Rehabilitation Practice and Science

Volume 2024 | Issue 1 Article 3

6-1-2024

Clinical Application of Intraoperative Neurophysiological Monitoring during Resection of a Spinal Tumor: A Case Report

Chia-Hung Hou
Department of Physical Medicine & Rehabilitation, Taipei Veterans General Hospital, tjhooaunvb@gmail.com

Sanford P C Hsu
Departments of Neurosurgery, Neurological Institute, Taipei Veterans General Hospital

Pang-Wei Chang
Department of Physical Medicine & Rehabilitation, Taipei Veterans General Hospital

Chen-Liang Chou
Department of Physical Medicine & Rehabilitation, Taipei Veterans General Hospital

Tsui-Fen Yang
Department of Physical Medicine & Rehabilitation, Taipei Veterans General Hospital

Recommended Citation

Hou, Chia-Hung; Hsu, Sanford P C; Chang, Pang-Wei; Chou, Chen-Liang; and Yang, Tsui-Fen (2024) "Clinical Application of Intraoperative Neurophysiological Monitoring during Resection of a Spinal Tumor: A Case Report," *Rehabilitation Practice and Science*: Vol. 2024: Iss. 1, Article 3.
DOI: https://doi.org/10.6315/3005-3846.2231
Available at: https://rps.researchcommons.org/journal/vol2024/iss1/3

CASE REPORT

Clinical Application of Intraoperative Neurophysiological Monitoring during Resection of a Spinal Tumor: A Case Report

Chia-Hung Hou [a,*], Sanford P.C. Hsu [b], Pang-Wei Chang [a], Chen-Liang Chou [a], Tsui-Fen Yang [a]

[a] Department of Physical Medicine & Rehabilitation, Taipei Veterans General Hospital, Taiwan
[b] Department of Neurosurgery, Neurological Institute, Taipei Veterans General Hospital, Taiwan

Abstract

Background: **Surgical resection of a spinal tumor is the first choice of treatment in clinical practice, however it carries a significant risk of creating new postoperative neurological deficits. It is believed that the concomitant use of intraoperative neurophysiological monitoring (IONM) during tumor resection can not only increase safety of the procedure, but also improve surgical outcomes.**

Case description: **A 52-year-old female who was in good health and neurologically intact presented with intermittent claudication, numbness and weakness of bilateral lower extremities, and bowel and urinary incontinence in June 2021. L-spine MRI revealed an intradural extramedullary tumor at T8 level. She received T7-9 laminectomy and tumor removal under IONM throughout the procedure. Preoperatively, except for motor-evoked potentials (MEPs) over the left lower limb, there were no elicitable somatosensory-evoked potentials (SSEPs) from bilateral tibial nerves or direct waves (D-waves), possibly related to a preoperative neurological deficit. D-waves appeared 30 min after beginning of tumor resection. MEPs over bilateral lower extremities showed significant improvement at the end of resection as well, although bilateral tibial SSEPs were not recordable.**

Improved motor control and muscle power of bilateral lower limbs were noted after the operation, however numbness over the right lower limb and poor proprioception were also noted, which affected her locomotion. At 4 months of follow-up, the numbness and impaired proprioception over the right lower limb had significantly improved, and her bowel and bladder function had also returned to normal.

Conclusion: **This case indicates that the application of IONM during resection of a spinal tumor can not only increase the safety of the surgical procedure, but also accurately predict postoperative functional outcomes.**

Keywords: Intraoperative neurophysiological monitoring (IONM), Spinal tumor, Motor evoked potential (MEP), Somatosensory evoked potential (SSEP), Direct wave (D-wave)

IRB

2023-02-012BC.

1. Background

Primary spinal tumors include intramedullary spinal tumors and extramedullary spinal tumors. Extramedullary spinal tumors can also be categorized into extradural and intradural types. Surgical resection of a spinal tumor is the first choice of treatment in clinical practice, however it carries a significant risk of creating new postoperative neurological deficits.[1] It is believed that concomitant use of intraoperative neurophysiological monitoring (IONM) during tumor resection can not

Received 21 January 2023; revised 15 March 2023; accepted 24 March 2023.
Available online 1 June 2024

* Corresponding author at: Department of Physical Medicine & Rehabilitation, Taipei Veterans General Hospital, No. 201, Section 2, Shihpai Road, Beitou, Taipei 11267, Taiwan.
E-mail address: tjhooaunvb@gmail.com (C.-H. Hou).

https://doi.org/10.6315/TJPMR.2231

only increase safety of the procedure, but also improve surgical outcomes. Multiple IONM modalities are widely available, including somatosensory sensory evoked potentials (SSEPs), motor-evoked potentials (MEPs), spontaneous and triggered electromyography (EMG), and direct waves (D-waves) recordings. Multimodal IONM has gradually become the standard practice for surgical procedures.[2–4] The use of IONM provides intraoperative information on spinal cord function, and the real-time feedback helps surgeons avoid permanent neurological deficits.

