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Spinal Cord Stimulation for Chronic Back and Leg Pain and Failed Back Surgery Syndrome: A Systematic Review and Analysis of Prognostic Factors

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Study Design. Systematic review.

Objectives. To assess efficacy and safety of spinal cord stimulation in patients with chronic leg and back pain and failed back surgery syndrome and to examine prognostic factors that predict spinal cord stimulation outcome.

Summary of Background Data. A previous systematic review of spinal cord stimulation in patients with chronic back and leg pain and failed back surgery syndrome by Turner *et al* in 1995 identified 39 case studies and no controlled studies.

Methods. A number of electronic databases were searched through January 2002. Citation searching of included papers was undertaken, and gray literature was sought through contact with clinical experts. No language restrictions were applied. All controlled and noncontrolled study designs were included. Study selection was carried out independently by two reviewers. Prognostic factors (age, sex, duration of pain, time post surgery, follow-up duration, publication year, data collection year, indication, data collection country, study setting, and quality score) responsible for pain relief outcome across case series were examined using univariate and multivariate metaregression.

Results. One randomized controlled trial, one cohort study, and 72 case studies were included. The randomized controlled trial reported a significant benefit ($P = 0.047$) in the proportion of patients with failed back surgery syndrome reporting 50% or more pain relief with spinal cord stimulation (37.5%) compared with patients undergoing back reoperation (11.5%). There was evidence of substantial statistical heterogeneity ($P < 0.0001$) in the level of pain relief following spinal cord stimulation reported across case series studies. The four principal prognostic factors found to be predictive of increased level of pain relief with spinal cord stimulation were poor study quality score, short follow-up duration, multicenter (*versus* single center) studies, and the inclusion of patients with failed back surgery syndrome (*versus* chronic back and leg pain). Overall, 43% of patients with chronic back and leg pain/failed back surgery syndrome experienced one or more complications following a spinal cord stimulation implant, although no major adverse events were reported.

Conclusions. Despite an increase in the number of studies over the last 10 years, the level of evidence for the efficacy of spinal cord stimulation in chronic back and leg pain/failed back surgery syndrome remains "moderate." Prognostic factors found to be predictive of the level of pain relief following spinal cord stimulation were study quality, follow-up duration, study setting, and patient indication.

Key words: systematic review, spinal cord stimulation, chronic low back pain, failed back surgery syndromes, prognostic factors. **Spine 2005;30:152–160**

Shealy *et al* published the first report of the electrical stimulation of the spinal cord in 1967.[1] Since then, spinal cord stimulation (SCS) has undergone a variety of technical modifications and advances and has been applied in a variety of pain conditions.[2] The group of patients in which SCS has been most commonly applied is those with chronic back and leg pain (CBLP) and failed back surgery syndrome (FBSS) (*i.e.*, CLBP following surgery of the lumbar spine).[3]

Although a number of reviews of literature and commentaries have promoted the use of SCS in patients with CBLP and FBSS, their failure to employ systematic review methods limits their conclusions fundamentally.[4–6] The one systematic review to date by Turner and colleagues reported 37 case series studies examining SCS for patients with FBSS but failed to identify any controlled clinical studies.[7] This review completed its literature searches in 1994 and is therefore now some 10 years old.

Although case series fail to provide adequate evidence of effectiveness, they do provide a useful vehicle to explore the prognostic factors associated with patient outcome a particular intervention.[8] A number of patient- (*e.g.*, age and sex) and device-related (*e.g.*, number of electrodes) prognostic factors have been identified as being associated with the SCS outcomes of patients with CLBP and FBSS.[5,9,10] However, the lack of standardization in prognostic factors assessed, the qualitative nature of many of the analyses, and the relatively small size of studies on which these findings are based makes interpretation difficult. A rigorous statistical exploration of prognostic factors across case studies of SCS in CLBP/FBSS is therefore needed.

The aims of the present report were two-fold: to update the previous systematic review of the efficacy and safety of SCS in patients with CLBP and FBSS and to

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identify those prognostic factors that influence SCS outcome in this patient group.

