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Resection of brachial plexus schwannomas while monitoring transcranial motor evoked potentials: report of two cases

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ABSTRACT

A schwannoma is a benign nerve sheath tumor treated by enucleation, which carries the risk of intraoperative nerve injury that is observed after awakening. Transcranial motor evoked potential (TcMEP) monitoring has been established as an effective method to predict and prevent intraoperative neurological complications during brain and spinal surgery. However, there have been few reports on its application in head and neck surgeries. We performed enucleation to relieve the symptoms due to schwannomas in the neck of two women, aged 25 years and 70 years. Both women presented with a left cervical mass, paresthesia of the left upper limb, and a Tinel-like sign without muscle weakness. TcMEPs were recorded before beginning surgery, during surgery, and immediately before completing surgery. The dissecting lines were decided using the stimulator attached to the dissecting instrument, which helped warn the surgeon regarding risky areas. Histopathological examinations confirmed the diagnosis of schwannoma. There was no significant difference in the pre- and postoperative TcMEP recordings, and no postoperative motor deficits were identified. Intraoperative TcMEP monitoring is expected to be useful in preventing operative complications while treating head and neck schwannomas.

1. Introduction

Schwannomas are relatively rare nerve sheath tumors, generally treated using enucleation [1]. Despite avoiding nerve damage during surgery, there is a risk of intraoperative neurological complications, such as motor deficits [2].

The efficacy and utility of intraoperative transcranial motor evoked potential (TcMEP) monitoring have been established in predicting postoperative motor function and complications after brain, skull base, and spinal surgeries [3–6]. TcMEP evaluation effectively enables the real-time monitoring of neurological stimulation. Most neurogenic tumors are treated by neurosurgeons and orthopedic surgeons, while head and neck surgeons also treat tumors in the cervical nerves. To the best of our knowledge, there is no detailed literature on the application of intraoperative TcMEP monitoring to treat schwannomas in the brachial plexus. In general, a virtuosic operative technique is required in head and neck surgeries, especially the enucleation of cervical nerve schwannoma, because of the anatomical complexity of these regions and to preserve postoperative neurological functions. We present two cases of enucleation to treat brachial plexus schwannomas, in which intraoperative neurological complications were avoided by monitoring TcMEPs.

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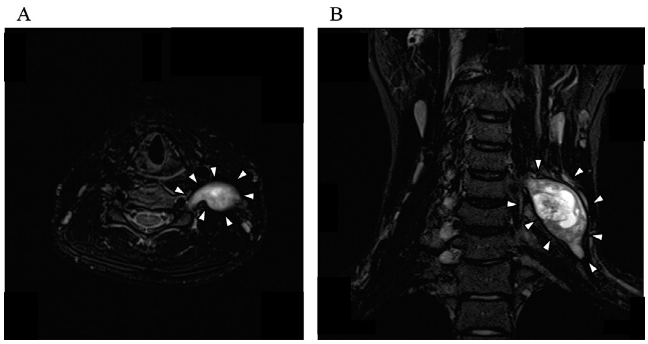

Fig. 1. Preoperative T2-weighted magnetic resonance image of Case 1 (the tumor is surrounded by arrowheads) A: The tumor is seen arising consecutively from cervical spinal nerve 5. B: Split fat sign is identified

2. Case reports

2.1. Case 1

2.1.1. Background

A 25-year-old woman presented with a left cervical mass and paresthesia of the left upper arm, especially on the radial side of cervical spinal nerve (C)5. The patient had no relevant medical history. A Tinel-like sign was identified; however, no muscle weakness was observed in the left upper limb. Preoperative magnetic resonance imaging (MRI) revealed a well-defined lobulated heterogeneous mass in the brachial plexus consecutively from C5 with split fat sign on T2 weighted images, indicative of schwannoma (Fig. 1). No tumor was found in the spinal canal.

