Clinical prognostic indicators of surgical outcome in cervical spondylotic myelopathy

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Object. The objective of this systematic review was to use evidence-based medicine to assess whether clinical factors predict surgical outcomes in patients undergoing cervical surgery.

Methods. The National Library of Medicine and Cochrane Database were queried using MeSH headings and keywords relevant to clinical preoperative factors. Abstracts were reviewed, and studies that met the inclusion criteria were selected. The guidelines group assembled an evidentiary table summarizing the quality of evidence (Classes I–III). Disagreements regarding the level of evidence were resolved through an expert consensus conference. The group formulated recommendations that contained the degree of strength based on the Scottish Intercollegiate Guidelines network. Validation was done through peer review by the Joint Guidelines Committee of the American Association of Neurological Surgeons/Congress of Neurological Surgeons.

Results. Preoperative sensory-evoked potentials may aid in providing prognostic information in selected patients in whom clinical factors do not provide clear guidance (Class II). Age, duration of symptoms, and preoperative neurological function may commonly affect outcome (Class III).

Conclusions. Age, duration of symptoms, and preoperative neurological function should be discussed with patients when surgical intervention for cervical spondylotic myelopathy is considered. Preoperative sensory-evoked potentials may be considered for patients in whom clinical factors do not provide clear guidance if such information would potentially change therapeutic decisions. (DOI: 10.3171/2009.1.SPINE08718)

KEY WORDS   •   cervical spine   •   cervical spondylosis   •   myelopathy   •   practice guidelines   •   prognosis   •   treatment outcome

Recommendations

It is recommended that preoperative SEPs be considered to aid in providing prognostic information in selected patients in whom clinical factors do not provide clear guidance if such information would potentially change treatment decisions (quality of evidence, Class II; strength of recommendation, B).

It is recommended that the prognostic value of clinical factors such as age, duration of symptoms, and preoperative neurological function results be considered and discussed with patients when surgical intervention for CSM is considered (quality of evidence, Class III; strength of recommendation, D).

Abbreviations used in this paper: CMCT = central motor conduction time; CSM = cervical spondylotic myelopathy; JOA = Japanese Orthopaedic Association; MEP = motor-evoked potential; mJOA = modified JOA; OPLL = ossification of the posterior longitudinal ligament; SEP = somatosensory-evoked potentials.

Rationale

Practitioners often advocate decompressive surgery in the management of CSM, because the natural history of this disorder is a progressive stepwise neurological decline in many patients. Surgical management may result in improvement in neurological functioning, worsened neurological functioning, or preservation of functioning without clear improvement or decline. Surgery may involve relatively complex decompression and stabilization procedures. The complication rate is not insignificant, particularly in the elderly. These issues, combined with the fact that CSM may stabilize clinically in a subset of patients without surgery,[11] increases the importance of prospectively determining which patients are most likely to benefit from surgical intervention.

Our goal in this manuscript is to evaluate the ability of clinical prognostic factors to predict surgical outcome in CSM. A number of factors have been purported to have an impact on surgical outcome in CSM, including neurophysiological function, age, duration of symptoms, preoperative neurological function, severity of spinal cord compression, spinal alignment, and radiographic abnormalities of the spinal cord on MR imaging. A review of the medical literature permits a distinct subclassification of these factors into either clinical or radiographical predictors. The focus of this chapter will be clinical predictors.

Search Criteria

We performed a computerized search of the Cochrane Database and the National Library of Medicine Database of the literature published between 1966 and 2007 using keywords and MeSH headings. A search using the subject heading "cervical spondylotic myelopathy" yielded 684 citations. A search using the headings "cervical spondylotic myelopathy and outcomes" provided 49 citations. We evaluated the abstracts and titles of the aforementioned citations and selected articles for review that focused on predictive clinical factors for outcome after surgery for CSM. We chose additional manuscripts from the reference lists of the selected articles. Among the articles reviewed, we found 14 that examined treatment of CSM and clinical prognostic factors (Table 1).