However, the value of IONM in spinal surgery is heterogenous and most research has included different types of spinal tumors. Few papers have focused on the clinical benefits of IONM in intradural extramedullary tumor resection surgery. Hence, we report this case of paralysis related to an intradural extramedullary spinal tumor. We focus on the relationship between a significant improvement in IONM signals and postoperative functional status.

2. Case description

A 52-year-old female who was in good health and neurologically intact started to experience intermittent claudication associated with numbness and weakness of bilateral lower extremities, especially the right side, and bowel and urinary incontinence in June 2021. MRI of the whole spine revealed an intradural extramedullary enhancing nodule at T8 level, causing marked extradural spinal compression and favoring meningioma (Fig. 1AB). She then received T7-9 laminectomy and tumor removal with a posterior approach and posterior lateral fusion without internal fixation under IONM throughout the procedure (Fig. 1C). IONM was performed with CadWell Cascade Elite. (MEP: recording filter setting 30–3000Hz, stimulation intensity: 200V–400V, stimulation duration: 0.05–0.75 ms; D-waves: recording filter setting 100–1000Hz, stimulation intensity: 100V–400V, stimulation duration: 0.05–0.75 ms; SSEP: recording filter setting 30–500Hz, stimulation intensity: 25mA–50mA, stimulation duration: 0.2–1 ms). Patients with skull defect or pacemaker are not suitable to undergo IONM due to safety concern.

Under total intravenous general anesthesia before surgical incision, except for MEPs recorded over the left lower extremity, there were no elicitable SSEPs from bilateral tibial nerves or D-waves (Fig. 2A), possibly related to a preoperative neurological deficit. However, D-waves appeared 30 min after beginning tumor resection (Fig. 2B). In addition, MEPs over bilateral lower extremities showed increased amplitude at the end of resection compared to the baseline signals (Fig. 3), which implied a possible improvement in postoperative neurological status based on IONM findings although bilateral tibial SSEPs were still not recordable.

Improved motor control and muscle power of bilateral lower extremities were noted after the operation, with 4/5 muscle strength found for bilateral iliopsoas, quadriceps, anterior tibialis and gastrocnemius muscles. Improved perineal sensation was also noted, however paresthesia over the right lower extremity still persisted. Impaired proprioception was also noted, particularly over the right lower extremity, with unperceived passive motion of the right interphalangeal and metatarsophalangeal joint of the right foot, which greatly affected her locomotion and functional stability. She could walk with a walker for safety concerns, and she was discharged 9 days after surgery.

At 4 months of follow-up, paresthesia over the right lower extremity had significantly improved, and a physical examination revealed complete recovery of proprioception over the right lower extremity. She could walk without the walker although with a relatively slow walking speed. Her bowel and bladder function had also returned to normal.

3. Discussion

Intradural extramedullary tumors account for about two thirds of primary intraspinal tumors, including schwannomas, meningiomas and ependymomas.[5] Patients with spinal tumors can suffer from local back pain, radicular pain, and more severely, sensory and motor complaints of lower extremities and even bladder dysfunction due to compression of the spinal cord or nerve root.[6] Spinal tumor resection is the first line of therapy, and significant improvements in neurological symptoms after surgery have