■ Methods

The present study was conducted and reported in accord with the recently updated method guidelines for systematic reviews of the Cochrane Collaboration Back Review Group.[11]

Literature Search. Studies were identified from the systematic review published previously.[7] This list of studies was updated by searching a number of electronic databases, including the Cochrane Controlled Trials Register, MEDLINE, and EMBASE. Searches were conducted up to January 2002. The search strategy was developed in order to maximize sensitivity of article identification and was not restricted by language. The search strategy used both key words and medical subject heading (*MeSH*) term searches and took the form of "spinal cord stimulation and synonyms" and "failed back surgery syndrome or chronic leg and back pain or synonyms." Further information was sought by hand searching the bibliographies of selected reports and through contacts with appropriate experts.

Inclusion Criteria and Data Extraction. Two reviewers independently scanned all the titles and abstracts and identified the potentially relevant articles to be retrieved. Where there was uncertainty, full text copies were obtained. Studies were considered eligible if they met the following criteria.

Study Design. Given the lack of controlled clinical trials identified by previous reviews, the present review sought both controlled and uncontrolled studies.

Participants. Patients with chronic back and leg pain, failed back surgery syndrome, or arachnoiditis.

Intervention. Must include reference to either unilateral or bilateral SCS as a single therapy or in combination with other therapies.

Outcomes. Pain relief, analgesic consumption, return to work, functional disability, health-related quality of life, patient satisfaction/preference, complications, and health service utilization (*e.g.*, drugs, outpatient hospital visits).

Studies were excluded on the basis of: 1) reporting of only technical outcomes (*i.e.*, device settings or stimulation protocols); 2) mixed case series (*i.e.*, case series that recruit patients from a number of indication groups) where only aggregated results were reported; 3) multiple reports that include results of same patient case series (*i.e.*, the study with largest series has been selected for inclusion in the review); and 4) single case report or case reports.

Two reviewers independently selected trials to be included in the present review. Disagreements about any study inclusions were resolved by consensus among the authors. A good level of agreement was obtained between reviewers [*i.e.*, weighted κ, RST *versus* EB: 0.81, 95% confidence interval (CI): 0.71–0.91; RST *versus* JPvB: 0.90, 95% CI: 0.81–0.99]. A single reviewer (RST) extracted the data once the studies were formally included in the review using a standardized ProForma.

Quality Assessment. Quality assessment was undertaken by a single reviewer (RST). The quality of controlled studies was assessed in terms of the method of randomization, adequacy of allocation concealment, blinding of outcome assessment, and proportion of patients lost to follow-up review and scored overall using the Jadad scale.[12]

As there is not an accepted instrument or standard approach to the assessment of the quality of case series, a quality assessment tool was developed specifically for the present review. This tool was adapted from a previously tried and tested checklist for the purpose of capturing information relevant to the principle categories of study bias/selection bias (*i.e.*, bias associated with the way the intervention group was assembled), attrition bias (*i.e.*, bias associated with withdrawal from the intervention group), performance bias (*i.e.*, bias as the result of aspects of care provided to the participants in the intervention group other than the intervention under investigation), and detection bias (*i.e.*, bias as the result of the assessment of outcome).[13]

Data Analysis. A qualitative analysis of the controlled evidence was undertaken.[11] In order to summarize the large body of case series evidence identified, quantitative data synthesis was deemed necessary. Given the uncontrolled nature of the present evidence base and high degree of statistical heterogeneity across studies, the primary focus of the present quantitative analysis was exploratory. Using a metaregression, the authors were able to examine the influence of number of factors on the level of pain relief reported across studies.[14,15] These factors were: 1) age; 2) sex; 3) duration of pain; 4) time post surgery; 5) duration of follow-up review; 6) year of publication; 7) year of data collection; 8) indication (CLBP *versus* FBSS); 9) country of data collection (USA and Canada *versus* Europe *versus* other); 10) study setting (single *versus* multicenter); and 11) quality score. Factors were assessed within both a univariate and multivariate model.

Outcomes were pooled across case series studies using inverse variance weighting and a conservative random effects method.[14,16] To simulate a controlled comparison, where case series studies reported outcomes before and after SCS implantation, a relative risk or risk difference was estimated (*i.e.*, the probability of patients achieving an outcome following SCS implantation compared with the probability of outcome before implantation).

