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Relief of Central Poststroke Pain Affecting Both the Arm and Leg on One Side by Double-independent Dual-lead Spinal Cord Stimulation Using Fast-acting Subperception Therapy Stimulation: A Case Report

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Abstract

Central poststroke pain is a chronic, intractable, central neuropathic pain. Spinal cord stimulation is a neuromodulation therapy for chronic neuropathic pain. The conventional stimulation method induces a sense of paresthesia. Fast-acting subperception therapy is one of the latest new stimulation methods without paresthesia. A case of achieving pain relief of central poststroke pain affecting both the arm and leg on one side by double-independent dual-lead spinal cord stimulation using fast-acting subperception therapy stimulation is presented. A 67-year-old woman had central poststroke pain due to a right thalamic hemorrhage. The numerical rating scale scores of the left arm and leg were 6 and 7, respectively. Using dual-lead stimulation at the Th 9-11 levels, a spinal cord stimulation trial was performed. Fast-acting subperception therapy stimulation achieved pain reduction in the left leg from 7 to 3. Therefore, a pulse generator was implanted, and the pain relief continued for 6 months. Then, two additional leads were implanted at the C 3-5 levels, and pain in the arm decreased from 6 to 4. Independent setting and adjustments of the dual-lead stimulation were required because the thresholds of paresthesia perception were significantly different. To achieve pain relief in both the arm and leg, double-independent dual-lead stimulation placed at cervical and thoracic levels is an effective treatment. Fast-acting subperception therapy stimulation may be effective for central poststroke pain, especially in cases where the paresthesia is perceived as uncomfortable or the conventional stimulation itself is ineffective.

Keywords: spinal cord stimulation, central poststroke pain, dual-lead, FAST, paresthesia-free

Introduction

Central poststroke pain (CPSP) is a chronic intractable central neuropathic pain that occurs following a stroke. The features of CPSP are spontaneous pain described as burning or aching, and it coexists with allodynia or hypoesthesia. Pain areas involve half the body, mainly affecting the arm and leg, corresponding topographically to the stroke lesion. Injury of the spino-thalamo-cortical sensory pathway appears to be crucial for the development of CPSP.[1-4] One of the mechanisms of CPSP is believed to be maladaptive plastic changes and reorganization of the pain network in the brain.[5] Pharmacological treatment of CPSP may only obtain partial relief or cause intolerable adverse effects.[2,6] Neuromodulation therapies including motor cortex stimulation, deep brain stimulation, or spinal cord stimulation (SCS) have been administered for such medically resistant CPSP.[5]

SCS has been used for decades to treat chronic neuropathic pain.[7,8] The conventional paresthesia-based SCS uses tonic stimulation that induces a sense of paresthesia. In the conventional SCS, the paresthesia must cover the painful area to achieve pain relief.[9] Because of the lack of high-level evidence, guidelines and recommendations do