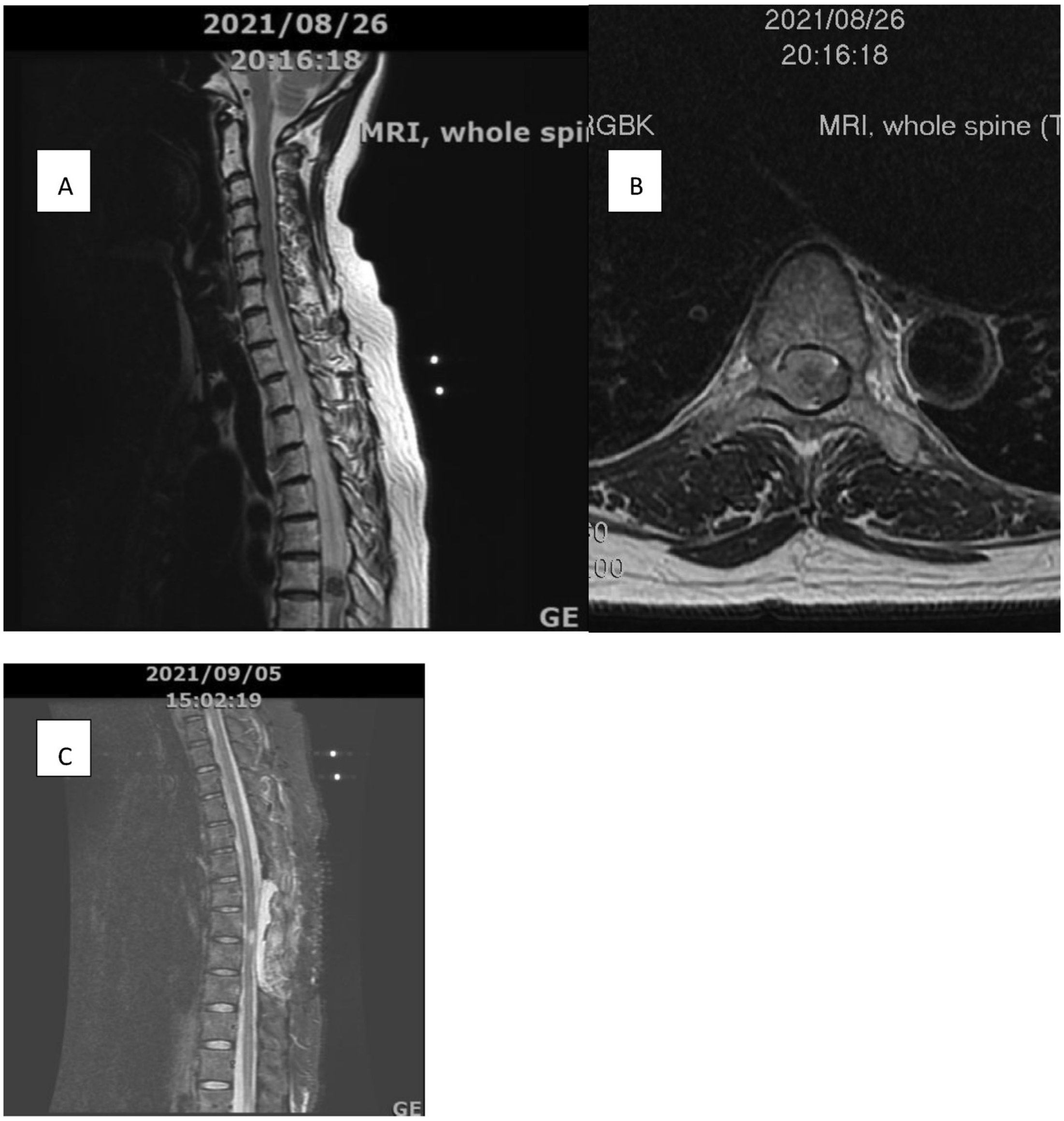

Fig. 1. A. Preoperatively, sagittal T2-weighted MRI of whole spine revealed a 2.2 x 1.5 × 2.4 cm intradural extramedullary enhancing nodule at T8 level, causing marked extradural spinal compression. B. Preoperatively transverse T2-weighted MRI image revealed extradural spinal compression at T8 level. C. Postoperative images showed laminectomy of T7-9, with hyperintensity at the posterior extradural region, favoring dural sealant or fluid accumulation.

been demonstrated if the tumor location and its attachment to the dura mater can be accurately identified preoperatively.[5,7,8]

Postoperative tumor recurrence has been reported, with risk factors including tumor location anterior to the spinal cord, intradural extramedullary plus extradural site, dumb-bell tumors, and neurofibroma, ependymoma, and malignant schwannoma tumor types.[9] Asazuma et al.[9] reported a 7.2 % overall re-operation rate due to tumor recurrence. Hence, aggressive surgical resection is favored to avoid tumor recurrence.[8]