Dependent on the distribution of an outcome, data are expressed as either mean plus 95% CI or as median plus a range. All analyses were performed using Stata v.6 (Stata Corp., College Station, TX).

■ Results

Identification and Selection of Studies

A total of 382 citations were obtained from searches of the various electronic bibliographies. An additional 110 papers were obtained: 39 papers from the previous Turner review[7] and 71 papers from either the citation list of included studies/reviews or by experts. Applying the inclusion and exclusion criteria to these papers, one randomized controlled trial (RCT), one cohort study, and 72 case series were included for review. The principle reasons for exclusion of papers were inappropriate indications, failure to report outcomes disaggregated by indication and case reports (details of excluded studies available from authors). The authors were unable to lo-

Table 1. Controlled Studies of SCS for FBSS: Study Characteristics

Authors	Dario *et al* (2001)	North *et al* (1994/1995 & 2002)
Country	Italy	USA
Design	Cohort*	Randomized controlled trial
Timing	1992–1997	Not reported
Setting	Single center	Single center
Indications	49 patients with FBSS who had undergone 6 mo of medical therapy†	60 patients with FBSS
Age	53.5 yr	50.2 yr
Sex	53% male	50% male
Prognostic characteristics	Mean of 2.4 previous operations	Mean of 2.5 previous operations
SCS group no. implanted	24	24‡ (30 allocated)
Comparison group	20 medical therapy	26‡ back surgery (reoperation) (30 allocated)
Outcomes	Pain relief, functional disability, analgesic use	Pain relief, patient crossover, analgesic use, functional disability, complications
Mean follow-up duration	42 mo	36 mo§

SCS = spinal cord stimulation; FBSS = failed back surgery syndrome.
* Not possible to conclude whether prospective or retrospective.
† After 6 mo of medical therapy, those failing allocated to SCS and those successful continued medical therapy.
‡ Only 6-mo follow-up results published on 12 patients with SCS and 15 patients with back surgery.
§ Patients allowed to cross over at 6 mo.

cate four papers that may have been appropriate for inclusion.

Controlled Studies

Observational Study. In the cohort study of Dario *et al*,[17] allocation to SCS or control study arms was made on the basis of the success of previous medical therapy (Table 1). As a result, there was likely to be a major imbalance in the prognostic features of these two groups (*i.e.*, medical failures are likely to be in those patients with more severe disease). Dario *et al* provided no description of the baseline characteristics to assess the extent of such a potential difference. Furthermore, no adjustment of outcome analysis was undertaken to allow for such potential baseline differences. Overall, the study was judged to be of poor quality (*i.e.*, a Jadad score of 1 out a maximum possible 5) (Table 2).

Dario *et al*[17] reported marked reduction in pain during the first 6 months, and while patients were undergoing medical therapy, no further reduction in either leg or back pain was observed during the remaining follow-up period. During this time period, patients were allocated either to SCS or control (*i.e.*, continued medical therapy). Similarly, Dario *et al* reported no difference in functional capacity between the SCS and control group as assessed by the Pain Disability Index and Oswestry scores.

Following SCS therapy, only seven (30%) patients required either regular or occasional drug administration. Although the proportion of patients taking medication is lower in the SCS than in the control group, it is difficult to interpret given that the patients in the control group were instructed to continue drug therapy.

Randomized Controlled Trial. To date, the one RCT in this area by North and colleagues has only been reported as interim results.[18,19] For the purposes of the present review, the authors used the full trial results presented at a recent meeting.[20] Patients were randomized initially to SCS or reoperation and allowed to cross over at 6 months. Trial follow-up review was at 12 months (Table 1). The overall quality of the RCT was judged to be of good quality with a Jadad score of 4 (Table 2).

Table 2. Controlled Studies of SCS for FBSS: Assessment of Study Quality

	Dario *et al* (2001)	North *et al* (1994/1995 & 2002)
Selection bias and confounding	Present	Not present*
Randomization and allocation concealment?	Nonrandom allocation†	Method of randomization and allocation concealment reported
Performance bias	Can't tell	Yes, analgesic drugs available
Groups treated equivalently other than comparison in question?	Not reported	Not reported
Detection bias	Can't tell	Independent assessor
Observer blinding?	Not reported	No
Validated outcomes?	Yes	Yes
Attrition bias	Not present	Not present
Loss to follow $\leq$ 20%?	Yes (0%)	Yes (17%)
Intention to treat analysis	Yes	Yes
Jadad score	1/5	4/5

SCS = spinal cord stimulation; FBSS = failed back surgery syndrome.
* Details of baseline characteristics of two groups not reported.
† Characteristics of patients in two groups not reported; no adjustment for potential group differences.

