The 70th Annual Meeting Special Topics — Part I: Validation and Prospects for Neuromodulation

Spinal Cord Stimulation for the Treatment of Abnormal Posture and Gait Disorder in Patients With Parkinson’s Disease

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Abstract

Patients with advanced Parkinson’s disease (PD) often present with axial symptoms, including abnormal posture, postural instability, and gait disorder. Although spinal cord stimulation (SCS) is effective for pain, little is known about the effect of SCS on motor function in PD patients. The present study investigated the effect of SCS on posture and gait in 15 PD patients, 5 men and 10 women aged 63–79 years (mean 71.1 years), with low back pain and leg pain who received SCS. A visual analog scale (VAS) was used for pain evaluation pre- and postoperatively. The Unified Parkinson’s Disease Rating Scale, Timed Up and Go tests, and Timed 10-Meter Walk tests were used to evaluate motor function and activities of daily living of patients. Preoperative mean VAS score was 8.9 (range 7.8–10), which showed significant postoperative improvement at 3 months to mean VAS score of 2.0 (range 0–3.3). The improvements in VAS scores persisted at 12 months after surgery with mean VAS score of 2.3 (range 0–4). Posture and postural stability motor subscores were improved at 3 months after SCS, and gait had significantly improved at 3 months and 1 year after surgery. Timed 10-Meter Walk tests also demonstrated that patient gait was significantly improved at 3 months and 12 months after surgery. Most advanced stage PD patients suffer considerable pain that causes abnormal posture and gait disturbance. SCS is expected to lead to both amelioration of pain and improvement of motor function in such patients.

Key words: spinal cord stimulation, Parkinson’s disease, chronic pain, neuromodulation, gait function

Introduction

Patients with advanced Parkinson’s disease (PD) often present with axial symptoms, including abnormal posture, postural instability, and gait disorder. Although deep brain stimulation (DBS) in PD patients improves off-period cardinal symptoms and motor fluctuations, its efficacy to control axial symptoms typically decreases gradually as the stage of the disease advances.17,19,28) These axial symptoms are the main factors which reduce the activities of daily living (ADL) and quality of life (QOL) of PD patients.

Patients with PD also suffer from pain significantly more frequently than normal subjects.9) One of the reasons is considered to be the decreased threshold of pain due to abnormality of the dopaminergic system in the basal ganglia of PD patients.5,10) Administration of anti-parkinsonian medication5,14) or DBS16,20,23) results in increased pain thresholds. Low back pain and leg pain are most commonly experienced pain symptoms in PD patients.6,21) Treatment by medication or DBS is often ineffective for low back pain caused by postural deformity, and is also ineffective for radicular or peripheral neuropathic pain.23) Because pain is an important factor that reduces the ADL and QOL of patients, the establishment of new and effective therapy is essential. Spinal cord stimulation (SCS) is an effective...
surgical therapy for chronic intractable pain, which has been applied with increasing efficacy, due to improved patient selection criteria, improved accuracy in electrode placement, and development of multipolar and multichannel devices. Patients with axial low back pain and with both low back and lower limb pain have benefited from increasingly effective treatment with the development of these devices.\(^\text{1,7,22,24}\) Since patients with low back pain suffering from severe scoliosis can now be effectively treated with SCS,\(^\text{8}\) the use of SCS for treatment of pain in PD patients is likely to increase. On the other hand, little is known about the efficacy of SCS for abnormal posture and motor dysfunction.

In the present clinical study, SCS was performed in PD patients with pain that was refractory to medication, DBS, and rehabilitation regimes, and the effects of SCS on pain, abnormal posture, and gait disturbance were examined.