However, this kind of surgery can involve neurological complications, including perioperative spinal cord injury, which can be devastating. Many factors may influence the complication rates, such as age, comorbidities, location and perioperative adverse events. Rani et al.[10] reported higher complication rates in thoracolumbar than in cervical procedures. For the surgeon, how to reduce perioperative adverse events is of

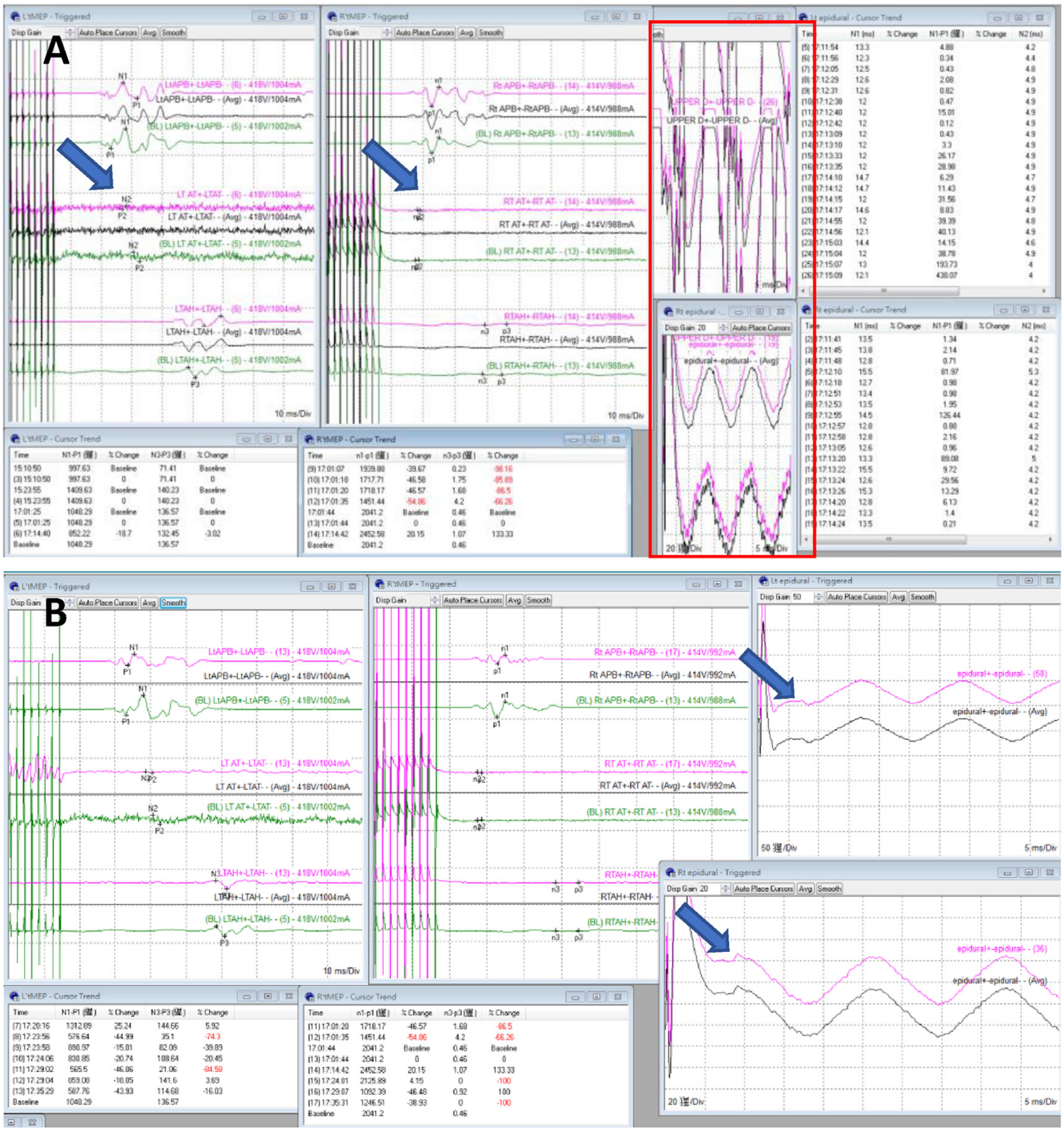

Fig. 2. A. Before tumor resection: no recordable D-waves (only interfering signals)(box) or MEPs over the right lower limb or the left anterior tibialis muscle (arrow). B. During tumor resection: D-waves appeared 30 min after beginning the operation (arrow).

