Original Article: Diagnostic Technology by EMG for Spine surgery: systematic review

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ABSTRACT

Introduction: There do not appear to be any distinct, accepted clinical or investigative standards for the diagnosis or, more importantly, the selection of cervical radiculopathy patients for surgery. To decide who to operate on and to give our patients a realistic prognosis estimate, it is critical that we can pinpoint the subgroup most likely to benefit from surgery. The purpose of this study is to determine whether electromyography (EMG) studies can be used to pinpoint the subgroup that will recover more favorably from surgery.

Material and Methods: The latency of muscle contractions is measured by recording MEPs, and the CMCT is calculated by subtracting the latency of nerve conduction from the cerebral cortex to the muscle via the corticospinal tract from the latency of nerve conduction between the spinal nerve root and the muscle where an electrode was attached. For BB-CMCT, APB-CMCT, and TA-CMCT, the cut-off values are 8 to 9 ms, 18 ms, and 20 ms, respectively.

Results: In the entire sample, there was a 40% agreement between NPS, MRI, and the level or levels that had undergone surgery. In group A, two patients' sensory nerve conduction studies show associated evidence of median nerve compression at the wrist. In group B, none of the patients had evidence of nerve root compression on preoperative NPS, but all of the patients had evidence of disc bulge and narrowing of the exit foramina on MRI scans.

Conclusion: This study has shown that preoperative NPS is useful in determining which cervical radiculopathy patients will benefit most from surgery. Patients who undergo preoperative abnormal needle EMG examination will likely benefit from surgical decompression and fusion much more than those who undergo preoperative normal EMG. Therefore, whenever evaluating a patient with cervical radiculopathy, particularly if surgery is being considered, EMG should always be used in conjunction with an MRI scan.

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Introduction

The number of patients with spinal disorders has progressively risen over time, and the disease's burden is difficult from an economic, social, and other perspective. The management and prognosis of spinal disease are intimately related to accurate diagnosis, just like with other pathologies [1]. The accurate diagnosis of spinal pathologies has been made possible thanks to improvements in diagnostic techniques [2-4].

Bony spine structures have been confirmed since the invention of X-rays in 1895, which prompted the creation of imaging-based diagnostic methods. Despite advancements in radiography technology, radiography still has many inherent limitations that make it difficult to identify many pathologies of the spine, particularly those of the disc, spinal cord, and root. Sir Godfrey Hounsfield created the first computed tomography (CT) scanner in 1967 using X-ray technology, and Raymond Damadian created the first magnetic resonance imaging (MRI) device in 1977 for clinical use in treating human diseases [5-7].

The creation of these cutting-edge technologies had a significant impact on the clinical diagnosis of every human disease as well as the formulation of treatment recommendations. However, despite these innovative advancements in diagnostic imaging technologies, there is a dearth in the diagnosis of spinal diseases because spinal pathologies are intricately linked to neural structures like the spinal cord, cauda equina, and nerve roots, and the extent of injury at the neural structure cannot be seen using conventional imaging techniques [8]. In order to better define spinal pathologies, modalities such as bone scans have been developed in addition to electrodiagnostic modalities like electromyography (EMG) and nerve conduction studies (NCSs), which have been used as spinal diagnostic techniques. Despite the development of numerous surgical techniques, the results of the surgical treatment of cervical disc herniation with radiculopathy are frequently unpredictable. The selection of patients who are appropriate for the procedure remains the main challenge [9-11].

It appears that there is little consensus regarding the selection criteria for surgical treatment, and there is no clear method for evaluating patients prior to surgery. From 66 to 98 percent of patients in previous studies had good to excellent surgical results. It is questionable whether a clinical examination for cervical radiculopathy actually provides a true diagnosis [12].

There may be varying degrees of motor weakness, deep tendon reflexes, and sensory deficit. The loss of deep tendon reflexes is typically regarded as the most reliable clinical finding, with C5 injury affecting the biceps reflex, C6 injury affecting the brachioradialis, and C7 affecting the triceps reflex. However, the correlation between MRI and surgical findings is frequently unreliable because the assessment of false positive and false negative findings can be influenced by the experience of both the radiologist and the surgeon [13].

