Spinal Cord Stimulators (SCS) for Injured Workers with Chronic Back and Leg Pain after Lumbar Surgery – A Prospective Study to Describe Costs, Complications, and Patient Outcomes: Final Report

September 30, 2008

Judith A. Turner, PhD [1]

William Hollingworth, PhD [2]

Bryan A Comstock, MSc [3]

Richard A. Deyo, MD, MPH [4]

[1] Departments of Psychiatry & Behavioral Sciences and Rehabilitation Medicine, University of Washington; [2] Department of Social Medicine, University of Bristol; [3]Department of Biostatistics, University of Washington; and [4] Department of Family Medicine and Department of Internal Medicine, Oregon Health and Science University

Funded by contract K311 from the State of Washington State Department of Labor & Industries.

Table of Contents

I. Executive Summary 4

a. Background 4

b. Study Design and Methods 4

c. Results 5

d. Conclusions 11

II. Introduction 13

III. Methods 16

a. Participants and Procedures 16

b. Interventions 19

c. Measures 19

d. Statistical Analysis 25

IV. Results 30

a. Baseline Characteristics 30

b. Follow-up Assessment Completion Rates 30

c. Primary Outcomes: SCS versus PC and UC 31

d. Alternate Success Criteria 31

e. RDQ and Leg Pain Scores 32

f. Self-reported Back Pain, Mental Health, Everyday Function 32

g. Self-reported Medication Use 33

h. Work and DLI Claim Status 33

i. Medication Prescriptions Covered by DLI 33

j. Subgroup Comparisons 34

k. Use of SCS 35

l. Baseline Characteristics Associated with Receiving Permanent Stimulator 35

m. Adverse Events 35

n. Costs 36

V. SCS-2 Cohort 37

VI. Discussion 39

a. Primary Findings 39

b. Secondary Outcomes 43

c. Adverse Events 45

d. Costs 45

e. SCS-2 Cohort 47

f. Study Limitations 47

g. Conclusions 48

VII. Acknowledgements 49

VIII. References 50

IX. Tables 52

X. Figure 1 73

XI. Appendix 74

Executive Summary

Background

Spinal cord stimulation (SCS) has been used since the late 1960s to treat intractable pain syndromes, especially chronic low back and leg pain that has failed to respond to spine surgery (often termed failed back surgery syndrome [FBSS]). Despite many years of use, there are few high-quality prospective controlled studies of SCS in this patient group. Two randomized controlled trials (RCTs) suggest that in carefully selected patients with FBSS, SCS may reduce leg pain in the short-term (six months). However, concerns remain about long-term effectiveness and neither RCT was performed in a workers' compensation setting. Until 2004, the Washington State Workers' Compensation Program administered by the Department of Labor and Industries (DLI) did not cover SCS. In 2004, the Washington State DLI agreed to cover SCS for injured workers with chronic back and leg pain provided that they met specific clinical criteria and that they agreed to participate in an independently conducted observational study of the costs, complications, and outcomes of their care.

The purpose of this study was to evaluate the outcomes of patients with FBSS who had compensable Washington State workers' compensation claims for back injuries and who received at least a trial of spinal cord stimulation, as compared with patients who were referred to a multidisciplinary pain clinic and with patients who were not referred for either SCS or pain clinic evaluation (usual care). We assessed the outcomes of pain, physical functioning, opioid medication use, adverse events, work disability, and work productivity and medical care costs to DLI up to two years after enrollment.

Study Design and Methods

This non-randomized prospective cohort study compared three groups of patients with FBSS who had compensable Washington State workers' compensation claims for back injuries: (1) patients who received at least a trial of SCS (SCS group); (2) patients who received multidisciplinary pain clinic evaluation (Pain Clinic [PC] group); and (3) patients randomly selected from a DLI administrative database who were not referred for SCS or pain clinic evaluation (Usual Care [UC] group). Study inclusion criteria for all three groups were pain radiating into one or both legs for more than 6 months, radicular pain greater than axial pain, average leg pain in the last month rated as 6 or greater on a 0-10 scale, and 1-3 previous open lumbar spine operations in the claim.

The pre-specified primary outcome was a composite measure, defined as 50% or greater reduction (relative to baseline) in leg pain intensity, less than daily opioid medication use, and a 2-point or greater improvement on the Roland-Morris Disability Questionnaire (RDQ; 0-24 scale). We also examined leg pain intensity, RDQ scores, and opioid medication use separately. These outcomes were assessed via patient self-report at baseline, 6 months, 12 months, and 24 months. The primary endpoint was 12 months. Secondary outcomes included three self-report measures (back pain intensity, work status, SF-36 Mental Health scores) and administrative database measures of numbers of days of compensation for time off work, workers' compensation claim status, and work productivity loss and medical services costs to DLI. We also examined adverse events associated with SCS, as documented in medical records.

Eligible claimants were enrolled in the study between December 2004 and June 2006. For data analyses, the study treatment groups were defined by evaluation and

treatment received in the year after enrollment (SCS trial for the SCS group and PC evaluation for the PC group). The total analysis sample consisted of 158 patients (51 SCS, 39 PC, and 68 UC).

Results

Baseline Comparisons of Treatment Groups

At baseline, patients in the SCS group did not differ significantly from those in the PC and UC groups on most characteristics, although they were more likely to have attorney representation. The SCS group also had longer wage replacement compensation, leg pain, and claim duration as compared with patients in the PC, but not the UC, group. Finally, patients in the SCS group reported greater leg pain intensity and worse physical function, but differences between groups were small and not clinically meaningful. Patients in all groups reported high levels of physical disability due to their pain.

Primary Outcome: Comparisons of Treatment Groups

The primary outcome was a composite measure of therapeutic success, requiring less than daily opioid use and specific levels of improvement in pain and function. At 12 months, 4% of patients in the SCS group, 5% of patients in the UC group, and no patients in the PC group achieved success by this definition. At six months, rates of $\geq$ 50% improvement in leg pain were higher in the SCS group (18%) than in the UC (3%) and PC (5%) groups. Also at six months, significantly fewer SCS patients (12%) reported less than daily opioid use as compared with the PC group (34%), but not the UC group (27%). The SCS group did not differ significantly from the PC or from the UC group on the primary outcome or any of the three individual criteria that constituted the primary

outcome at 12 or 24 months.

We also examined different criteria for success, based on recent empirical work related to clinically meaningful change. At six months, significantly more SCS patients achieved ≥ 5-point improvement on the RDQ (22% versus 5% in the PC and UC groups). Similarly, more patients in the SCS group achieved ≥ 30% improvement on the RDQ at six months (16% versus 5% in the PC group and 3% in the UC group), although this difference was statistically significant only as compared with the UC group. Nonetheless, using either alternate RDQ criterion, only a minority of the SCS group achieved clinically meaningful improvement at six months, and at 12 and 24 months, the SCS group did not differ significantly from the other two groups.

We also examined the proportions in each group who achieved ≥ 30% improvement in leg pain intensity ratings. The SCS group did not differ significantly from the other two groups at any time point. Examining the proportion who achieved all three alternate success criteria (≥ 5-point RDQ improvement, ≥ 30% leg pain improvement, and less than daily opioid use), the results were similar to those using the original definition of success. At one year, 4% of the SCS group, 3% of the UC group, and no patients in the PC group achieved the alternate composite success measure.

The three groups showed modest and similar improvements in RDQ scores over the 24 months of the study. At six months, the mean score on the 0-24 RDQ scale, adjusted for baseline differences, was 1.2 points (95% CI = 0.0 - 2.4) lower (better) in the SCS group than in the UC group. However, this difference is below accepted levels of minimal clinical importance and the SCS group did not differ significantly on the RDQ from the PC group at six months or from either the UC or the PC group at 12 and 24

months. All three groups also showed modest improvements in leg pain over time, with no significant differences between groups, adjusting for baseline factors, at any time point.

Secondary Outcomes

At the primary endpoint of 12 months, the SCS group did not differ significantly from PC or UC in back pain intensity or mental health scores, adjusted for baseline factors. There were also no significant differences between groups in ratings of ability to perform everyday tasks at 12 months relative to baseline. In each group, substantially more patients said their ability to perform everyday tasks was worse (34-50%) than said that it was better (14-19%). There were also no group differences in self-reported medication use at 12 months. As at baseline, the majority of patients in each group reported using opioid medication.

Fewer than 10% of patients in each group were working at 12 months. By 24 months, slightly less than one-fourth of patients in each group reported that they were working. The groups did not differ significantly in work status at either time point. The majority of patients (71-82% across groups) were still receiving time loss compensation or on pension at 12 months. This rate decreased to 56-73% at 24 months. The groups did not differ significantly in proportion receiving time loss compensation or on pension, proportion with closed claims, or days of time loss compensation at either 12 or 24 months.

Adverse Events

Medical records were reviewed to abstract information concerning adverse events associated with SCS that occurred within 18 months. Among the 51 patients who had a

trial of SCS, 8 (16%) had an adverse event associated with the trial, one of which was life-threatening. Adverse events associated with permanent implantation and the percent of patients who had each event within 18 months after the permanent implantation procedure were: superficial infection (11%), deep infection (4%), persistent pain in the region of the stimulator components (19%), other biological complication (11%), and revision surgery (19%). One of the five patients who had revision surgery had three revision operations within 18 months. Five patients (19%) had the stimulator permanently explanted, one due to a deep infection and the rest due to insufficient pain relief.

Costs

The unadjusted mean cost of medical treatment (including inpatient, outpatient, office, and care in other settings) per patient in the year prior to enrollment was similar across the three study groups (range, $1,516-1,783) per month. Over the 18 months after enrollment, total unadjusted medical costs per patient were a mean (SD) of $19,246 ($15,550) in the UC group, $29,250 ($16,357) in the PC group, and $47,190 ($33,997) in the SCS group. In each group, the costs peaked in the first six months after study enrollment. By 12-18 months after enrollment, mean monthly medical costs were lower than in the year prior to enrollment. Unadjusted mean productivity costs (primarily for time loss compensation) paid by DLI were similar across groups over the 18 months, totaling a mean (SD) per patient of $35,527 ($14,492) in the SCS group, $38,753 ($19,987) in the PC group, and $33,552 ($15,670) in the UC group. Adjusting for medical and productivity costs in the 12 months pre-enrollment and other baseline covariates, the mean total medical and productivity cost over the 18 months after study

enrollment per patient was $18,644 (95% CI, $4,746-$32,542; $P = 0.009$) lower in the PC group and $28,064 (95% CI, $16,619-$40,909; $P < 0.001$) lower in the UC group, compared to the SCS group.

Comparison of Permanent Stimulators to Pain Clinic Treatment

In the SCS group, 27 of the 51 patients who had trial stimulation (53%) received a permanent stimulator in the first year after enrollment. Among the 39 patients in the PC group, 23 (59%) received at least some pain clinic treatment. We compared the subgroup of patients who received permanent stimulators to the subgroup of patients who received any pain clinic treatment. Similar to the results for the full SCS and PC analysis groups, fewer than 10% of patients in each subgroup achieved the primary composite success outcome at any time point. There were no significant differences between groups on the composite outcome or any of the three individual success criteria at 12 or 24 months.

SCS-2

After enrollment for the initial study ended in June 2006, DLI continued to cover SCS for patients with compensable Washington State workers' compensation claims who met all the U.W. study inclusion criteria and utilization review criteria and agreed to participate in a separate observational cohort study (SCS-2). Thirty patients enrolled in the SCS-2 study July 1, 2006 - April 26, 2007 and had trial SCS. The SCS-2 group was similar to the original SCS group on most baseline characteristics, although all SCS-2 participants were male and their average leg pain intensity was slightly lower. Comparable proportions of patients in the SCS-2 group (57%) and the original SCS cohort (53%) received a permanent implantation in the year after enrollment.

Comparing all patients who received trial stimulation, significantly more in the SCS-2 group than in the original cohort showed a 2-point or greater decrease on the RDQ (63% vs. 32%) and significantly more reported less than daily opioid use (30% vs. 19%) at 12 months. However, the two groups did not differ significantly in the proportion meeting the primary composite success outcome or any of the alternate success criteria. Comparing the subgroups who received permanent stimulators, there was a trend for a higher proportion in the SCS-2 group than in the original group to report less than daily opioid use. However, the SCS-2 permanent stimulator subgroup did not differ from the original permanent stimulator subgroup on any of the seven other success measures examined.

The SCS-2 group did not differ from the original SCS group at 12 months on back pain or mental health scores, change in ability to perform daily tasks, or work status. No patient in the SCS-2 group reported working at 12 months. However, patients in the SCS-2 group were less likely than those in the original group to report use of sedative-hypnotic medication at 12 months, with trends towards less use of muscle relaxant and more use of antidepressant medication. Finally, the SCS-2 group had significantly more time loss compensation days in the year after enrollment, although the number of time loss days was high in each group and the trend towards more claim closures in the SCS-1 group might explain the lower number of time loss days in that group.

Conclusions

In summary, we found little evidence for the superiority of SCS over alternative treatments among Washington State workers' compensation claimants with failed back surgery syndrome. A small advantage of SCS in improving leg pain and function at six

months disappeared at later follow-ups. There was no statistically or clinically meaningful difference between groups in any comparison of leg pain, function, or opioid use at the 12- and 24-month assessments. Adverse events associated with SCS included infections and persistent pain in the region of the stimulator components. Trial stimulation was also associated with adverse events, including one that was life-threatening. Almost 20% of patients who received permanent stimulators had them removed within 18 months.

We also found no evidence that SCS reduced medical or productivity costs. Total medical and productivity costs per patient over the 18 months after study enrollment were substantially higher in the SCS group than in the PC group ($18,644 adjusted mean difference) and the UC group ($28,064). There was no evidence of lower costs in the SCS group than in the PC and UC groups in the period between 12 and 18 months after study enrollment.