2.1.2. Surgery

Enucleation surgery was performed, during which TcMEPs were monitored. Rocuronium (40 mg) was administered for muscle relaxation only before tracheal intubation. Anesthesia was maintained with propofol at 3–5 μg/ml using a target-controlled infusion pump (TE-371, Terumo Corporation, Tokyo, Japan) and remifentanil at 0.94–1.89 μg/kg/minute. The depth of anesthesia was monitored using the bispectral index. A train of four monitor was used to assess intraoperative muscle relaxation. The Neuromaster neurophysiologic monitoring system (Nihon Kohden Ltd., Tokyo, Japan) was used to evaluate the baseline TcMEP. Corkscrew electrodes were placed on the scalp at C3 and C4 according to the international 10–20 electrode system. Transcranial stimulation was performed in five single pulse trains with an interstimulus interval of 2 ms. TcMEPs were recorded using subdermal needle electrodes at the upper extremities, including the deltoid, biceps brachii, brachioradialis, and abductor digiti minimi muscles, as well as at the lower extremities, including the tibialis anterior and abductor hallucis muscles. The amplitude of TcMEP was defined by identifying the peak-to-bottom amplitude, whereas latency was measured from the start of stimulation to the onset of myogenic activity. Intraoperatively, the stimulation intensity was set at 20% more than the threshold level to ensure that MEPs of at least 50 μV amplitude could be stably obtained. Threshold levels were rechecked every 30 min, and baseline levels for MEPs were renewed. A 50% reduction in TcMEP amplitude and/or 10% prolongation of latency were considered significant changes. If significant TcMEP changes were identified, the surgeon was notified. Additionally, spontaneous electromyography (EMG) was performed using the same electrodes. Moreover, somatosensory evoked potentials (SEPs) were recorded to monitor sensory deficits. The upper extremity cortical SEPs (N20/P25) were recorded using Fz, A1, and A2 as reference electrodes, and CP3 or CP4 as ipsilateral or contralateral exploration electrodes to the stimulated ulnar nerve. The stimulation frequency was set at 4.37 Hz with a pulse duration of 0.2–0.5 msec. Band pass filters were set at 10–2000 Hz for the cortical recording. TcMEPs and SEPs were recorded using the same device.

A collar incision was made on the anterior region of the neck, and the tumor was approached through the posterior border of the sternocleidomastoid muscle. After making a longitudinal incision in the neuroectoderm, the tumor was enucleated using the stimulator attached to the dissecting instrument; the response to direct stimulation was then recorded. The tissue from which response was confirmed by stimulation was not cut and dissected. Simultaneously, transcranial stimulation was performed to evaluate nerve injury due to dissection, traction, and ischemia during surgery.

There was no remarkable decline in amplitudes compared with the preoperative TcMEP amplitudes throughout the surgery (Fig. 2). Further, there were no significant changes in spontaneous EMG readings and SEP as well. The operation was completed without respiratory complications. No complications, such as bite injury due to transcranial stimulation and chemical injury due to electrical stimulation, were observed.

2.1.3. Postoperative course

Histological examination confirmed a diagnosis of schwannoma, characterized by Antoni A tissue with nuclear palisading, Antoni B tissue with loosely arranged spindled cells in a myxoid stroma, and positive S100 protein by immunostaining. The tumor size was 39 × 20 × 18 mm, with no evidence of malignancy (Fig. 3).

The patient experienced slight numbness in the left upper arm, dominated by C5, which improved on the third postoperative day. There was no muscle weakness in both upper extremities, including the deltoid and biceps brachii. She remained in good condition, and no postoperative motor deficits were identified after discharge.

2.2. Case 2

2.2.1. Background

A 70-year-old woman presented with a left cervical mass involving a 2-year history of paresthesia and pain of the left upper limb, especially on the radial side of C6. A Tinel-like sign was identified; no muscle weakness was observed in the left upper limb. Preoperative MRI showed a mass in the brachial plexus consecutive from C6 with split fat sign on T1 weighted images.

