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Somatosensory Evoked Potential Monitoring During Anterior Cervical Discectomy and Fusion

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Study Design. A retrospective, multicenter clinical review was conducted.

Objective. To examine our experience using somatosensory evoked potential (SSEP) monitoring during anterior cervical discectomy and fusion (ACDF) to determine if monitoring of the spinal cord with SSEPs was helpful in identifying reversible causes of neurologic impairment while performing the procedure.

Summary of Background Data. Recent studies have strongly supported the use of SSEP monitoring during complicated and upper-cervical spine surgery.

Methods. The complete medical records of 163 patients who underwent ACDF, and who were monitored with SSEPs during the procedure between 1995 and 2002 were retrospectively reviewed. A single observer who was uninvolved with patient care abstracted these medical records. Demographic data, length of symptoms, workers' compensation status, primary diagnosis, preoperative neurologic status, number of levels fused, bone graft type, implants used, SSEP findings, postoperative neurologic status, complications, and recovery from complications were recorded. Final neurologic status was determined through phone contact with patients or outpatient charts of patients who could not be contacted personally.

Results. There were 3 false positive (1.8%) intraoperative SSEP findings in which SSEP changes intraoperatively did not reflect a neurologic deterioration after surgery. There was 1 false negative (0.6%) in which a new neurologic deficit occurred after surgery, despite no change in SSEP amplitudes during the operation. There were 2 true negatives (1.2%) in which SSEP monitoring showed a preexisting neurologic deficit, which did not change during the operation.

Conclusion. In no instance were positive SSEP findings clinically useful in alerting the surgeon to potential intraoperative complications. Intraoperative SSEP monitoring is not helpful to the surgeon when performing routine ACDF. Additionally, ACDF is a safe procedure with a low rate of neurologic complications.

Key words: somatosensory evoked potential monitoring, anterior cervical discectomy and fusion, nerve monitoring. **Spine 2005;30:1970–1972**

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For more than 20 years, somatosensory evoked potentials (SSEPs) have been used to monitor the function of the spinal cord during the surgical treatment of thoracolumbar spine deformities.[1] However, monitoring of the cervical spine has been given less emphasis despite the fact that neurologic injury there can have very severe consequences, including quadriplegia. Recent studies have strongly supported the use of SSEP monitoring during complicated and upper-cervical spine surgeries, with SSEP sensitivity as high as 99%.[2] Yet, some investigators have discounted SSEP monitoring because of the high rate of false positives[3] or because general anesthesia reduces the responses to stimuli too much.[4–6] Others have criticized the sensory only monitoring of SSEP and report that purely motor deficits can be missed despite SSEP monitoring.[7,8]

The senior surgeon (K.S.S.) proposed that the benefit of spinal cord monitoring, the immediate identification of acute neurologic impairment enabling prompt correction of the cause,[9] outweighed any potential shortcomings. Therefore, he began routinely using intraoperative SSEP monitoring while performing anterior cervical discectomy and fusion (ACDF) in 1995. We retrospectively reviewed that surgeon's ACDF cases to determine the clinical usefulness of intraoperative SSEP monitoring. Our primary goal was to elucidate if routine monitoring of the spinal cord with SSEPs was helpful in identifying reversible causes of neurologic impairment and to determine whether or not intraoperative neurologic injury was avoided as a result of the monitoring.

Materials and Methods

ACDF was performed on 175 patients by the same surgeon between September 1995 and April 2002. Of these patients, 163 were monitored with SSEPs during the operation. All patients underwent ACDF through a left-sided approach. Either autologous iliac crest bone graft or allograft was used at the discretion of the patient and the surgeon. Anterior instrumentation (*i.e.,* plating) was used at the discretion of the surgeon. The indications for surgery included pain secondary to cervical radiculopathy, which had failed nonoperative treatment, cervical myelopathy, unstable cervical spine fracture with or without spinal cord injury, and neck pain nonresponsive to exhaustive conservative treatment. All patients had a preoperative magnetic resonance imaging or computerized tomography myelogram, which supported their clinical diagnosis.