Scientific Foundation

Neurophysiological Function

Many authors have described the use of neurophysiological monitoring in patients with CSM during cervical spine surgery (Chapter 17 topic). In contrast, fewer studies have examined the use of these modalities as prognostic indicators in the surgical outcome of this population. Authors of various studies have suggested that MEPs, SEPs, and other forms of neurophysiological monitoring may potentially provide prognostic information regarding the clinical outcome of decompression surgery in patients with CSM.[1,4,9,10,12,13]

Lyu and colleagues[12] performed preoperative MEPs and SEPs in 39 patients with CSM who had hyperin-tensity on T2-weighted MR images of the cervical cord and who were to undergo surgical decompression. The authors used pre- and postoperative JOA scale scores[19] and 6-month neurological recovery rates as described by Hirabayashi et al.[8] as functional outcome measures. The mean JOA scale score in these patients increased from 13.1 preoperatively to 16.2 (p < 0.001) postoperatively. The mean recovery rate was 51%, and this did not correlate with sex, arm or leg MEP findings, or tibial SEP readings. However, the neurological recovery rate significantly correlated with age younger than 55 years and normal median SEP results. Abnormal SEP variables N9–20, N9–13, and N20 were associated with a poor recovery ratio (p = 0.017, p = 0.027, and p = 0.021, respectively). Stepwise linear regression analysis demonstrated that only the N9–20 variable significantly correlated with the recovery rate when controlled for patient age.

Morshita et al.[13] performed pre- and postoperative median nerve (N18) SEPs in 14 patients with CSM undergoing cervical decompression surgery. The authors used the JOA scale to grade patients' conditions, and obtained follow-up SEPs at 1, 2, 4, 12, and 24 weeks postoperatively. Seven of the 14 patients showed an improved N18 latency at the 1-week postoperative evaluation. Eventually, all patients demonstrated gradual improvement in the N18 latency over the 24-week postoperative period. Patients who manifested an improvement in median nerve SEPs not only demonstrated neurological improvement in the upper extremities, but in the lower extremities as well. There was a statistically significant correlation between 1-week postoperative improvement in median nerve SEPs and 12-week postoperative JOA scale score for recovery rate (p = 0.0019). Conversely, a lack of improvement in N18 latency in the early decompression period was associated with a poor neurological outcome. The authors concluded that evaluation of median nerve SEPs is useful for predicting postoperative prognosis in patients with CSM.[13]

Ishida and associates[9] evaluated recovery of sensory function postoperatively in patients with CSM and similarly found that early onset of SEP recovery after surgery correlated with a favorable clinical course. These authors obtained preoperative median and tibial SEPs in a group of 13 patients with CSM undergoing surgical decompression. They evaluated light touch perception in the hands and feet in each patient. They acquired postoperative SEPs at 1–2 weeks, 4 weeks, and at 1–2 month intervals following surgery. The authors observed 3 different recovery patterns of median and tibial SEP latencies: latency decrease of ≥ 0.5 msec starting within 2 weeks postoperatively; latency decrease of ≥ 0.5 msec commencing after 2 weeks postoperatively; and a latency change that never reached 0.5 msec. Recovery of sensory function was correlated with early improvement in SEPs.

Bednarik et al.[1] divided a group of 61 patients with CSM into 2 groups according to myelopathy severity. Forty-nine patients had mild or moderate myelopathy (mJOA scale score ≥ 12), and 12 had severe myelopathy (mJOA scale score < 12). The authors randomly separated patients with mild or moderate myelopathy into nonoperative and operative treatment groups. All patients with

TABLE 1: Evidentiary summary of studies on prognosis and surgical outcome in patients with CSM*