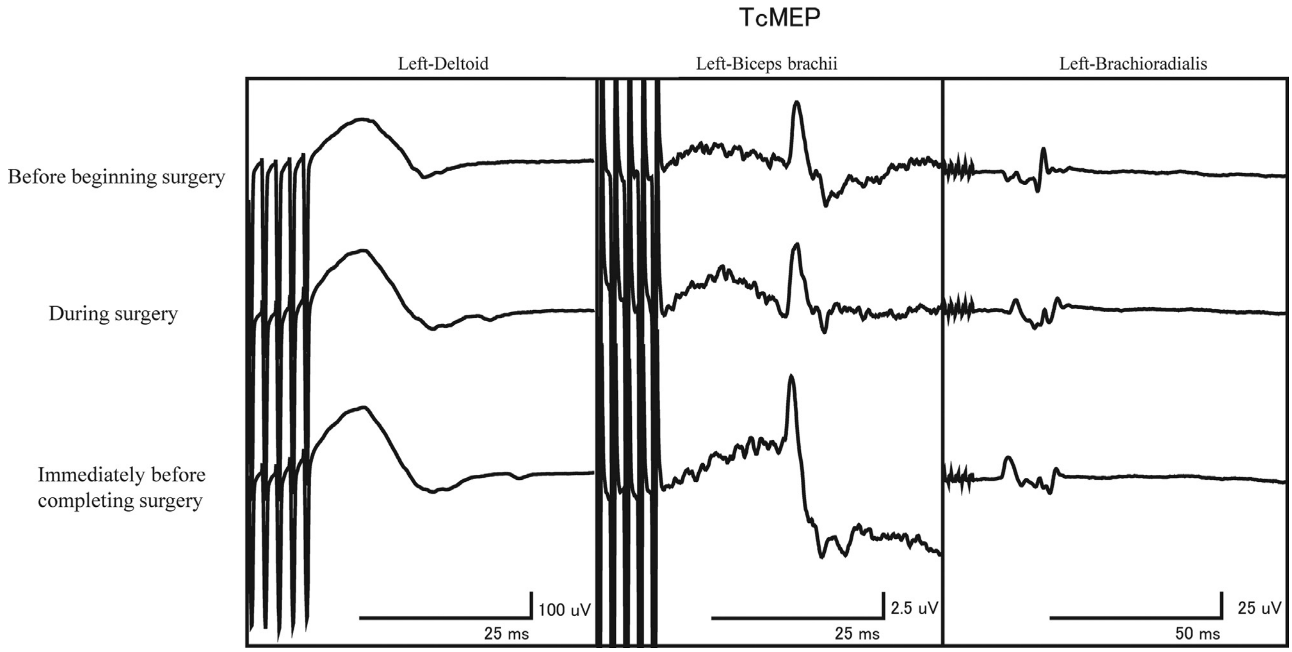

Fig. 2. The waveform of transcranial motor evoked potential in Case 1 exhibiting no significant changes throughout surgery

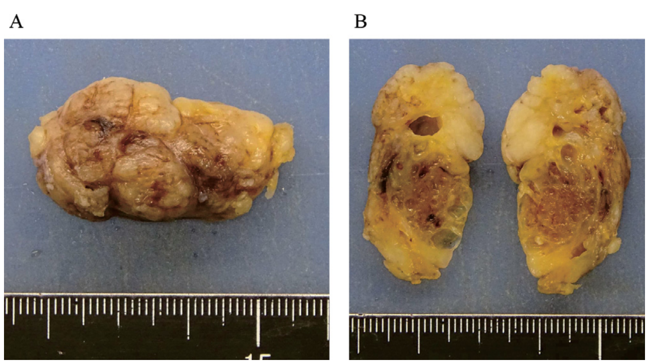

Fig. 3. The resected tumor of Case 1. A: Macroscopic appearance, B: Yellowish cut surface

2.2.2. Surgery

The patient underwent enucleation with intraoperative TcMEP and SEP monitoring as well as spontaneous EMG recording, based on the preoperative diagnosis of schwannoma. These procedures and administration of general anesthesia were the same as those in Case 1, except that after rocuronium (40 mg) was administered during tracheal intubation, and sugammadex was administered just before beginning the surgery.

The tumor was resected using the same approach as in Case 1. Intraoperative significant decline of TcMEP and remarkable changes in SEP and spontaneous EMG readings were not observed (Fig. 4).

2.2.3. Postoperative course

After surgery, the patient experienced slight numbness at the end of the left thumb, dominated by C6, which disappeared after two days. There was no muscle weakness in both upper extremities, including the biceps brachii. Schwannoma was definitively diagnosed through histological examination. The postoperative course was favorable without complications such as pain, paralysis, and muscle weakness.

