[26] Because of the proximity of the acoustic nerve to the lower cranial nerves decompressed during this procedure, the cochlear nerve is stretched or damaged in many patients, resulting in hearing impairment. A change in latency or a decrease in the wave V amplitude of BAEPs has been reported as a predictor of hearing loss.[1,30] Facial paresis has also been reported to be associated with MVD for GN, despite occurring rarely.[2] As IONMs, BAEP and facial MEP plays important roles in avoiding hearing loss and facial paresis after MVD, not only for hemifacial spasm (HFS), but also for GN.[29]

The most frequent complication in MVD for GN is lower cranial nerve dysfunction, which is less likely than with other surgical interventions such as rhizotomy and radiofrequency thermocoagulopathy. The frequency of lower cranial nerve impairment ranges from 0% to 33.3% even according to literature limited to the last decade.[4,5,9,16,19,22,23,25,28,32,33] Reasons include the fragility of the lower cranial nerves and difficulty accessing the REZs of those nerves originating from the ventral surface of the medulla oblongata and covered by the cerebellar tonsil, which requires reflection by dissection of the arachnoid membrane at the cerebellomedullary cistern in order to obtain appropriate exposure.

Kawashima *et al*.[19] reported the usefulness of a transcondylar fossa approach in MVD for GN. Reduction of the mechanical stress on the glossopharyngeal and vagus nerves due to retraction of the cerebellar hemisphere and wider operative field can be obtained using this method, providing a sufficient corridor to show the relationships between the cisternal portion of the glossopharyngeal nerve and nearby arteries such as the PICA or anterior inferior cerebellar artery.[19] In the present three cases, we applied the same approach in MVD for GN. Even though the risk of vertebral artery injury and sigmoid sinus occlusion should be considered, this method to approach the REZ of the glossopharyngeal nerve appears key to a successful operation. Another crucial aspect for safer operation and reduction of postoperative sequelae is IONM, particularly for the glossopharyngeal and vagus nerves. Sudden onset of glossopharyngeal or vagus nerve dysfunction can lead to dysphagia and aspiration pneumonia, severely impacting quality of life and representing a serious threat to life. Lesioning treatments including rhizotomy and radiofrequency thermocoagulopathy inevitably cause deficits in relevant nerve function. On the other hand, MVD for GN is a treatment that can maintain the anatomical integrity of the nerve. However, even MVD for GN carries a risk of postoperative sequelae, due to the unavoidable mechanical stress on the nerve with direct or indirect retraction and compression due to use of prostheses. A variety of methods have been described as IONM targeting the glossopharyngeal and vagus nerves to minimize the risk of postoperative dysphagia and hoarseness. These methods are roughly classifiable into two types. One involves monitoring to identify a relevant nerve, such as an electromyography (EMG) elicited by direct stimulation; this is useful in situations where the nerve root is trapped or involved in a tumor. The other involves monitoring to evaluate the integrity of a relevant nerve, which is used to assess whether the nerve root is preserved anatomically and functionally. This type of monitoring includes transcranial MEP recording of CMAPs from target muscles such as the stylopharyngeal muscle innervated by the glossopharyngeal nerve and the false vocal cord innervated by the vagus nerve. The best method to record EMG or CMAPs from the innermost muscles of the pharynx and larynx has remained contentious. Direct insertion of a needle electrode has been adopted with assistance of the endoscope, laryngoscope, or sometimes under surgical dissection of the vocal cord, even though direct insertion of electrodes carries risks of injury, bleeding, and infection.

