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THE EFFICACY OF INTRAOPERATIVE SPINAL CORD MONITORING DURING SURGERY FOR SPINAL STENOSIS

LOMBER SPİNAL STENOZ CERRAHİSİNDE İNTRAOPERATİF NÖROMONİTÖRİZASYONUN ETKİNLİĞİ

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SUMMARY:

Objectives: To compare the findings of intraoperative spinal cord monitoring during posterior decompression and instrumentation for lumbar spinal stenosis and the clinical results obtained at the sixth month postoperatively.
Patients and methods: Twenty patients, who received surgery in our clinic because of lumbar spinal stenosis and were monitored using an intraoperative spinal cord monitor between May 2011 and November 2011, were included in this study. The mean age of the patients was 69, and 10% were male (two patients) and 90% were female (18 patients).
The preoperative radiological assessments of the patients were achieved using plain X-rays and MRI. The preoperative and postoperative clinical evaluations were performed with SF36, the Oswestry score and the Visual Analog Scale (VAS). Decompression was applied to all patients after completion of posterior spinal instrumentation during surgery. Interbody fusion was applied to one patient only. Transcortical Motor Evoked Potentials were used for neurological monitoring and the amplitude and latency changes were recorded. The correlation of the amplitude changes and the clinical results were evaluated.
Results: The average preoperative VAS score of the patients was 8, which regressed to 1.8 postoperatively (p=0.0001). The average preoperative SF36 score was 29.5, which became 76.6 postoperatively (p=0.0001). The average preoperative Oswestry score was 65.5, and this regressed to 9.95 postoperatively (p=0.0001). A general rise in the amplitudes of the TkMEPs was observed during surgery in all of the patients. The TkMEP amplitudes increased more than 50% in 14 of the 20 patients, and increased less than 50% in six of the patients. The amount of stenosis present and the preoperative VAS scores of the patients were both found to be unrelated to the group of patients with a low amplitude increase (p=0.156, p=0.079).
Conclusion: It was observed that the motor evoked potentials of all patients were raised during surgery, and this rise was found to correlate with the positive clinical results achieved postoperatively.
Key words: Spinal stenosis, intraoperative neural monitoring, clinical results
Level of Evidence: Prospective case series, Level II

ÖZET:

Amaç: Lomber spinal stenoz nedeniyle posterior dekompresyon ve enstrümantasyon uygulanan hastaların ameliyat sırasında nöromonitörizasyon bulguları ile ameliyat sonrası 6. ay kontrolünde klinik bulgularının karşılaştırılması.

Hastalar ve Metot: Mayıs 2011-Kasım 2011 tarihleri arasında lomber spinal stenoz nedeniyle opere edilen ve ameliyat sırasında nöromonitörizasyon uygulanan 20 hasta çalışmaya dâhil edilmiştir. Hastaların ortalama yaşı 69'dur, % 10'u (2 hasta) erkek, % 90'ı (18 hasta) bayandır. Hastaların ameliyat öncesi radyolojik değerlendirmeleri direk grafileri ve MR ile yapılmıştır. Ameliyat öncesi ve sonrası klinik değerlendirme SF36, Oswestry skoru ve Vizüel Analog Skor (VAS) ile yapılmıştır. Cerrahi tedavide bütün hastalara posterior enstrümantasyon yapıldıktan sonra dekompresyon uygulanmıştır. Bir hastaya cisimler arası füzyon uygulanmıştır. Nörolojik monitörizasyon için Transkortikal Motor Uyarılmış Potansiyeller kullanılmış, Amplitüd ve latans değişiklikleri kaydedilmiştir. Amplitüd değişikliklerin ile klinik sonuçların korelasyonu incelenmiştir.

Sonuçlar: Hastaların ameliyat öncesi VAS skoru ortalaması 8 iken ameliyat sonrası ortalama skor 1.8'e gerilemiştir (p= 0,0001). Ameliyat öncesi SF 36 Skoru ortalaması 29,5 iken ameliyat sonrası 76,6'ya yükselmiştir (p= 0,0001). Ameliyat öncesi Oswestry skoru ortalaması 65,5 iken ameliyat sonrası 9,95'e gerilemiştir (p= 0,0001). Bütün hastalarda ameliyat sırasında TcMEP amplitüdlerinde artış saptanmıştır. 20 hastanın 14'ünde TcMEP amplitüdleri % 50'nin üzerinde artış göstermiştir. 6 hastada ise % 50'den az yükselme olmuştur. Amplitüd yükselmesinin az olduğu gruptaki hastaların stenoz seviyeleri veya ameliyat öncesi VAS skorlarıyla bir ilintisi bulunamamıştır. (p=0,156, p= 0.079)

