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Cervical and cervicomedullary spinal cord stimulation for chronic pain: Efficacy and outcomes

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ABSTRACT

Background: The role for spinal cord stimulation (SCS) in the management of chronic spinal cord forms of pain involving cervical dermatomes or the cervicomedullary junction (CMJ) for facial pain remains largely uncharted.
Objective: To review outcomes with cervical and CMJ SCS performed by a single surgeon, with particular emphasis on complications and efficacy.
Methods: All patients that underwent cervical or CMJ SCS by the lead author were identified and follow-up obtained by telephone questionnaires. Patient demographics, surgical details, outcomes and complications for all patients identified were critically reviewed.
Results: Of 121 patients identified that underwent at least trial SCS, 100 underwent permanent lead implantation. Indications for cervical SCS included brachial plexus lesions (8), complex regional pain syndrome (33), degenerative disc disease (4), failed neck surgery syndrome (23), chronic radiculopathy (6) and post-herpetic neuralgia (PHN) (1); for CMJ SCS, indications included trigeminal deafferetiation pain (10), trigeminal neuropathic pain (4), PHN (4) and occipital neuralgia (7). Pain relief was greater along the extremities than axially, and less in the occipital area than in the head or face. Mean pain reduction averaged 56.6% at a mean follow-up of 4.2 years. Of 24 revision surgeries required, 8 were for presumed lead migration or fracture. Complications included 4 CSF leaks, 5 wound infections, and 4 cases of persistent numbness or pain. Pain relief lasted an average of 3.6 years.
Conclusion: Cervical and CMJ SCS are safe and efficacious and may provide greater relief along the upper extremities than axially, and in the head rather than in the occipital region.

1. Introduction

Chronic pain is a debilitating condition [8,9]. Over 100 million adults in the United States are estimated to be afflicted, and rates of chronic pain are increasing due to a combination of factors including the obesity epidemic, the aging population, as well as the improved survival rates following traumatic injuries [12,35]. Causes of chronic pain conditions are numerous and include injuries, chronic disease (such as cancer, diabetes), peripheral and/or autonomic nerve disorders (such as complex regional pain syndrome or CRPS) as well as primary pain disorders (such as neuropathic pain, and fibromyalgia) [12]. However, the underlying etiology for many of these pain disorders remains unclear. Involved dermatomes vary; pain relating to the cervical spinal cord may present in the head, neck, anterior and/or posterior shoulders, and upper limbs. Various modalities, both medical and surgical, have been used in the treatment of these disorders including structural and ablative operations, pharmacotherapy, and physical therapy. Recently, spinal cord stimulation (SCS) has become increasingly popular; through stimulating the spinal cord via low intensity electric impulses, spinal cord stimulation creates a neuromodulatory effect on the nervous system, changing the perception of pain in a certain percentage of patients [12].

Favorable long-term outcomes as well as substantial long-term economic benefits have been reported with the use of thoracic spinal cord stimulation in the management of certain medically refractory, chronic pain conditions such as CRPS types I and II, ischemic pain, angina, and injury or disease of the peripheral nerves [18,21,24–26,31,32,38]. In contrast, little has been documented

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regarding the long-term results following the use of cervical SCS or cervicomedullary junction (CMJ) SCS for chronic pain conditions. The spinal trigeminal tract and nucleus (particularly the nucleus caudalis) form the anatomic basis for CMJ SCS. The nucleus caudalis (NC) is located at the CMJ and contains cell bodies of second order neurons carrying pain and temperature input from the ipsilateral face [39]. The NC also receives extra-trigeminal pain input from the head via cranial nerves VII, IX, and X. Cervical SCS targets the analogous lateral spinothalamic tracts that carry similar pain and temperature input from the body, typically from 2 to 3 levels below the level of the tract due to the crossing over of fibers in Lissauer's tract [8,34,39]. Consequently the NC, spinal trigeminal tract and spinothalamic tracts form ideal targets for various open and surgical and percutaneous neuroablative procedures for head and facial pain as well as pain from the trunk and upper extremities.

A recent cost-effectiveness analysis of cervical SCS suggested that this modality may be effective in pain management, improving the quality of life in most patients; similar results have been reported for CMJ SCS [12,39]. In this report, we review our single-center experience with cervical and cervicomedullary junction spinal cord stimulation in 121 patients, and discuss their outcomes (including extent and duration of relief) and complications. To our knowledge, this represents the largest series of patients treated using spinal cord stimulation of the cervical spinal cord.

2. Materials and methods

2.1. Patient population

A Boolean search of the electronic medical record (EMR) system was conducted to identify all patients that underwent cervical or CMJ spinal cord stimulation by a single neurosurgeon (J.J.M.) at the University of Pittsburgh Medical Center (UPMC) between January 1991 and January 2014; although our experience predates this period, these dates represent the extent of archived records available at our institution. This study was approved by the Institutional Review Board (IRB) at UPMC. Medical records were reviewed to determine the patients' diagnoses, location of the pain, age and gender, prior medical/surgical treatments. All patients being considered for SCS in the practice of the senior author undergo a 3-day paddle lead trial. A successful trial requires that the patient report at least 50% pain relief. Patients were excluded from the study if they received SCS only outside of the CMJ or the cervical spine (i.e. at thoracic or lumbar levels only). All patients who underwent cervical or CMJ SCS and for whom follow-up information could be obtained were included in the current report.