Surface electrodes mounted on an endotracheal tube or laryngeal mask have been reported for recording EMG and CMAPs from the posterior wall of the pharynx and vocal cord.[7,14,15] Disadvantages of this method using surface electrodes are the reduced accuracy and reproducibility compared to needle electrodes in target muscles, but surface electrodes are safer and less invasive. Fukuda *et al*. reported that devices improving accuracy and reproducibility would make transcranial pharyngeal MEP useful for predicting the deterioration of swallowing following skull base surgery, especially in patients with swallowing disturbances that are mainly due to reductions in the motor functions of the pharyngeal muscles.[7] Ito *et al*. described the usefulness of vagal MEP with transcranial electrical stimulation and endotracheal tube electrode recording to provide continuous information on the integrity of both the supra- and infra-nuclear vagal pathways.[15]

Free-running EMG is another important method for IONM, providing immediate feedback to the surgeon. The most important type of EMG recording during surgery is the neurotonic discharge, which comprises muscle unit potential activity in response to mechanical or metabolic irritation of the nerve innervating the monitored muscles.[12] Although there is agreement regarding the usefulness of continuous free-running EMG for detecting unexpected mechanical trauma, the potential role in lower nerve function prediction remains controversial. One limitation is that free-running EMG provides only an approximate correlation between the frequency of neurotonic discharges and the degree of nerve injury, so that neither their presence nor absence assures the anatomical and functional integrity of the relevant nerve at the completion of tumor resection.[12] Moreover, it is also worth noting that sharp transection of the relevant nerve may not evoke neurotonic discharges, whereas mechanical stimulation of a distal nerve stump still in continuity with the muscle may provoke EMG activities.[12,13] In our Case 2, free-running EMG worked well as an alarm for early mechanical injury to the glossopharyngeal nerve, which was confirmed by transcranial pharyngeal MEP as a significant reduction of amplitude <50% and pleomorphic change [Figure 4]. Free-running EMG has the advantage of offering real-time monitoring, and transcranial MEP is superior for evaluating the integrity of the relevant nerve function. These types of IONM should be combined and implemented with each other.

We adapted an alarm point of a 50% decrease in the amplitude of CMAPs from the stylopharyngeal muscle and false vocal cord elicited by transcranial electrical stimulation based on previous reports.[7,15] Ito *et al*. described that stable MEP activities from the vocal muscle during surgery predicted a good outcome of postoperative swallowing function, and transient deterioration of vagal MEPs may imply transient postoperative difficulty in swallowing, while patients with permanent deterioration of vagal MEPs might show permanent dysphagia.[15] In our Case 2, when transient deterioration of pharyngeal MEP to <50% was recorded, the procedure was temporarily suspended, immediately improving the amplitude of MEP to within normal limits. As a result, postoperative sequelae could be avoided.

Establishment of criteria for the evaluation of intraoperative impairment and prediction of outcomes for glossopharyngeal and vagus nerves represents an issue for the future.

Fukuda *et al*. reported that the amplitude of facial MEP after MVD for HFS was decreased in patients whose symptoms were resolved postoperatively, suggesting normalization of facial nerve excitability.[6] In our patients, whose symptoms disappeared immediately after surgery, IONM demonstrated transient changes in pharyngeal MEP in only one case. In another patient, we could not even observe transient changes in pharyngeal and vagal MEPs. The transient change we observed intraoperatively might thus have been caused by mechanical stress on the lower cranial nerves due to retraction during the procedure. Even though, differences exist between motor and sensory nerves, hyper excitability of the affected nerves might lead to decreased amplitude of the relevant MEPs after MVD. However, no reports of MVD for GN have described how pharyngeal and vagal MEPs change after decompression of the relevant nerves. Future research with MVD for GN needs to reveal intraoperative findings for pharyngeal and vagal MEPs after the appropriate decompression.

CONCLUSION

IONM is useful during MVD for GN, facilitating the prevention of postoperative complications. CMAPs from the stylopharyngeal muscle and false vocal cord can be used in IONM of glossopharyngeal and vagus nerve functions. Transcranial pharyngeal and vagal MEP allow evaluation of the integrity of the relevant nerve functions, facilitating avoidance of dysphagia and hoarseness due to retraction of glossopharyngeal and vagus nerves after MVD for GN.

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Conflicts of interest
There are no conflicts of interest.

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