**Clinical Materials and Methods**

A total of 15 PD patients, 5 men and 10 women aged 63–79 years (mean 71.1 years) with disease duration of 7–31 years (mean 17.2 years), with low back and lower limb pain that were refractory to medication and rehabilitation, were treated with trial SCS and achieved 50% or greater pain relief as determined by the visual analog scale (VAS). The preoperative Hoehn and Yahr stage was III in 8 patients and IV in 7 patients. Pain locations were the lower back in 2 patients, lower back plus leg in 9 patients, leg in 2 patients, and lower back plus abdomen in 2 patients. The pain features were classified according to the Ford Criteria\(^\text{12}\): 12 patients had musculoskeletal pain, 8 patients had radicular/peripheral neuropathic pain, and one patient had central pain. In our department, the criteria for administering SCS to PD patients with intractable pain were: failure of conventional pain management such as medication, physiotherapy, neural block to provide adequate pain control; significant impairment of ADL by pain; improvement of residual pain (pain not necessarily associated with PD), despite fluctuating pain levels, by the administration of anti-Parkinson drugs or DBS; absence of any major psychiatric disorder or remarkable cognitive impairment; and the patient could understand the treatment. Anti-Parkinson drugs or DBS is the first choice for treating pain associated with PD, but patients more than 70 years old often received SCS on a trial basis, rather than DBS, due to lesser invasiveness. Seven patients had received DBS one or more years before SCS surgery. No remarkable changes had occurred in DBS stimulation parameters or medication doses, so we considered that the perioperative periods of SCS surgery were unaffected by prior DBS and medication in our patients.

Percutaneous leads with 4 or 8 electrodes were inserted into the epidural space in parallel under local anesthesia. Electrodes were placed at the exact location where test stimulation paresthesia indicated coverage of more than 80% of the pain region. The tips and lower ends of the electrodes were placed between T7 and T12 in most patients. Initial stimulation trials were always performed using a dual-lead and multi-channel stimulation system. Stimulation levels were modified to reduce pain. The stimulation parameters were as follows: amplitude range 0–4 V, pulse width range 210–330\(\mu\text{sec}\), and frequency range 5–20 Hz (Fig. 1).

A VAS (range 0–10.0 points) was used to evaluate pain preoperatively and postoperatively at 3 months, 6 months, and 12 months. The Unified Parkinson’s Disease Rating Scale (UPDRS) was used to evaluate motor function and ADL of the patients. Timed Up and Go tests (TUG) and Timed 10-Meter Walk tests were used to evaluate gait function. All patients were in good condition, approximately an 80% drug-on state, at the time of these evaluations. Statistical analysis of the data used a Wilcoxon signed-rank test for nonparametric data (UPDRS ADL score and motor score, TUG, Timed 10-Meter Walk). Data are presented as means and standard deviation. Statistical significance was accepted at \(p < 0.05\).
Results

Preoperative mean VAS score was 8.9 (range 7.8–10). Postoperative mean VAS score at 3 months was significantly improved to 2.0 (range 0–3.3). All patients achieved 50% or greater relief after SCS, as determined by the VAS. This improvement was still evident 1 year after surgery (mean VAS score 2.3, range 0–4) (Fig. 2). Daily fluctuation of pain was observed in 12 patients experiencing wearing-off, but 4 patients without wearing-off did not experience such fluctuations. Patients with wearing-off still experienced daily fluctuation of pain at some level after SCS had decreased their pain.

Changes in motor function and ADL are shown in Table 1. Among the motor subscores (Part III) of the UPDRS, rigidity (item 22) did not change significantly after surgery. Posture (item 28), postural stability (item 30), and body bradykinesia (item 31) were significantly improved at 3 months after surgery, but improvement was reduced at 12 months after surgery. Gait (item 29) also showed significant improvement at 3 months after surgery, but the improvement had decreased at 12 months. Among the ADL scores (Part II) in the UPDRS, the ADL total scores, turning in bed and adjusting bed clothes (item 12), and walking (item 15) showed significant improvement after surgery. TUG times were significantly improved at 3 months after surgery, but the times at baseline and 12 months after surgery showed no significant change. Timed 10-Meter Walk times also were significantly improved, both at 3 months and 12 months after surgery. Among the patients with TUG improvement, 3 patients showed improvement in start hesitation.