Table 3. Pain Relief and Analgesic Drug Use at Long-Term Follow-Up Review: North *et al* (1994/1995 and 2002)

	Intention to Treat Analysis			Analysis by Treatment Received		
	SCS	Reoperation	*P* Value*	SCS	Reoperation	*P* Value*
≥50% Pain relief	9/24 (19)†	3/26	0.0475	15/33	3/17	0.0673
Increase in opiate analgesia	3/23	11/16	0.0149 0.0005			

SCS = spinal cord stimulation.
* Fisher's exact test.
† Six patients not available at long-term follow-up review and assumed to be "failures" of treatment.

A total of five of 24 (21%) patients allocated to SCS elected to cross over to reoperation and 14 of the 26 (54%) patients allocated as reoperation elected to cross over to SCS. When analyzed by intention to treat, patients in the SCS group experienced significantly more pain relief and required less opiate drug than patients who were reoperated (Table 3). This benefit of SCS on pain relief was retained when six patients who were lost to long-term follow-up review were assumed to be treatment failures. Although North *et al* reported that patients who were reoperated experienced greater levels of functional loss than SCS patients, no data were presented.

North *et al* reported that four (17%) and six (26%) patients with FBSS experienced complications at 6 and 12 months post SCS implantation, respectively. Long-term (*i.e.*, at 12 months) complications were reported to include one infection, which was treated with antibiotics initially but the patient was reimplanted, two implantation generator (IPG) pocket-related complications, and one defective lead. North *et al* reported that no factors other than treatment allocation influenced the treatment effect.

Case Series

Study Characteristics. A total of 72 case series studies were identified for review (75 citations are listed in Appendix 1[a1-a75]), accounting for a total of 3427 implanted patients; the majority of studies were undertaken in North America or Europe (Table 4). A wide range of sample size (*i.e.*, 1–304 patients implanted) and follow-up periods (*i.e.*, 1–106 months) were reported across the case series. The majority of case series have been on patients defined as either "CBLP" or "FBSS"; a few studies included patients with other related diagnoses, such as arachnoiditis.

Study Quality. A notable aspect of the case series in the present review was the general inadequate reporting, which prevented an appropriate assessment of methodologic quality (Table 5). However, when the relevant information was reported, the quality of these case series was in general relatively poor, scoring a median quality score of 1 out of a potential maximum score of 7. No one case series was found to have used a design that prospectively studied consecutive patients with CBLP/FBSS using independently assessed and validated outcome measures. There was some evidence of higher quality in those case series published more recently (*i.e.*, median quality score of studies published in 1975–1984: 1 *versus* 1985–1994: 1.5 *versus* 1995 onwards: 2).

Pain Relief and Exploration of Heterogeneity. As has been reported previously and in accord with current pain assessment standards, most case series reported pain relief using the threshold cutoff of 50% or more, although a variety of reporting methods were used.[13] Some studies

Table 4. Characteristics of Included CBLP/FBSS Case Series

Characteristic (No. of Studies)	Median (Range)	Frequency (%)
"Average"* age (yr) (n = 51)	48 (34–74)	
Sex (% male) (n = 49)	55 (22–80)	
Duration of pain (yr) (n = 27)	6.5 (3.8–17)	
No. of previous operations (n = 22)	2.7 (1.5–5.2)	
Sample size		
Patients tested (n = 21)	33 (9–182)	
Patients implanted (n = 72)	33 (1–304)	
Duration of follow-up review (mo) (n = 64)	26 (1–120)	
Year of study publication (n = 72)	1991 (1975–2001)	
Year of data collection† (n = 42)	1985 (1971–1998)	
Indications		
CBLP		27 (37%)
FBSS		31 (43%)
Mixture		1 (1%)
Other		13 (19%)
Country of data collection (no. of studies)		
USA and Canada		40 (56%)
Europe		29 (40%)
Other countries		3 (4%)
Non-English language studies		5 (7%)
Study setting		
Single center		31 (72%)
Multicenter		10 (28%)
Type of series		
CBLP or FBSS indication only		59 (64%)
Mixed		1 (2%)
Other		12 (15%)
Outcomes reported‡		
Pain relief		72 (100%)
Functional capacity		4 (6%)
Quality of life		3 (5%)
Drug utilization		17 (25%)
Patient satisfaction/preference		6 (10%)
Return to work		13 (21%)
Complications		32 (51%)