Authors & Year	Description	Results	Case	Conclusions
Lyu et al., 2004	49 patients w/ CSM were scored using the mJOA & underwent baseline SEP & MEP. 39 patients underwent surgery, & then repeat SEPs & MEPs 6 mos later. The clinical & neurophysiological significance of SEPs & MEPs were evaluated, as well as their usefulness in predicting surgical outcome in patients w/ CSM.	Abnormal MEPs were found in 43 patients, & abnormal SEPs in 32. Patients w/ abnormal SEPs had a worse JOA score than those w/ normal SEPs. Patients w/ normal median nerve SEPs also had better recovery rates than those w/ abnormal ones. When controlling for age, only the N9-20 was significantly associated w/ recovery ratio.	II	Arm MEP was the most sensitive for detecting myelopathy in patients w/ CSM. Median & tibial SEPs correlated w/ severity of myelopathy. Normal median nerve SEPs correlated w/ good surgical outcome.
Morishita et al., 2005	14 pts w/ CSM underwent preop SEPs & at sequential interval up to 6 mos postoperatively. This was correlated to improvement in neurological recovery rate using mJOA as a functional outcome measure.	There was a statistically significant correlation between improvement in the median nerve SEP & the 12-wk postop JOA recovery rate (p = 0.0019).	II	Evaluating the median nerve SEP is useful for predicting the prognosis in patients w/ CSM undergoing surgical decompression.
Bednarik et al., 1999	61 patients w/ CSM were divided into 2 groups: 49 w/ mild/moderate myelopathy, & 12 w/ severe myelopathy. The mild/moderate myelopathy patients were randomized into groups that underwent either surgery or nonoperative treatment. All of the severe myelopathy patients underwent surgery. SEPs & MEPs were obtained at baseline & at multiple time-points over the 2-yr evaluation period.	There were no significant electrophysiological changes after 6 mos & 2 yrs in the mild/moderate group treated w/ surgery or nonoperatively. Patients w/ severe myelopathy displayed significant improvement in clinical end evoked parameters postop. In a subset of patients the isolated N13 abnormality could predict outcome.	II	Longitudinal electrophysiological monitoring showed limited use for evaluating the results of therapy in an individual patient, but could be used in group assessment & labeling a subgroup w/ potentially favorable surgical outcome.
Suri et al., 2003	Radiographic & clinical parameters were prospectively evaluated in 146 patients w/ CSM undergoing surgical decompression. The predictive factors evaluated included signal change, age, surgical approach, & duration of symptoms.	Younger patients (<40 yrs) & those w/ duration of symptoms < 2 yrs had the best outcomes. There was no significant difference between patients w/ or w/o T2 signal changes. Regression of signal change was associated w/ better outcomes.	III	The presence of T1/T2 changes indicates a poor prognosis. T2 signal intensity represents a broad spectrum of reparative potentials. Class III due to unbalanced allocation.
Chagas et al., 2005	39 patients w/ CSM underwent anterior corpectomy & fusion. Neurological outcome was correlated w/ age, duration of symptoms, severity of preop neurological deficit, & single-level vs multilevel procedure. The Nurick grading system was used as the functional outcome measure.	70% of patients <60 yrs old had an improved Nurick score, whereas 56% of patients >60 yrs had an improved Nurick score (p = 0.0425). 73% of patients w/ a duration of symptoms <2 yrs had a better postop Nurick score, whereas 53% w/ symptoms >2 yrs had an improved postop score (p = 0.0117).	III	Age & duration of symptoms before treatment are directly related to postop improvement.
Fujiwara et al., 1989	50 patients w/ CSM underwent surgery & were evaluated using mJOA & postop JOA score & neurological recovery rate percentage. Clinical & radiographic prognostic indicators were evaluated.	There was a significant negative correlation between advanced age at surgery & chronicity of disease w/ recovery rate.	III	Advanced age at surgery & duration of preop symptoms appear to be negative predictors following surgery for CSM.
Okada et al., 1993	74 cervical myelopathy patients (CS, OPLL, & CDH) underwent decompression surgery. Age at op, duration of disease, & preop neurological dysfunction were correlated w/ neurological outcome.	The mean mJOA scores improved from 10.5 to 14.1 w/ a neurological recovery rate of 59%. There was no significant correlation between age & neurological recovery rate. There was a significant correlation between the duration of symptoms & neurological recovery rate in the CS & OPLL subgroups.	III	There was no relationship between age at the time of surgery & neurological recovery rate. In a subset of patients w/ CS & OPLL, there was a correlation w/ shorter duration of preop symptoms & better neurological outcomes.