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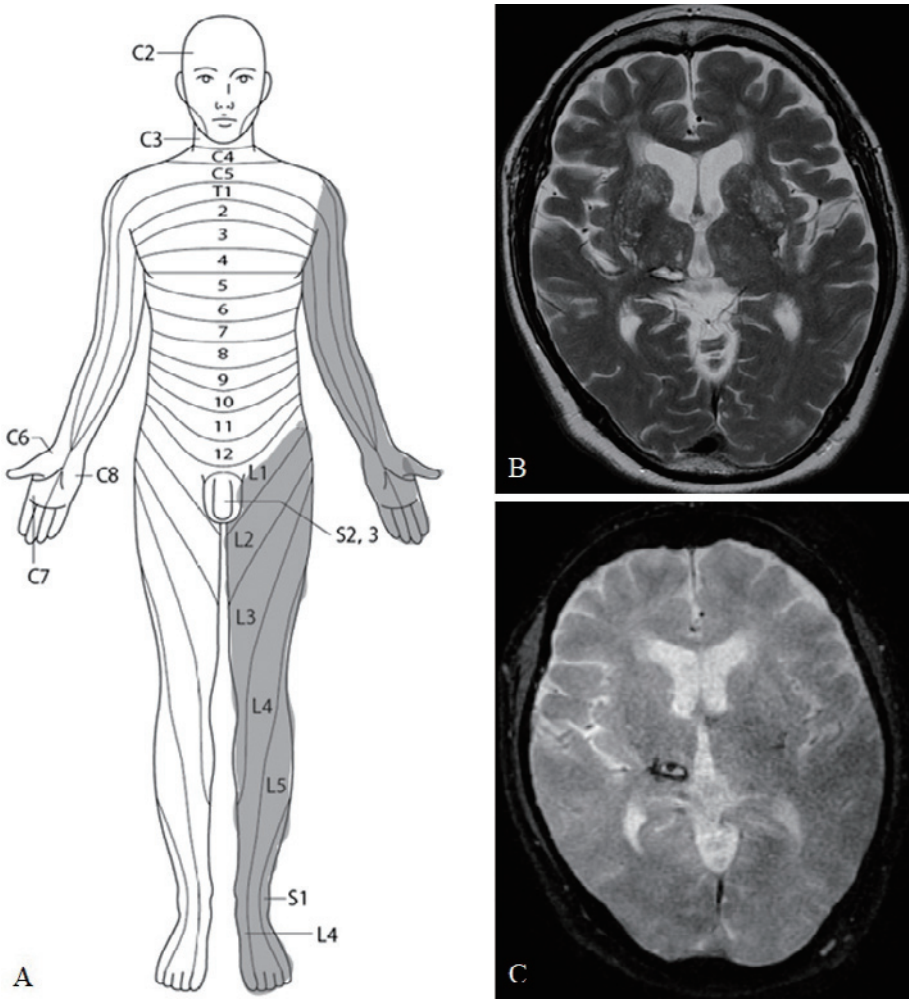

Fig. 1 A: Schematic diagram shows the locations of pain as a gray color. The degree of pain is 6 in the left arm and 7 in the left leg assessed using a visual analog scale. B, C: Magnetic resonance images show a hemorrhagic scar at the right dorsal thalamus (B: T2-weighted, C: T2*-weighted).

not recommend the use of SCS for the treatment of CPSP.[10,11] However, these decisions were based on two previous reports in which SCS was performed using an old-type, single lead with a low number of contacts.[12,13] Since 2009, some case series using new devices reported the possible efficacy of SCS for CPSP.[14-17] In 2022, a multicenter, retrospective study assessing the efficacy of the conventional SCS for CPSP was reported, and approximately 40% of patients achieved long-term pain relief of greater than 30%.[18] This report showed that SCS may provide modest benefits for CPSP.

Recently, new SCS stimulation methods without inducing a sense of paresthesia have been developed. These new stimulation methods are described as "paresthesia-free" or "subperception" SCS.[19-21] Paresthesia-free SCSs may be more effective than the conventional SCS.[19-21] Fast-acting, subperception therapy (FAST) (Boston Scientific, Marlborough, MA, USA) stimulation is one of the latest paresthesia-free SCSs.[21] In this report, a case of pain relief of CPSP affecting both the arm and leg by double-independent dual-lead SCSs using FAST stimulation is described.

Case Report

A 67-year-old woman presented with right thalamic hemorrhage 9 years earlier. She had sensory disturbances in the left arm and leg, with mild motor weakness. Then, the sensory disturbances changed to severe pain with allodynia of the palm and sole (Fig. 1A). The numerical rating scale (NRS) scores for the pain in the left arm and leg were 6 and 7, respectively. Magnetic resonance imaging showed a hemorrhagic scar at the right dorsal thalamus, and the pain was diagnosed as CPSP (Fig. 1B, C). Pharmacological treatment including pregabalin and antidepressants did not achieve pain relief. Therefore, two percutaneous eight-contact leads were inserted at the Th 9-11 levels confirming the paresthesia by intraoperative stimulation, and an SCS trial was performed for 1 week (Linea ST lead

