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## Guideline update for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 15: Electrophysiological monitoring and lumbar fusion

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Intraoperative monitoring (IOM) is commonly used during lumbar fusion surgery for the prevention of nerve root injury. Justification for its use stems from the belief that IOM can prevent nerve root injury during the placement of pedicle screws. A thorough literature review was conducted to determine if the use of IOM could prevent nerve root injury during the placement of instrumentation in lumbar or lumbosacral fusion. There is no evidence to date that IOM can prevent injury to the nerve roots. There is limited evidence that a threshold below 5 mA from direct stimulation of the screw can indicate a medial pedicle breach by the screw. Unfortunately, once a nerve root injury has taken place, changing the direction of the screw does not alter the outcome. The recommendations formulated in the original guideline effort are neither supported nor refuted with the evidence obtained with the current studies. (<http://thejns.org/doi/abs/10.3171/2014.4.SPINE14324>)

**KEY WORDS** • intraoperative monitoring • fusion • lumbar spine • practice guidelines

### Recommendations

There is no evidence that conflicts with the previous recommendations regarding electrophysiological monitoring published in the original version of the “Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine.”

#### Grade I

The use of direct screw stimulation evoked electromyography (EMG) responses, as a diagnostic modality during lumbar fusion surgery, is an option since evidence suggests that EMG monitoring can be highly sensitive in detecting breaches of the pedicle (one Level III study).

*Abbreviations used in this paper:* EMG = electromyography; IOM = intraoperative monitoring; MEP = motor evoked potential; SSEP = somatosensory evoked potential.

The data are insufficient to support a recommendation regarding the use of neuromonitoring as a modality that can be used for the preservation of nerve root function during lumbar fusion surgery (one Level IV study).

### Rationale

Intraoperative monitoring (IOM) is commonly used during spinal deformity surgery and resection of intramedullary tumors, as well as other nonspine surgeries including repair of aortic aneurysms.<sup>2–8</sup> The use of IOM during routine surgery for degenerative lumbar disease remains controversial; however, supporters of IOM claim that this modality enhances the placement of pedicle screws. Based on the review from the original guidelines, there is relatively good evidence that the use of IOM provides useful information pertaining to the integrity of the pedicle wall and the potential for neurological injury during pedicle screw insertion.<sup>11</sup>

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Several important questions pertaining to the use of IOM during lumbar fusion surgery remain unanswered and include the following:

1) Does intraoperative electrophysiological monitoring of the nerve roots increase the safety of lumbar or lumbosacral instrumentation?

2) Does the use of intraoperative electrophysiological monitoring influence patient outcomes following lumbar spine fusion surgery for degenerative disease?

The current literature review was intended to address these queries and examine the evidence pertaining to the utility of IOM during lumbar fusion surgery for degenerative disease.

### *Search Criteria*

A computerized search of the database of the National Library of Medicine from 2004 to December 2011 was conducted using the search terms (((“Lumbosacral Region”[MeSH] OR “Lumbar Vertebrae”[MeSH]) AND “Spinal Fusion”[MeSH]) OR “lumbar fusion”[All Fields] OR (“lumbar”[title] AND “fusion”[title])) AND (“Electrophysiology”[MeSH] OR “Evoked Potentials”[MeSH] OR “electromyography”[MeSH]). The search was restricted to the English language and human subjects, yielding a total of 89 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 removed. The references that provided either direct or supporting evidence relevant to the use of monitoring for lumbar or lumbosacral fusion procedures were included for review. Relevant references from the bibliographies of these papers were also identified and listed. Since the previous guidelines publication, 3 new articles have been published that specifically address the role of IOM in lumbar fusion. Two studies examined the role of neuromonitoring in thoracolumbar procedures as well as decompressive procedures.<sup>1,10</sup> One published case report reported injury to the iliac artery that was detected by IOM.<sup>9</sup>

### **Scientific Foundation**

Under ideal circumstances, the use of IOM would allow the surgeon to perform the intended procedure with less risk and provide information predictive of outcome. Since the publication of the original guidelines, there have been relatively few studies published that provide further insight into the utility of IOM for procedures to treat degenerative disease of the lumbar spine. The recommendations published in the original guidelines support the use of IOM, both somatosensory evoked potential (SSEP) and EMG, when the surgeon desires immediate intraoperative feedback regarding the potential of neurological injury and/or immediate feedback regarding the integrity of the pedicle wall when internal stabilization is intended with pedicle screws.<sup>11</sup>

Alemo and Sayadipour<sup>1</sup> performed a retrospective study in 86 patients who underwent lumbar fusion (37 patients) or lumbosacral fusion (49 patients), all with the placement of titanium pedicle screws (Table 1). Somato-

sensory evoked potential, motor evoked potential (MEP), and evoked EMG testing of pedicle screws were performed. In their study, 28 (5%) of 414 screws were found to have a response with evoked EMG testing intraoperatively. All of these screws were repositioned, and none of these patients were found to have a postoperative neurological deficit. There were 3 false-negative EMG evoked responses during surgery. These were discovered after the patients woke up with a new neurological deficit. Unfortunately, the misplacement of the screws was detected by postoperative CT scanning and not through neuromonitoring. Based on this study there is no evidence to suggest that intraoperative neuromonitoring can be used to prevent neurological deficits during surgery.

