

## Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 15: electrophysiological monitoring and lumbar fusion

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### Diagnostic Recommendations

**Standards.** There is insufficient evidence to recommend a treatment standard.

**Guidelines.** Use of intraoperative SSEP or DSEP monitoring is recommended as an adjunct in those circumstances during instrumented lumbar spinal fusion procedures in which the surgeon desires immediate intraoperative information regarding the potential of a neurological injury. The occurrence of a postoperative neurological deficit is highly correlated with intraoperative changes in these monitoring modalities. An abnormal SSEP or DSEP during surgery, however, often does not correlate with a postoperative neurological injury because of a high false-positive rate.

Use of intraoperative evoked EMG recordings is recommended in those circumstances in which the operating surgeon wishes to confirm the lack of a neurological injury during pedicle screw placement. A normal evoked EMG response is highly predictive of the lack of a neurological injury. An abnormal EMG response during the sur-

gical procedure may or may not be associated with a clinically significant injury.

**Options.** Intraoperative evoked EMG recording is recommended as an option during lumbar spinal fusion surgery in those situations in which the operating surgeon desires immediate information regarding the integrity of the pedicle wall, as a normal evoked EMG response is correlated with an intact pedicle wall.

### Therapeutic Recommendations

**Standards.** There is insufficient evidence to recommend a treatment standard.

**Guidelines.** There is insufficient evidence to recommend a treatment guideline.

**Options.** Intraoperative SSEP, DSEP, EMG, and/or evoked EMG monitoring are recommended only as adjunctive options during instrumented lumbosacral fusion procedures for degenerative spinal disease. The use of any of these modalities has not been convincingly demonstrated to influence patient outcome favorably.

### Rationale

Intraoperative electrophysiological monitoring of spinal cord and nerve root function is used in a variety of clinical scenarios. Various techniques are thought to be useful for the detection and prevention of neurological deficits

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*Abbreviations used in this paper:* CMAP = compound muscle action potential; CT = computerized tomography; DSEP = dermatomal sensory evoked potential; EMG = electromyography; NMEP = neurogenic motor evoked potential; NPV = negative predictive value; PPV = positive PV; SSEP = somatosensory evoked potential.

during surgery to repair aortic aneurysms, correct scoliotic or traumatic spinal deformities, and during resection of spinal cord tumors.<sup>11,13,29,30,38,45</sup> Intraoperative monitoring for routine lumbosacral fusion for degenerative disease is also being performed. The primary justification for the use of these surgical adjuncts is the perception that the safety and efficacy of pedicle screw fixation are enhanced through the use of intraoperative electrophysiological monitoring. The purpose of this review is to examine the medical evidence concerning intraoperative monitoring to answer the following questions. 1) Does intraoperative electrophysiological monitoring of the nerve roots or spinal cord increase the safety of lumbar or lumbosacral instrumentation? 2) Does the use of intraoperative electrophysiological monitoring of the spinal cord and nerve roots influence patient outcomes following lumbar spinal surgery for degenerative disease?

### Search Criteria

A computerized search of the database of the National Library of Medicine from 1966 to March 2003 was conducted using the search terms "electrophysiology and spinal surgery," or "EMG and spinal surgery," or "evoked potentials and spinal surgery." The search was restricted to the English language and yielded a total of 1068 citations. The titles and abstracts of each of these references were reviewed and papers not concerned with the use of monitoring for lumbosacral fusion were discarded. References were identified that provided either direct or supporting evidence relevant to the use of monitoring for lumbar or lumbosacral fusion procedures. These papers were obtained and reviewed, and relevant references from the bibliographies of these papers were also identified. All papers providing Class II or better medical evidence regarding the use of electrophysiological monitoring for lumbar or lumbosacral fusion procedures are summarized in Table 1. Additional information is provided by other references listed in the bibliography.