particular importance. To this end, IONM is used to provide intraoperative information and help minimize the risk of surgical-related neurological complications.[11]

The application of IONM in spinal surgery has become more widespread, however the role of IONM remains under debate. In addition, most previous studies have included different types of spinal tumors rather than focusing on one specific type. Hence, there are currently no specific IONM guidelines for intradural extramedullary spinal tumors. Ishida et al.[12] included 103 patients with intradural extramedullary spinal tumors and reported that significant changes in IONM were predictive of new postoperative neurological complications at 6 months of follow-up, with a sensitivity of 82.4 % and specificity of 90.7 %. Consequently, the authors concluded that IONM was a suitable modality for resection of intradural extramedullary spinal tumors. Van der Wal et al.[13] analyzed 78 patients who received surgical resection of intradural extramedullary spinal tumors, and their results also revealed a high sensitivity and specificity for predicting postoperative neurologic outcomes. Cofano et al.[14] collected 249 patients who received intradural extramedullary spinal tumor resection,

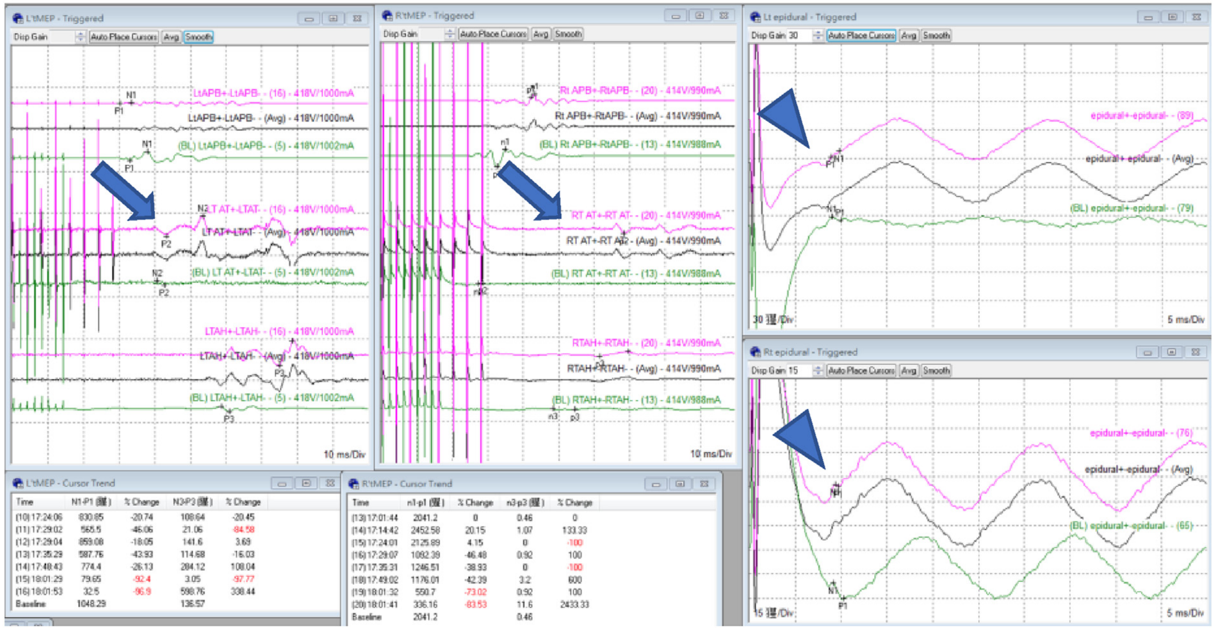

Fig. 3. After tumor resection: improved MEPs over both lower limbs (arrow) along with persistence of D-waves (arrowhead).

and found that the use of IONM was correlated with a better prognosis, but that there was no association with the extent of resection. These three studies collected data on the utilization of IONM with heterogenous monitoring modalities in each case.