CBLP = chronic back and leg pain; FBSS = failed back surgery syndrome.
* Average age sometimes reported as mean and sometimes as median.
† If range of years, middle year taken (*e.g.*, 1982–1987 = 1984).
‡ In case series, these outcomes were not always reported in a usable way for this review.

Table 5. Quality of Included CBLP/FBSS Case Series

	Frequency of Studies (%)		
	Yes	No	Not Reported
Selection bias			
Consecutive or representative sample	15 (23%)		57 (77%)
Performance bias			
Absence of cointerventions		41 (57%)	31 (43%)
Detection bias			
Prospective or before/after study	11 (16%)	61 (84%)	
Blinded or independent assessment	9 (13%)	2 (2%)	51 (85%)
Validated/objective outcomes used	43 (60%)	1 (1%)	28 (39%)
Attrition bias			
Loss to follow-up review ≤ 20%	48 (67%)	5 (7%)	10 (26%)
	Median (Range)		
Overall quality score (0–7)			
Median (range)		1 (0–6)	

CBLP = chronic back and leg pain; FBSS = failed back surgery syndrome.

reported pain relief without reference to a specific cutoff figure (*e.g.*, "poor," "fair," "good," or "excellent"). In these cases, "good or excellent" pain relief was taken as the equivalent to the 50% or more cutoff.

A substantial level of statistical heterogeneity was observed in the level of pain relief with SCS across studies (Q, 2521.910; *df*, 64; $P < 0.0001$). When pooled by a random effects model, overall some 62% (95% CI: 56–67%) of patients with CBLP/FBSS achieved a reduction in pain relief of 50% following the implantation of a SCS system (see Table 6). Relative to the number of patients tested, this proportion was reduced to 48% (95% CI: 43–50%).

In an exploration of heterogeneity, the only prognostic factor found to be predictive of pain relief across studies in univariate analysis was study quality (see Table 7). The direction of this effect was in accord with the notion of bias (*i.e.*, the greater the quality score, the lower the treatment effect in terms of pain relief). In a multivariate analysis, patient indication, study setting, and duration of follow-up review were all found to be significant predictors of pain relief. The percentage of patients achieving 50% of pain level of pain relief following SCS was 15 to 20% lower in studies of high quality (>3 *versus* ≤3), was reduced by 5% for every additional 10 months of follow-up review, was 10% higher for multicenter studies (compared with single center); and was 20% higher for studies for the indication of FBSS or CLBP (compared with other included indications).

Analgesic Consumption, Return to Work, Functional Capacity, Quality of Life, and Patient Satisfaction. Analgesic consumption was assessed across studies using a variety of definitions (*i.e.*, either total analgesic drug consumption or narcotic drug consumption). Following SCS, 53% of patients (95% CI: 48–56%) reported taking no analgesia. In 10 of these studies, analgesic consumption was assessed both before and after SCS implantation. The pooled relative risk (*i.e.*, probability of taking analgesic post SCS/probability of taking analgesic pre SCS) was not significant (relative risk: 1.03; 95% CI: 0.90–1.18; Q: 31.1; *df*: 9; $P < 0.001$) across studies.

Following SCS, 40% (95% CI: 28–50%) of patients reported return to work. In the five studies that reported return to work, there was a significant increase in the proportion of patients working post SCS compared with before SCS (relative risk: 1.60; 95% CI: 1.10–2.20; Q: 29.6; *df*: 4; $P < 0.0001$).