### Scientific Foundation

There are two potential uses for electrophysiological monitoring: an intraoperative diagnostic test for nerve injury during screw placement or a treatment tool to improve postoperative outcome. Because two different uses of monitoring are being considered, medical evidence was classified (as Class I, II, or III) separately when the evidence was used to support monitoring as a diagnostic study or when monitoring was used as a treatment modality. The level of evidence provided by a particular paper is therefore referred to as diagnostic, treatment, or both in Table 1.

#### *Somatosensory Evoked Potential Monitoring*

Intraoperative SSEP monitoring has been used in spinal surgery since the 1940s.<sup>2,12,30</sup> Initially, SSEPs were used for assessing spinal cord function during scoliosis surgery, resection of spinal cord tumors, spinal cord decompression, or during vascular procedures with the potential to alter spinal cord blood flow.<sup>4,11,13,20,21,23,24,30,33,40–42,45,46</sup> More recently, the use of this technique has been extended to patients being treated with lumbosacral fusion for degenerative disease. Balzer, et al.,<sup>1</sup> reported their results from a

group of 44 patients who were treated with lumbosacral fusion. All patients were studied with SSEP as well as spontaneous EMG and evoked EMG monitoring. Thirty-eight of these patients were surgically treated for degenerative spinal disease; postoperative S-1 radiculopathy developed in two. Intraoperative SSEPs were reported to be abnormal in one of these patients, despite repositioning of a screw. Intraoperative SSEPs were also reported to be abnormal in another patient who did not suffer a neurological deficit. In this patient, recordings normalized following adjustment of a cross-link. The sensitivity of SSEP monitoring for the detection of new deficits in this series was 50%.<sup>1</sup> Although the NPV of normal SSEPs in this series was high (97%), the incidence of safe screw placement irrespective of SSEP monitoring was also high (95%). Bose and colleagues<sup>3</sup> monitored continuous SSEPs as well as continuous EMG in a group of 61 patients being treated with instrumented posterolateral fusion procedures of the lumbosacral spine. These authors reported that SSEP monitoring was less useful than EMG monitoring for the detection of nerve injuries. Lencke, et al.,<sup>22</sup> similarly used continuous SSEP as well as evoked EMG monitoring during placement of 233 lumbar pedicle screws. They reported that no useful information was provided by the SSEP monitoring. Reidy and colleagues<sup>37</sup> noted that SSEPs were relatively insensitive to pedicle fracture during thoracic pedicle screw placement when compared with EMG monitoring. Mochida, et al.,<sup>28</sup> compared SSEP monitoring with evoked EMG monitoring and found that the use of evoked EMG monitoring was more sensitive and specific for diagnosing intraoperative injury to nerve roots than were SSEPs.

Manninen<sup>26</sup> reported his experience with continuous SSEP recording in a series of 309 patients who were treated with spinal surgery, 169 of whom underwent surgery for degenerative lumbar disease. He noted a 4.4% rate of false-positive changes in responses, a 1.1% incidence of false-negative changes in responses, a sensitivity of 57%, and a specificity of 95%. When the lumbar group was considered alone, the sensitivity of SSEP monitoring for detecting new deficits was 50%. Nishijima and colleagues<sup>31</sup> noted significant SSEP changes in 11 of 58 patients they treated with thoracolumbar or lumbar surgery, yet none of these patients were noted to have a postoperative deficit. Meyer and colleagues<sup>27</sup> compared their results with SSEP monitoring in a group of patients with traumatic injuries of the thoracolumbar spine. They compared two groups of patients who underwent surgical stabilization of the spine: 150 with monitoring and 145 without monitoring. These authors found that new neurological injuries occurred less frequently in the monitored group. They reported that six patients had significant changes in SSEP responses, only one of whom had a neurological deterioration (sensitivity 100%, specificity 96%, PPV 16%, NPV 100%). In the comparison group, 10 of 145 patients had new postoperative neurological deficits. There were, however, significant differences between the patient groups. The nonmonitored group was made up of a historical cohort combined with more severely injured patients in whom there were no reliable SSEPs preoperatively. The relevance of these findings to the current discussion is questionable because of disparities between the treatment groups, because the patient population treated was a trauma population, and because the