There are still no standard guidelines for the use of IONM in spinal surgery, and hence different modalities are widely used. Both single and multiple modalities have been used as predictive tools for postoperative neurologic outcomes.[13] MEP monitors the corticospinal tract, with transcranial stimulation of the brain and recording at the muscles of the extremities. D-wave monitoring is also used to evaluate the function of the corticospinal tract, with the same transcranial stimulation and electrodes inserted into the subdural space to record descending motor signals along corticospinal tract due to the proximity of electrodes placement and surface of spinal cord. Compared to MEPs which can predict the immediate postoperative motor function, D-waves can be more predictive of the long-term neurological function based on the recent study.[15] Hence, we included the D-wave monitoring in this surgery. D-wave monitoring is not commonly used as a monitoring modality in spinal surgery, and few papers have reported the efficacy of D-wave monitoring in preventing postoperative neurological complications, especially specific to intradural extramedullary spinal tumors. Ghadirpour et al.[16] highlighted the feasibility of using D-wave monitoring among patients with intradural extramedullary spinal tumors without severe motor deficits preoperatively. The use of D-wave monitoring could also predict postoperative neurological deficits. These findings suggest that both MEPs and D-waves can be used to monitor the integrity of the corticospinal tract.

In our case, there were significant improvements in IONM signals during the surgical resection, and we assessed the postoperative outcome after 4 months of follow-up. We used multiple modalities of IONM, including SSEPs, MEPs, and D-waves during the surgical resection of the thoracic intradural extramedullary spinal tumor. Preoperatively, the patient had severe impairment of bilateral lower extremity function, which may explain the absence of IONM signals including SSEPs, MEPs and D-waves. During the perioperative period, significant improvements in IONM signals were noted, in particular MEPs and D-waves more than SSEP. Postoperatively, as expected, the patient had significantly improved motor function but impaired proprioception. This outcome was consistent with the IONM findings.

In the current literature, most studies have focused on the signal loss of IONM corresponding to postoperative neurological deficits, and few studies have emphasized the relationship between improved IONM signals and postoperative neurological status. These studies have reported similar finding to our case, with a positive correlation between improved IONM signals and better postoperative clinical outcomes, however they only used a single modality, either MEPs or SSEPs.[17–19] Wi et al.[20] analyzed 29 patients with improved IONM signals during spinal surgery, and reported no new neurological complications and improved postoperative neurological outcomes in follow-up. However, their cases were heterogenous, with different types of spinal surgery and multimodality IONM including MEPs, SSEPs or both, but not D-waves. In our case, we used multimodality IONM signals with D-waves in conjunction with SSEPs and MEPs, which is more popular in modern surgery.

In this case, preoperatively, the absent D-waves and SSEP and small amplitude MEP IONM signals reflected the patient's preoperative neurological deficits. For the surgeon, only MEPs could be used to monitor neural injury during the initial period of the operation. However, as the tumor was resected, D-waves signals appeared and the MEPs improved, probably due to decompression of the spinal nerve tract (Fig. 2B). Hence, D-waves could also be used to monitor injury after 30 min of tumor resection, which could be expected to improve safety of the remaining surgery. Dong-Ki et al.[8] found that the degree of preoperative symptoms were correlated with the percentage of tumor occupying the intradural space. Neurological symptoms would be expected to improve as the nerve tract is decompressed, as reflected in the improvement in intraoperative signals.

Previous studies have reported that IONM was not associated with the extent of tumor resection, and hence IONM could not replace the surgeon's clinical opinions.[13] However, in our case, we suggest that the improved IONM signals during tumor resection provided positive feedback for the surgeon and helped to achieve complete tumor resection.

4. Conclusion

In this case, there were significant improvements in IONM signals during the operation. At 4 months of follow-up, neither neurological deterioration nor new neurological complications were noted. We suggest that significant improvements in IONM signals can be a predictor of better neurological status in intradural extramedullary spinal tumor surgery. Our case indicates that the application of IONM during resection of a spinal tumor can not only increase the safety of the surgical procedure, but also accurately predict postoperative functional outcomes.

Funding/support statement

None.

Conflicts of interest

None.