Sonuç: Bu çalışmada bütün hastalarda ameliyat sırasında motor evoked potansiyeli değerlerinde yükselme saptanmış ve bu değerdeki artışların ameliyat sonrası olumlu klinik sonuçlarda etkili olduğu fikri elde edilmiştir.
Anahtar Kelimeler: Spinal stenoz, intraoperatif nöromonitörizasyon, klinik sonuçlar
Kanıt Düzeyi: Prospektif ardışık olgu serisi, Düzey II

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INTRODUCTION:

Spinal stenosis is defined as stenosis of the spinal canal, lateral recess or neural foramen, depending on bone or soft tissue compression. The standard surgical procedure for spinal stenosis is laminectomy and decompression of the nerve root[3]. The neurological complication rate in spinal surgery due to decompression ranges between 1% and 33%[4]. The most important complications that can worsen the clinical outcomes are root injury, dura damage, and the presence of inadequate decompression.

In the last few decades, electrophysiological monitoring has routinely been used in spinal surgery. The use of these techniques in deformity surgery, especially for idiopathic scoliosis, assists surgeons in the avoidance of neurological complications. Although sensory evoked potentials (SEP) were initially used, motor evoked potentials (MEP) have begun to be used, as these are more effective in showing any damage to motor function in the spinal cord. The introduction of transcortical magnetic stimulation in the early Nineties, and the expansion of this over the last ten years, alongside developments in software and technology, eliminates the requirement for the interpretation of intraoperative neural monitoring personally by a neurologist. There are few studies in the literature on the use of this technique with spinal stenosis surgery. Moreover, there are very few studies which consider the usefulness of this method routinely with spinal stenosis and investigate the correlation with clinical outcomes. Therefore, this study aims to investigate whether clinical results are correlated with the results of intraoperative neuromonitorization applied during lumbar spinal stenosis surgery, and to present the usefulness of this method in spinal stenosis surgery.

PATIENTS AND METHODS:

Prospectively, 20 patients who received surgery for lumbar spinal stenosis between May 2011 and November 2011, with neuromonitorization applied during surgery, were included in the study. The mean age of the patients was 69, 10% (two patients) were male and 90% (18 patients) were female. Preoperative radiographic evaluations of the patients were made with direct X-rays and MRI. These showed spondylolisthesis secondary to stenosis in three patients, degenerative scoliosis in 16 patients and post-traumatic stenosis in one patient.

2 mg of intravenous midazolam was administered to the patients before surgery. 2 $mgkg^{-1}$ of propofol and 2 μgkg^{-1} of fentanyl were applied to the patients for the induction of anesthesia. 0.5 $mgkg^{-1}$ of rocuronium was given as a single dose for tracheal intubation after induction. After tracheal intubation, infusion of 5–10 $mgkg^{-1}hr^{-1}$ of propofol and 0.5–1 $\mu gkg^{1}min^{-1}$ of remifentanil was begun. The infusion drug doses were determined through titration according to hemodynamic responses, such as blood pressure and heart rate. Intraoperative monitoring was provided by measuring non-invasive blood pressure, peripheral oxygen saturation (SpO2), ECG, and invasive arterial blood pressure. Patients were turned to a prone position after induction. The end-tidal carbon dioxide (EtCO2) was maintained at 35–45 mmHg. Vasoactive drug support was not given to the patients.

During surgery, transcranial motor evoked potentials (TkMEP, Nim-spiner, Nim-eclipser)

were used. Measurements were performed through stimulus over the motor cortex from the cranial by placing recording electrodes at L2–L3–L4–L5 and S1. The latency and amplitude changes were recorded and calculated as a percentage. A maximum change in the level of the spinal stenosis was determined. If the data at the end of the operation were lower than the data after the operation, then these data were not used. For patients with multiple levels of spinal stenosis, the electrophysiological changes were recorded for each level. Clinical evaluation was performed, preoperatively and postoperatively at a six-month follow-up, using SF36, the Oswestry score and the Visual Analogue Score (VAS). In surgical therapy, decompression was applied to all patients after performing posterior instrumentation. Interbody fusion was performed for one patient.