In the three case series that reported functional capacity, two reported both pre- and post-SCS implantation using the Oswestry Disability Questionnaire. Across

Table 6. Pooled Outcomes with SCS for CBLP/FBSS Case Series

Outcome	N_s	Cases/Sample Size	Pooled Estimate Mean (95% CI)*	Heterogeneity *P* Value
Pain relief ≥ 50%†				
Tested patients	20	624/1165	48% (43–53%)	<0.0001
Implanted patients	65	1992/3313	62% (56–69%)	<0.0001
No analgesics‡	16	324/681	53% (48–56%)	<0.0001
Return to work	15	405/1133	40% (28–50%)	<0.0001
Patient satisfaction	6	147/220	70% (62–85%)	0.003

SCS = spinal cord stimulation; CBLP = chronic back and leg pain; FBSS = failed back surgery syndrome; N_s = no. of case series; CI = confidence interval.
* Random effects meta-analysis used because of evidence of statistically significant heterogeneity between studies.
† Includes 19 studies that expressed pain relief as either "excellent" or "good" or both.
‡ In 12 case series, assessed as "no analgesics" and in four case series, assessed as "no narcotic analgesics."

Table 7. Exploration of Heterogeneity and Identification of Prognostic Factors: Univariate and Multivariate Analysis of CLBP/FBSS Case Series*

	Univariate *P* Value	Multivariate† *P* Value
"Average" age (yr) (n = 45)‡	0.262	0.335
Sex (% male) (n = 43)‡	0.681	0.259
Duration of pain (n = 24)‡	0.582	0.252
No. of previous operations (n = 20)‡	0.881	§
Duration of follow-up review (mo) (n = 59)‡	0.359	<0.0001
Year of study publication (n = 65)‡	0.574	0.2937
Year of data collection (n = 40)‡	0.566	§
Indications (CLBP, FBSS, both, others) (n = 63)‡	0.607	<0.0001
Country of data collection (no. of studies) (USA & Canada, Europe, other countries) (n = 65)‡	0.067	0.522
Study setting (single center, multicenter, not known) (n = 39)‡	0.312	0.013
Quality score (0–7 scale) (n = 63)‡	0.010	0.194

CBLP = chronic back and leg pain; FBSS = failed back surgery syndrome.
* Based on percentage of patients with ≥ 50% relative to the no. of patients implanted.
† 14 studies in multivariate model.
‡ No. of studies in univariate analysis.
§ Insufficient cases to be entered into multivariate model.

these studies, there was a significant improvement in pooled functional capacity [*i.e.*, reduction in Oswestry score of 8.8 U (95% CI: 3.5–14.1; χ^2: 0.9; *df*: 1; P = 0.370)].

Few case series collected or reported health related quality of life data. Two case studies used the quality of life measure, the Sickness Impact Profile. There was pooled improvement in total Sickness Impact Profile score across the two trials of 6.3 U (95% CI, 3.0–9.6; χ^2, 0.35; *df*, 1; $P = 0.552$).

Definitions of satisfaction with SCS across studies included "procedure was worthwhile," "recommending procedure to others," and "willing to go through the procedure again." Assuming these approaches were broadly comparable, satisfaction results across studies were pooled. On average, 70% of patients (95% CI, 62–85%) reported satisfaction following SCS.

Complications. Although complications with SCS were stated to have been collected in the majority of the case series, only in 18 studies were these data usable in the context of the present review. The two principal reasons for this data loss were the failure of mixed case series (*i.e.*, more than one indication) to report complications disaggregated by CBLP/FBSS and the fact that the number of complications was reported rather than the number of patients who experienced them. Overall, 43% (48/112) of patients with CBLP/FBSS experienced one or more complications with SCS. The majority of these complications were due to electrode or lead problems (195/722; 27%). Infections (6%), generator problems (6%), extension cable problems (10%), or other issues, such as cerebrospinal fluid leaks (7%), accounted for the remainder. No neurologic-related complications were reported.

■ Discussion

Summary of Findings

The previous systematic review of SCS for patients with CBLP and FBSS by Turner *et al* in 1995[7] identified 37 case series and no controlled studies, concluding that "there was insufficient evidence for drawing conclusions on the relative effectiveness of SCS." The present review highlights the growth in the body of the evidence base since that time, identifying an additional two controlled studies and 35 published case series.