Patients age averaged 48.6 years (range 14–84) at surgery. An average of 1.6 levels (range 1–4, median 2) were treated with ACDF. A total of 103 fusions were performed with allograft, while 72 had autogenous iliac crest bone graft harvested. There were 155 patients who had anterior instrumentation (plating) at the fusion site, and 20 were not instrumented.

A total of 132 patients underwent surgery for pain secondary to cervical radiculopathy, which had failed nonoperative treatment, 30 underwent surgery to treat cervical myelopathy, 11 were treated operatively for unstable cervical spine fractures with or without spinal cord injury, and 2 underwent surgery for neck pain nonresponsive to exhaustive conservative treatment. The average length of symptoms before surgery as reported by the patient was 10 months (range 2 days to 96 months). The average length of postoperative follow-up was 2 years and 10 months (range 1 month to 7 years).

Biotronic, Incorporated (Ann Arbor, MI), performed intraoperative SSEP monitoring on 163 of 175 patients according to its protocol. Both the median and tibial nerves were used bilaterally to monitor SSEPs because this has had the highest sensitivity for cervical spine procedures.[2] All patients had general inhalation anesthesia. Twelve patients were not monitored for a number of reasons, including prior spinal cord injury, known peripheral neuropathy, which would limit the effectiveness of SSEP monitoring, or absence of a monitoring technician.

Complete records, including preoperative office notes, hospital records, and postoperative office notes, were available for review in all 175 cases. A single observer who was uninvolved with patient care abstracted these records, which included preoperative consultations and notes, operative notes, progress notes, discharge summaries, and postoperative notes. Preoperative outpatient records were reviewed to determine demographic data, length of symptoms, workers' compensation status, the primary diagnosis, and preoperative neurologic status. Hospital records were reviewed, and the diagnosis, number of levels fused, bone graft type, implants used, SSEP findings, postoperative neurologic status, and complications were recorded. Postoperative outpatient records were reviewed again to determine postoperative neurologic status, recovery from complications, and length of follow-up. Long-term neurologic status was determined through phone contact with patients or outpatient charts of patients who could not be contacted personally.

Statistical Methods. No statistical analysis of the data is presented because of the extremely small number of positive findings in this large cohort. Incidences are reported in simple percentages.

■ Results

A total of 163 patients were monitored intraoperatively using SSEP monitoring. There were 3 false positive (1.8%) intraoperative SSEP findings in which SSEP changes intraoperatively did not reflect a neurologic deterioration after surgery. There were 2 true negatives (1.2%) in which SSEP monitoring showed a preexisting neurologic deficit, which did not change during the operation. There was 1 false negative (0.6%) in which a new neurologic deficit occurred after surgery, despite no change in SSEP amplitudes during the operation. The remaining 157 patients who were monitored intraoperatively had no SSEP changes and no neurologic deterioration after surgery (96.3%).

False Positives

In 2 instances, 2 male patients with myelopathy (52 years old and 60 years old) had decreased SSEP amplitudes at graft placement. The first patient underwent an ACDF of 3 levels (C3–C6) with allograft fibula. The second patient underwent an ACDF at 2 levels (C5–C7) with allograft fibula. Intraoperative visualization of the posterior longitudinal ligament was adequate, and no unusual intraoperative findings or complications were encountered in each case. Intraoperative radiographs were obtained and showed appropriate graft positioning. No change in the operative protocol was made, despite the positive SSEP findings, and anterior instrumentation with a plate was performed in both cases. Both patients had improved neurologic function and no neurologic deterioration after surgery. Both remained improved at the 2 and 4-year follow-up, respectively.

A third patient (42-year-old female) with radiculopathy had a positive right median nerve SSEP finding at graft placement during a single-level ACDF without instrumentation using autogenous iliac crest bone graft. Intraoperative findings were normal. No surgical complication had been encountered. An intraoperative radiograph showed appropriate graft placement. No change in the operative protocol was made despite the positive SSEP findings. She had pain relief, normal neurologic function, and no neurologic deterioration after surgery. She remained improved at the 2-year follow-up.

