High-Frequency Spinal Cord Stimulation (HF-SCS) at 10 kHz for Chronic Unilateral Pain Syndrome of the Forearm and Hand: A Case Report

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Introduction

High-frequency spinal cord stimulation (HF-SCS) at 10 kHz has been demonstrated to be effective for the treatment of chronic neuropathic low back and leg pain. The use of the therapy for the treatment of upper limb pain has not been extensively reported to date. Therefore, we present a case report of chronic unilateral pain syndrome of the forearm and hand treated with HF-SCS at 10 kHz.

Case History:

A 42-year-old male presented at our clinic suffering from chronic pain in his forearm and hand. The pain originated from a benign tumor compressing his left ulnar nerve. Additional symptoms included grip weakness, decreased sensation in his auricular finger, and hyperalgesia around the area of the tumor. Previous surgical examination deemed the tumor inoperable due to the risk of sensory-motor deficit. Conservative pharmacological treatment of the patient's neuropathic pain failed. As a result, he was an appropriate candidate for trial stimulation with HF-SCS at 10 kHz.

Methods:

Two 8-contact percutaneous trial leads were placed in the epidural space of the cervical spinal cord and attached to an external programmable pulse generator. The distal tips of the leads were placed along the radiographic midline in a staggered fashion at the C3 and C4 vertebral levels. The patient underwent a successful trial with HF-SCS at 10 kHz and went on to receive a permanent system.

Results:

The trial resulted in 100% pain relief without stimulation-induced paresthesia, as well as complete suppression of hyperalgesia around the area of the tumor. Functionality also improved in the affected hand. The results were replicated after implantation of a permanent system and sustained at 12 months postimplantation.

Conclusion:

HF-SCS at 10 kHz provided complete pain relief for our patient suffering from chronic unilateral pain syndrome of the forearm and hand. The therapy is a promising paresthesia-independent treatment option for chronic neuropathic pain syndromes of various etiologies, including the upper limb. Further clinical studies are required to confirm our results.

Keywords: Spinal cord stimulation, High-frequency spinal cord stimulation, 10 kHz, SCS, HF-SCS, HF10, Limb pain, Neuropathic pain.

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Introduction

A large randomized, controlled, pivotal study recently confirmed the safety and effectiveness of HF-SCS at 10 kHz in patients with chronic low back and leg pain [1]. The study also demonstrated superior pain relief in subjects treated with HF-SCS at 10 kHz over traditional low-frequency spinal cord stimulation (LF-SCS). During spinal cord stimulation (SCS), electrical pulses are applied to the spinal cord by electrodes implanted in the epidural space. In traditional LF-SCS, paresthesia coverage of the area of pain is considered critical to therapy success [2] but may be uncomfortable for some patients. During HF-SCS at 10 kHz, pain relief is provided without paresthesia by a proprietary high-frequency waveform [3]. The mechanism of action has not yet been established and may be different to that of traditional LF-SCS and/or recently developed technologies using paresthesia sub threshold approaches.

Our clinic has successfully used HF-SCS at 10 kHz for the treatment of pain syndromes of different etiologies. The use of the therapy for the treatment of upper limb pain has not been extensively reported to date. Therefore, we present a case report...
of chronic unilateral pain syndrome of the forearm and hand treated with this therapy.

**Case History**

A 42-year-old male was referred to our clinic in 2016 with chronic pain of 3 years duration. The pain originated from a benign tumor (xanthoma) compressing his left ulnar nerve (Figure 1) and encompassed his left forearm and hand. The patient reported undergoing a failed carpal and cubital tunnel decompression procedure in 2015. Surgical examination found that the tumor enveloped two fascicles. Since removal posed a high risk for motor-sensory deficit, only an epineurotomy and biopsy were carried out. The epineurotomy did not alleviate the patient’s pain. Medical comorbidities included syringomyelia, diabetes mellitus (type 2), arterial hypertension, chronic bronchitis, and obesity. The patient’s daily medication included oxycodone (20 mg), pregabalin (200 mg), and mirtazapine (30 mg).

Upon thorough medical examination, the patient reported an average pain intensity of 7-8 on an 11-point numerical rating scale (NRS; 0 = no pain, 10 = worst possible pain) with peak pain intensity of 10 upon touching the area around the tumor. Grip weakness was noted in the patient’s left hand along with decreased sensation in his auricular finger and hyperalgesia around the area of the tumor. A Tinel’s sign was also present over the tumor. His symptoms resulted in impaired functionality and capacity to work. Since the patient had failed appropriate conventional medical management for his ulnar nerve compression and neuropathic pain, including surgical options as well as opioid, anticonvulsant, and antidepressant medication, he was a candidate for trial stimulation with HF-SCS at 10 kHz.