The second cohort of patients receiving at least a trial of SCS (SCS-2) was similar to the original SCS group on most baseline characteristics assessed and in rate of permanent implantation (slightly over half of each group). There was no strong and consistent pattern of differences between the original and the later SCS group.

Spinal Cord Stimulators (SCS) for Injured Workers with Chronic Back and Leg Pain after Lumbar Surgery – A Prospective Study to Describe Costs, Complications, and Patient Outcomes

Introduction

Spinal cord stimulation (SCS) has been used since the late 1960s to treat patients with intractable pain syndromes. Most commonly, SCS has been recommended for patients with chronic low back and leg pain that has failed to respond to spine surgery (often termed failed back surgery syndrome [FBSS]) and for complex regional pain syndrome (CRPS) type I. SCS devices and implantation methods vary, but all involve the insertion of electrodes into the epidural space. These electrodes are connected to an electrical pulse generator.

Despite many years of use, there are few high-quality prospective controlled studies of SCS. In a single center study, North et al. randomly assigned 60 patients with FBSS to SCS or re-operation (laminectomy, foraminotomy, discectomy and/or fusion).[1-3] At least 38% of patients randomized to SCS reported a 50% reduction in leg pain intensity and satisfaction with care at long-term follow-up, compared to 12% of patients randomized to re-operation. However, the high unintended crossover rate among patients randomized (54% of patients assigned to reoperation crossed over to SCS and 21% of patients assigned to SCS crossed over to reoperation) complicates interpretation. Additionally, 39% of patients eligible for the study did not participate because they preferred reoperation, and patients receiving workers' compensation benefits were less likely than others to be randomized and treated due to lack of insurance authorization. These factors may limit the study's generalizability. Furthermore, the study design did

not allow conclusions regarding how these therapies compare to treatment involving strictly nonoperative care.

In an international multi-center RCT, Kumar et al.[4] randomized 100 patients with FBSS to receive SCS and conventional medical management (CMM) or CMM only for at least 6 months. In the intention-to-treat analysis at 6 months, 48% of the SCS patients and 9% of the CMM patients ($P < 0.001$) achieved the primary outcome, $\geq$ 50% improvement in leg pain. Furthermore, the SCS group had better back pain, physical functioning, and other quality of life outcomes. These 6-month results provide evidence supporting the short-term benefits of SCS but they do not yield information concerning long-term benefits. Study data suggested a trend towards improvement among controls and worsening of leg pain after three months in the SCS group, consistent with previous studies that have suggested that pain relief with SCS diminishes over time.[5, 6]

Concerns also remain about the rate of adverse events associated with SCS. In a systematic review of 22 studies with variable lengths of follow-up, Turner et al.[5] found that 34% of patients had one or more undesirable outcomes after SCS implantation and 24% required revision surgery. The most frequent of these were re-operations to reposition electrodes and stimulator removal due to infection, equipment failure, or inadequate pain relief. In the Kumar et al. RCT,[4] among the patients who received either a trial only or trial plus permanent SCS implantation, almost a third experienced at total of 40 SCS-related adverse events and almost one-fourth required additional surgery for a complication during the year after study enrollment.

Another concern relates to the cost of SCS. There have been several estimates of the costs of SCS versus alternate therapy for patients with FBSS.[7-9] For example, Kumar

et al.[7] estimated the costs of care for 104 patients with FBSS. Sixty patients with permanent SCS implants were compared to 44 patients in whom trial SCS implantation had failed to reduce pain. Costs of surgical and medical care in the initial years were extrapolated to five years post-surgery, assuming that the SCS pulse generator needed replacing after four years. The authors concluded that the higher initial costs to the Canadian health care system would be recouped through lower maintenance costs by 2.5 years after implantation. However, patients who respond to an SCS trial and go on to permanent implantation may have a more favorable prognosis than those who fail a trial; the extent to which patients who respond to a trial may have better outcomes and lower treatment costs in the long-run due to these favorable prognostic characteristics versus the effects of the stimulator is unknown.

In 1995, Medicare issued a national coverage determination supporting the use of SCS as a late or last resort for patients with chronic intractable pain. Many other insurers have adopted a similar policy. Until 2004, the Washington State Workers' Compensation Program administered by the Department of Labor and Industries (DLI) did not cover spinal cord stimulator surgery for injured workers with FBSS. In 2004, Washington State DLI agreed to cover SCS for injured workers with chronic back and leg pain provided that they met specific clinical criteria and that they agreed to participate in an independently conducted research study of the cost, complications and outcomes of their care. Washington State DLI contracted the University of Washington to conduct this research study.

The purpose of this non-randomized prospective cohort study was to evaluate the outcomes of patients with FBSS who had compensable Washington State workers'

compensation claims for back injuries and who received at least a trial of spinal cord stimulation (SCS group). We compared the outcomes of this group to those patients with FBSS who had compensable Washington State workers' compensation claims for back injuries and who met the same clinical criteria, but who were either: (1) referred to a multidisciplinary Pain Clinic (PC group) and not for SCS or (2) not referred for SCS or to a pain clinic (Usual Care [UC] group). We assessed the outcomes of pain, physical disability, opioid medication use, adverse events, work disability, and work productivity and medical care costs up to two years after enrollment. After study enrollment ended, DLI continued to authorize SCS for patients with FBSS who had compensable Washington State workers' compensation claims, were referred for SCS, and met the original study inclusion criteria, if they agreed to enroll in the U.W.-conducted study and complete the original study measures at baseline (prior to SCS trial) and at 12-month follow-up. The baseline characteristics and outcomes of this "SCS-2" group were compared with those of the original SCS group.

Methods

Participants and Procedures

Inclusion and Exclusion Criteria

The study inclusion criteria were: 1) a current Washington State workers' compensation state fund claim for a back injury; 2) currently receiving time loss compensation; 3) pain radiating into one or both legs for more than 6 months; 4) radicular pain greater than axial pain; 5) average leg pain in the last month rated as six or greater on a 0-10 scale; 6) no previous SCS surgery; 7) no current diagnosis of diabetes or cancer; and 8) ability to speak English or Spanish. In the initial phase of subject

recruitment, additional inclusion criteria were age between 18 and 55 years, claim of less than three years' duration, and one or two previous open lumbar spine operations. In February 2005, after slow initial enrollment, these three criteria were broadened to age 18-60 years, claim of any duration, and between one and three previous open lumbar spine operations during the current claim.

SCS Group

Washington State workers' compensation claimants who potentially were good candidates for SCS, met the study inclusion criteria, and did not have progressive motor deficit, bony deformity, or any contraindication for surgery were initially identified by their physicians. The physicians discussed SCS and the study with these patients, and informed them that DLI would cover SCS only if the patient agreed to participate in the study. Patients who remained interested in having a trial of SCS were then referred to DLI for administrative utilization review, involving examination of the medical and administrative records to confirm that the patient met all study inclusion criteria. Patients provisionally accepted for SCS were sent a study information statement and telephoned by the University of Washington (U.W.) research team for screening on all study inclusion criteria. If the patient met the study inclusion criteria and consented to participate in the study, the provider and patient were informed that the SCS procedure could be scheduled.

PC Group

Claimants who were potentially eligible for the PC group were identified from DLI administrative databases at the time they were approved for pain clinic evaluation. The contact details of workers approved for pain clinic evaluation and who met the claim,

time loss compensation, past surgery, and age inclusion criteria were forwarded to the research team. Potentially eligible claimants were sent an introductory letter with study information and were telephoned by research staff for eligibility screening, informed consent, and enrollment into the study.

UC Group

Each month the DLI provided the research team a list of all claimants who currently met the claim, time loss compensation, past surgery, and age inclusion criteria, and who had not been approved for pain clinic evaluation. Each week, computer-generated random numbers were used to select eight claimants from this list who had not been enrolled in the SCS or PC groups. Potentially eligible claimants were sent a study information statement and telephoned for screening. Claimants who met the inclusion criteria, provided informed consent, and enrolled in the study formed the UC group.

Injured workers were enrolled in the study between December 2004 and June 2006. Health care providers registered with Washington State DLI were sent a bulletin notifying them of the study in November 2004. The U.W. institutional review board reviewed and approved the study methods, and all study participants provided informed consent.

Initial Study Enrollment

We targeted a sample of 50 patients in each of the three comparison groups. Overall, 573 claimants were approached for participation in one of the three study groups; among these, 170 could not be contacted and 111 were contacted but declined to enroll (Table 1). Among the remaining 292 claimants, 133 did not meet inclusion criteria (the most common reason for exclusion was leg pain not worse than back pain), leaving

159 who met the inclusion criteria and enrolled (Table 1).

Among 112 patients referred for DLI utilization review for SCS, 51 (46%) did not meet the utilization review criteria. The remaining 61 patients were referred to the U.W. research team for final study screening and consent procedures; 52 (85%) were eligible and enrolled in the study (Table 1). These 52 patients were referred by 19 physicians. Enrollment rates in the PC (n = 51, 24% of those approached) and UC (n = 56, 19% of those approached) groups were much lower than in the SCS group.

Interventions

Because this was an observational study, decisions regarding treatments were left to the patients and their health care providers. SCS trial procedures and equipment, criteria for proceeding with a permanent implant, and permanent implant procedures and equipment were determined by the physicians. Similarly, in the Pain Clinic group, the patients' health care providers made the decisions regarding whether the patient would be treated in the pain clinic program and if so, the program length and content.

Measures

Baseline Characteristics

DLI administrative databases were used to obtain information regarding patient age, gender, industry, county of residence, claim receipt date, and legal representation. In baseline interviews, patients reported on their race, education, marital status, work status, history of symptoms and hospitalizations for their injury, and medications used for pain.

Outcome Measures

Self-report Measures. Patients completed self-report measures of pain, functioning, work status, medication use, and mental health at baseline (study enrollment)

and 6, 12, and 24 months later. Most assessments were conducted by telephone, but a questionnaire was mailed to patients who could not be reached by telephone. In each interview, patients were asked to rate the average intensity of their leg pain in the last month on a scale of zero (no pain) to ten (pain as bad as could be). Physical functioning was assessed by the Roland-Morris Disability Questionnaire (RDQ).[10] RDQ scores range from 0-24, with higher scores indicating greater disability.

Patients were also asked in each interview to name every medication that they regularly took for their back or leg pain more than five times in the past month and the number of days on which they used it. We considered less than 28 days to be less than daily. We used the World Health Organization (WHO) Collaborating Centre for Drug Statistics Methodology Anatomical Therapeutic Chemical/Defined Daily Dose (ATC/DDD) Index (http://www.whocc.no/atcddd/), an internationally accepted classification system for drug consumption studies, to determine the type of each medication. We grouped medications into the following seven categories: opioids, sedative-hypnotics (including benzodiazepines and anti-anxiety medications), muscle relaxants, non-opioid analgesics (nonsteroidal anti-inflammatory drugs and acetaminophen), antidepressants, anticonvulsants, and other.

Secondary outcomes assessed at each interview included average back pain intensity in the past month (0-10 scale), work status and the SF-36 version 2 [15] Mental Health (MH) scale. The MH scale is normalized such that a score of 50 equals the mean score in the U.S. population and lower scores indicate worse mental health. At each follow-up, patients who had received a permanent SCS implantation were asked whether they still had the device implanted and, if so, how many days they used it in the past

month and for how many hours each day. At 12 and 24 months, patients were asked about their ability to perform everyday tasks compared to one year ago.

Primary Outcome. The primary outcome, specified prior to beginning the study, was a composite measure of therapeutic success, defined as 50% or greater reduction (relative to baseline) in leg pain, a 2-point or greater improvement on the RDQ, and less than daily opioid medication use. Our rationale for this composite measure was that, at that time, 50% improvement in pain was a common measure of success in studies of SCS and was regarded as a standard for clinically meaningful improvement in chronic pain.[11] We added a very modest improvement in function (2-point RDQ improvement) to the definition of success. We added the opioid medication dimension because it would be difficult to interpret the independent benefit of SCS in patients who still use opioid medication daily. Furthermore, it could be argued that patients with a successful outcome would not require daily opioid use. We also examined leg pain intensity, RDQ scores, and opioid medication use separately.

Alternate Definitions of Clinically Meaningful Improvement. After we selected our primary outcome measure and began enrolling subjects, further research on clinically meaningful change in pain and function pointed to different criteria for clinically meaningful improvement in numerical pain ratings and RDQ scores. There is growing consensus that a 2-point change on the RDQ is of dubious clinical importance and that a 30% or greater improvement or 5-point or greater decrease on the RDQ represents a clinically meaningful improvement in physical function.[12, 13] Furthermore, recent evidence supports $\geq$ 30% improvement in pain intensity rating as a clinically meaningful difference and $\geq$50% as substantial improvement.[11, 12, 14] The Initiative on Methods,

Measurement, and Pain Assessment in Clinical Trials (IMMPACT) group has recommended reporting both the proportion with ≥ 30% and the proportion with ≥ 50% pain relief in clinical trials of chronic pain treatments.[14] Thus, we also examined the proportions in each treatment group who achieved improvement by these alternate criteria.

Work disability days and status. DLI administrative data were used to calculate the number of days that the patient received compensation for time lost from work (time loss), as well as time loss compensation status, at 12 and 24 months from the date of study enrollment.

Medication Prescriptions Covered by DLI. The DLI billing database lists each medication bill submitted for reimbursement, including the drug name, date the prescription was filled, and dollar amount paid by DLI. For analysis, we examined only bills that DLI paid. We categorized these medications into the seven categories used for the self-reported medications, using the WHO ATC/DDD Index. We summarized DLI pharmacy bill records to derive the number of patients in each group who filled medication prescriptions in each category. We examined baseline use (prescription filled in a window from 60 days before study enrollment through 60 days after enrollment) and one year use (365 days from study enrollment plus or minus 60 days).

Medical Costs. DLI pays for injury-related costs, including medications, hospitalization, outpatient care, emergency department, home health care, and other health care services. DLI also reimburses patients for some travel, accommodation, and food expenses incurred in receiving care.