(continued)

TABLE 1: Evidentiary summary of studies on prognosis and surgical outcome in patients with CSM* *(continued)*

Authors & Year	Description	Results	Case	Conclusions
Yamazaki et al., 2003	64 patients w/ CSM underwent expansile laminoplasty & were divided into 2 groups: younger (<65, n = 29), & older (>65, n = 35). The JOA scale was used as an outcome measure.	There was no significant difference in the neurological recovery rate between older & younger patients. In elderly patients, duration of symptoms (<1 yr) was predictive of an excellent neurological recovery.	III	Duration of preop symptoms is an important factor in the neurological recovery of elderly patients.
Handa et al., 2002	The neurological outcomes of 22 elderly (age >70 yrs) & 39 younger patients w/ CSM undergoing laminoplasty were compared. Pre- & 12-mo postop JOA scores & neurological recovery rate were used as outcome measures.	The mean neurological recovery rate was not statistically different in the 2 groups, (59% in the elderly group & 62% in the younger group). In the elderly group: duration of symptoms, & severity of canal stenosis significantly affected the neurological outcome. In younger patients only the severity of preop symptoms was prognostic.	III	The neurological recovery rate following decompression surgery was not significantly different between elderly & younger patients w/ CSM. Significant predictive factors for clinical outcome in elderly patients were duration of symptoms & the severity of stenosis.
Ishida et al., 2003	13 patients w/ CSM underwent SEPs preoperatively & 6 mos or longer postoperatively. Neurological recovery was correlated w/ changes in SEPs.	3 groups of SEP recovery patterns were found: latency decrease by ≥0.5 msec w/in 2 wks, after 2 wks, or never reaching 0.5 msec. Sensory recovery correlated w/ SEP change in each group.	III	An early onset of SEP recovery predicts a favorable clinical course. SEPs improve in a delayed fashion, & once they do, progressive return of function will occur.
Jaskolski et al., 1990	12 patients w/ CSM & 3 w/ cervical radiculopathy underwent preop & postop TMS. Mean MCTs were obtained & correlated w/ neurological outcome.	All patients w/ radiculopathy had normal MCTs preoperatively & postoperatively. 6 myelopathy patients were considered to be neurologically improved, 5 unchanged, & 1 clinically worse. In those improved w/ surgery, the mean postop MCT was significantly shorter (p < 0.05) than the mean preop MCT. There was no significant difference in the MCT in the 5 patients who were clinically unchanged after surgery.	III	Preop MCT did not provide any clear, predictive information, but magnetic stimulation may be of value in quantifying motor function before & after surgery in patients w/ CSM.
De Mattei et al., 1995	18 patients w/ CSM underwent TMS preoperatively, and at 3 & 12 mos after surgical decompression. Changes in neurophysiological parameters were correlated w/ neurological function.	Statistically significant neurophysiological improvement was found in patients who had single-level disease. In patients w/ multilevel disease, there was no neurophysiological improvement.	III	Preop MCT has good diagnostic value, but little prognostic significance. Motor action potentials may have more prognostic value.
Naderi et al., 1998	The effect of patient age, symptom duration, & preop neurological status were evaluated in 27 patients w/ CSM undergoing decompression surgery. The mJOA scale was used as the functional outcome measure.	There was no correlation between duration of symptoms & postop neurological recovery. Advanced age was correlated w/ decreased postop neurological improvement.	III	Advanced age at the time of surgery is associated w/ decreased postop neurological recovery.
Ebersold et al., 1995	A variety of clinical factors affecting prognosis following decompression surgery for CSM were retrospectively reviewed in a group of 100 patients. Preop & postop neurological status was measured using the Nurick scale.	Age, preop status, & severity of disease were not predictive of outcome. Increased duration of symptoms correlated w/ a worsened neurological outcome.	III	Increased duration of symptoms was negatively associated w/ neurological outcome after CSM decompression surgery. There was no correlation w/ age, severity of disease, or preop neurological status.