**Methods**

In September 2016, two 8-contact percutaneous trial leads were placed into the epidural space at the thoracic level using standard techniques under fluoroscopic control. An intravenous prophylactic antibiotic (cefazolin) was administered. The procedure was carried out under general anesthesia. Two leads were advanced and positioned along the radiographic midline (Figure 2) in a staggered fashion to allow coverage of a wider area of the cervical spine. The first lead tip was placed at the low C3 vertebral level and the second at the mid-C4 vertebral level (Figure 3). The leads were subsequently attached to an external programmable pulse generator. Stimulation was optimized using a programming algorithm (proprietary to Nevro Corp., Redwood City, CA, USA) and applied to the distal pair of electrodes on the upper lead.
USA) was implanted without complications and programmed to the same stimulation settings and electrodes used during the trial. The patient was also given a remote-control device to allow adjustment of stimulation settings within preset ranges. Clinical outcomes were evaluated during regular postimplantation follow-ups. Sensation tests and provocative neck maneuvers were also performed along with an assessment of any adverse device effects since the last follow-up. Data for this case report were collected up to 12 months postimplantation.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 1983. Local ethics committee approval was not required in accordance with the (Model) Professional Code for Physicians in Germany (Section 15) [4].

**Results**

During the trial, the patient experienced 100% pain relief (NRS = 0) without stimulation-induced paresthesia, as well as complete suppression of hyperalgesia around the area of the tumor. Functionality in the patient’s left hand also significantly improved. During the 3-week period between the end of the trial and implantation of the permanent system, the patient’s pain, hyperalgesia, and functional impairment returned. The trial results were replicated immediately after implantation and programming of the permanent system.

In the months following implantation, the patient reduced and finally stopped opioid and anticonvulsant medications. At 12 months postimplantation, the patient reported continued complete pain relief (NRS = 0) with no stimulation-induced paresthesia. Improved functionality in his left hand was also maintained, enabling him to return to full employment. No adverse device effects were observed during the 12-month follow-up period.

**Discussion**

Clinical evidence relating to the safety and effectiveness of HF-SCS at 10 kHz has mainly been reported from patient populations with chronic neuropathic back and leg pain. However, chronic neuropathic pain in the arms or hands represents a substantial proportion of all neuropathic pain cases [5]. Recently, HF-SCS at 10 kHz was evaluated in a small cohort of patients with chronic neuropathic upper limb pain [6]. Epidural lead tips were positioned between C2 and C7 in eight patients. Six months after implantation, most patients (6/8) reported a reduction in pain intensity of 50% or greater. All but one patient (7/8) rated their treatment as excellent or good. Placement of the lead tip between C3 and C4 was found to produce the best pain relief. None of the patients experienced stimulation-induced paresthesia, and no adverse neurological events were reported. Moreover, three prospective studies are ongoing to evaluate additional safety and efficacy aspects of this therapy for upper limb pain [7-9].

The successful and safe application of HF-SCS at 10 kHz in our patient is in line with the previously reported study and supports the utility of the therapy in this patient group. Our patient had an unusual etiology of forearm and hand neuropathic pain originating from an inoperable benign tumor compressing his ulnar nerve (Figure 1). Treatment with HF-SCS at 10 kHz resulted in 100% pain relief without any stimulation-induced paresthesia. The use of a paresthesia-independent SCS modality may be of particular advantage in patients with leads placed at the cervical level of the spinal cord. In traditional LF-SCS, stable paresthesia coverage of the area of pain is necessary to achieve pain relief. However, this can be challenging to maintain with cervically placed leads due to the high degree of movement in the neck. Variations in paresthesia intensity can result in uncomfortable under- or overstimulation [10]. Our patient did not experience such discomfort. The additional findings in this case of improved motor symptoms and suppression of hyperalgesia are also interesting and may indicate that this therapy has a different mechanism of action than traditional LF-SCS.

A major limitation of this report is its presentation of a single case. As such, the results cannot be generalized. Another limitation is its retrospective design. However, it adds to the limited data currently available on the successful use of the therapy for the treatment of upper limb pain. The results also suggest that it may be considered in the treatment of pain syndromes secondary to rare indications where all other treatments options have been exhausted, have already failed, or are considered more invasive. The reversible nature of the therapy is an advantage in such cases.

**Conclusion**

We presented a case of chronic unilateral pain syndrome of the forearm and hand successfully treated with HF-SCS at 10 kHz. The therapy is a promising, paresthesia-independent treatment option for chronic neuropathic pain syndromes of various etiologies, including the upper limb. Larger clinical trials are required to confirm our results.

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