All cost data on medical services were extracted from the DLI billing database.

Inpatient hospital care was categorized using diagnosis-related group (DRG) codes. We used Healthcare Common Procedure Coding System (HCPCS) codes to identify inpatient medical services and equipment provided by health care professionals. Facilities and health care providers are reimbursed by DLI based on DRG and HCPCS codes.

Outpatient hospital care (including emergency department and ambulatory surgery centers) and services provided in physicians' offices were categorized using HCPCS codes, supplemented by local billing codes. The local codes identify services specific to workers' compensation claimants not included in the HCPCS (e.g., pain clinic treatment per day). Outpatient facility and health care professional costs are reimbursed by DLI for each HCPCS and local code.

Reimbursement rates vary according to the type of service provided, the type of health care professional providing the service, and the setting in which the service is provided. DLI reimbursement is generally lower than the charges billed. In our analyses, we used actual reimbursement paid by DLI, not billed charges, to calculate the medical costs to the payer.

Productivity Costs. DLI provides work time loss compensation payments to workers unable to work due to injury for four or more days. The benefit usually amounts to 60-75% of the pre-injury wage up to a ceiling based on the State average wage. DLI also provides "loss of earning power" payments to those who return to modified work duties with wages less than 95% of their regular salary. If the injury is judged to cause permanent loss of function, the claimant may be eligible for a partial permanent disability, pension payments, and other reimbursements based on the degree of disability. We obtained data from the DLI regarding the number of days of time lost from work and

the cumulative dollar payments made by DLI to claimants for time loss, loss of earning power, permanent partial disability, pension, and other reimbursements. The total lost productivity costs to DLI were estimated as the sum of these payments made in the 18 months after the date of study enrollment.

Costs Analyzed. Medical, productivity, and total costs were examined over 18 months after enrollment rather than 12 months (the primary endpoint for the self-report outcomes) to examine whether, after the initial medical costs and time off work associated with receiving trial and permanent SCS, there was a trend for decreasing costs over time in the SCS group as compared with the PC and UC groups. Given the lag (approximately 2-3 months) between provision of medical services and the recording of billing data in the DLI database, complete costs data for all subjects were not available for periods longer than 18 months.

Adverse Events

The study Principal Investigator (PI) and a surgeon experienced in SCS surgery trained a research coordinator to abstract SCS-related information from medical records and record the information on a standardized form. For each claimant, DLI keeps copies of medical records related to the work injury. The research coordinator reviewed these records for each patient in the SCS group to record information concerning trial stimulation and permanent spinal cord stimulator implantation as well as adverse events and subsequent operations related to SCS. The medical records of nine (18%) randomly selected SCS cases were abstracted independently by the PI and the research coordinator; there was excellent agreement. In addition, for each patient identified as having a serious adverse event or further surgery related to SCS, the PI double-checked the completed

form against the medical records. Because of the study focus on adverse events specific to SCS, we did not record adverse events related to other therapies (e.g., medications, non-SCS operations) in the SCS group or in the UC and PC groups.

Statistical Analysis

Analysis Sample

Not all study participants received the anticipated therapy (SCS or PC). For analysis, we defined treatment groups by the evaluation and treatment the patient received during the year after enrollment, according to billing information provided by DLI (and confirmed by self-report for all patients and by medical record review for SCS patients). Table 1 provides information concerning crossovers from original study groups. Primary analyses compared the SCS group (patients who received at least a trial of SCS) to each of two control groups: PC (patients who received multidisciplinary pain clinic evaluation) and UC (patients who received neither trial SCS nor pain clinic evaluation).

SCS Analysis Sample. Among the 52 patients initially enrolled in the SCS group, five did not receive a trial within one year (Table 1). Two of these five patients received a pain clinic evaluation within one year and were analyzed in the PC group. The other three were analyzed in the UC group. Three patients initially enrolled in the UC group subsequently received trial SCS within one year and thus were analyzed in the SCS group. One patient initially enrolled in the PC group received no PC evaluation but received trial SCS device within one year of enrollment and thus was included in the SCS group analysis group. Interviews for these patients were rescheduled to take place at the time of SCS referral (before undergoing the SCS trial) and 6, 12, and 24 months later.

Among the 51 patients in the SCS analysis group (all of whom, by definition, received trial stimulation), 27 (53%) received a permanent stimulator (Figure 1). By 6 months, 48 had received a trial and 25 had received a permanent stimulator. The primary analysis sample for the SCS group was patients who received trial SCS within one year of study enrollment, regardless of whether they proceeded to a permanent implantation. Our rationale for this was that using only patients who had a successful trial would introduce selection bias by focusing only on those patients who have a good initial response to SCS (by analogy, this approach would suggest only analyzing those with a favorable initial response in the other treatment groups, as well). The RCT results published by Kumar et al.[4] also considered the primary SCS analysis group to be all patients who received a trial, regardless of whether they went on to receive a permanent implant. In a secondary analysis, we compared the outcomes of SCS patients who received a permanent stimulator to those of PC patients who received some pain clinic treatment. This created analogous groups in that patients in each group not only passed the screening criteria, but went on to receive at least some of the intended therapy.

PC Analysis Sample. The PC group analysis sample consisted of patients who received a pain clinic evaluation in the two months prior to enrollment or the year after enrollment in the study. Among the 51 subjects enrolled in the PC group, 17 were not evaluated at a pain clinic within this period. One of these received trial SCS and was analyzed in the SCS group. The other 16 were analyzed in the UC group. Four subjects who initially enrolled in the UC group were evaluated at a pain clinic within the first year and thus were included in the PC group rather than the UC group for analyses. Finally, within six months of enrollment in the PC group, one patient had an SCS trial and

permanent implantation that were paid for by private insurance. The patient did not go through the DLI utilization review process and it is unknown whether the patient would have met utilization review criteria for SCS, so we excluded this patient from all study analyses.

The final analysis samples thus included 51 patients in the SCS group, 39 patients in the PC group, and 68 patients in the UC group.

Baseline Comparisons

Baseline characteristics of the SCS group was compared with those of the UC and PC groups using t-tests for normally distributed continuous or ordinal measures, Fisher's exact test for categorical variables, and the Kruskal-Wallis H test for continuous or ordinal measures with skewed distributions.

Comparisons of Self-report Outcomes and Work Time Loss Outcomes

To compare the SCS versus the UC and PC groups on the primary outcome measure of therapeutic success (successful on all three criteria versus not), we used a logistic regression analysis with treatment group as an independent variable (SCS = reference), adjusting for the baseline values of the three criterion measures. We used a similar approach to compare the groups on each of the three criterion measures alone, adjusting for the baseline value of the criterion measure. We did not adjust for other baseline variables in analyses of these categorical outcomes due to the small n in the subgroups. We also used this approach to compare on the primary outcome the SCS subgroup who received a permanent stimulator and the PC subgroup who received some pain clinic treatment, and the outcomes of the SCS-2 group versus the original SCS group.

For analyses comparing SCS to PC and UC on the continuous self-report outcome measures (RDQ, leg pain intensity, back pain intensity, mental health), which allowed adjustment for a few baseline factors, we sought parsimonious statistical models that adjusted for the most important potential confounders. We therefore conducted a series of analyses to identify potentially confounding baseline variables to adjust for in these analyses (see Appendix for details). We then constructed a linear regression model for each outcome at each follow-up, adjusting for the selected baseline covariates and the baseline value of the outcome, with treatment group as an independent variable.

We compared the groups on the time loss outcomes using linear regression (for number of time loss days) and logistic regression models (proportion on time loss, proportion on time loss or pension) adjusted for baseline wage replacement compensation duration. Other administrative outcomes with small cell counts were analyzed using Fisher's exact test with continuity correction for small cell counts.

We examined the associations of baseline variables with whether or not the SCS trial was followed by a permanent implantation using separate logistic regression models for each baseline variable examined.

Cost Analyses

All costs were converted into 2007 dollars, using the consumer price index medical care commodities (on average, 2.5% per annum for pharmaceuticals) and medical care services (on average, 4.8% per annum for other health care) components (http://www.bls.gov/cpi/cpifact4.htm). Costs occurring after the first year of study enrollment were discounted at a rate of 3%, as recommended by current guidelines. [16] We calculated mean total medical care costs and total productivity costs per patient for

the three study groups at three time points (6, 12, and 18 months after enrollment).

For the analyses of total medical care and productivity costs, our null hypotheses were that the total cost in the SCS group was not different from the total cost in either the PC group or the UC group. We tested these hypotheses separately for medical costs and productivity costs using an ordinary least squares (OLS) regression with cost as the dependent variable and treatment group (SCS as reference, PC, UC) as an independent variable. In each analysis, we adjusted for the total medical and productivity costs in the 12 months prior to study enrollment and the same baseline covariates selected for the outcomes analyses. Cost data often are skewed with a few high cost outliers. Therefore, in an exploratory secondary analysis, we repeated the above regression after log-transforming the total cost dependent variable and the "cost in the 12 months prior to study enrollment" covariate. Before log transformation, we added $1 to the total costs of the small number of patients in the usual care group who had no medical costs during follow-up.

Whether or not *P*-values should be adjusted for multiple comparisons is controversial. [17, 18] We elected not to adjust for multiple comparisons because of the increased likelihood of committing Type II errors (incorrectly concluding that a true difference is not significant). Therefore, we considered all statistical tests as significant at a 2-sided $P < 0.05$. In interpreting the findings, we place emphasis on consistent patterns of findings and on clinically as well as statistically meaningful differences between groups and place little emphasis on isolated statistically significant findings modest in size. All statistical analyses were conducted using Microsoft Excel 2000 and STATA/IC 10.0 (College Station, TX).

Results

Baseline Characteristics

Of the 158 baseline interviews, four were conducted in Spanish (one in the PC, one in the SCS, and two in the UC analysis group). The average age of study participants was 44 years and participants were predominantly male (Table 2). At baseline, the three groups were similar on most characteristics (Table 2). Patients in the SCS group did not differ significantly from those in the PC and UC groups on demographic characteristics, work status, back pain intensity, mental health scale scores, or number of previous lumbar operations during the period of the workers' compensation claim. However, patients in the SCS group were significantly more likely than those in the PC and UC groups to have attorney representation. In addition, the SCS group had significantly longer time loss compensation, leg pain, and claim duration as compared with the PC, but not the UC, group. Although SCS patients reported significantly greater leg pain intensity as compared to UC patients and significantly worse physical function as compared to PC and UC patients, the group mean differences were small and well under the threshold for clinically meaningful differences. Patients in all groups reported high levels of physical disability due to their back and leg pain (mean of 20-21 on the 0-24 RDQ scale). The groups did not differ in proportions reporting use of different types of medication for pain. In each group, the majority reported using opioid medication, with substantial minorities also reporting use of sedative-hypnotic, muscle relaxant, antidepressant, anticonvulsant, and non-opioid analgesic medications.

Follow-up Assessment Completion Rates

Follow-up interview completion rates were 98% at 6 months, 94% at 12 months,

and 87% at 24 months (Figure 1). No baseline measure was significantly associated with 12-month follow-up completion. Administrative outcome data (time loss compensation days, claim status, work productivity and medical costs) were complete for all participants at each time point.

Primary Outcomes: SCS versus PC and UC

Few patients achieved success at any time point, as defined by the composite outcome encompassing less than daily opioid use and improvement in leg pain and function (Table 3). At 12 months (the primary endpoint), 4% of patients in the SCS group, 5% of patients in the UC group, and no patients in the PC group achieved success by this definition.

At six months, rates of ≥50% improvement in leg pain were higher in the SCS group (18%) than in the UC (3%) and PC (5%) groups (Table 3). The difference from the UC group was statistically significant and there was a trend towards a statistically significant difference from the PC group. Also at six months, significantly fewer SCS patients reported less than daily opioid use as compared with the PC group (12% vs. 34%), but not the UC group (27%). The SCS group did not differ significantly from the PC or from the UC group on the primary outcome or any of the three individual criteria that constituted the primary outcome at 12 or 24 months.

Alternate Success Criteria

At six months, although the SCS group did not differ from the other two groups in proportion with ≥ 2-point improvement on the RDQ (Table 3), significantly more SCS patients achieved the criterion of ≥ 5-point improvement on the RDQ (22% vs. 5% in the PC and UC groups; Table 4). Similarly, more patients in the SCS group achieved ≥30%

improvement on the RDQ at six months (16% vs. 5% in the PC group and 3% in the UC group), although this difference was statistically significant only as compared with the UC group. Nonetheless, using either alternate RDQ criterion, only a minority of the SCS group achieved clinically meaningful improvement at six months, and at 12 and 24 months, the SCS group did not differ significantly from the other two groups.

Examining the proportions in each group who achieved ≥ 30% improvement in leg pain intensity ratings, the SCS group did not differ significantly from the other two groups at any time point (Table 4). Examining the proportion who achieved all three alternate success criteria (≥ 5-point RDQ improvement, ≥ 30% leg pain improvement, and less than daily opioid use), results were similar to those using the original definition of success. At one year, 4% of the SCS group, 3% of the UC group, and no patients in the PC group achieved the alternate composite measure of success.

RDQ and Leg Pain Scores

The three groups showed modest and similar improvements in RDQ scores over the 24 months of the study (Table 5). At six months, the mean score on the 0-24 RDQ scale, adjusted for baseline differences, was 1.2 points (95% CI = 0.0 - 2.4) lower (better) in the SCS group than in the UC group ($P = 0.049$). However, the SCS group did not differ significantly on the RDQ from the PC group at six months or from either UC or PC at 12 and 24 months. All three groups also showed modest improvements in leg pain over time, with no differences between groups, adjusting for baseline factors, at any time point (Table 5).