Fig. 2 Changes in visual analogue scale (VAS) scores for 16 patients: preoperative to 12 months after surgery. Significant improvement compared with baseline: **p < 0.01.

Table 1 Effect of spinal cord stimulation on Unified Parkinson's Disease Rating Scale (UPDRS) motor scores and activities of daily living (ADL) scores, and gait function

<table>
<thead>
<tr>
<th></th>
<th>Baseline (preoperative)</th>
<th>Postoperative 3 months</th>
<th>Postoperative 12 months</th>
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<tbody>
<tr>
<td><strong>UPDRS ADL score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24.0 ± 8.1</td>
<td>18.9 ± 6.8**</td>
<td>20.4 ± 8.8*</td>
</tr>
<tr>
<td>Hygiene (item 11)</td>
<td>1.8 ± 0.9</td>
<td>1.7 ± 0.8</td>
<td>1.9 ± 0.9</td>
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<tr>
<td>Turning in bed and adjusting bed clothes (item 12)</td>
<td>2.3 ± 1.0</td>
<td>1.7 ± 0.8**</td>
<td>1.7 ± 0.9*</td>
</tr>
<tr>
<td>Falling (item 13)</td>
<td>1.7 ± 1.0</td>
<td>1.4 ± 0.8</td>
<td>1.7 ± 1.0</td>
</tr>
<tr>
<td>Freezing (item 14)</td>
<td>1.0 ± 0.7</td>
<td>0.8 ± 0.6</td>
<td>1.1 ± 0.8</td>
</tr>
<tr>
<td>Walking (item 15)</td>
<td>2.5 ± 0.6</td>
<td>1.9 ± 0.6*</td>
<td>2.1 ± 0.7</td>
</tr>
<tr>
<td>Sensory complaints related to parkinsonism (item 17)</td>
<td>3.8 ± 0.4</td>
<td>0.7 ± 0.7**</td>
<td>0.7 ± 0.8**</td>
</tr>
<tr>
<td><strong>UPDRS motor score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23.5 ± 9.7</td>
<td>18.9 ± 10.4*</td>
<td>21.3 ± 12.2</td>
</tr>
<tr>
<td>Rigidity (item 22)</td>
<td>2.9 ± 3.3</td>
<td>2.1 ± 2.9</td>
<td>2.4 ± 2.9</td>
</tr>
<tr>
<td>Leg agility (item 26)</td>
<td>2.3 ± 1.3</td>
<td>2.0 ± 1.3</td>
<td>2.3 ± 1.5</td>
</tr>
<tr>
<td>Arising from chair (item 27)</td>
<td>1.7 ± 1.0</td>
<td>1.2 ± 0.9</td>
<td>1.5 ± 1.1</td>
</tr>
<tr>
<td>Posture (item 28)</td>
<td>2.4 ± 0.9</td>
<td>1.8 ± 1.1*</td>
<td>2.1 ± 1.2</td>
</tr>
<tr>
<td>Gait (item 29)</td>
<td>2.5 ± 0.6</td>
<td>1.5 ± 0.6*</td>
<td>1.8 ± 0.9*</td>
</tr>
<tr>
<td>Postural stability (item 30)</td>
<td>2.3 ± 0.6</td>
<td>1.5 ± 0.8*</td>
<td>1.8 ± 1.1</td>
</tr>
<tr>
<td>Body bradykinesia (item 31)</td>
<td>1.8 ± 0.7</td>
<td>1.5 ± 0.8*</td>
<td>1.7 ± 1.0</td>
</tr>
<tr>
<td><strong>Gait function</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Timed Up and Go test (sec)</td>
<td>21.6 ± 10.7</td>
<td>15.6 ± 7.3**</td>
<td>18.2 ± 10.8</td>
</tr>
<tr>
<td>Timed 10-Meter Walk test (sec)</td>
<td>14.7 ± 8.4</td>
<td>12.7 ± 8.0**</td>
<td>13.3 ± 9.3*</td>
</tr>
</tbody>
</table>

