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Feasibility, Safety, and Efficacy of Subcutaneous Peripheral Nerve Field Stimulation for the Treatment of Refractory Low Back Pain: A Two-year Single-center Study

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Abstract—Chronic low back pain (CLBP) is challenging to treat. Minimal invasive neurostimulation therapies, such as subcutaneous peripheral nerve field stimulation (SPNS), improve pain relief and quality of life. The goal of the present study was to assess the usefulness, safety, and efficacy of SPNS in patients with CLBP. Twenty-six consecutive patients with CLBP were prospectively included in the study. For trial neurostimulation, two electrodes were implanted vertically at a depth of 1 cm into the subcutaneous tissue, ≤10 cm from the region of maximum pain. Trial neurostimulation was performed in all patients for 14 days. A successful outcome was defined as at least 50% pain relief. To monitor the effects of permanent neurostimulation, the Visual Analog Scale (VAS), the Oswestry Disability Index (ODI), and quality of life (EQ-5D-3L) were scored preoperatively and at 6-month and 24-month follow-ups. Thirteen patients responded to trial stimulation and had a permanent neurostimulator implanted. The use of pain medication, including opioid analgesics, was reduced in 92% of patients after 24 months. VAS, ODI, and EQ-5D-3L scores were significantly improved in these patients at the 24-month follow-up. The complication rate was 23% (3/13 patients). In non-responders, VAS and ODI at 24 months dropped significantly as well but the decrease was less pronounced compared to responders and had not led to a decrease in pain medication. SPNS is a novel, safe, and effective treatment for CLBP and may have advantages over interventional treatments including intrathecal therapy and spinal cord stimulation.

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Key words: subcutaneous peripheral nerve field stimulation, SPNS, neurostimulation, chronic low back pain, quality of life.

INTRODUCTION

Chronic low back pain (CLBP) is one of the most common chronic pain disorders in the western industrialized world and represents a high socioeconomic burden (Hoy et al., 2014). It is a major cause of disability in both elderly and young patients, affecting work performance, causing disabling pain, and significantly decreasing quality of life (Deyo and Weinstein, 2001).

The diagnosis and treatment of CLBP are complicated because the pain is complex and often resistant to conventional medical therapies and management strategies (Rainov et al., 2007). In the majority of CLBP cases, the etiology is unknown and psychosomatic components play an important role (Ghaffari et al., 2008). Failed back surgery syndrome (FBSS) refers to continued pain after surgery and occurs after 5–74.6% of spinal surgeries. However, FBSS only plays a minor role in CLBP (Hussain and Erdek, 2014; Shapiro, 2014). The pain-generating mechanism in CLBP is poorly understood. Nociceptive and neuropathic pain components have been distinguished in 20–35% of patients in large epidemiological studies (Freynhagen et al., 2006a,b, Torrance et al., 2006).

Neuromodulation represents a major advance in the management of CLBP and was first introduced in 1967 as spinal cord stimulation (SCS). Electrodes were placed in the epidural space to stimulate the dorsal column of the spinal cord (Barolat et al., 2001, Alo and Holsheimer, 2002, Cameron, 2004). SCS has successfully relieved pain in the lower extremities and buttocks, but is not recommended for treatment of CLBP in the current national guidelines (http://www.awmf.org/uploads/tx_szleitlinien/nvl-007l_S3_Kreuzschmerz_2017-03.pdf). However, maintaining long-term pain relief in patients with CLBP has been difficult, despite recent advances in SCS technology, such as programmable multicontact electrodes and the self-adjustment of the stimulation intensity

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Abbreviations: AACCI, age-adjusted Charlson's Comorbidity Index; BMI, body mass index; FBSS, failed back surgery syndrome; ODI, Oswestry's Disability Index; SCS, spinal cord stimulation; SPNS, subcutaneous peripheral nerve field stimulation; CLBP, chronic low back pain; VAS, Visual Analog Scale.

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(Barolat et al., 2001; North et al., 2006; Winkelmueller et al., 2016). Pain-paresthesia overlap is necessary for effective pain relief using SCS (Burton, 1977; North et al., 2006). Paresthesia refers to an uncomfortable sensation in the legs, flanks, or abdomen as the stimulation intensity increases (Barolat et al., 1993). Patients with CLBP often require frequent pain medication, including opioids. These are administered orally or by local injection and cannot be discontinued. Therefore, intrathecal pumps need to be implanted. The constant administration of morphine has significant adverse effects (Yakovlev et al., 2011). Invasive therapy in general including intrathecal morphine is not recommended in the current guidelines for CLBP (http://www.awmf.org/uploads/tx_szleitlinien/nvl-007l_S3_Kreuzschmerz_2017-03.pdf).