The demographics of our series are outlined in Table 1. Of 121 patients included, 51 (42.1%) were male and 70 (57.9%), female. Their mean age was 46.3 years (range, 20.1–84.7) at the time of the SCS trial. One hundred of the 121 patients (82.6%) had successful initial 3-day trials (stage I) of paddle cervical SCS, and underwent permanent paddle lead and pulse generator implantation (stage II). It is the practice of our senior author to classify failures as technical, physiological, or system in nature [8,39]. Technical failures refer to topographically poor stimulation-induced paresthesia patterns; physiological failures refer to inadequate pain relief despite topographically appropriate stimulation-induced paresthesias and finally, system failures refer to inadequate pain relief from the device even at maximal settings. As depicted in Table 1, the mean age at surgery amongst patients that underwent stage II implantation was 46.4 years (range, 21.2–84.7), which was not statistically different ($p = 0.613$) from that for those that failed the SCS trial, mean of 45.5 years (range, 20.1–65.7).

Seventy-five of 100 (75%) patients implanted with permanent paddle leads had undergone prior structural surgery. Sixty-five of 100 (65%) patients were implanted with resume leads (Medtronic, Minneapolis, MN), 34 (34%) with specify leads (Medtronic, Minneapolis, MN) and a single (1%) patient with a synergy lead (Medtronic, Minneapolis, MN). The type of lead did not statistically differ between the two groups of patients ($p = 0.781$). Diagnoses were grouped in two categories, namely those including the neck and/or extremity dermatomes, and those including head and/or facial dermatomes. The former comprised 75 of 100 (75%) patients implanted with permanent paddle leads, while the latter included the remaining 25 (25%) patients.

Table 1
Presenting patient demographics.

Demographics	Total	Implanted	Failed
	N = 121	*N* = 100	*N* = 21
Males	51 (42.1)	35 (35.0)	16 (76.2)
Age at surgery (years)			
Mean (SD)	46.3 (11.7)	46.4 (12.0)	45.5 (10.5)
Range	20.1–84.7	21.2–84.7	20.1–65.7
Electrode			
Resume	77 (63.6)	65 (65.0)	12 (57.1)
Specify	43 (35.5)	34 (34.0)	9 (42.9)
Synergy	1 (0.8)	1 (1.0)	0
Diagnosis			
Neck and/or extremity	85 (70.2)	75 (75.0)	10 (47.6)
BPI	9 (7.4)	8 (8.0)	1 (4.8)
CRPS	36 (29.8)	33 (33.0)	3 (14.3)
CRPS I	26 (21.5)	24 (24.0)	2 (9.5)
CRPS II	10 (8.3)	9 (9.0)	1 (4.8)
DDD	5 (4.1)	4 (4.0)	1 (4.8)
FNSS	27 (22.3)	23 (23.0)	4 (19.0)
Radiculopathy	7 (5.8)	6 (6.0)	1 (4.8)
PHN	1 (0.8)	1 (1.0)	0
Head/Facial pain	36 (29.8)	25 (25.0)	11 (52.4)
TDP	14 (11.6)	10 (10.0)	4 (19.0)
TNP	7 (5.8)	4 (4.0)	3 (14.3)
PHN	4 (3.3)	4 (4.0)	0
ON	11 (9.1)	7 (7.0)	4 (19.0)

Note: all numbers within parentheses represent fractions as percentages unless otherwise noted (as standard deviation).
SD, standard deviation; BPI, brachial plexus injury; CRPS, complex regional pain syndrome; DDD, degenerative disc disease; FNSS, failed neck surgery syndrome; PHN, post-herpetic neuralgia; TDP, trigeminal deafferentation pain; TNP, trigeminal neuropathic pain; ON, occipital neuralgia.

Amongst the 75 patients with neck and/or extremity pain, the spinal cord stimulation was cervical in location, and for brachial plexus injury (BPI) in 8 (10.7%), CRPS type I in 24 (32.0%), CRPS type II in 9 (12.0%), degenerative disc disease (DDD) in 4 (5.3%), failed neck surgery syndrome (FNSS) in 23 (30.7%) radiculopathy in 6 (8.0%%) and for post-herpetic neuralgia (PHN) in a single patient (1.3%). The remaining 25 patients underwent cervicomedullary junction stimulation (CMJ-S), for trigeminal deafferentiation pain (TDP) in 10 (40%) patients, trigeminal neuropathic pain (TNP) in 4 (16%), PHN in another 4 (16%), and finally for occipital neuralgia (ON) in 7 (28%). In a single patient with chronic ON, the CMJ stimulation (CMJ-S) was intended for a concomitant diagnosis of glossopharyngeal neuralgia (GPN).

2.2. Surgical technique

All operations were performed by our senior neurosurgeon (J.J.M.) with the patient under general anesthesia. Cervical spinal cord stimulators were placed using a staged approach. In stage I, quadripolar paddle leads were placed with the patient prone in Mayfield head pins and the wiring from the lead connected to an external pulse generator for a 3-day trial. Pain reduction of at least 50% was required for patients to undergo stage II surgery, during which the patient was placed in a lateral decubitus position and lead wires connected to an internalized pulse generator, placed in