Self-reported Back Pain, Mental Health, Everyday Function

At the primary endpoint of 12 months, the SCS group did not differ significantly

from PC or UC in back pain intensity or mental health scores, adjusted for baseline factors (Table 6). There were also no significant differences between groups in ratings of ability to perform everyday tasks at 12 months relative to baseline (Table 6). In each group, substantially more patients said their ability to perform everyday tasks was worse (34-50%) than said it was better (14-19%).

Self-reported Medication Use

There were no group differences in self-reported medication use at 12 months (Table 6). As at baseline, the majority of patients in each group reported using opioid medication.

Work and DLI Claim Status

Fewer than 10% of patients in each group were working at 12 months (Table 7). By 24 months, slightly less than one-fourth of patients in each group reported that they were working. The groups did not differ significantly in work status at either time point. The DLI administrative data were consistent with patient self-reported data. The majority of patients (71-82% across groups) were still receiving time loss compensation or on pension at 12 months (Table 7). This rate decreased to 56-73% at 24 months. The groups did not differ significantly in proportion on time loss compensation or pension, proportion with closed claims, or days of time loss compensation at either 12 or 24 months.

Medication Prescriptions Covered by DLI

Table 8 shows the proportion of patients in each group who filled medication prescriptions covered by DLI during the 120-day baseline and 12-month windows. The table does not include prescriptions paid by other sources (e.g., Social Security Disability,

other health insurance, self-pay), including prescriptions filled by patients with closed claims at 12 months. At baseline, significantly fewer SCS than PC patients had prescriptions for non-opioid analgesics. There were no other significant differences between groups at either baseline or 12 months, although at one year, there were trends towards more SCS patients than UC patients (but not PC patients) filling prescriptions for opioid and anticonvulsant medications.

Subgroup Comparisons: Permanent Stimulator Implantation versus Pain Clinic Treatment

Among the 51 patients who had trial SCS, 27 (53%) received a permanent stimulator in the year after enrollment. Among the 39 patients in the PC group, 23 (59%) received at least some pain clinic treatment. Similar to the results for the full SCS and PC analysis groups, fewer than 10% of patients in the SCS permanent stimulator and PC treatment subgroups achieved the primary definition of a successful outcome at any time point, with no significant differences between the subgroups (Table 9). As with the entire samples, at six months, there was a trend towards more patients in the permanent stimulator group than in the pain clinic treatment group reporting $\geq$ 50% improvement in leg pain (33% vs. 10%, $P = 0.06$), but also a trend towards fewer permanent stimulator patients than pain clinic treatment patients reporting less than daily opioid use (15% vs. 43%, $P = 0.05$). There were no significant differences on any of the three individual success criteria at 12 or 24 months.

Both patients who received a permanent stimulator and patients who received some pain clinic treatment showed improvement in RDQ scores and leg pain intensity ratings over the 24 months of the study, with comparable scores on both measures at 24

months. Adjusting for baseline differences between groups, there were no statistically significant or clinically important differences between the two treatment groups at any time point.

Use of SCS

Among patients who had a permanent stimulator at the time of assessment, the proportion who said they used their stimulator every day decreased from 88% at 6 months to 52% at 24 months; however, most patients said they used the stimulator every day or nearly every day at each time point (Table 10). The use on a typical day also tended to decrease over time. Fifty-four percent of patients who used their stimulator reported using it almost all of the day at 6 months, compared to 37% at 24 months.

Baseline Characteristics Associated with Receiving Permanent Stimulator

Among patients who had an SCS trial, those aged 40 years or younger were significantly more likely than those aged over 40 years to receive a permanent stimulator (OR = 3.7, 95% CI = 1.1-13.1; Table 11). Patients with high baseline expectations that the stimulator would be effective were also significantly more likely to receive a permanent stimulator (OR = 3.9, 95% CI = 1.2-13.1). Other baseline variables were not significantly associated with receiving a permanent stimulator, although there was a trend towards men being more likely than women to receive a permanent implant.

Adverse Events

Among the 51 patients who had a trial of SCS, 8 (16%) had an adverse event associated with the trial (Table 12). Four of these were symptoms of unclear etiology (e.g., dizziness, increased back or leg pain). There was one very serious (life-threatening) adverse event associated with trial stimulation.

Table 13 summarizes adverse events associated with permanent implantation, as noted in medical records during the 18 months after the permanent implantation. Permanent implantation was attempted for 28 patients. For one of these, during the permanent implantation procedure, there was a dural puncture and CSF leak. The procedure was terminated and the patient was hospitalized for two days for neurological monitoring and IV opioid medication. No further attempt at permanent implantation was made; the remaining 27 patients had a permanent implantation. Three patients (11%) had a superficial infection, 1 (4%) had a deep infection, 5 (19%) had persistent pain in the region of the stimulator components that was not due to infection, and 3 (11%) had a biological complication other than infection or pain at the implant site. Five patients (19%) had revision surgery; one of these had three revision operations in the first 18 months after the permanent implant. Among the seven revision operations within 18 months, one involved pulse generator revision only (movement of pulse generator due to pain in the region of the original pulse generator site), four were a result of lead migration, and two involved both pulse generator revision and lead revision. Five patients (19%) had the stimulator permanently explanted within 18 months after permanent implantation.

Costs

The unadjusted mean cost of medical treatment (including inpatient, outpatient, office, and care in other settings) per patient in the year prior to enrollment was similar across the three study groups ($1,516-1,783 per month). Over the 18 months after enrollment, total unadjusted mean medical costs per patient were substantially higher in the SCS group ($47,190) than in the PC ($29,250) and UC ($19,246) groups (Table 14).

In each group, the highest monthly costs were incurred in the first six months after study enrollment, followed by a decrease in costs 6-18 months after enrollment. Mean (SD) monthly costs per patient in the first six months were $4,996 ($4,062) in the SCS group, $2,503 ($1,846) in the PC group, and $1,398 ($1,198) in the UC group. By 12-18 months after enrollment, mean monthly medical costs were lower than those in the 12 months prior to enrollment [$1,243 (SD, $2,228) in SCS, $736 (SD, $579) in PC, and $896 (SD, $1,330) in UC]. Unadjusted mean productivity costs (primarily for time loss compensation) were similar across groups over the 18 months, totaling a mean per patient of $35,527 in the SCS group, $38,753 in the PC group, and $33,552 in the UC group (Table 14).

Adjusting for medical and productivity costs in the 12 months pre-enrollment and other baseline covariates, the mean total medical and productivity cost over the 18 months after study enrollment per patient was $18,644 lower in the PC group and $28,064 lower in the UC group, compared to the SCS group (Table 14). Sensitivity analyses using log-transformed costs found similar differences in costs between groups.

SCS-2 Cohort

After enrollment for the initial study ended in June 2006, DLI continued to cover SCS for patients with compensable Washington State workers' compensation claims who met all the U.W. study inclusion criteria and utilization review criteria and agreed to participate in a separate observational cohort study (SCS-2). Unlike the original study, the SCS-2 study did not include UC or PC comparison groups, and interviews were conducted only at baseline and 12 months. The SCS-2 measures and procedures were

approved by the U.W. institutional review board and all participants provided informed consent.

Thirty patients enrolled in the SCS-2 study July 1, 2006 - April 26, 2007 and had trial SCS. The SCS-2 group was similar to the original SCS group on most baseline characteristics, although all SCS-2 participants were male, their average leg pain intensity was slightly lower, and they were less likely to report taking an anticonvulsant medication (Table 15). As with the original cohort, 12-month follow-up interview completion was high in the SCS-2 group (90%). Comparable proportions of patients in the SCS-2 group (57%) and the original SCS cohort (53%) received a permanent implantation in the year after enrollment.

At 12 months, comparing all patients who received trial stimulation, significantly more in the SCS-2 group than in the original cohort showed a 2-point or greater decrease on the RDQ (63% vs. 32%, $P = 0.01$) and significantly more reported less than daily opioid use (30% vs. 19%, $P = 0.04$) (Table 16). However, the two groups did not differ significantly in proportion meeting the primary success outcome criterion or any of the alternate success criteria. Comparing the subgroups who received permanent stimulators, there was a trend for a higher proportion in the SCS-2 group than in the original group to report less than daily opioid use ($P = 0.05$). The SCS-2 permanent stimulator subgroup did not differ from the original permanent stimulator subgroup on any of the seven other success measures examined.

These groups were also compared on the RDQ and leg pain measures at 12 months, adjusting for age, gender, and baseline scores on these measures (Table 17). In comparisons using all patients who received at least trial stimulation, there was a trend

towards lower leg pain intensity in the SCS-2 group than in the original group ($P = 0.06$). Comparisons of the subgroups who received permanent stimulators showed no significant differences.

The SCS-2 group did not differ from the original SCS group at 12 months on back pain and mental health scores, change in ability to perform daily tasks, or work status (Table 18). No patient in the SCS-2 group reported working at 12 months. Patients in the SCS-2 group were less likely to report use of sedative-hypnotic medication at 12 months, with trends towards less use of muscle relaxant and more use of antidepressant medication. Finally, the SCS-2 group had significantly more time loss days in the year after enrollment, although the number of time loss days was high in each group and the trend towards more claim closures in the SCS-1 group might explain the lower number of time loss days in that group.

Discussion

Primary Findings

At 12 months, on the primary outcome measure combining improvement on the RDQ measure of function, improvement in leg pain intensity, and less than daily opioid use, patients who underwent at least a trial of SCS did not differ significantly from patients evaluated at a pain clinic or patients who received neither SCS nor pain clinic evaluation. Five percent or fewer of the patients in each treatment group achieved this definition of success. Comparisons of groups on the separate components of this outcome at six, 12, and 24 months revealed only two statistically significant differences, both at six months. At six months, the SCS group was more likely than the usual care group (but not the pain clinic group) to report $\geq$ 50% improvement in leg pain, but the

SCS group was also more likely than the pain clinic group (but not the usual care group) to report daily opioid use.

We also examined alternative definitions of clinically important change, based on recent empirical work, that were more stringent for the RDQ and less stringent for leg pain intensity. By these criteria, the SCS group was more likely than the usual care and pain clinic groups to show clinically meaningful improvement on the RDQ at six months. However, only a minority of SCS patients reported clinically meaningful improvement in function at six months, there were no treatment group differences in function after six months, and there were no differences in leg pain or on the composite success measure using the alternate criteria at any time point.

Overall, the pattern of findings suggests that the SCS group was somewhat worse on average than the other groups at baseline in terms of longer duration of pain and slightly greater leg pain and physical disability, and that the SCS group showed greater improvement than the UC and PC groups in physical function and leg pain at six months, but with greater opioid use. Any advantages disappeared after six months. There was no statistically or clinically meaningful difference between groups in any comparison of leg pain, function, or opioid use at the 12- and 24-month assessments.

There was no sham control group in this unblinded study and the extent to which the modest benefit of SCS at six months was due to active treatment effects rather than nonspecific (placebo) effects cannot be determined. Patients with high baseline expectations that the stimulator would be effective, compared to those with lower expectations, had almost four times the odds of a successful trial and receipt of a

permanent stimulator, consistent with the possibility that expectations played a role in short-term pain response.

The primary analyses included all patients who received trial SCS, regardless of whether they received a permanent stimulator. A concern may be raised that this unfairly prejudiced SCS results in that patients who received a permanent stimulator would be expected to have better outcomes than those who did not. However, excluding patients who failed the trial and did not receive a permanent stimulator might also bias the results. A screening trial of SCS weeds out those who are unlikely to respond to this particular treatment, and perhaps also those unlikely to respond to any pain treatment. No similar screening process exists in usual care. However, pain clinic initial evaluations exclude from pain clinic treatment programs patients judged unlikely to benefit from such programs, analogous to the SCS screening.

To approach this issue in a balanced fashion, we compared the SCS subgroup who received a permanent stimulator to the PC subgroup who received some pain clinic treatment. We did not impose any criteria regarding amount or quality of pain clinic treatment, just as we did not impose criteria on daily use or hours of use of an implanted stimulator. In these comparisons of the SCS permanent stimulator and PC treatment subgroups, although there were non-significant trends towards a higher rate of improvement in leg pain and a higher rate of daily opioid use in the SCS group at six months, there were no other differences at any time point. Only one patient who received a permanent stimulator achieved success on the primary outcome at 12 months.

The pain clinic group served only as a control for the SCS group and the study was not designed to evaluate the effectiveness of pain clinic treatment. We did not assess

quality, intensity, duration, content, or other characteristics of the pain clinic treatments received by patients in this study.

The rate of trial stimulation success and permanent implantation in our study (slightly over 50%) is at the lower end of the range reported in previous studies. In a review of studies of SCS for FBSS or complex regional pain syndrome,[5] the range was 58-96%. In a subsequently published RCT,[3] 71% of FBSS patients randomized to a trial of SCS had a successful trial and permanent implant. In a multi-center RCT,[4] 83% of patients with FBSS who were randomized to SCS had a successful trial and an additional 10% received a permanent stimulator despite an unsuccessful trial.

The success rate after permanent implantation was also lower in our study than in the two previous RCTs for FBSS. In a comparison of SCS versus repeat lumbosacral spine surgery,[3] at least 38% of patients who had trial stimulation and 53% of those who had a permanent implant reported $\geq$ 50% pain relief at long-term (average of three years) follow-up. In our study, 16% of patients who had a trial and 30% of patients who received a permanent stimulator reported $\geq$ 50% pain relief at 24 months. In the multi-center RCT, [4] 48% of patients randomized to SCS reported $\geq$ 50% improvement in leg pain at six months compared to 9% in the conventional medical management group. In our study, 18% in the SCS group and 3% in the usual care group achieved this level of improvement at six months.

It is unclear why the trial and permanent implantation success rates in our study were lower than those previously reported. However, studies of other therapies have found that patients with workers' compensation benefits have worse outcomes.[19-21] The extent to which differences in outcomes are due to factors related to workers'

compensation versus other patient differences (e.g., socioeconomic) is unclear.[22] In the North et al. RCT, patients with workers' compensation benefits were under-represented due to difficulty in obtaining authorization for surgery and the Kumar et al. RCT was conducted outside of the U.S. workers' compensation setting.