There do not appear to be any distinct, accepted clinical or investigative standards for the diagnosis or, more importantly, the selection of cervical radiculopathy patients for surgery. To decide who to operate on and to give our patients a realistic prognosis estimate, it is critical that we can pinpoint the subgroup most likely to benefit from surgery. The purpose of this study is to determine whether electromyography (EMG) studies can be used to pinpoint the subgroup that will recover more favorably from surgery.

Material and Methods

In our unit, cervical radiculopathy patients undergoing anterior cervical interbody fusion using the AcroMed® carbon fiber cage were

prospectively evaluated for study eligibility. Only patients in our unit who had an unclear operative level after a clinical and MRI assessment underwent neurophysiological studies (NPS). Patients who had cervical myelopathy, had previously undergone cervical surgery for radiculopathy, were unable to undergo NPS, had a history of mental illness, drug or alcohol abuse, or had diabetes were excluded from the trial. The study involved 20 patients, with 12 women and 8 men. The median age was 50 years, and the mean age was 49 years. On the basis of the results of the preoperative NPS, the patients were split into two groups (A and B).

According to the neurophysiological results from before surgery—normal or abnormal—patients were categorized. The study was approved by the appropriate ethical committee, and all participants provided their informed consent. Preoperative symptoms and indications of cervical root involvement served as the basis for the diagnosis. These included stiffness in the neck and shoulder, weakness and muscle atrophy in the myotomal distribution, dermatomal sensory impairment, and depressed or absent reflexes, in addition to pain that radiates from the neck and shoulder down the arm.

MRI of the cervical spine and flexion and extension lateral radiographs were used for preoperative radiological evaluation. At least a year after surgery, a standard electrophysiological examination was conducted. This included concentric needle EMG using a computerized EMG machine (Nicolet Biomedical-Viking IVP®) and nerve conduction studies (NCS). The presence of spontaneous activities (fibrillations, positive sharp waves, and fasciculations), as well as long-lasting polyphasic motor units, provided evidence of denervation changes on needle EMG.

Using a modified version of the Prolo functional and economic scoring system, patient outcome was also evaluated at least a year after surgery. This outcome measure was initially created for lumbar spine symptoms, and it has been standardized and validated. Davis and associates. modified this as the modified Prolo functional and economic scoring system for use postoperatively. This system analyzes any alteration in symptom severity, functional capacity, and quality of life.

The combined functional and economic scores make up the modified Prolo total score. A score of 4 or less indicates a poor outcome, a score of 5 or 6 a moderate outcome, a score of 7 or 8 a good outcome, and a score of 9 or 10 an excellent outcome. The patient's satisfaction and opinion were also evaluated using other validated instruments(Fig 1).

Figure 1: EMG test in spine

These included eight items on the patient's satisfaction scale and four separate items regarding the patient's opinion. The ability to perform work or daily tasks more effectively as well as symptom relief and functional improvement were considered signs of successful surgery. The mean score of the answered items on each scale was used to calculate scale scores.

With five response options that are equivalent to those on the satisfaction scale, the first of the

four distinct items regarding the patient's opinion asks about satisfaction with the overall results of surgery. The second question asks about how surgery affects quality of life and offers five response options (much better, slightly better, unchanged, slightly worse, much worse). The third and fourth items, both of which have five response options, ask whether respondents would choose to undergo the same procedure again if given the chance and whether they would suggest it to a close friend.

The values for CMCTs are typically recorded from the bilateral biceps brachii (BB), abductor pollicis brevis (APB), and tibialis anterior (TA) muscles. Central motor conduction time (CMCT) studies assess the condition of the corticospinal tract in the brain or spinal cord based on motor evoked potentials (MEPs). In order to cause an MEP, electrodes are attached to the chosen muscles. Starting over the primary motor cortex, magnetic stimulation is delivered to the muscles on the opposite side of the stimulated cortex by inducing muscle contraction.