Parker et al.<sup>10</sup> performed a retrospective study examining the records of 418 patients in whom 2450 consecutive pedicle screws were placed (Table 1). Multimodality neuromonitoring was performed (MEPs, SSEPs, and evoked EMG response) for all surgeries that were performed on the lumbar spine (L1–S1). This study was unique in that CT scans were obtained 48 hours after the surgery to confirm placement of the screws. Screw positions on CT scans were correlated to EMG evoked responses during surgery. A response below 7 mA indicated to the surgeon that there might be malpositioning of the screw. It is unclear from the paper the number of screws that were repositioned during surgery. Overall there was a 0.7% false-negative rate (intraoperatively the screw demonstrated no stimulation below 10 mA while it was found to have a medial breach on CT scanning). The authors correlated the EMG evoked responses to the position of the screw on the CT scan to determine if there was a particular threshold. In this study, the authors were able to demonstrate that an EMG evoked response below 5 mA had a low sensitivity (43.4%) but high specificity (99.9%) in detecting a medial breach of the pedicle screw. This study supports previous literature that supports the use of EMG testing during placement of instrumentation in lumbar fusion procedures. Unfortunately, the paper could not demonstrate any neuromonitoring findings that could be used to help the surgeon avoid neurological injury during placement of the instrumentation.

### **The Use of Neuromonitoring During Anterior Lumbar Fusion**

The majority of publications investigating the utility of IOM with anterior lumbar procedures have been case reports, limiting the strength of the data and any conclusions that may be formulated. In one published case report, there was a loss of MEP and SSEP signal to the left lower extremity during surgery that correlated to occlusion of the left iliac artery.<sup>9</sup> Intraoperative exploration revealed that the iliac artery had become trapped within the L4–5 disc space. Following a release of the artery, a full recovery of signal was observed and no neurological deficits were observed following the procedure. Although this evidence is purely anecdotal, at best Level IV evidence, this study provides an example of the use of IOM identified a potential injury that was correctable.

TABLE 1: Electrophysiological monitoring and lumbar fusion: summary of evidence

Authors & Year	Description	Results	Level of Evidence	Conclusions
Alemo & Sayadipour, 2010	Retrospective study that examined the use of pedicle screws in lumbar fusion.	28/414 screws (5%) evoked an EMG response during surgery. All of these screws were repositioned & there were no permanent neurological deficits associated w/ these screws. Three false-negative evoked EMGs (3.48%) were detected. These patients woke up w/ a new neurological deficit.	IV, retrospective case series	The use of intraop neuromonitoring during lumbar fusion surgery cannot be routinely recommended as it does not always detect new postop neurological deficits.
Parker et al., 2011	Retrospective review of the placement of 2450 pedicle screws. Intraop neuromonitoring was correlated to postop CT scans.	An EMG evoked response <5 mA demonstrated a low specificity & high sensitivity in detecting a medial breach of the pedicle screw.	III, retrospective case series	This paper does not provide the surgeon any information that can be used during surgery to avoid neurological deficits during the placement of lumbar pedicle screws.

### Summary

The current literature review provided no new high-quality studies supporting the use of IOM during lumbar fusion for degenerative spine disease. The routine use of IOM for this type of surgery, therefore, cannot be recommended. The recommendations formulated in the original guideline effort are neither supported nor refuted with the evidence obtained with the current studies.

Several low-quality studies demonstrated a correlation between changes in SSEP signals and nerve root injury. Unfortunately, once a change has occurred, there is no evidence to suggest that intraoperative maneuvers can lead to recovery of the nerve function. There is evidence to suggest that a threshold below 5 mA indicates a medial breach of the pedicle screw, although it is unclear how this affects the overall outcome. Finally, there is no evidence to suggest that neurophysiological monitoring during lumbar spine fusion can alter the outcome of surgery. Unfortunately, the recent literature does little to address the concerns previously stated.

### Key Issues for Future Investigation

To date, there has been no randomized, prospective, multicenter trial that has examined the value of IOM during lumbar fusion surgery. Investigating the utility of IOM may prove impractical, as the true value of intraoperative signal changes could only be determined through a study in which a cohort of patients received no intervention for alternations in IOM observed during surgery. Such a study would in all likelihood be considered unethical. Such information, however, will be essential to perform a validated cost-effectiveness analysis to determine whether the benefits of IOM justify the added cost.

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