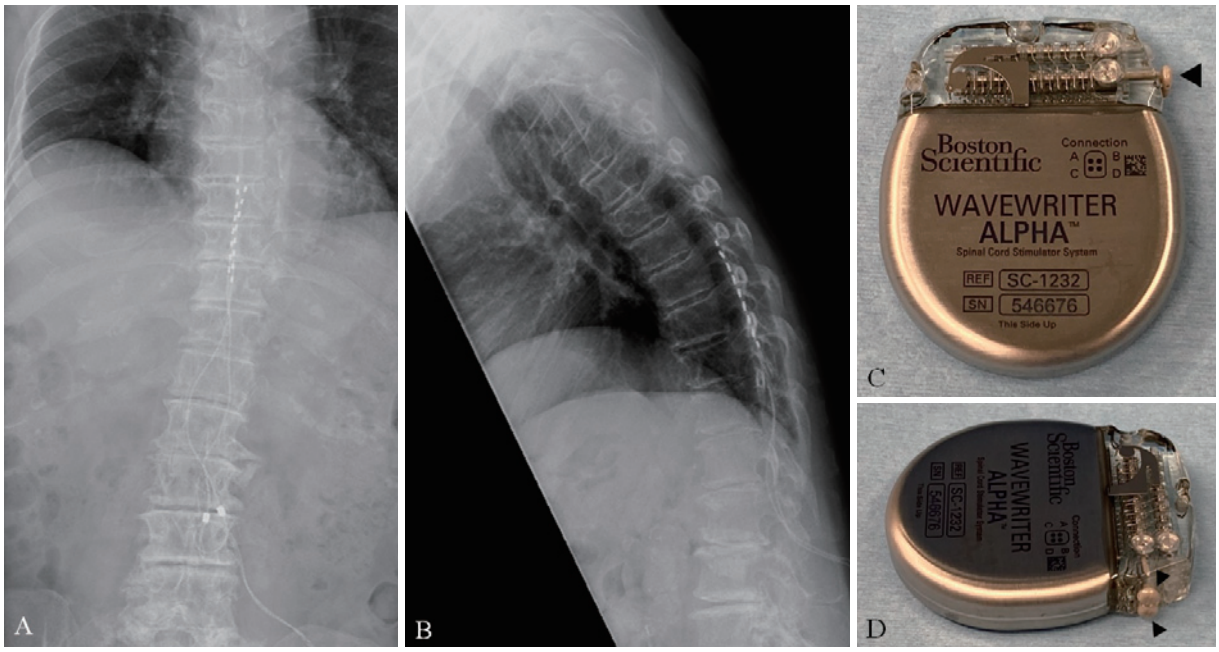

Fig. 2 A, B: Two percutaneous eight-contact leads are located at the Th 9-11 levels at the first spinal cord stimulation trial (A: anterior–posterior view, B: lateral view). C, D: Two plugs are inserted to lead connection holes of an implantable pulse generator for future use (arrowhead: plugs).

50 cm; Boston Scientific) (Fig. 2A, B). First, conventional SCS was tested. The paresthesia covered the painful area of the left leg, although she felt the paresthesia as an uncomfortable sensation and did not obtain an analgesic effect. Next, FAST stimulation was tried, and pain reduction of the NRS score from 7 to 3 was achieved without an uncomfortable sensation. One month later, two percutaneous eight-contact new leads and an implantable pulse generator (IPG) were implanted (WaveWriter Alpha 32; Boston Scientific) on general anesthesia referring to the previous X-ray of trial leads placing. At that time, two plugs were inserted to lead connection holes of the IPG for future use (Fig. 2C, D). The effects of SCS for pain relief in the left leg continued for 6 months, although the pain in the left arm still remained. Because the patient demanded alleviation of the left arm pain, two additional eight-contact leads were implanted at the C 3-5 levels on general anesthesia without intraoperative stimulation (Linear ST lead 70 cm; Boston Scientific) (Fig. 3A, B). Two plugs of the previously placed IPG were pulled out, and the two leads were connected. FAST stimulation was applied to the arm, and the NRS score decreased from 6 to 4. Cervical SCS did not have an additional pain-relieving effect on the leg pain.