The latency of muscle contractions is measured by recording MEPs, and the CMCT is calculated by subtracting the latency of nerve conduction from the cerebral cortex to the muscle via the corticospinal tract from the latency of nerve conduction between the spinal nerve root and the muscle where an electrode was attached. For BB-CMCT, APB-CMCT, and TA-CMCT, the cut-off values are 8 to 9 ms, 18 ms, and 20 ms, respectively.

The condition of the sensory tract in the brain or spinal cord is assessed by sensory evoked potential (SEP) studies. SEPs of the bilateral median and posterior tibial (PT) nerves are typically measured; SEPs of PT nerve stimulation at the ankle (N37, N45) and median nerve stimulation at the wrist (N19, P23) are recorded on the scalp overlying the primary sensory area (median nerve: Cz'), which is in the parietal lobe opposite the stimulated side. The cut-off values for median-SEP and PTSEP are respectively 21.0 (N19) and 24.6 (P23) and 4 (P37) and 51 (N45) ms.

Peripheral nerves and muscles are assessed using NCS and EMG, which can provide details on the severity and location of nerve damage. The presence of muscle pathology can be examined using EMG. In NCS, the stimulating electrode stimulates the nerves while the recording electrode, which is attached to particular sites on the nerves, records electrical activity. Subsequently, the latency for the muscles to contract in response to the nerve electrical stimulation, conduction velocity, and amplitude are measured.

By inserting a tiny needle electrode into the muscle tissue, an electromyogram (EMG) can assess the electro-physiological health of a muscle. If there is nerve or muscle damage, this results in electrophysiological changes in the muscle. The presence and severity of radiculopathy can be assessed in spinal disorders using NCS/EMG. The use of NCS/EMG prior to spinal surgery allows for the accurate diagnosis of the lesions causing neurological symptoms, such as motor neuron disease, Guillain-Barré syndrome, and peripheral demyelinating disease, thereby avoiding the need for unnecessary spinal surgery.

Results

Group A patients (n = 8) demonstrated positive evidence of radiculopathy on NPS, whereas group B patients (n = 12) did not demonstrate any evidence of radiculopathy. Using an AcroMed® cage and an autologous iliac bone graft, anterior cervical interbody fusion was performed on all patients.

The presence of a radicular pattern of pain, a sensory deficit, a motor weakness, or both, were used to make the diagnosis of cervical radiculopathy. The most common presenting symptoms were neck and shoulder pain radiating to one arm in all patients (100%) followed by neck and shoulder stiffness,

weakness, and paresthesia in a dermatomal distribution. Roots C6, C7, and C5 were the most frequently affected levels. Both plain radiography and magnetic resonance imaging revealed cervical degenerative disease in all of the patients(Fig 2).