There were other differences in the study settings that might have affected results. In the North et al. RCT, patients were recruited and treated at one academic medical center using a standardized protocol. Although the Kumar et al. RCT was conducted at 12 centers in Europe, Canada, Australia, and Israel, there was a protocol for the SCS procedure, whereas our study left surgical procedures and SCS devices to the discretion of the physician. It is possible that the effectiveness of SCS is highest at the specialist centers that participate in randomized trials.[23] Furthermore, patients in the Kumar et al. sample differed from those in our sample in ways that might have been favorable prognostically. At baseline, in the Kumar et al. sample, more patients were working, average back pain intensity was lower, and Mental Health scores were substantially better. Finally, patients who participate in RCTs differ in potentially important ways from those who decline participation; these differences could affect outcomes.[24]

Secondary Outcomes

We conducted a large number of statistical comparisons. Because we did not adjust for multiple comparisons, some statistically significant differences may have resulted from chance alone. Thus, it is prudent not to focus on isolated statistically significant differences between groups. More confidence may be placed in consistent patterns of clinically meaningful differences.

At 12 months, the SCS group did not differ from the other groups on any of the

secondary self-report outcomes, including back pain intensity, mental health, and medication use. In each group, substantially more patients reported a decline than reported improvement over the past year in ability to perform everyday tasks.

The DLI pharmacy data substantially under-estimated the number of patients using opioid medication at one year, as compared with patient self-report. For example, in the SCS group at 12 months, 85% of patients reported regular use of opioid medication in the last 30 days, but DLI paid for an opioid prescription within a 120-day window around this date for only 55%. DLI denies coverage of opioid prescriptions under certain circumstances (e.g., lack of documentation of pain relief from the treating physician) and does not cover prescriptions for patients whose claims have closed. It is likely that a number of patients were using other sources (e.g., insurance through an employer or spouse, Medicare, Medicaid) to pay for the prescriptions. DLI data were less discrepant from self-report data for sedative-hypnotic, muscle relaxant, and anticonvulsant medications at one year, but yielded higher rates of non-opioid analgesic use. Estimates of antidepressant medication use were also higher using DLI data, perhaps because patients were asked to report only medications used for pain and they may not have considered antidepressants as pain medications.

The treatment groups did not differ in work status or on any DLI administrative measure of time loss (e.g., time loss days, claim status) at 12 or 24 months. In each group, fewer than 10% of patients were working at one year. By 24 months, slightly fewer than 25% of patients in each group reported working. The DLI administrative data were consistent with patient-reported data. Approximately three-quarters of patients were still receiving time loss compensation or were on pension at 12 months. At 24

months, this proportion had decreased but was still over half in each group. Although many claims had closed by 24 months, not all of these reflected return to work, with some patients receiving other disability compensation and some off work and not receiving compensation. These results indicate that SCS was not effective in returning patients to work or in reducing the number of days of wage replacement compensation.

Adverse Events

A systematic review [5] of studies evaluating adverse events associated with SCS implantation, most of which had average follow-up periods longer than 18 months, found a median superficial infection rate of 4%, lower than the 11% rate in our study. Among the studies reviewed, the mean rate of persistent pain in the region of the stimulator components was 5.8% (median 0), also lower than in our study (19%). The median rate of stimulator revision surgery was 22% across the studies in the review, comparable to the rate of 19% in our study. However, the explantation rate in our study (19%) was much higher than the median explantation rate across studies in the review (6%). The rates of these adverse events varied considerably across studies in the review, and the rate for each adverse event in our study falls within the range reported in the review.

Published studies typically have not reported information about adverse events associated with trial stimulation. Among the patients in our study who had trial SCS, 16% had a trial-related adverse event, one of which was life-threatening. This underscores the fact that even trial stimulation carries potential risks, and points to the importance of reporting trial-related adverse events in studies of SCS.

Costs

Over the 18 months after study enrollment, total medical costs per patient were

lowest in the UC group, higher in the PC group, and highest in the SCS group. In each group, post-enrollment costs were highest in the first six months. Productivity costs (primarily for time loss compensation and loss of earning power) were fairly similar across groups over the 18 months. Adjusting for costs in the pre-enrollment year and other baseline factors, the mean total medical and productivity costs per patient over the 18 months were substantially lower in the PC group ($18,644 lower) and the UC group ($28,064 lower), compared to the SCS group. An economic evaluation of therapies in the Kumar et al.[4] RCT also found significantly higher medical costs over the first six months in the group randomized to SCS compared to conventional medical management (mean adjusted difference of $15,395 CAD, approximately $14,698 USD as of September 2008).[25]

Kumar et al.[7] performed a cost analysis of Canadian patients with FBSS who underwent permanent SCS implantation versus patients who continued conservative treatment. They concluded that the cost of medical treatment for the SCS group was greater than that for the conservatively treated group for the first 2.5 years, but that after 2.5 years, the costs of SCS were less than those for the conservatively treated group. Others have also concluded that the initial costs of SCS are offset by subsequent reduction in healthcare utilization after approximately two years.[8, 26, 27] There was no evidence of lower costs in the SCS group relative to the other groups in the period between 12-18 months in our study. Furthermore, given the lack of evidence concerning benefits of SCS beyond six months, it might be anticipated that SCS would not reduce resource utilization in our study sample long-term. It would be of interest in the future to examine costs in the three study groups over a longer time period.

SCS-2 Cohort

The second cohort of patients receiving at least a trial of SCS, selected for the study using the same criteria as for the original group, was similar to the original SCS group on most baseline characteristics assessed, although all SCS-2 participants were male. Comparable proportions (slightly over half) of patients in the SCS-2 group and in the original SCS cohort received a permanent implant in the year after enrollment. These findings suggest no major differences in Washington State workers' compensation claimants with FBSS authorized for SCS from 2006-2007, compared to 2004-2006.

At one year, the SCS-2 cohort appeared to have somewhat better outcomes as compared with the original SCS group. Comparing only the subgroups who received permanent stimulators, there was only one difference that approached statistical significance: more patients in the original group reported daily opioid use. We conclude that there was no strong and consistent pattern of differences between the original and the later SCS group. Unmeasured differences (e.g., in other therapies received, surgeons, SCS equipment, patient characteristics) may have contributed to any differences in outcomes between group. The differences may also be due to chance, especially given the number of statistical analyses and the modest study sample size.

Study Limitations

We tried to minimize the limitations inherent in a non-randomized study design. We enrolled two comparison groups using the same inclusion criteria as the SCS group. Despite this, there were some significant differences across the three groups at baseline. To the extent possible, we adjusted analyses for these baseline differences. However, the groups may also have differed on unmeasured factors that could affect outcomes.

The study had a limited sample size. However, post-hoc power calculations indicated that there was 81% power to detect a 2.5-point difference on the RDQ and 97% power to detect a 1.5-point difference in leg pain intensity in comparisons of the SCS and PC groups. Power was greater in comparisons of SCS to the UC group, which was larger than the PC group.

Mean scores on the RDQ were very high in all groups at baseline, indicating that these patients were close to the ceiling of dysfunction that the RDQ is capable of measuring. This resulted in little ability to detect worsening in the sample.

Conclusions

In summary, we found little evidence for the superiority of SCS over alternative treatments among Washington State workers' compensation claimants with failed back surgery syndrome. A small advantage of SCS in improving leg pain and function at six months disappeared by later follow-ups. We also found no evidence that SCS reduced medical or productivity costs. Differences in study population, study design, and delivery of care may explain why these results are more disappointing than those of randomized trials.

Acknowledgements

This study was funded by contract K311 from the Washington State Department of Labor and Industries. The authors thank John Loeser, MD for advice regarding the study design and abstraction and reporting of information concerning adverse events. We also thank Kelley Chaddock, Catherine Farr, Jeremy Gluck, Laura Henderson, Brook Martin, LaVonda McCandless, Deana Rich, and Blaine Robbins for help with the data collection and management.

References

1. North RB, Wetzel FT. Spinal cord stimulation for chronic pain of spinal origin: a valuable long-term solution. Spine 2002;27(22):2584-91.
2. North RB, Kidd DH, Lee MS, Piantodosi S. A prospective, randomized study of spinal cord stimulation versus reoperation for failed back surgery syndrome: initial results. Stereotact Funct Neurosurg 1994;62:267-72.
3. North RB, Kidd DH, Farrokhi F, Piantadosi SA. Spinal cord stimulation versus repeated lumbosacral spine surgery for chronic pain: a randomized, controlled trial. Neurosurgery 2005;56:98-107.
4. Kumar K, Taylor RS, Jacques L, et al. Spinal cord stimulation versus conventional medical management for neuropathic pain: A multicentre randomised controlled trial in patients with failed back surgery syndrome. Pain 2007;132:179-88.
5. Turner JA, Loeser JD, Deyo RA, Sanders SB. Spinal cord stimulation for patients with failed back surgery syndrome or complex regional pain syndrome: a systematic review of effectiveness and complications. Pain 2004;108:137-47.
6. Kemler MA, de Vet HC, Barendse G, van der Wildenberg F, Van Kleef M. Spinal cord stimulation for chronic reflex sympathetic dystrophy--five-year follow-up (letter to the editor). N Engl J Med 2006;354:2394-6.
7. Kumar K, Malik S, Demeria D. Treatment of chronic pain with spinal cord stimulation versus alternative therapies: cost-effectiveness analysis. Neurosurgery 2002;51(1):106-16.
8. Taylor RS, Taylor RJ, Van Buyten JP, Buchser E, North R, Bayliss S. The cost effectiveness of spinal cord stimulation in the treatment of pain: a systematic review of the literature. J Pain Symptom Manage 2004;24:370-8.
9. Bell GK, Kidd D, North R. Cost-effectiveness analysis of spinal cord stimulation in treatment of failed back surgery syndrome. J Pain Symptom Manage 1997;13:286-95.
10. Roland M, Morris R. A study of the natural history of back pain. Part 1: Development of a reliable and sensitive measure of disability in low-back pain. Spine 1983;8(2):141-4.
11. Farrar JT, Young JP, LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. Pain 2001;94:149-58.
12. Ostelo RWJG, Deyo RA, Stratford P, et al. Interpreting change scores for pain and functional status in low back pain. Spine 2008;33:90-4.
13. Jordan K, Dunn KM, Lewis M, Croft P. A minimal clinically important difference was derived for the Roland-Morris Disability Questionnaire for low back pain. J Clin Epidemiol 2006;59:45-52.
14. Dworkin RH, Turk DC, Wyrwich KW, et al. Interpreting the clinical importance of treatment outcomes in chronic pain clinical trials: IMMPACT recommendations. J Pain 2008;9:105-21.
15. Ware JE, Kosinski M, Dewey JE. How to score version two of the SF-36 health survey. Lincoln, RI: QualityMetric Incorporated; 2000.
16. Gold ML, Siegel JE, Russell LB, Weinstein MC. Cost-effectiveness in health and medicine: The report of the Panel on Cost-Effectiveness in Health and Medicine. New York: Oxford University Press; 1996.

17. Rothman KJ. No adjustments are needed for multiple comparisons. Epidemiology 1990;1:43-6.
18. Perneger TV. What's wrong with Bonferroni adjustments. Br Med J 1998;316:1236-8.
19. Harris I, Mulford J, Solomon M, van Gelder JM, Young JP. Association between compensation status and outcome after surgery: a meta-analysis. JAMA 2005;293(13):1644-52.
20. Atlas SJ, Chang Y, Keller RB, Singer DE, Wu YA, Deyo RA. The impact of disability compensation on long-term treatment outcomes of patients with sciatica due to a lumbar disc herniation. Spine 2006;31:3061-9.
21. Anderson PA, Schwaegler PE, Cizek D, Leverson G. Work status as a predictor of surgical outcome of discogenic low back pain. Spine 2006;31:2510-5.
22. Atlas SJ, Tosteson TD, Hanscom B, et al. What is different about worker's compensation patients? Spine 2007;32:2019-26.
23. Flather M, Delahunty N, Collinson J. Generalizing results of randomized trials to clinical practice: reliability and cautions. Clinical Trials 2006;3:508-12.
24. Steg PG, Lopez-Sendon J, Lopez de Sa E, et al. External validity of clinical trials in acute myocardial infarction. Arch Intern Med 2007;167(1):68-73.
25. Manca A, Kumar K, Taylor RS, et al. Quality of life, resource consumption and costs of spinal cord stimulation versus conventional medical management in neuropathic pain patients with failed back surgery syndrome (PROCESS trial). Eur J Pain 2008;12(8):1047-58.
26. Taylor RJ, Taylor RS. Spinal cord stimulation for failed back surgery syndrome: a decision-analytic model and cost-effectiveness analysis. Int J Technol Assess Health Care 2005;21:351-8.
27. Mekhail NA, Aeschbach A, Stanton-Hicks M. Cost benefit analysis of neurostimulation for chronic pain. Clin J Pain 2004;20:462-8.

Table 1. Study enrollment

SCS		Pain Clinic		Usual Care	
Approached	61	Approached	217	Approached	295
Unable to contact	3 (5%)	Unable to contact	59 (27%)	Unable to contact	108 (37%)
Declined to enroll	3 (5%)	Declined to enroll	46 (21%)	Declined to enroll	62 (21%)
Ineligible[a]	3 (5%)	Ineligible[a]	61 (28%)	Ineligible[a]	69 (23%)
Enrolled	52 (85%)	Enrolled	51 (24%)	Enrolled	56 (19%)
No SCS trial	5	No pain clinic services (16 crossed to UC, 1 to SCS)	17	Crossed over to Pain Clinic	4
Crossed over from Usual Care	3	Crossed over from SCS (no SCS trial)	2	Crossed over to SCS	3
Crossed over from Pain Clinic	1	Crossed over from Usual Care	4	Crossed over from SCS (no SCS trial)	3
Analysis sample[b]	51	SCS outside of study	1	Crossed over from Pain Clinic	16
		Analysis sample[b]	39	Analysis sample[b]	68

[a] Reasons for ineligiblity were no leg pain (n=17 across groups), leg pain < 6 months (4), leg pain not worse than back pain (72), leg pain intensity < 6 on 0-10 scale (17), diabetes or cancer (15), and unable to complete interviews in English or Spanish (2). No reason was recorded for 6 workers.