Statistical Evaluation:

Statistical analysis in this study was performed with the NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) program package. For evaluation of the data, the Wilcoxon test was used to compare before and after surgery, as well as descriptive statistical methods (mean, standard deviation, median, interquartile range). The Pearson Correlation Regression test was used to examine the correlations between two variables. The results were considered significant when $p<0.05$.

RESULTS:

It was determined that a statistically significant improvement was seen, on comparison of the preoperative and postoperative values for the SF36, Oswestry and VAS scores used for clinical assessment ($p=0.0001$) (Table-1). The use of neuromonitorization during surgery allows for early realization of any damage to neural structures that may occur. This is manifested by a reduction in latency, in particular. It was shown that there was no change in the preoperative latency value for any of the patients during and after surgery. In other words, no temporary or permanent neural damage occurred during surgery in any of the patients in this study.

The preoperative and postoperative amplitude values and increase rates are shown in Table-2. An increase in the TkMEP amplitudes during surgery was detected in all patients. When all patients were included, it was determined that the preoperative mean amplitude was 374.1±130.7 (224–634) mA, while the postoperative mean amplitude increased to 590.2±202.6 (326–986) mA, and the percentage increase was 63.9±37.4% (2–176%), on average (Table-2). The resulting improvement was determined to be statistically significant ($t=8.12$, $p<0.05$). The TkMAP amplitudes of 14 of the 20 patients in this study were observed to increase by more than 50%. In six patients, there was an increase of less than 50%.The correlation between the rates of change in amplitude and the rates of change of the VAS scores was examined, and it was observed that there was a statistically significant correlation ($r=0.964$) between both variables ($t=0.014$, $p<0.05$).

When the patients were divided into two groups according to the amplitude recovery rate (an increase of more or less than 50%), the change in the VAS scores of the patients was also examined.

Table-1. Comparison of preoperative and postoperative values of SF36, Oswestry and VAS scores

		Preoperative	Postoperative	t	p
SF36	**Mean±SD Median (IQR)**	29.5±5.73 30 (24-35.5)	76.6±5.2 76 (72.5-80)	- 3.92	0.0001
Oswestry	**Mean±SD Median (IQR)**	65.5±4.4 66 (60.5-69.5)	9.95±3.79 9.5 (6-14)	- 3.93	0.0001
VAS	**Mean±SD Median (IQR)**	1.8±0.77 2 (1-2)	8±0.86 8 (7-8.75)	- 3.98	0.0001

Table-2. Age, gender, decompressed levels and amplitude changes of patients

Patient No	Age	Gender	Level	Amplitude before decompression (mA)	Amplitude after decompression (mA)	% Change
1	58	M	L3-L4	262	452	74
2	76	F	L3-L4-L5	291	496	70
3	67	F	L4-L5	600	986	64
4	74	F	L4-L5	285	326	14
5	68	F	L3-L4-L5	224	398	77
6	75	F	L3-L4	411	678	64
7	67	F	L3-L4	495	639	29
8	52	F	L3-L4	634	986	55
9	72	F	L5-S1	385	621	61
10	74	M	L3-L4	299	426	42
11	84	F	L5-S1	485	492	2
12	76	F	L5-S1	402	568	45
13	64	F	L4-L5	456	710	56
14	62	F	L5-S1	241	667	176
15	78	F	L4-L5	256	423	65
16	58	F	L4-L5	306	387	26
17	70	F	L5-S1	243	403	65
18	68	F	L3-L4	297	548	85
19	78	F	L4-L5	310	611	97
20	74	F	L5-S1	280	589	110

For 14 patients showing a more than 50% improvement in amplitude, the rate of improvement in the VAS scores was determined to be 80.7±7.5% (70–89%) on average, and for six patients with a less than 50% improvement in amplitude, the rate of improvement in the VAS scores was determined to be 75.4±10.8% (57–89%). When the rate of improvement in the VAS scores of these two groups were compared, no statistical difference was seen between the two groups ($t=4.29$, $p>0.05$). However, the VAS average of the group with a greater than 50% improvement was slightly higher than the average of the other group.