* The criteria for scoring each manuscript into a class are described in *Introduction and Methodology: Guidelines for the Surgical Management of Cervical Degenerative Disease*, which appears in this issue of the *Journal of Neurosurgery: Spine*. Abbreviations: CDH = cervical disc herniation; CS = cervical spondylosis; MCT = motor conduction time; TMS = transcranial magnetic stimulation.

severe CSM underwent surgery. The patients underwent baseline clinical assessment and evoked potential evaluation (median/tibial SEPs and MEPs) at 6, 12, and 24 months posttreatment. There were no significant mJOA scale score changes within the operative or nonoperative mild/moderate CSM subgroups. However, there were statistically significant changes in the mJOA scale scores pre- and postoperatively in the severe myelopathy group. No difference was encountered in clinical course in patients with either normal or abnormal electrophysiology test results, except for median SEP N13 component abnormality. A total of 8 patients had an isolated N13 abnormality preoperatively. Normalization of this abnormality was associated with improvement in the 6-month mJOA score in 4 patients. In the remaining 4, the N13 component remained abnormal, but there was no postoperative neurological deterioration. In contrast, in the other 26 surgical patients without isolated N13 abnormalities, mJOA score deterioration occurred at 6 months in 11 patients, and improvement occurred in 7 patients. The authors concluded that the presence of a baseline isolated median nerve segmental N13 abnormality could predict a more favorable clinical prognosis in a subset of patients with CSM.

Jaskolski et al.[10] used transcranial magnetic stimulation to obtain preoperative and 3-month postoperative CMCTs in a group of 12 patients with CSM and 3 with radiculopathy. The study defined CMCT as the time for the stimulation from a head coil to reach the exit zone of the cervical neural foramina. Thus, the CMCT represented the conduction time in the central motor pathways and a short segment of peripheral motor pathway. The abductor digiti minimi was used as the target muscle, and 24 normal volunteers served as the control group. The CMCTs were abnormal (> 13 msec) in 6 patients with CSM, and normal in the other 6 patients wtih CSM and in 3 patients with radiculopathy. Six of those with CSM showed clinical improvement postoperatively; 5 remained unchanged; and 1 worsened neurologically. In the patients with CSM, the mean CMCT decreased postoperatively (11.3 msec) compared to preoperatively (13.7 msec), but this was not statistically significant. The mean postoperative CMCT in patients who showed neurological improvement, 11.0 msec, was significantly lower than the preoperative CMCT (15.6 msec; p < 0.05). There was no significant difference between pre- and postoperative CMCTs in patients who were clinically unchanged. Additionally, the mean preoperative CMCT was not significantly different between the patients with CSM who showed clinical improvement and the ones who remained unchanged. The authors concluded that magnetic stimulation could be used to quantify response of surgical treatment in patients with CSM, but that preoperative CMCTs did not have any prognostic value.