[b]See Statistical Analysis section for details regarding analysis sample selection.

Table 2. Baseline characteristics of the three study groups

	Spinal Cord Stimulator (n=51)	Pain Clinic (n=39)	Usual Care (n=68)	*P*-value* SCS vs PC	*P*-value* SCS vs UC
Age mean (SD), years[a]	44.7 (7.8)	43.2 (6.5)	44.1(8.7)	0.39	0.70
Male[a]	78%	67%	82%	0.24	0.64
Caucasian[b]	84%	90%	88%	0.54	0.59
Hispanic[b]	6%	10%	6%	0.46	0.99
Some college education or higher[b]	41%	28%	31%	0.27	0.25
Married[b]	63%	62%	56%	0.99	0.57
Residence[a]					
King / Pierce / Snohomish County	35%	54%	37%	0.09	0.85
Job in construction industry[a]	33%	21%	34%	0.24	0.99
Months from claim receipt to study enrollment, median (IQR)[a]	46 (30-82)	28 (18-63)	38 (24-62)	0.02	0.22
Lumbar operations in claim, mean (SD)[a]	1.6 (0.8)	1.4 (0.6)	1.5 (0.7)	0.31	0.32
Legal representation[a, c]	49%	26%	29%	<0.01	<0.01
Wage replacement compensation duration, months, median (IQR)[a]	39 (20-53)	24 (14-37)	30 (18-51)	0.01	0.26
Disability benefit in addition to DLI (e.g., SSDI, private)[b]	16%	10%	19%	0.54	0.81
Work status[b]					
Not working	98%	97%	93%	0.68	0.45
Working	2%	0%	3%		
Other (e.g., student, retired)	0%	3%	4%		
Leg pain duration, months, median (IQR)[b]	48 (29-74)	31 (14-49)	36 (25-65)	0.02	0.25
Leg pain intensity (0-10), past month, mean (SD)[b]	7.7 (1.0)	7.3 (1.1)	7.2 (1.1)	0.07	0.02
Pain in both legs[b]	47%	41%	41%	0.67	0.58
Back pain intensity (0-10), past month, mean (SD)[b]	6.0 (1.9)	6.3 (1.9)	6.2 (1.8)	0.43	0.56
RDQ (0-24), mean (SD)[b]	21.1 (2.1)	20.1 (2.5)	20.0 (2.4)	0.04	0.01
SF-36 v2 Mental Health Scale, mean (SD)[b]	33.6 (12.4)	32.0 (13.1)	35.6 (10.4)	0.53	0.36
Patient-reported surgeries for back/leg pain, mean (SD)[b]	1.9 (1.0)	1.5 (0.7)	1.8 (0.9)	0.07	0.47
Hospitalizations for					

back/leg pain, mean (SD)[b]	2.5 (2.3)	2.8 (4.0)	2.5 (2.0)	0.59	0.95
Medication taken for back/leg pain, mean (SD) days, past month[b]	27.0 (9.0)	27.0 (8.9)	26.2 (9.3)	0.97	0.66
Medications taken in past month for back/leg pain[b]					
Opioid	86%	77%	78%	0.28	0.34
Benzodiazepine/sedative -hypnotic/anti-anxiety	16%	15%	12%	0.99	0.59
Muscle relaxant	29%	33%	34%	0.82	0.69
Antidepressant	22%	10%	16%	0.25	0.48
Anticonvulsant	31%	21%	25%	0.34	0.54
Non-opioid analgesic	18%	31%	29%	0.21	0.20

DLI = Department of Labor & Industries, IQR = interquartile range, RDQ = Roland Disability Questionnaire, SD = standard deviation, SSDI = Social Security Disability Insurance

* Proportions compared with Fisher's exact test; group means compared with t-tests; group medians compared with the Kruskal-Wallis H Test

[a]Data obtained from DLI

[b]Data obtained from patient interview

[c] Legal representation information was obtained from DLI administrative data at the time of study enrollment and reflected notification to DLI that an attorney was involved in the claim. This information was not available for five patients in the SCS group.

Table 3. Rates of successful patient outcomes as indicated by self-reported physical function, leg pain, and opioid medication use at 6, 12, and 24 months

	Spinal Cord Stimulator %	Pain Clinic %	Usual Care %	*P*-value[a] SCS vs PC	*P*-value[a] SCS vs UC
≥ 2-point improvement in RDQ relative to baseline					
6 Months	41	29	32	0.38	0.32
12 Months	32	36	48	0.69	0.07
24 Months	51	41	44	0.50	0.53
≥ 50% improvement in leg pain relative to baseline					
6 Months	18	5	3	0.09	0.02
12 Months	15	8	17	0.46	0.69
24 Months	16	15	21	0.66	0.62
Less than daily opioid use					
6 Months	12	34	27	0.04	0.17
12 Months	19	25	31	0.87	0.43
24 Months	21	32	34	0.53	0.24
Primary outcome (all three criteria)					
6 Months	4	0	0	0.51	0.19
12 Months	4	0	5	0.50	0.99
24 Months	5	3	10	0.99	0.47

RDQ = Roland Disability Questionnaire
See Figure 1 for n at each follow-up.
[a] *P*-values from logistic regression models adjusted for the baseline value of the outcome measure (i.e., baseline RDQ for the RDQ analysis, baseline leg pain for the leg pain analysis, baseline opioid use for the opioid analysis, and all three baseline values for the composite outcome analysis)

Table 4. Rates of successful patient outcomes as indicated by alternate criteria

	Spinal Cord Stimulator %	Pain Clinic %	Usual Care %	*P*-value[a] SCS vs PC	*P*-value[a] SCS vs UC
≥ 5-point improvement in RDQ from baseline					
6 Months	22	5	5	0.03	0.01
12 Months	17	17	17	0.99	0.88
24 Months	21	15	20	0.58	0.87
≥ 30% improvement in RDQ from baseline					
6 Months	16	5	3	0.06	0.02
12 Months	15	8	11	0.31	0.33
24 Months	14	11	18	0.80	0.65
≥ 30% improvement in leg pain from baseline					
6 Months	29	18	26	0.28	0.97
12 Months	21	8	25	0.20	0.51
24 Months	28	29	31	0.86	0.52
Composite outcome (≥ 5-point RDQ improvement, ≥ 30% leg pain improvement, less than daily opioid use)					
6 Months	4	0	2	0.51	0.58
12 Months	4	0	3	0.50	0.99
24 Months	7	6	8	0.99	0.99

RDQ = Roland Disability Questionnaire
See Figure 1 for n at each follow-up.
[a] *P*-values from logistic regression models adjusted for the baseline value of the outcome measure (i.e., baseline RDQ for the RDQ analyses, baseline leg pain for the leg pain analysis, baseline opioid use for the opioid analysis, and all three baseline values for the composite outcome analysis)

Table 5. Observed RDQ and leg pain scores, and adjusted comparisons between treatment groups

	Spinal Cord Stimulator Mean[a] (SD)	Pain Clinic Mean[a] (SD)	Adjusted Mean Difference[b] (95% CI)	Usual Care Mean[a] (SD)	Adjusted Mean Difference[b] (95% CI)
RDQ (0-24)					
Baseline	21.1 (2.1)	20.1 (2.4)	–	20.0 (2.4)	–
6 Months	19.0 (4.1)	19.4 (3.2)	1.1 (-0.2, 2.4)	19.4 (2.9)	**1.2 (0.0, 2.4)***
12 Months	18.9 (4.8)	18.8 (4.0)	0.4 (-1.2, 2.0)	18.4 (3.7)	0.2 (-1.2, 1.6)
24 Months	18.1 (4.8)	17.9 (4.7)	0.5 (-1.4, 2.4)	17.5 (5.1)	0.1 (-1.6, 1.7)
Leg Pain (0-10)					
Baseline	7.7 (1.0)	7.3 (1.1)	–	7.2 (1.1)	–
6 Months	6.3 (2.3)	6.8 (2.1)	0.8 (-0.1, 1.7)	6.2 (1.6)	0.3 (-0.5, 1.0)
12 Months	6.8 (1.9)	7.0 (1.7)	0.6 (-0.2, 1.3)	5.8 (2.2)	-0.6 (-1.3, 0.2)
24 Months	6.3 (2.0)	6.2 (2.1)	0.4 (-0.6, 1.3)	5.7 (2.1)	-0.2 (-1.0, 0.6)

RDQ = Roland Disability Questionnaire

[a] Unadjusted mean

[b] Regression model coefficient comparing treatment groups, adjusted for the following baseline variables: age, gender, RDQ score, leg pain intensity, duration of wage replacement compensation, disability benefit in addition to DLI (yes or no), unilateral versus bilateral leg pain, legal representation (yes or no), and SF-36 Mental Health. A mean difference greater than zero (i.e., a positive mean difference) indicates that the treatment group had a worse outcome relative to the SCS group, adjusting for the baseline variables.

* $P = 0.049$; all other adjusted mean differences are not statistically significant

Table 6. Self-report measures of back pain intensity, mental health, ability to perform everyday tasks, and medication use at 12 months

	Spinal Cord Stimulator (n=47)	Pain Clinic (n=36)	Usual Care (n=65)	*P*-value[a] SCS vs PC	*P*-value[a] SCS vs UC
Back Pain Intensity, mean (SD)	6.8 (2.1)	7.2 (2.0)	6.3 (1.9)	0.23	0.88
Mental Health, mean (SD)	33.3 (14.2)	31.9 (12.6)	34.7 (11.7)	0.47	0.65
Ability to perform everyday tasks (compared to one year ago), n (%)				0.21	0.89
Much/somewhat better	8 (17%)	7 (19%)	9 (14%)		
About the same	23 (49%)	11 (31%)	32 (49%)		
Much/somewhat worse	16 (34%)	18 (50%)	24 (37%)		
Medications taken in past month for back/leg pain					
Opioid	40 (85%)	27 (75%)	46 (71%)	0.27	0.11
Benzodiazepine/sedative-hypnotic/anti-anxiety	13 (28%)	7 (19%)	10 (15%)	0.45	0.16
Muscle relaxant	19 (40%)	11 (31%)	17 (26%)	0.49	0.15
Antidepressant	6 (13%)	3 (8%)	8 (12%)	0.73	0.99
Anticonvulsant	10 (21%)	6 (17%)	13 (20%)	0.78	0.99
Non-opioid analgesic	8 (17%)	5 (14%)	15 (23%)	0.77	0.49

[a]Comparisons of groups on back pain intensity and mental health in linear regression analyses were adjusted for age, gender, and the following baseline variables: RDQ score, leg pain intensity, duration of wage replacement compensation, disability benefit in addition to DLI (yes or no), unilateral versus bilateral leg pain, Mental Health score, and legal representation (yes or no). The analysis for back pain intensity also adjusted for back pain intensity at baseline. Ability to perform everyday tasks was compared using Fisher's exact test with a continuity correction for small cell counts, not adjusting for other factors. Medication use was compared using logistic regression and adjusted for use of the medication (yes, no) at baseline.

Table 7. Work status and disability

	SCS	Pain Clinic	Usual Care	*P*-value SCS vs PC	*P*-value SCS vs UC
Self-reported,[a] 12 months, n (%)	n=47	n=36	n=65		
Work Status				0.11	0.99
Working	4 (9%)	2 (6%)	6 (9%)		
Off work, on disability[b]	39 (83%)	24 (67%)	52 (80%)		
Off work, not on disability	4 (9%)	9 (25%)	6 (9%)		
Other	0 (0%)	1 (3%)	1 (2%)		
Disability compensation other than DLI	11 (23%)	7 (19%)	18 (28%)	0.79	0.67
Self-reported,[a] 24 months, n (%)	n=43	n=34	n=61		
Work Status				0.35	0.66
Working	10 (23%)	8 (24%)	14 (23%)		
Off work, on disability[b]	31 (72%)	22 (65%)	39 (64%)		
Off work, not on disability	1 (2%)	4 (12%)	5 (8%)		
Other	1 (2%)	0 (0%)	3 (5%)		
Disability compensation other than DLI	12 (28%)	6 (18%)	22 (36%)	0.42	0.41
DLI data†	n=51	n=39	n=68		
Time loss days, mean (SD)					
0-12 Months	320 (99)	309 (98)	311 (109)	0.95	0.79
0-24 Months	589 (215)	526 (235)	532 (245)	0.51	0.29
Time loss days, median (IQR)					
0-12 Months	365 (354-365)	365 (273-365)	365 (354-365)	0.45	0.84
0-24 Months	730 (524-730)	693 (324-730)	687 (362-730)	0.20	0.22
On Time Loss, n (%)					
12 Months	41 (80%)	28 (71%)	51 (75%)	0.75	0.66
24 Months	32 (63%)	20 (51%)	34 (50%)	0.63	0.24
Perm. Partial Disability, n (%)					
12 Months	1 (2%)	2 (5%)	3 (4%)	0.58	0.63
24 Months	0 (0%)	1 (3%)	1 (1%)	0.43	0.99
Pension, n (%)					
12 Months	1 (2%)	0 (0%)	2 (3%)	0.99	0.99
24 Months	5 (10%)	2 (5%)	7 (10%)	0.69	0.99
Time Loss *or* Pension, n (%)					
12 Months	42 (82%)	28 (71%)	53 (78%)	0.71	0.79
24 Months	37 (73%)	22 (56%)	41 (60%)	0.53	0.30
DLI claim closed, n (%)					
12 Months	6 (12%)	8 (21%)	9 (13%)	0.52	0.96
24 Months	17 (33%)	17 (43%)	30 (44%)	0.65	0.32

[a] For the self-report measures, proportions were compared using Fisher's exact test with continuity correction for small cell counts

[b] Workers' compensation or other disability insurance

† Linear or logistic regression analyses comparing groups on mean number of time loss days,

proportion on time loss, proportion on time loss *or* pension, and closed claim status were adjusted for wage replacement compensation duration at baseline. Other proportions were compared using Fisher's exact test with continuity correction for small cell counts. Groups were compared on median time loss days using the Kruskal-Wallis H test.