Table-3. Preoperative and postoperative VAS values of the patients and the rates of change

Preop VAS	Postop VAS	% Change
8	2	75
9	1	89
8	2	67
10	3	70
7	1	86
7	3	57
7	1	86
8	2	75
8	3	62
7	1	86
9	1	89
8	2	75
8	2	75
9	1	89
8	1	87
9	2	78
7	1	86
8	3	62
7	2	71
8	2	75

DISCUSSION:

Our knowledge about spinal stenosis that occurs due to compression of the neural canal in the spine is based on studies that are not very recent. The majority of cases are of a degenerative type, seen in patients with advanced age. The standard surgical procedure for spinal stenosis is laminectomy and nerve root decompression[3]. In lumbar spinal stenosis decompression surgery, an 80% success rate has been reported[5].

Intraoperative neuromonitorization is used to detect early neurological damage in spinal surgery[9]. Neuromonitorization should be started when the surgical procedure begins, and should be continued during instrumentation and laminectomy. The surgical team should be informed occasionally about the neuromonitorization status. There are few studies in the literature on the use of this technique in spinal stenosis surgery. Moreover, there are very few studies showing the usefulness of this method routinely for spinal stenosis, and investigating any correlation with clinical outcomes. Therefore, this study aimed to investigate whether the clinical results were correlated with the results of intraoperative neuromonitorization applied during lumbar spinal stenosis surgery, and to present the usefulness of this method in spinal stenosis.

According to Weiss, an amplitude increase that occurs during surgery does not mean that the patient has been clinically cured. Weiss used intraoperative neuromonitorization in more than 1,000 cases of spinal surgery and reported that this was not helpful for prediction of the clinical consequences[9].

In contrast, in a prospective study by Sutter et al. that included 409 patients who received lumbosacral surgery with intraoperative neuromonitorization, they reported that the surgery-related complication rates decreased and the long-term outcomes improved[7].

The continuity of neural structures with intraoperative neuromonitorization and the association with surgical intervention were reported by Santiage-Perez et al. in lumbosacral spinal surgery[6], and by Eggspuehler et al. in thoracic spinal stenosis surgery[2]. Voulgaris et al. monitored the amplitudes of the spinal roots with intraoperative neuromonitorization during decompression of spinal stenosis, and compared the changes in amplitudes with the preoperative and postoperative clinical outcomes[8].

No changes to the preoperative latency value, either during surgery or postoperatively, were observed for any of the patients included in our study. In other words, no temporary or permanent neural damage occurred in any of the patients in this study during surgery. It was determined that the TkMEP amplitudes of all the patients were increased during surgery. The resulting improvement was determined to be statistically significant ($p<0.05$). These data were found to be consistent with the results of the study of Voulgaris et al., in contrast to the work of Weiss. This suggests that neural decompression causes an increase in amplitude, and this increase is an indicator of successful decompression.

It was detected that the TkMEP amplitudes of 14 out of 20 patients in this study increased by over 50%, while in six patients there was an increase of less than 50%. The correlation between the rates of change in the amplitude and the rates of change in the VAS scores was examined, and this showed that there was a statistically significant correlation ($r=0.964$) between both variables ($t=0.014$, $p<0.05$).

The patients were divided into two groups according to the improvement in amplitude ratio, and the changes in the VAS scores were also examined. No statistical differences were found between the VAS scores of the patients with amplitude increases of less than 50% and the patients with amplitude increases of more than 50% ($p>0.05$). This shows that an amplitude increase resulted in a decrease of the VAS scores, regardless of the amplitude ramp rate.

Although we know that the main cause of improvements in amplitude and VAS scores is surgical decompression, the most important limitation of this study is that it provides no information as to which variables, such as the initial rate of stenosis, how long the patient had had spinal stenosis (central or foraminal), whether the decompression technique was applied well or not, the size of the decompression area, and neuropathological variables, play the greatest role in this amplitude rise, and about the dependence of this impact on quantitative variables rather than qualitative. However, a correlation between two variables in which improvement has already occurred can be assumed. However, when the patients with an amplitude increase of more or less than 50% are divided into two groups, the failure to find a statistically significant difference between the VAS scores of the two groups reduces the reliability of the outcomes obtained from this study, in spite of the specificity in the pain and disability scores, and several supporting studies.

Additionally, another major limitation of the study is the small number of cases included.

In conclusion, this study shows that neuromonitorization with TkMEP is an important indicator allowing the avoidance of iatrogenic neural injury during surgery, and suggests that neural decompression is effective for spinal stenosis patients with indications for surgery.

It can also be said, although not yet for certain, that the increase in amplitude detected during neuromonitorization with TkMEP is a useful method for predicting the expected clinical results after neural decompression of the spinal stenosis. However, larger prospective randomized studies are needed to draw more definite conclusions.

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