True Negatives

Another patient with myelopathy (67-year-old male) who underwent a 3-level (C3–C6) ACDF with allograft fibula and anterior plating, had weak left-sided SSEP readings both before surgery and intraoperatively. During the operation, intraoperative visualization of the posterior longitudinal ligament was good, and no unusual intraoperative findings or complications were encountered. An intraoperative radiograph was obtained and showed appropriate graft positioning. No change in the operative protocol was made despite the positive SSEP finding. The patient had improved neurologic function and no neurologic deterioration after surgery. He remained neurologically improved at the 3-year follow-up, despite some residual complaints of neck pain.

A fifth patient (46-year-old male) with positive SSEP findings had a C5 fracture with instability, and a severe left-sided C5 radiculopathy and deltoid palsy before surgery. A positive left upper-extremity latency was appreciated before and throughout the surgical procedure. There was no intraoperative change in the latency throughout the 2-level (C4–C6) ACDF with autogenous iliac crest bone graft and anterior plating. The patient's neurologic status was unchanged after surgery. His left deltoid palsy resolved completely over 8 months. He was neurologically intact at the 2-year follow-up.

False Negative

One patient (44-year-old female) who underwent a 2-level ACDF from C4–C6 with autogenous iliac crest bone graft and anterior plating for right-sided radiculopathy had a postoperative neurologic deficit, which was not present before surgery. No SSEP amplitude changes occurred during the operation. There were no intraoperative complications, and a routine intraoperative radio-

graph showed the graft and plate in good position. After surgery, she had a right deltoid palsy, but her pain was improved from her preoperative status. The deltoid palsy resolved almost completely within 2 weeks. She was completely, neurologically intact at the 4-year follow-up.

■ Discussion

There has been debate in the literature as to the usefulness of SSEP monitoring during cervical spine surgery.[2–4] Proponents of SSEP monitoring tout its sensitivity,[2,10] while others discount it because of its high rate of false positives[3] or because SSEPs rely on the sensory system and occasionally miss a purely motor deficit.[7,8] We reviewed our experience using SSEP monitoring during ACDF to determine if it was a clinically helpful tool to the community orthopedic spine surgeon performing the procedure.

A total of 163 patients in this series underwent ACDF with SSEP monitoring. Only 1 (0.6%) patient had a new postoperative neurologic deficit. However, SSEP monitoring was negative in this instance. This undetected, purely motor deficit (deltoid palsy) illustrates a drawback in SSEP monitoring because it monitors only sensory pathways and has been previously shown to overlook purely motor deficits.[7,8,11]

There were 5 (3.1%) positive SSEP findings in the study cohort. Of these findings, 2 (1.2%) reflected a clinically obvious preexisting condition. The other 3 (1.8%) positive findings did not correlate with any intraoperative findings and ultimately had no influence on surgical technique. After surgery, none of these 3 patients had a clinically perceptible deterioration in their neurologic status, and they reported their condition as improved.

To our knowledge, this is the first report of a large series of patients undergoing ACDF in whom SSEP monitoring was routinely performed. In no instance were positive SSEP findings clinically useful in alerting the surgeon to potential intraoperative complications. Furthermore, SSEP monitoring was negative in the one instance that a patient did sustain an intraoperative neurologic injury.

■ Conclusions

Therefore, intraoperative SSEP monitoring is not helpful to the surgeon when performing routine ACDF. Additionally, we conclude that ACDF is a safe procedure with a low rate of neurologic complications (0.6% in our series). Given these findings, we have ceased routinely using SSEP monitoring while performing ACDF.

■ Key Points

- There is debate as to the usefulness of SSEP monitoring during cervical spine surgery.
- To our knowledge, this is the first report of a large series of patients undergoing ACDF in whom SSEP monitoring was routinely performed.
- A total of 163 patients in this series underwent ACDF with SSEP monitoring. Only 1 patient (0.6%) had a new postoperative neurologic deficit. SSEP monitoring was negative in this instance.
- Intraoperative SSEP monitoring is not helpful to the surgeon when performing routine ACDF.

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