De Mattei et al.[4] performed transcranial magnetic stimulation in a group of 18 patients with CSM preoperatively and at 3 and 12 months postoperatively. The authors divided the cohort into 2 groups of 9 patients: those with single-level compression and those with multilevel compression. The authors compared this group to a cohort of 20 healthy volunteers. The authors calculated the

CMCT and obtained motor action potentials from the first dorsal interosseous in the upper extremity, and the extensor digitorum brevis in the lower extremity. The authors found that CMCTs for both the upper and lower extremity were significantly lower in the study patients than in the normal volunteers. In the single-level compression subgroup, there was an overall improvement in both of the aforementioned neurophysiological parameters at both the 3- and 12-month postoperative evaluations. The authors reported symptom regression in 5 patients. Three of these patients achieved normalization of their CMCTs and motor action potentials, whereas the other 2 showed substantial improvements in these neurophysiological parameters. In the other 4 patients, there was no direct correlation between changes in clinical condition and neurophysiological parameters. In the multilevel group, there was no significant improvement in the mean CMCTs or in motor action potential values at 3 or 12 months postoperatively. The authors concluded that CMCT has good diagnostic, but relatively low prognostic significance.

Effect of Age, Preoperative Neurological Status, and Duration of Symptoms

Other commonly investigated clinical prognostic factors predictive of surgical outcome in patients with CSM include age, preoperative neurological status, and duration of symptoms. Suri et al.[17] prospectively evaluated clinical factors that correlated with prognosis in 146 consecutive patients with CSM over a 2-year period. They assessed patients clinically and with the Nurick[15] grading system preoperatively and at 3 and 6 months postoperatively. Patients younger than 40 years of age showed significantly higher improvements in their postoperative Nurick scores than patients 40–60 years or older than 60 years of age (p < 0.001). Patients with > 2-year duration of symptoms also showed significantly worse improvement in their postoperative Nurick score (p < 0.05).

Chagas and colleagues[3] found similar results in a prospective study of 51 patients with CSM undergoing anterior decompression and fusion. The study graded patients preoperatively with the Nurick scoring system. The authors included in the study a total of 39 patients who completed the minimum 18-month follow-up. The mean follow-up time was 57.5 months (range 18–156 months). There was a statistically significant improvement in the mean Nurick score postoperatively (p = 0.0147). Seventy percent of the patients younger than 60 years of age had an improved Nurick score, whereas only 56% of patients older than 60 years of age had an improved Nurick score (p = 0.0425). Seventy-three percent of patients with a duration of symptoms < 2 years had an improved Nurick score postoperatively, whereas 53% with symptoms > 2 years had an improved score postoperatively (p = 0.0117). The authors concluded that age younger than 60 years and duration of symptoms < 2 years were predictors of better postoperative outcome in patients with CSM.

Handa et al.[7] evaluated 22 elderly (defined as older than 70 years of age) and 39 younger (younger than 70) undergoing expansive laminoplasty for CSM. These authors assessed function preoperatively and at 12 months postoperatively using the JOA scale and calculated the

JOA recovery rate. There was no significant difference in preoperative neurological status or duration of symptoms in the older or younger groups. The mean neurological recovery rate was 59.8% in the elderly group and 61.8% in the younger group (p > 0.05). In the elderly group, patients in whom the duration of symptoms was < 1 year had a significantly better neurological recovery rate (mean 65%) compared with those > 1 year (mean 50.3%; p = 0.043). There was no correlation between duration of symptoms and recovery rate in the younger group. Rather, preoperative neurological status was the sole clinical predictor in this cohort. Patients with a JOA scale score < 12 achieved a significantly worse neurological recovery rate (mean 40.5%) compared with those with a JOA scale score ≥ 12 (68.7%; p = 0.018).

Yamazaki et al.[18] studied 64 patients with CSM who underwent decompressive surgery via expansive laminoplasty. They divided the patients into 2 groups: an elderly group of 35 patients 65 years of age and older, and a younger group of 29 patients younger than 65 years old. The study evaluated patients with the JOA scoring system, and the mean follow-up time was 40 months. The mean preoperative (p < 0.0001) and postoperative (p = 0.047) JOA scale scores of the elderly patients were significantly lower. However, there was no significant difference in neurological recovery rate between the 2 cohorts (p = 0.758). In the elderly group, there was a significant difference in duration of symptoms between patients with excellent results (11.1 months) and fair results (39.0 months; p = 0.004). There were no clinical factors predictive of clinical outcome in the younger group.