As the authors were able to identify only one RCT, the results of which have yet be published in full, the level of evidence that SCS is more efficacious than other therapies (conventional medical care or reoperation) in promoting pain relief or improving the quality of life of patients with CLBP and FBSS remains "moderate."[11] However, the fact that there is now a published body of clinical experience of the use of SCS in over 3000 patients with CLBP/FBSS worldwide (with some clinical centers reporting follow-up durations of 10 years or more) without a single report of major adverse events, such as neurologic sequelae, is evidence that SCS is a safe procedure in this group of patients.

The large body of case series evidence allowed the authors to examine which prognostic factors are predictive of the magnitude of pain relief across studies. The level of pain relief following SCS was highest in studies of poor quality, with short duration of follow-up review, that were undertaken in a multicenter setting, and that recruited patients with FBSS and CLBP specifically.

Potential Limitations of the Present Study

Quality of Studies Reviewed. A disappointing finding of the present review was not only the small amount of controlled evidence but also the poor quality and reporting of the identified case series studies. Many of the case series could only provide incomplete or inadequate information concerning their conduct. The importance of quality is amplified by the authors' finding that those case series studies judged to be of poor methodologic quality (*i.e.*, score <3) exaggerated the proportion of patients reporting 50% or more pain relief following SCS implant by up to 20% compared with those case series of higher quality (*i.e.*, score ≥3).

Publication Bias. Inevitably, any review of the literature can be subject to publication bias (*i.e.*, studies that publish positive results and benefits are more likely to be published and therefore identified); consequently, there is an underreporting of side effects or treatment failures.[14] The authors incorporated two procedures within the present review to minimize such bias. First, the authors attempted to identify case series studies that included the same patients and excluded any duplicate reports. Second, the authors sought out any relevant results that were available in the report rather than limiting to those highlighted by the study authors.

Metaepidemiology. A potential criticism of the examination of prognostic factors across case series is that of ecological fallacy.[15] A correlation between outcome and prognostic factors at a study level may not reflect such a correlation within a study and therefore, at the level of individual patients. To overcome such criticism, the authors used multivariate analyses, therefore adjusting for what might be potential confounders. Moreover, the present finding that patient indication, study duration, and study setting were prognostic factors has also been shown in previous analyses undertaken at the individual case study level.[5,10,21]

Implications for Further Research

The present systematic review demonstrates the urgent need for additional controlled studies of SCS in patients with CBLP and FBSS as well as further investigation into those prognostic factors (both patient- and device-related) that might best predict the outcome of patients receiving SCS.

One ongoing randomized controlled study is that of PROCESS (a prospective randomized controlled trial of the clinical effectiveness and cost effectiveness of spinal cord stimulation). PROCESS is an industry-supported multicenter study currently taking place across approximately 10 centers in Australia, Europe, Canada, and Israel. Patients with FBSS are randomized to either SCS or conventional medical management and followed up over a 12-month period. Outcomes assessed include pain assessment, functional disability, quality of life, and healthcare resources and costs. Subgroup analysis will be undertaken to identify potential patient- and device-related prognostic factors. It is anticipated that the 12-month results of this trial will be published early in late 2005.[22]

■ Conclusions

Despite an increase in the number of studies over the last 10 years, the authors were able to identify only one randomized controlled trial; therefore, the level of evidence for the efficacy of SCS in patients with CLBP/FBSS remains "moderate."[11] The greatest level of pain relief following SCS appeared to be associated with case series that were of poor quality, short follow-up duration, undertaken in a multicenter setting, and that recruited patients with CLBP or FBSS specifically. PROCESS is an ongoing multicenter RCT trial designed to examine the clinical and cost effectiveness of SCS in patients with FBSS.

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■ Key Points

- A systematic review of controlled and uncontrolled evidence of the use spinal cord stimulation (SCS) for patients with chronic back and leg pain and failed back surgery syndrome (CLBP/FBSS) was undertaken.
- A total of 2 controlled studies and 72 case series studies were identified. Given there is one high quality randomized controlled trial, the level of evidence for efficacy of SCS in CBLP/FBSS is judged as moderate.
- A number of factors appear be predictive of the level of pain relief following SCS - study quality, patient indication duration of follow up and study setting.

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