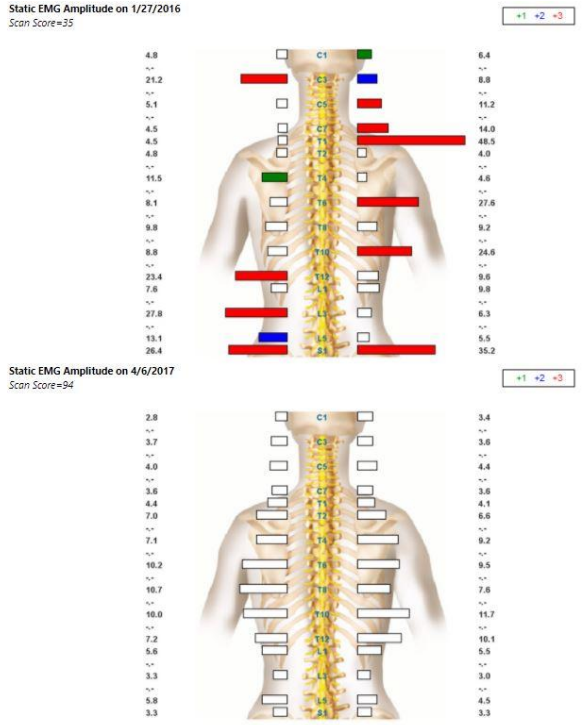

Figure 2: EMM Application methods

To support the diagnosis and rule out other related peripheral nerve lesions, neurophysiological tests were carried out. In group A, preoperative NPS (EMG and NCS) revealed evidence of denervation and re-innervation in the distribution of one or more cervical nerve roots. All patients had disc bulges and narrowed exit foramina on magnetic resonance imaging scans of the cervical spine.

In the entire sample, there was a 40% agreement between NPS, MRI, and the level or levels that had undergone surgery. In group A, two patients' sensory nerve conduction studies show associated evidence of median nerve compression at the wrist. In group B, none of the patients had evidence of nerve root compression on preoperative NPS, but all of the patients had evidence of disc bulge and narrowing of the exit foramina on MRI scans(Fig 3).

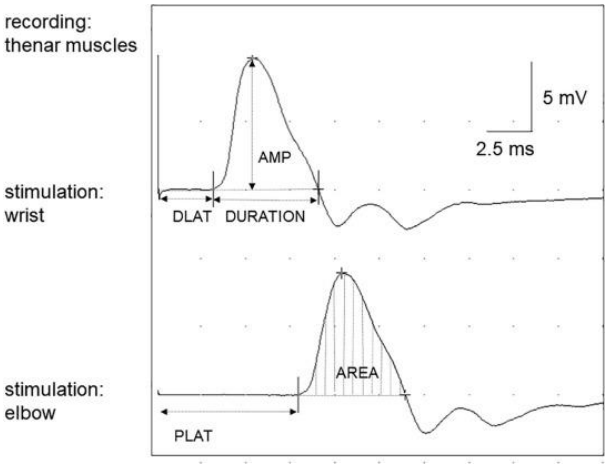

Figure 3: EMG results between tow groups

One patient has an ulnar nerve lesion at the elbow, and two patients in group B have evidence of median nerve compression at the wrist, according to pre- and post-operative nerve conduction studies. At least a year after surgery, the overall group's results were evaluated. Overall, a moderate result was achieved with a Prolo mean score of 6.

These results are based on a mean follow-up time of 28 months. A comparison of the Prolo outcome score between group A's abnormal EMG studies and group B's normal studies was made. Unpaired Student t-test results showed that group A performed significantly better than group B. The total Prolo mean score SEM for groups A and B was, and, respectively. Prolo descriptive statistics for groups A and B, respectively, are displayed in.

Age, the number of levels involved (MRI, EMG, and surgery), the type of work done before and after the surgery (manual, office work, and unemployed), the dominant hand, and the severity of the symptoms were all taken into account in the multivariate analysis. Preoperative EMG results were the only significant predictor of outcome. All but one (7 of 8) of group A's postoperative NPS (NCS and EMG) results showed long-lasting stable re-

innervations changes, which were manifested by the absence of spontaneous activities and the presence of sizable polyphasic motor units. However, one patient had active denervation, indicating that the C5 nerve root was still being compressed.

The preoperative or postoperative NPS of any patients in group B did not reveal any signs of root irritation or compression. Group A patients' working status included seven people who were employed before surgery and one person who was not.

One patient had to take an early retirement while the other five patients were able to return to their prior jobs with only minor or no restrictions. He said that persistent symptoms, primarily mild neck stiffness and pain, had limited his activity. Ten of the twelve patients in group B were working, compared to seven who had to retire early and identified as limited to disabled.

Discussion

Here, we'll talk about using electromyography (EMG) to identify patients who might have better postoperative outcomes. This is crucial because numerous other strategies have been shown to be of only marginal help. If the patient is in pain, a clinical examination may not always be straightforward. Plain radiographs in a variety of projections may be useful, but clinical symptoms frequently don't match up well with radiological findings.