Subcutaneous peripheral nerve field stimulation (SPNS) is a novel approach to treating well-localized chronic pain syndromes and was first used to treat intractable occipital neuralgia (Weiner and Reed, 1999). SPNS has successfully treated a variety of neuropathies, including trigeminal, facial, intercostal, pelvic, and inguinal pain syndromes (Johnson and Burchiel, 2004, Tamimi et al., 2009; Yakovlev and Resch, 2010; Yakovlev et al., 2010). However, the efficacy of SPNS in patients with CLBP has not been well investigated (Paicius et al., 2007; Krutsch et al., 2008, McRoberts et al., 2013, Kloimstein et al., 2014).

The neurophysiological mechanism of SPNS is not completely understood. According to the 'gate-control-theory', subcutaneous stimulation of myelinated Aβ afferent nerve fibers inhibits myelinated Aδ and unmyelinated C fibers at the level of the spinal cord (Wall and Sweet, 1967). Local anti-inflammatory and membrane-depolarizing effects on subcutaneous fiber endings, or central activation of Aβ nerve afferents may also play a role (Reverberi et al., 2009).

Because treatment of CLBP with SPNS has not been well investigated, treatment guidelines are lacking. To the best of our knowledge, only a few studies have evaluated SPNS as therapy for CLBP. When investigating treatment of CLBP with SPNS, it is important to define patient selection, duration of trial stimulation, electrode selection and position, and follow-up care.

The aim of the present study was to evaluate the feasibility, safety, and efficacy of SPNS for isolated CLBP after conservative and/or surgical treatment had failed.

EXPERIMENTAL PROCEDURES

Patient demographics and preoperative diagnosis

Approval for this study was obtained from the local ethics committee (no. S-198). Twenty-six patients suffering from intractable CLBP for a minimum of 6 months without radiating leg pain were prospectively included. Detailed information on all patients including age, sex, duration of pain, other pain locations, psychiatric diseases, blood values (CRP, leukocytes and hemoglobin), previous and current surgical treatment as well as concomitant disease is contained in Table 1. Chronic symptoms were defined as persistent daily symptoms. Additional inclusion criteria included failed guideline-based conservative and medical treatment (http://www.awmf.org/uploads/tx_szleitlinien/nvl-007l_S3_Kreuzschmerz_2017-03.pdf, 2017), including opioids, that was supervised by the center of pain medicine for 6 months. All included patients had a recent CT and MRI scan that indicated no further spinal surgical intervention would be necessary. In addition, prior to treatment, all patients were referred to a psychiatrist to identify potential psychiatric–psychosomatic diseases that might interfere with treatment. One patient in the responder group and one patient in the non-responder group suffered from endogenous depression. In addition, one patient in the responder group suffered from bipolar disease. However, all three patients were stable, i.e. asymptomatic under psychiatric medication during the time course of this study. The inclusion and exclusion criteria are listed in Table 2. Patients were enrolled between December 2013 and December 2014. Informed consent was obtained from all patients. Surgeries were performed by the same surgeon (R.A.) at the same institution. The average patient age at surgery was 55.8 years (range 36–75 years).

Study documentation and clinical parameters

In responders, we measured low back pain with the Visual Analog Scale (VAS) preoperatively, 6 and 24 months after implantation of a permanent stimulator. Oswestry's Disability Index (ODI) and quality of life (EQ-5D-3L questionnaire) were completed by patients preoperatively, and 6 and 24 months postoperatively. The EQ-5D-3L questionnaire is a widely used instrument to measure health-related quality of life involves five questions. The score ranges from −0.11 to 1, with a higher score indicating better quality of life (Shaw et al., 2005; Devlin and Brooks, 2017). For non-responders, preoperative and follow-up scores at 24 months were available (VAS, EQ-5D-3L and ODI) for 11/13 patients. Two patients were lost to follow-up. Co-morbidities were assessed preoperatively using the age-adjusted Charlson Comorbidity Index (AACCI) (Deyo et al., 1992; de Groot et al., 2003). A routine clinical and neurological follow-up was performed before each patient was discharged from hospital. Further follow-ups were performed 14 days, 6 months, and 24 months after surgery. Variables such as current medical treatment, previous lumbar surgery, and body mass index (BMI) were recorded. Perioperative and postoperative complications were registered.

In responders, pain medication was reduced under supervision and was monitored at 3, 6, and 24 months after surgery. For non-responders, pain medication was assessed prior to test stimulation and at 24 months postoperatively. Operation success was determined by a subjective satisfaction rate based on a three-scale grading system: 'highly satisfied', 'satisfied', and 'not satisfied'.

Surgical technique

Trial stimulation. All included patients received temporary percutaneous stimulation for 14 days with

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