Naderi et al.[14] retrospectively evaluated 27 consecutive patients with CSM who underwent cervical laminectomy. The authors evaluated patients using mJOA scores preoperatively and postoperatively at multiple time points. The mean follow-up time was 54.1 months (range 12–96 months). There was a statistically significant difference between the mean preoperative (12.2) and postoperative mJOA scores (14.4; p < 0.0001).[2] Age appeared to be a factor in neurological recovery. The 12 patients in their fifth and 9 in their sixth decade of life obtained significant improvement in their mJOA scale scores postoperatively (p < 0.0005 and p < 0.0001, respectively). However, patients in their seventh decade did not demonstrate statistically significant improvement postoperatively (p > 0.05). There was no correlation between duration of symptoms (range 4 months to 13 years; mean 3.8 years), and neurological outcome after surgery.

Okada et al.[16] analyzed a group of 74 patients with CSM who underwent surgical decompression for either cervical spondylosis (in 34 patients), OPLL (in 23), or central disc herniation (in 17). The mean mJOA score significantly improved from 10.5 to 14.1 postoperatively. There was no significant correlation between age and neurological recovery rate. The authors reported a correlation between the duration of symptoms and neurological recovery rate in the cervical spondylosis and OPLL subgroups. Fujiwara et al.[6] similarly evaluated 50 patients with CSM who underwent surgical decompression, and found a significant negative correlation between neurological recovery rate and both advanced age at the time of

surgery and duration of symptoms (p < 0.01). Ebersold et al.[5] studied 100 patients with CSM who underwent surgical decompression. They used the Nurick scoring system to assess the patients preoperatively and again at multiple time-points postoperatively. The mean follow-up period was 7.4 years, with a range of 3–9.5 years. Age, severity of disease, and preoperative Nurick grade were not predictors of neurological outcome; increased duration of preoperative symptoms was related to poor neurological outcome.

Summary

Controversy regarding the optimal treatment strategy for CSM still exists. An understanding of clinical factors that may predict surgical outcome is likely to play an important role in determining the optimal treatment paradigm in this population. Presently, there are significant limitations with the current medical literature that prevent making formal recommendations regarding the use of clinical prognostic factors in treatment algorithms. One of the major concerns is that validated outcome measures are not consistently used in the reported studies. Therefore, in some cases, the actual surgical results may not be optimally analyzed. In this setting, interstudy comparisons are difficult to interpret.

A number of the studies have been performed using only a single type of surgical procedure. The surgical approach may introduce a bias that could affect clinical outcome. The manner in which the various authors determined the duration of symptoms was unclear and difficult to standardize. In many cases, the true onset of symptoms may have preceded the actual time frame acknowledged by the patient. A number of studies evaluated patient age, yet there were significant variations in what age was considered elderly.

Although limited, there are some Class II data to suggest that SEPs may have a role in predicting surgical outcome in patients with CSM. In particular, normal preoperative median nerve potentials and/or normalization of potentials in the early decompression period appear to be associated with a more favorable outcome. Motor-evoked potentials are highly sensitive for detecting myelopathy, but there is a lack of data supporting its predictive value. Predominantly Class III data suggest that elderly patients may show neurological improvement postoperatively, but the study designs limit the effectiveness of a generalized comparison with younger patients. Thus, although this may be borne out in future studies, there is presently only Class III evidence supporting the use of patient age or duration of symptoms as prognostic indicators in the surgical outcome of patients with CSM.

Key Issues for Future Investigation

The major obstacles in prior studies concerning clinical predictors of outcome following surgery in patients with CSM were as follows: 1) the majority of reported studies were retrospective case series; 2) studies failed to use validated outcome measures; and 3) studies had a lack of standardization in analyzing functional outcome.

Future studies will mandate that all 3 of these issues be addressed to potentially elucidate definitive clinical prognostic indicators.

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