3. Discussion

Schwannomas are benign encapsulating tumors that arise from Schwann cells of the peripheral nerve sheath in a solitary and sporadic form [1,7]. They are generally treated by enucleation, which can sometimes cause nerve damage [2]. Thus, it is important to perform neurological monitoring to prevent intraoperative complications. Some reports have shown that the incidence of postoperative motor deficits is higher in patients with abnormal responses to intraoperative neuromonitoring [3,6].

TcMEP neuromonitoring is a tool used to evaluate motor function by stimulating the motor cortex [8]. C3 and C4 defined by the international 10–20 electrode system, indicates to primary motor cortex which dominates limbs motor function, are stimulated to evaluate limbs motor deficits, similar to spinal surgery. The efficiency and utility of intraoperative TcMEP monitoring have already been established for spinal surgery and neurosurgery [3,4,6]. However, there are few reports related to the application of TcMEP monitoring during head and neck surgeries. Nerve monitoring in pathways from the site stimulated directly by the surgeon to the periphery, conventionally performed in head and neck surgeries, can only identify local nerve damage. However, MEP recordings by transcranial stimulation can identify neurological deficits in pathways from the primary motor cortex to the periphery [8]. Therefore, TcMEP monitoring enables evaluation of the effects on nerve roots and the central nervous system by intraoperative traction and ischemia as well as local nerve damage and is expected to be an effective device for monitoring real-time motor functional decline [9,10].

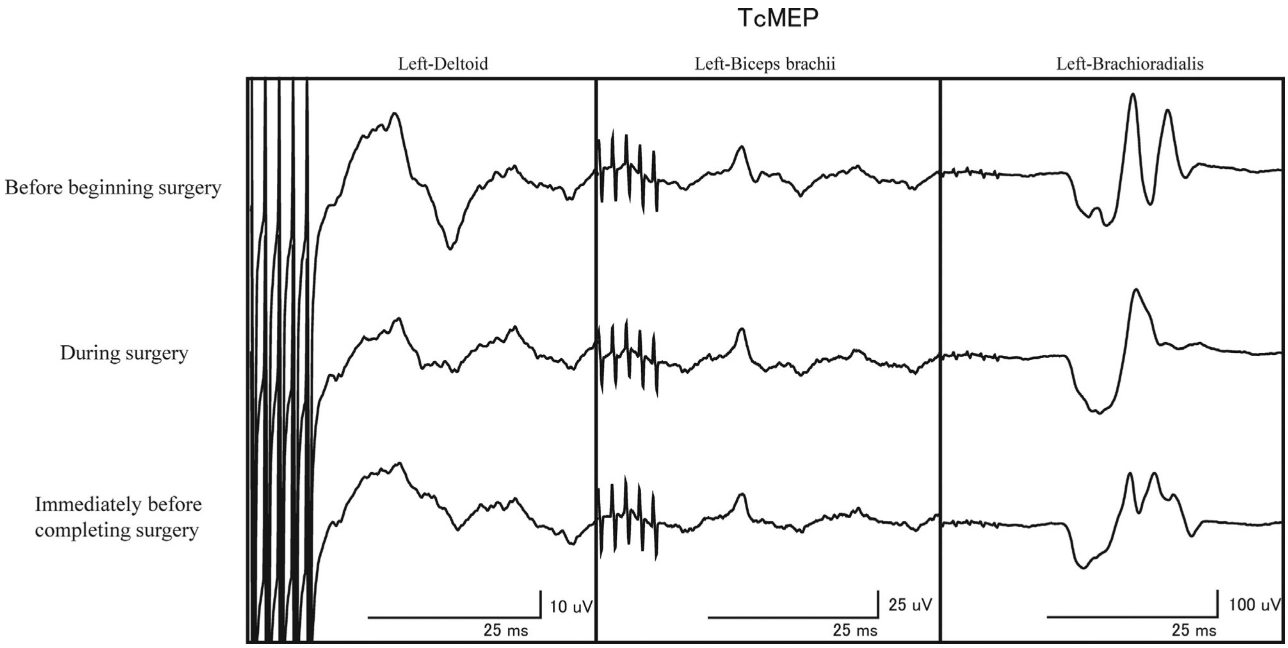

Fig. 4. The waveform of transcranial motor evoked potential in Case 2 exhibiting no significant changes throughout surgery