References

1. Charalampidis A, Jiang F, Wilson JR, Badhiwala JH, Brodke DS, Fehlings MG. The use of intraoperative neurophysiological monitoring in spine surgery. *Global Spine J* 2020;10(1_suppl), 104S-14S.
2. Deletis V, Sala F. Intraoperative neurophysiological monitoring of the spinal cord during spinal cord and spine surgery: a review focus on the corticospinal tracts. *Clin Neurophysiol* 2008;119(2): 248–64.
3. Quraishi NA, Lewis SJ, Kelleher MO, Sarjeant R, Rampersaud YR, Fehlings MG. Intraoperative multimodality monitoring in adult spinal deformity: analysis of a prospective series of one hundred two cases with independent evaluation. *Spine* 2009;34(14):1504–12.
4. Bello JP, Pérez-Lorensu PJ, Roldán-Delgado H, Brage L, Rocha V, Hernández-Hernández V, et al. Role of multimodal intraoperative neurophysiological monitoring during positioning of patient prior to cervical spine surgery. *Clin Neurophysiol* 2015;126(6):1264–70.
5. Albanese V, Platania N. Spinal intradural extramedullary tumors: personal experience. *J Neurosurg Sci* 2002;46(1):18.
6. Helweg-Larsen S, Sørensen PS. Symptoms and signs in metastatic spinal cord compression: a study of progression from first symptom until diagnosis in 153 patients. *Eur J Cancer* 1994;30(3):396–8.
7. El-Mahdy W, Kane P, Powell M, Crockard H. Spinal intradural tumours: Part I-extramedullary. *Br J Neurosurg* 1999;13(6):550–7.
8. Ahn D-K, Park H-S, Choi D-J, Kim K-S, Kim T-W, Park S-Y. The surgical treatment for spinal intradural extramedullary tumors. *Clin Orthop Surg* 2009; 1(3):165–72.
9. Asazuma T, Toyama Y, Watanabe M, Suzuki N, Fujimura Y, Hirabayashi K. Clinical features associated with recurrence of tumours of the spinal cord and cauda equina. *Spinal Cord* 2003;41(2):85–9.
10. Nasser R, Yadla S, Maltenfort MG, Harrop JS, Anderson DG, Vaccaro AR, et al. Complications in spine surgery: a review. *J Neurosurg Spine* 2010;13(2): 144–57.
11. Ahn H, Fehlings MG Prevention. identification, and treatment of perioperative spinal cord injury. *Neurosurg Focus* 2008;25(5):E15.
12. Ishida W, Casaos J, Chandra A, D'Sa A, Ramhmdani S, Perdomo-Pantoja A, et al. Diagnostic and therapeutic values of intraoperative electrophysiological neuromonitoring during resection of intradural extramedullary spinal tumors: a single-center retrospective cohort and meta-analysis. *J Neurosurg Spine* 2019;30(6):839–49.
13. van der Wal EC, Klimek M, Rijs K, Scheltens-de Boer M, Biesheuvel K, Harhangi BS. Intraoperative neuromonitoring in patients with intradural extramedullary spinal cord tumor: a single-center case series. *World Neurosurg* 2021;147:e516–23.
14. Cofano F, Giambra C, Costa P, Zeppa P, Bianconi A, Mammi M, et al. Management of extramedullary intradural spinal tumors: the impact of clinical status, intraoperative neurophysiological monitoring and surgical approach on outcomes in a 12-year double-center experience. *Front Neurol* 2020;11: 598619.
15. Kimchi G, Knoller N, Korn A, Eyal-Mazuz Y, Sapir Y, Peled A, et al. Delayed variations in the diagnostic accuracy of intraoperative neuromonitoring in the resection of intramedullary spinal cord tumors. *Neurosurg Focus* 2021;50(5):E21.
16. Ghadirpour R, Nasi D, Iaccarino C, Romano A, Motti L, Sabadini R, et al. Intraoperative neurophysiological monitoring for intradural extramedullary spinal tumors: predictive value and relevance of D-wave amplitude on surgical outcome during a 10-year experience. *J Neurosurg Spine* 2018;30(2):259–67.
17. Bouchard JA, Bohlman HH, Biro C. Intraoperative improvements of somatosensory evoked potentials: correlation to clinical outcome in surgery for cervical spondylitic myelopathy. *Spine* 1996;21(5): 589–94.
18. Visser J, Verra WC, Kuijlen JM, Horsting PP, Journée HL. Recovery of TES-MEPs during surgical decompression of the spine: a case series of eight patients. *J Clin Neurophysiol* 2014;31(6):568–74.
19. Wang S, Tian Y, Wang C, Lu X, Zhuang Q, Peng H, et al. Prognostic value of intraoperative MEP signal improvement during surgical treatment of cervical compressive myelopathy. *Eur Spine J* 2016;25(6): 1875–80.
20. Wi SM, Lee H-J, Kang T, Chang SY, Kim S-M, Chang B-S, et al. Clinical significance of improved intraoperative neurophysiological monitoring signal during spine surgery: a retrospective study of a single-institution prospective cohort. *Asian Spine J* 2020;14(1):79.