Significant improvement compared with baseline: *p < 0.05, **p < 0.01.
Discussion

The frequency of pain in patients with PD ranges from 40% to 83%. The causes of pain in these patients are difficult to determine because of the mixture of PD-unrelated pain (musculoskeletal, neuronal, and radicular) and PD-related pain (severe dystonic pain in off periods, and central pain). Pain in PD patients often shows daily fluctuation along with motor fluctuation caused by the wearing-off phenomenon, and the central dopaminergic system is considered to be involved in such pain threshold changes. Therapy based on the use of anti-Parkinson drugs or DBS can reduce daily motor fluctuation and mitigate PD pain. Improvement in motor fluctuation sometimes also reduces pain unrelated to PD. However, pain is unremitting in most patients, and SCS is considered to be the treatment of choice if ADL deteriorates significantly and spinal surgery cannot be performed due to the bony changes caused by PD progression.

SCS is considered to be effective for neuropathic pain. In the present study, significant pain reduction was obtained because low back and leg pain may be caused by partially chronic neuropathic pathological conditions, which are factors even in musculoskeletal pain that has many nociceptive pain components. Although SCS might be effective for reducing central pain in PD patients, daily fluctuation of pain still occurs after surgery.

SCS treatment improved abnormal posture and gait disturbance in PD patients, and improvement was still evident one year after surgery. In the present study, all patients had severe pain, so the effect of SCS on abnormal posture and motor function may be an indirect effect of pain reduction. In general, one third of patients with PD demonstrate abnormal posture, i.e. the typical features of stooped, simian appearance, with flexion of the hips and knees, and rounding of the shoulders. Severe postural deformities include camptocormia, antecollis, Pisa syndrome, and scoliosis. The pathophysiology of these clinical conditions is still unknown, but the causes are thought to include central mechanisms (dystonia, rigidity, and proprioceptive disintegration), peripheral processes (myopathy, and skeletal and soft tissue changes), and the side effects of medications.

The causes of abnormal posture are generally accepted as hard to treat, but camptocormia has been treated with botulinum toxin injection to the rectus abdominis, iliopsoas, or selected paraspinal muscle groups, mainly in patients with a predominantly dystonic element to their deformity. DBS is effective for mild postural abnormality, and camptocormia has sometimes been successfully treated by DBS. DBS may be effective for postural abnormality of central origin, but the efficacy is limited for conditions with peripheral origin, such as myopathy, and skeletal and soft tissue changes. Spine surgery can be performed in PD patients with bony changes, but the degree of bony changes can increase in some patients so that reoperation is required. In the present study, abnormal posture was improved at 3 months after surgery, but gradual deterioration again occurred later. The reason for the observed postural improvement is not clearly understood.

The effects of SCS on the motor symptoms of PD patients remain controversial. SCS may have a direct effect on locomotive function in PD patients. Dorsal column stimulation (DCS) at the level of the thoracic spine in a PD animal model had a dramatic effect on the amount of locomotion observed during stimulation periods in the animals. The detailed mechanism is not known yet, but DCS may help motor-related brain areas shift into a state that permits initiation of movements through direct modulation of thelemniscal/thalamic pathways. SCS for PD patients did not result in improvement of akinesia or locomotion. High cervical SCS was performed in two patients with PD, and a double-blind crossover study was conducted. No differences in motor UPDRS according to stimulation conditions, and no improvement of gait disturbance in the off periods were observed.

Pain is often observed in advanced stage PD patients, and many such patients demonstrate postural abnormalities and gait disturbance, in addition to experiencing pain. SCS is effective not only for amelioration of pain, but also for improvement of postural abnormalities and motor function in these patients.

References

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Neurol Med Chir (Tokyo) 52, July, 2012