In our cases, a stimulator attached to the dissecting instrument enabled simultaneous direct stimulation of nerves, evaluation of the response, and dissection during surgery. Stimulation of the nerve showed an EMG waveform of the muscle dominated by the stimulated nerve, which helped confirm the nerve from which the tumor arose. During enucleation, the appropriate dissection along the tumor capsule was performed by evaluating the response of transcranial and direct electrical stimulation, the information regarding which was provided by the neuromonitoring technician. The dissecting line was set based on the results of TcMEP monitoring, and the surgeon was notified if the motor nerve itself was stimulated. Simultaneously, information regarding significant changes in response recorded using spontaneous EMG in real time was provided. The comparison between preoperative baseline and intraoperative responses to transcranial stimulation during surgery helped ensure no loss of motor function. In both the cases, the tumor was safely resected with no remarkable decline in the TcMEP amplitude. After surgery, the patients did not have any motor deficits in the upper extremities, as indicated by the TcMEP results.

The reliability of TcMEP monitoring is affected by anesthetic and physiological factors, such as body temperature and blood pressure [11,12]. Therefore, if the response is identified, it is necessary to consider whether it would be affected by surgery. In our cases, the bispectral index was used to assess the depth of anesthesia. Moreover, TcMEP on the unresected side was recorded, and motor functional decline was evaluated by comparing the difference in values between both sides. These findings confirmed the intraoperative decline of TcMEP.

Although motor nerve function can be assessed using TcMEPs, postoperative sensory deficits cannot be confirmed using this method. Therefore, not all intraoperative neuropathies can be detected. In enucleation for schwannoma, the preservation of sensory neural function as well as motor nerve function is required. In our cases, SEP was used to monitor sensory deficits. There were no remarkable changes in SEPs throughout the surgery. Although both the patients temporarily experienced slight numbness after surgery, they recovered well in a few days. Therefore, these symptoms were likely caused by local swelling and inflammation due to surgery.

As in our cases, it is suggested that combining TcMEP evaluation with other monitoring methods, such as direct electrical stimulation and spontaneous EMG, can help better predict postoperative motor function [13]. In both cases, there were no abnormal spontaneous EMG wave patterns, such as polyphasic or burst patterns, and tonic or train activity. While direct electrical stimulation and spontaneous EMG alone can only evaluate local nerve damage, the effects of intraoperative traction and ischemia on nerve roots and the central nervous system can also be evaluated comprehensively by combining with TcMEP, which can predict postoperative motor function. Evaluation using multimodalities, including SEP, are more effective to prevent irreversible neural injury. However, there are limitations like that temperature and pain sensation as well as tactile perception cannot be evaluated with SEP. Further, adverse events such as bite injury due to transcranial stimulation and chemical injury due to electrical stimulation need to be avoided. Soft bite blocks are used to prevent bite injury in our institution and the cooperation between anesthesiologists, surgeons, clinical laboratory technicians, clinical engineers and nurses is essential for the success of intraoperative monitoring.

The feasibility of predicting postoperative recovery of motor deficits by intraoperative TcMEP monitoring has been discussed for spinal surgery. Currently, there is no consensus on the acceptable level of TcMEP decline to preserve postoperative motor function in cases of head and neck schwannomas. In future studies, the role of TcMEP as an indicator to predict postoperative complications should be investigated.

Conclusion

In both our cases, the brachial plexus schwannoma was safely resected without postoperative motor deficits with the aid of intraoperative TcMEP monitoring. Although there have been few reports of its application in head and neck surgeries, it is expected to be useful in preventing operative complications, similar to the results in other departments.

Ethical statement

Hereby, I /Akihisa Tanaka/ consciously assure that for the manuscript / Resection of schwannoma using transcranial motor evoked potential monitoring during head and neck surgery; Report of two cases/ the following is fulfilled:

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation).
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

I agree with the above statements and declare that this submission follows the policies as outlined in the Guide for Authors and in the Ethical Statement.

Date: 10/11/2021

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Disclosure statement

The authors declare no financial disclosures or conflicts of interest.

Declaration of Competing Interest

The authors declare that they have no competing interests.

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Not applicable.

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