Table 8. Medication use[a] at baseline and 12 months: DLI pharmacy data

	SCS (n=51) n (%)	Pain Clinic (n=39) n (%)	Usual Care (n=68) n (%)	*P*-value[b] SCS vs PC	vs UC
Baseline					
Opioid	32 (63%)	29 (74%)	39 (57%)	0.27	0.58
Sedative-hypnotic[c]	14 (27%)	10 (26%)	17 (25%)	0.99	0.83
Muscle relaxant	22 (43%)	21 (54%)	21 (31%)	0.40	0.18
Non-opioid analgesic[d]	7 (13%)	15 (38%)	14 (21%)	0.01	0.47
Antidepressant	21 (41%)	19 (49%)	22 (32%)	0.53	0.34
Anticonvulsant	18 (35%)	14 (36%)	21 (31%)	0.99	0.69
Other	25 (49%)	12 (31%)	14 (21%)	0.09	<0.01
One year					
Opioid	28 (55%)	21 (54%)	25 (37%)	0.99	0.06
Sedative-hypnotic[c]	16 (31%)	10 (25%)	13 (19%)	0.64	0.14
Muscle relaxant	16 (31%)	10 (25%)	15 (22%)	0.64	0.29
Non-opioid analgesic[d]	20 (39%)	13 (33%)	20 (29%)	0.66	0.33
Antidepressant	19 (37%)	13 (33%)	18 (26%)	0.83	0.23
Anticonvulsant	16 (31%)	7 (18%)	11 (16%)	0.22	0.08
Other	12 (24%)	11 (28%)	10 (15%)	0.63	0.24

[a] Number and percent with ≥1 prescription filled for one or more medications in the category within a 120-day window around the time point

[b] Proportions were compared using Fisher's exact test with a continuity correction for small cell counts and comparisons were not adjusted for other factors.

[c]Includes sedative-hypnotics, benzodiazepines, anti-anxiety medications

[d]Includes non-steroidal anti-inflammatory drugs (NSAIDs), acetaminophen

Table 9. Patients who received a permanent stimulator (n = 27) versus patients who received some Pain Clinic treatment (n = 23) in the year after study enrollment: Rates of successful outcomes

	Spinal Cord Stimulator %	Pain Clinic %	*P*-value [a]
≥ 2-point improvement in RDQ relative to baseline			
6 Months	67	38	0.10
12 Months	50	50	0.88
24 Months	61	47	0.44
≥ 50% improvement in leg pain relative to baseline			
6 Months	33	10	0.06
12 Months	25	10	0.25
24 Months	30	26	0.61
Less than daily opioid use			
6 Months	15	43	0.05
12 Months	13	20	0.81
24 Months	17	42	0.16
All three criteria			
6 Months	7	0	0.50
12 Months	4	0	0.99
24 Months	9	5	0.99

[a] *P*-values calculated from logistic regression models adjusted for the baseline value of the outcome measure

Table 10. Use of SCS (among patients who still had a stimulator)

	6 Months (n=24) n (%)	12 months (n=23) n (%)	24 Months (n=21) n (%)
Days used			
Every day	21 (88%)	18 (78%)	11 (52%)
Almost every day	1 (4%)	3 (13%)	5 (24%)
About half the time	0 (0%)	1 (4%)	2 (10%)
Occasionally	2 (8%)	1 (4%)	1 (5%)
Never	0 (0%)	0 (0%)	2 (10%)
Use on a typical day [a]			
Almost all of the day (18–24 hrs)	13 (54%)	12 (52%)	7 (37%)
Most of the day (12–17 hrs)	4 (17%)	4 (17%)	3 (16%)
Some of the day (6–11 hrs)	2 (8%)	3 (13%)	5 (26%)
A little of the day (0–5 hrs)	5 (21%)	4 (17%)	4 (21%)

[a] Excludes patients who never use SCS

Table 11. Associations of baseline patient characteristics with stimulator implantation (trial only versus permanent implantation)

	Permanent Implant %	Odds Ratio (95% CI)	*P*-value[a]
Age			0.04
> 40 years	31		
≤ 40 years	63	3.7 (1.1-13.1)	
Gender			0.07
Female	27		
Male	60	4.0 (0.9-17.4)	
Education			0.62
< some college education	50		
≥ some college education	57	1.3 (0.4, 4.1)	
Wage replacement duration			0.13
> 40 months	63		
≤ 40 months	42	0.4 (0.1-1.3)	
Leg pain duration			0.78
> 48 months	52		
≤ 48 months	56	1.2 (0.4-3.6)	
Number of lumbar surgeries in claim			0.37
1	58		
2	46	0.6 (0.2-2.4)	
3	29	0.3 (0.1-1.8)	
Expectation of efficacy (0-10)			0.03
< 8	36		
≥ 8	69	3.9 (1.2-13.1)	
Leg pain intensity (0-10)			0.95
< 8	52		
≥ 8	53	1.0 (0.3-3.2)	
Back pain intensity (0-10)			0.13
< 8	59		
> 8	33	0.3 (0.1-1.4)	
Leg pain			0.69
Unilateral	56		
Bilateral	50	0.8 (0.3, 2.4)	
RDQ			0.63
< 20	42		
20 - 22	54	1.6 (0.4-6.7)	
> 22	60	2.1 (0.5-9.8)	
Mental Health			0.29
≤ 30	48		
31 - 40	43	0.8 (0.2–3.2)	
≥ 40	69	2.4 (0.6-9.4)	
Residence			0.54
King/Pierce/Snohomish	44		
Other	53	1.5 (0.4-5.0)	

[a] From logistic regression models predicting permanent SCS implant status.

Table 12. Adverse events associated with trial SCS among 51 patients who had a trial

Patient	Description of adverse event
	Unexplained symptoms
1	Transient dizziness reported on the fifth day of the trial
2	Muscles aching and sore immediately after trial procedure (electrodes could not be placed successfully so the trial was not continued beyond the initial attempt at electrode placement)
3	Patient later reported severe leg pain and attributed it to trial-medical records did not indicate date relative to trial
4	Severe pain at electrode entry site reported 5 days after trial stimulation
5	Increased low back pain resulting in several emergency department visits over two days after the trial
	Operator error
6	Fluid leaking from site-no further detail was provided in medical records
7	Severe post-spinal headache
8	5 days after trial (which was not successful), drainage at the lead sites was noted when trial leads were removed. Patient was thought possibly to have cellulitis and was treated with an antibiotic. Two days later, the patient experienced severe back and neck pain, lower extremity numbness, difficulty urinating; patient found to have superficial infection and epidural abscess from approximately T5 through L3 requiring hospitalization for irrigation and debridement of the abscess and T2-L3 hemilaminotomy. On the first postoperative day, the patient experienced severe neck pain and stiffness, and during preparation for lumbar puncture as part of evaluation to exclude meningitis, the patient had acute respiratory failure requiring cardiopulmonary resuscitation and then mechanical ventilatory support. The medical records indicated narcotic-induced respiratory depression and aspiration of vomitus. Patient was discharged after 19-day hospitalization.

Table 13. Adverse events associated with attempted permanent SCS implantation (n = 28) and documented in medical records in the first 18 months

Complication	Pts n	Pts % [a]	Comments
Superficial skin/wound infection	3	11	One of these 3 pts underwent surgery for irrigation and debridement at the pulse generator wound site 5 wks after permanent implantation, but was diagnosed as having only a superficial infection.
Deep infection/ abscess	1	4	Pt had abscess over signal generator and underwent surgery for wound irrigation, debridement, and removal of the stimulator. Pt decided not to have equipment replaced.
Persistent pain in region of stimulator component	5	19	
Other biological complica-tion	3	11	1. Pt had seizures after permanent implantation which subsided after the stimulator was turned off but resumed after the stimulator was turned on again; pt had stimulator removed 8 months later because of the seizures and insufficient pain relief 2. Pt had discomfort when sitting due to placement of the SCS equipment (more than 18 months later, pt had two revision surgeries) 3. During attempted placement of a permanent stimulator in one pt, there was a dural puncture and CSF leak. The procedure was terminated. The pt was hospitalized for 2 days for neurological monitoring and IV opioid medication. No further attempt was made to implant a stimulator.
Stimulator revision (surgical revision, but stimulator not removed)	5	19	1. Pt had 3 revision operations: a. 4 mo. after permanent implantation, because of pain at generator site, pulse generator was removed then replaced in the same operation in a different site b. 7 mo. after permanent implantation, pt underwent another surgery because a lead migrated and pt was not obtaining good lower extremity stimulation. During surgery, another lead in the dual lead system migrated, so both leads were removed and replaced with two new leads. c. 18 mo. after permanent implantation, due to loss of lower extremity stimulation, electrode was repositioned in another revision surgery 2. Due to lead migration and "SCS malfunction" (no other detail given), revision surgery 17 mo. after permanent implantation to remove original system and replace with a new system in a different location (same pt described above in comments for superficial infection) 3. Revision surgery 4 mo. after permanent implantation due to lead migration (pt later had system explanted 20 mo. after permanent

			implantation) 4. Pulse generator revision and electrode revision 12 mo. after permanent implantation due to lead migration 5. Lead revision surgery 12 mo. after permanent implantation due to decreased effectiveness of SCS
Stimulator explanted (permanently removed and not replaced)	5	19	1. One of these was the pt with the deep abscess (described above). 2. Removal of equipment 10 mo. after implantation due to ineffectiveness in relieving pain 3. Explantation 16 mo. after implantation apparently due to discomfort and ineffectiveness 4. As noted above under "other biological complications," one pt had explantation 8 mo. after permanent implantation due to seizures and insufficient pain relief 5. 17 mo. after permanent implantation, system removed due to pain at pulse generator site and decreased effectiveness in relieving pain
Pulse generator replaced because of battery failure	0	0	

Pt = patient, CSF = cerebrospinal fluid, IV = intravenous

[a] In calculating percents, the denominator was 28 for all events that could be associated with the permanent implantation procedure (infection, other biological complication) and 27 for all events that could only be associated with a completed permanent implantation (pain in region of stimulator component, revision surgery, stimulator explanted).

Events that occurred more than 18 months after permanent implantation:

1. Pt 2 in "other biological complications" in the table had two revision surgeries, with the second resulting in infection.
2. One patient not included in the table had leads and pulse generator replaced due to decreased effectiveness of the SCS.
3. Pt 3 under "stimulator revision" in the table had the system explanted 20 months after permanent implantation because it was ineffective and causing discomfort.

Table 14. Unadjusted costs in year before enrollment and in 18 months after enrollment, and adjusted group differences in costs from enrollment to 18 months

	SCS (n=51)	Pain Clinic (n=39)	Usual Care (n=68)
	M (SD)	**M (SD)**	**M (SD)**
Per-Patient Costs (12-months pre-enrollment)			
Total	$43,437 ($15,212)	$47,572 ($16,424)	$40,598 ($16,045)
Productivity	$24,286 ($10,864)	$26,170 ($13,219)	$22,402 ($9,833)
Medical	$19,151 ($12,463)	$21,401 ($11,898)	$18,195 ($13,869)
Per-Patient Costs (enrollment to 18 months)			
Total	$82,718 ($37,962)	$68,273 ($28,253)	$52,798 ($24,401)
Productivity	$35,527 ($14,492)	$38,753 ($19,987)	$33,552 ($15,670)
Medical	$47,190 ($33,997)	$29,520 ($16,357)	$19,246 ($15,550)
Adjusted difference in 18-months total costs,[a] Mean (95% CI)			
Pain Clinic	-$18,644 (-$32,542, -$4,746), $P = 0.009$		
Usual Care	-$28,064 (-$40,909, -$16,619), $P < 0.001$		

[a] Mean difference (95% CI) in 18-month total costs in Pain Clinic and Usual Care groups versus the SCS reference group. Models adjusted for costs in the 12 months prior to enrollment, age, gender, RDQ score, leg pain intensity, duration of wage replacement compensation, disability benefit in addition to DLI (yes or no), unilateral versus bilateral leg pain, legal representation (yes or no), and SF-36 Mental Health. A mean difference less than zero (i.e., a negative mean difference) indicates that the treatment group had lower costs relative to the SCS group, adjusting for the baseline variables.