Finally, double-independent dual-lead SCS was performed at the C 3/4 level and Th 10 level, using all four eight-contact leads connected to one IPG. Thresholds of paresthesia using FAST stimulation (frequency 90 Hz, pulse width 210 μs) of the arm and leg were approximately 1 and 5 mA, respectively. The power setting of FAST stimulation is approximately 30% of the paresthesia threshold, so the actual stimulation powers of the arm and leg were 0.3 and 1.5 mA, respectively. Therefore, independent set-up and adjustments of FAST stimulation were required for the arm and leg. The pain relief in both the arm and leg has continued for 6 months since the second operation. Using the Short-Form McGill Pain Questionnaire-2, the score decreased from 52 (preoperatively) to 35 (6 months after the first operation) and then 10 (6 months after the second operation). The score on the Pain Catastrophizing Scale decreased from 19 (preoperatively) to 16 (6 months after the first operation), and then 7 (6 months after the second operation).

Discussion

There have been no randomized, controlled trials of SCS for CPSP, although a retrospective, multicenter study reported the outcomes of a trial of SCS and the long-term effects of SCS for CPSP.[18] A total of 166 patients with CPSP were enrolled in the study. The trial of SCS was performed on 163 patients, resulting in SCS device implantation in 103 (63%) of them. Three patients underwent implantation without a trial of SCS. Long-term achievement of pain reduction of greater than 30% was seen in 63 (38%) of the total 166 patients. The rate of SCS trial success and implantation was 63% in patients with CPSP, which was lower than in patients with failed back surgery syndrome and peripheral neuropathic pain (71%-93%).[22-25] However, of the patients who underwent implantation, the rate of efficacy preservation was 59% (63/106) in patients with CPSP,

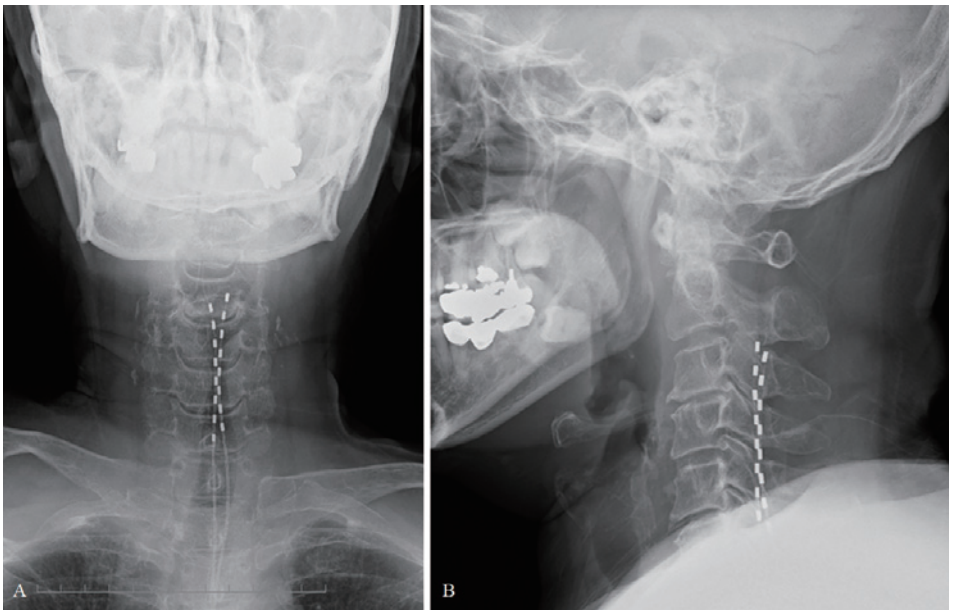

Fig. 3 A, B: Two additional percutaneous eight-contact leads are implanted at the C 3-5 levels (A: anterior–posterior view, B: lateral view).

which was similar to that in patients with failed back surgery syndrome and peripheral neuropathic pain (55%-60%).[22-25] Young age, less sensory disturbance, implantation of cervical leads, upper limb treatment, and large target region were associated with good outcomes after implantation.[18] In the study, 78% (83/106) of patients underwent dual-lead SCS, and conventional SCS (87%) was mostly performed. Differences in effects between the conventional and paresthesia-free SCSs were not compared.