Imaging methods are primarily used to pinpoint the abnormality, identify spinal cord compression, locate nerve roots, and rule out intraspinal lesions. Shafaie and co. have noted that there is frequently a lack of reliability in the correlation between MRI and surgical results. The vast majority of MRI scans are still carried out while the patient is lying flat with the spine still, despite the fact that patients spend the majority of their time upright with the spine moving. Additionally, asymptomatic subjects have had abnormalities in their MRI results.

It is estimated that 10% of people under the age of 40 have disc herniations, 20% of people over that age have foraminal stenosis, and 8% have disc protrusion or herniation. Many people believe that neurophysiological tests are helpful in identifying cervical radiculopathy and in ruling out peripheral nerve lesions. With sensitivity in cervical radiculopathy ranging from 50 to 93 percent, concentrated needle EMG appears to be the most effective and widely accepted method among all electrodiagnostic procedures for the diagnosis of radiculopathy.

Based on the presence of fibrillations and positive sharp waves in limb muscles, Knutsson reported that needle EMG correlates with root injury at surgery in 79 percent of patients. Falck and associates According to, a positive outcome was associated with an EMG finding that was normal both one year and five years after surgical decompression. Khan and others.

In patients who had fully recovered from surgery, reported that cervical SSEP (somatosensory evoked potential) had returned to normal. Ashkan and associates. According to, MRI and NPS both had similar positive predictive values of 91 and 86 percent, while their sensitivity for the diagnosis of cervical radiculopathy was 93 and 42 percent, respectively.

The negative predictive value of MRI was higher (25 vs.7 %). However, there was a higher level of agreement between MRI and EMG in patients who had obvious radicular symptoms and abnormal clinical signs (60 percent), indicating that MRI and EMG are still complementary diagnostic tools for cervical radiculopathy.

A review of the literature suggests that there is some disagreement about the prognostic significance of NPS in radiculopathies. For instance, pre- and postoperative EMG have failed to offer prognostic information in cervical radiculopathy in several studies, according to

Toyokura et al compared to standard motor nerve conduction studies, F-wave has been reported to have prognostic value. Studies using validated outcome measures to compare neurophysiological findings and outcomes following spinal surgery are notably rare. The visual analogue scale served as the foundation for Tullberg et al.'s assessment of the lumbar radiculopathy outcome [14-16].

When compared to patients with normal electrophysiological studies, those with abnormal studies had significantly better surgical outcomes one year after surgery. No study has [17], to date, compared the neurophysiological and imaging results obtained prior to surgical decompression and fusion for cervical radiculopathy with the surgical outcome as measured by a validated outcome instrument [18-20].

In a number of articles, radiculopathy patients who underwent anterior cervical discectomy and interbody fusion were shown in series that appeared to be successful [21-23]. However, few offer comprehensive assessment scores to show how severe the symptoms are. In this paper, we have shown that [24], overall, there was a moderate improvement in outcome following anterior discectomy and fusion at the levels suggested by clinical symptoms and MRI scans in the group of patients with radiculopathy [25-27]. People in group A (who also had abnormalities in the needle EMG examination) showed a noticeably larger improvement, though [28-30]. The better results in these patients imply that the best candidates for surgery are probably those who have a positive needle EMG examination [31-33].

This implies that limiting surgery to those who have abnormal neurophysiological tests is one way to increase the likelihood of predicting patients who will benefit from any surgical intervention [34-36]. Despite the fact that this is not the only cause for surgery, patients with normal neurophysiological tests [37] who are scheduled for surgery should be warned beforehand that any postoperative improvement in symptoms might not be significant [38-40].

Conclusion

This study has shown that preoperative NPS is useful in determining which cervical radiculopathy patients will benefit most from surgery. Patients who undergo preoperative abnormal needle EMG examination will likely benefit from surgical decompression and fusion much more than those who undergo preoperative normal EMG. Therefore, whenever evaluating a patient with cervical radiculopathy, particularly if surgery is being considered, EMG should always be used in conjunction with an MRI scan.

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