Table 15. Baseline characteristics of SCS-1 versus SCS-2 study groups

	SCS-1 (n=51)	SCS-2 (n=30)	*P*-value*
Age mean (SD), years	44.7 (7.8)	44.5 (9.1)	0.90
Male	78%	100%	<0.01
Caucasian	84%	93%	0.31
Hispanic ethnicity	6%	3%	0.99
Some college education or higher	41%	53%	0.36
Married	63%	43%	0.11
Residence			
King / Pierce / Snohomish County	35%	46%	0.34
Job in construction industry	33%	27%	0.62
Months from date of claim receipt to study enrollment, median (IQR)	46 (30-82)	46 (36-77)	0.66
Lumbar operations in claim, mean (SD)	1.6 (0.8)	1.6 (0.8)	0.92
Wage replacement compensation duration, months, median (IQR)	39 (20-53)	37 (26-60)	0.70
Disability benefit in addition to DLI (e.g., SSDI, private)	16%	23%	0.39
Work status			
Not working	98%	100%	0.99
Working	2%	0%	
Leg pain duration, months, median (IQR)	48 (29-74)	50 (31-72)	0.77
Leg pain intensity (0-10), past month, mean (SD)	7.7 (1.0)	7.2 (1.0)	0.04
Pain in both legs	47%	43%	0.82
Back pain intensity(0-10), past month, mean (SD)	6.0 (1.9)	5.9 (1.1)	0.75
RDQ (0-24), mean (SD)	21.1 (2.1)	20.9 (1.5)	0.63
SF-36 v2 Mental Health Scale, mean (SD)	33.6 (12.4)	30.6 (11.5)	0.28
Patient-reported surgeries for back/leg pain, mean (SD)	1.9 (1.0)	1.9 (1.2)	0.84
Hospitalizations for back/leg pain, mean (SD)	2.5 (2.3)	1.9 (1.2)	0.21
Expectation of efficacy (0-10) $\geq$ 8	54%	57%	0.99
Medication taken for back/leg pain in past month, mean (SD) days	27.0 (9.0)	27.0 (9.2)	0.99
Medications taken in past month for back/leg pain			
Opioid	86%	87%	0.99
Benzodiazepine/sedative-hypnotic/anti-anxiety	16%	17%	0.99
Muscle relaxant	29%	33%	0.81
Antidepressant	22%	27%	0.60
Anticonvulsant	31%	10%	0.03
Non-opioid analgesic	18%	13%	0.76

IQR = interquartile range, RDQ = Roland Disability Questionnaire, SD = standard deviation, SSDI = Social Security Disability Insurance

* Proportions compared using Fisher's exact test with continuity correction for small cell counts; group means compared using t-tests; group medians compared using the Kruskal-Wallis H Test

Table 16. Rates of successful patient outcomes at 12 months in SCS-1 versus SCS-2 groups: all patients who received trial SCS (regardless of permanent implant status) and subgroup who received permanent implant

	All patients who received trial stimulation			Patients who received permanent stimulator		
Criterion	**SCS-1 (n=47) n (%)**	**SCS-2 (n=27) n (%)**	***P*-value***	**SCS-1 (n=24) n (%)**	**SCS-2 (n=16) n (%)**	***P*-value***
Prespecified criteria						
≥ 2-point RDQ improvement from baseline	15 (32%)	17 (63%)	0.01	12 (50%)	12 (75%)	0.12
≥ 50% leg pain improvement from baseline	7 (15%)	4 (15%)	0.72	6 (25%)	3 (19%)	0.73
Less than daily opioid use	9 (19%)	8 (30%)	0.04	3 (13%)	6 (38%)	0.05
All three criteria (primary outcome)	2 (4%)	1 (4%)	0.99	1 (4%)	1 (6%)	0.99
Alternate criteria						
≥ 5-point RDQ improvement from baseline	8 (17%)	7 (26%)	0.35	7 (29%)	6 (38%)	0.54
≥ 30% RDQ improvement from baseline	7 (15%)	4 (15%)	0.99	6 (25%)	3 (19%)	0.65
≥ 30% leg pain improvement from baseline	10 (21%)	9 (33%)	0.07	9 (38%)	7 (44%)	0.49
Composite outcome (≥ 5-point RDQ improvement, ≥ 30% leg pain improvement, and less than daily opioid use)	2 (4%)	1 (4%)	0.99	1 (4%)	1 (6%)	0.99

RDQ = Roland Disability Questionnaire

* *P*-values calculated from logistic regression models adjusted for baseline leg pain and the baseline outcome measure (i.e., baseline RDQ for the RDQ analyses, baseline opioid use for the opioid analysis, and all three baseline values for the composite outcome analysis).

Table 17. Observed RDQ and leg pain scores, and adjusted comparisons of SCS-1 versus SCS-2: all patients who received trial SCS (regardless of permanent implant status) and subgroup who received permanent implant

	Patients who received trial SCS			Patients who received permanent SCS		
Measure	**SCS-1 Mean[a] (SD)**	**SCS-2 Mean[a] (SD)**	**Adjusted Mean Difference[b] (95% CI)**	**SCS-1 Mean[a] (SD)**	**SCS-2 Mean[a] (SD)**	**Adjusted Mean Difference[b] (95% CI)**
RDQ (0-24)						
Baseline	21.1 (2.1)	20.9 (1.5)	–	21.5 (2.0)	21.3 (1.3)	-
12 Months	18.9 (4.8)	18.3 (3.6)	-0.4 (-2.4, 1.6)	17.8 (5.4)	17.9 (3.0)	0.6 (-2.2, 3.4)
Leg Pain (0-10)						
Baseline	7.7 (1.0)	7.2 (1.0)	–	7.7 (1.0)	7.4 (1.1)	-
12 Months	6.8 (1.9)	5.5 (2.1)	-1.1 (-2.3, 0.0)*	5.9 (2.0)	5.0 (2.4)	-0.7 (-2.4, 1.0)

RDQ = Roland Disability Questionnaire
[a] Unadjusted
[b] Regression model coefficient comparing SCS groups, adjusting for age, gender, and baseline RDQ and leg pain intensity
* $P = 0.06$ (the SCS-2 group reported lower leg pain intensity at 12 months as compared with the SCS-1 group)

Table 18. Work status and disability at 12 months: SCS-2 versus original SCS group

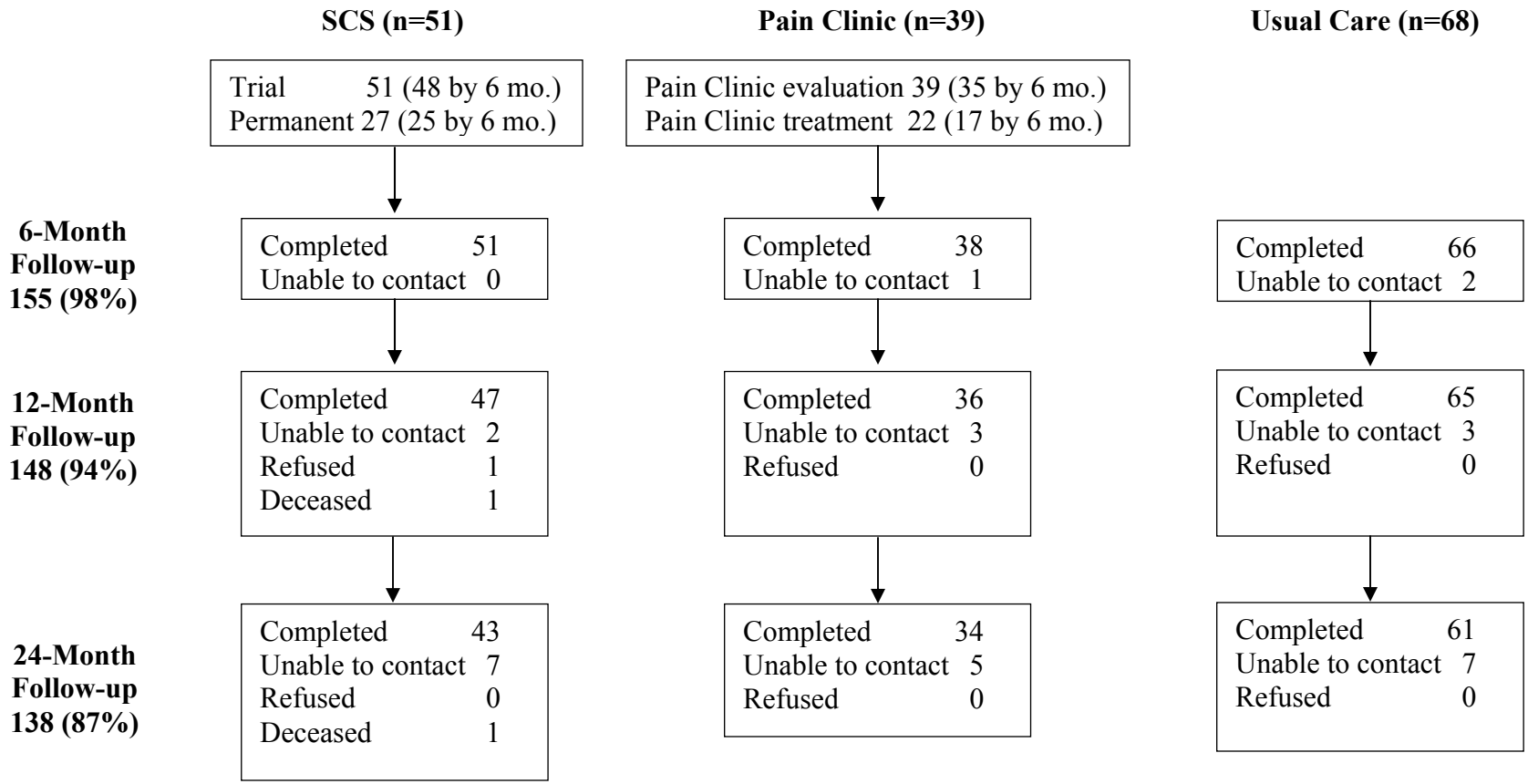
	SCS-1	SCS-2	*P*-value
Self-reported	**n=47**	**n=27**	
Back Pain Intensity, mean (SD)	6.8 (2.1)	6.2 (1.6)	0.15[a]
Mental Health, mean (SD)	33.3 (14.2)	32.9 (9.4)	0.33[a]
Ability to perform everyday tasks (compared to one year ago), n (%)			0.23[b]
Much/somewhat better	8 (17%)	9 (33%)	
About the same	23 (49%)	9 (33%)	
Much/somewhat worse	16 (34%)	9 (33%)	
Work Status, n (%)			0.29[b]
Working	4 (9%)	0 (0%)	
Off work, on disability	39 (83%)	24 (89%)	
Off work, not on disability	4 (9%)	2 (7%)	
Other	0 (0%)	1 (4%)	
Disability compensation other than DLI, n (%)	11 (23%)	11 (41%)	0.19[b]
Medications taken in past month for back/leg pain, n (%)			
Opioid	40 (85%)	21 (78%)	0.53[b]
Benzodiazepine/sedative-hypnotic/anti-anxiety	13 (28%)	2 (7%)	0.04[b]
Muscle relaxant	19 (40%)	5 (19%)	0.07[b]
Antidepressant	6 (13%)	9 (33%)	0.07[b]
Anticonvulsant	10 (21%)	6 (22%)	0.99[b]
Non-opioid analgesic	8 (17%)	9 (33%)	0.15[b]
DLI data†	**n=51**	**n=30**	
Time loss days, mean (SD)	320 (99)	357 (32)	0.02
On time loss, n (%)	41 (80%)	29 (97%)	0.07
Permanent partial disability, n (%)	1 (2%)	0 (0%)	0.99
Pension, n (%)	1 (2%)	0 (0%)	0.99
On time loss *or* pension, n (%)	42 (82%)	29 (97%)	0.10
DLI claim closed, n (%)	6 (12%)	0 (0%)	0.08

[a] Groups compared in linear regression models adjusting for age, gender, baseline RDQ, baseline leg pain intensity, and the baseline value of the outcome measure

[b] Proportions compared using Fisher's exact test with continuity correction for small cell counts.

† Comparisons of mean time loss days, proportion on time loss, and proportion on time loss *or* pension were made in linear or logistic regression models adjusted for baseline wage replacement compensation duration. Permanent partial disability, pension, and claim closure were compared using Fisher's exact test with continuity correction for small cell counts.

Figure 1. Subject flow through study



Appendix: Covariate Selection

We conducted a series of analyses to identify baseline variables for adjustment in comparisons of SCS to the PC and UC groups on the continuous self-report outcome measures (RDQ, leg pain intensity, back pain intensity, mental health). We first examined the association between each baseline variable and treatment group status (SCS vs. PC, SCS vs. UC) using logistic regression models. Next, we used linear regression analyses with robust standard error estimates to examine the association of each baseline variable with each of the two important secondary outcome measures, leg pain intensity and RDQ scores at 12 months. Baseline variables were considered as potential covariates if they were associated both with treatment group (in either the SCS vs. PC or the SCS vs. UC comparison) and with either leg pain or RDQ at 12 months with P-values < 0.20. To evaluate multicollinearity, we next examined the associations between all pairs of potential covariates identified by the first analyses, using Pearson correlation, chi-square tests, or point biserial correlations, as appropriate. Patient-rated back pain intensity (0-10) was eliminated as a covariate (except in analyses with back pain intensity at follow-up as an outcome) due to high correlation with patient-rated leg pain intensity (0-10, r = 0.50), and patient-reported number of surgeries for back or leg pain was eliminated as a covariate due to correlation with duration of wage replacement compensation (r = 0.33).

Next, we examined the association between each potential covariate identified in the preceding analyses and 12-month RDQ score in linear regression models that adjusted for baseline RDQ score and treatment group. We also examined the association between each potential covariate and 12-month leg pain rating in linear regression models that adjusted for baseline leg pain rating and treatment group. Our criteria for inclusion as a covariate (adjustment variable) in all subsequent analyses comparing outcomes of SCS versus PC and versus UC were

either: (1) association ($P < 0.10$) with treatment group (SCS vs. PC or SCS vs. UC) and association ($P < 0.10$) with 12-month RDQ or leg pain score; or (2) addition of the potential covariate to baseline RDQ (or to baseline leg pain) and treatment group in the model predicting 12-month RDQ (or leg pain) resulted in >10% change in the coefficient for the treatment effect (SCS vs. PC or SCS vs. UC) and a P-value < 0.25 for the potential covariate. The binary indicator of legal representation was identified as a covariate due to its association both with treatment group and with baseline leg pain intensity. Because baseline legal representation data were missing for five subjects, we multiply-imputed legal representation status ten times using the five baseline variables most strongly associated with legal representation: duration of wage replacement compensation, leg pain intensity, RDQ, SF-36 Mental Health, and study group. Stata's ICE command for multiple imputations was used to combine the results across the 10 regression models. We used the imputed values for the missing cases in all analyses that adjusted for legal representation. We conducted sensitivity analyses to compare the results of models that used imputed values for the missing data versus models that did not, and the results were comparable.