Various SCS devices have been improved and developed. The dual-lead SCS became available in the mid-2000s in Japan. The dual-lead SCS makes it possible to properly stimulate the dorsal horn without the stimulus spreading to other areas and to increase stimulation intensity without inducing unpleasant paresthesia.[26] The dual-lead SCS can more easily induce paresthesia over the painful area than single-lead SCS, which enhances the analgesic effects. Similarly, when setting up the paresthesia-free SCS, initial confirmation of the paresthesia covering the painful area is performed, and then, the stimulation power is reduced below the paresthesia threshold.[19-21] It is still important that the paresthesia covers the painful area. Therefore, the dual-lead SCS is also useful even when using paresthesia-free SCS.

Multiple independent current control is a new technology that enables multiple lead contacts to stimulate using various percentages of the total current, which produces a virtual cathode and anode at central stimulation points. FAST stimulation has a programmed frequency of 90 Hz and a pulse width of 210 ± 50 μs with a symmetrical biphasic waveform, one for each rectangular phase of the charge-balanced stimulation cycle. During the first rectangular phase of the biphasic stimulating waveform, a negative current is injected through negatively configured electrodes, and a positive current is injected through positively configured electrodes. During the second rectangular phase, the polarities are reversed to achieve charge balance.[21] Then, positive and negative reversal stimulations are repeated. In FAST stimulation, stimulation electrodes and distributions are automatically calculated by multiple independent current control technology. The stimulation power is lowered to approximately 65% of the paresthesia threshold. In a retrospective review of 41 patients with chronic back and/or leg pain, the mean overall pain score was decreased by 7.1 points from 8.4 ± 0.2 at baseline after activation of FAST stimulation. This analgesia was sustained for 3 and 6 months or up to the patients' last follow-up.[21] There are still few reports of the use of paresthesia-free SCS for CPSP, although paresthesia-free SCS may be effective when the paresthesia is perceived as uncomfortable or the conventional SCS itself is ineffective. The new IPG (WaveWriter Alpha 32; Boston Scientific) can use other stimulation patterns such as Contour and MicroBurst 3D (Boston Scientific), although there are still few clinical reports. In the present case, the two stimulation patterns were not applied because FAST stimulation was effective. If tonic or FAST stimulations are ineffective, these stimulation patterns may be available options.

The positions of SCS lead placement for CPSP are determined by the main site of pain, such as a cervical lead position for arm pain or a thoracic lead position for leg pain. It is known that the cervical spine contains sensory tracts from the leg, and cervical leads located on the midline can induce paresthesia in the leg.[16] However, when trying to

induce paresthesia in the leg using cervical leads, the paresthesia in the arm may increase because of differences in paresthesia thresholds. In fact, achieving pain relief in both the arm and leg at the same time with only cervical leads is challenging. The 32-pole stimulating IPG can perform double dual-lead SCS using four 8-pole leads, and one can also independently adjust each dual-lead SCS with just one IPG. If there are any problems with placing four leads in a one-stage procedure, two-staged procedures are safe and reasonable, as in the present case. This involves implanting two leads and an IPG as the first step. After confirming its continuous analgesic effect, two leads are then added and connected to the IPG.

It has been found that SCS can be effective for CPSP, although the success rates of conventional SCS are still unsatisfactory.[14-18] Double-independent dual-lead stimulation placed at cervical and thoracic levels is an effective treatment for achieving pain relief of CPSP affecting both the arm and leg. Furthermore, paresthesia-free SCS may have the potential to increase the success rates of SCS for CPSP.[19-21]

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Informed Consent

Informed consent for publication was obtained from the patient.

Conflicts of Interest Disclosure

The authors declare no conflicts of interest directly relevant to the content of this article.

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