Peripheral neuromodulation for pain

Richard G. Bittara,b,c,d,*, Peter J. Teddya,b

aDepartment of Neurosurgery, Royal Melbourne Hospital, Parkville, Victoria, Australia
bDepartment of Surgery, The University of Melbourne, Parkville, Victoria, Australia
cDepartment of Neurosurgery, The Alfred Hospital, Prahran, Victoria, Australia
dDepartment of Surgery, Monash University, Prahran, Victoria, Australia

ABSTRACT

The past decade (1999–2009) has witnessed a dramatic increase in the use of electrical stimulation to treat chronic, intractable pain. The implantation of electrodes in close proximity to peripheral nerves, known as peripheral nerve stimulation, has been enthusiastically adopted by neurosurgeons and interventional pain specialists. The most common conditions treated with this technique are headache and complex regional pain syndromes. The potential application of peripheral neuromodulation to relatively common and frequently disabling conditions such as migraine and lower back pain represents an exciting phase in the evolution of contemporary pain surgery.

We review the available evidence relating to the use of peripheral nerve stimulation for the treatment of medically refractory, chronic non-cancer pain in a variety of clinical situations, highlight the absence of randomised controlled studies, and emphasise the need for scientifically sound research in this field.

Crown Copyright © 2009 Published by Elsevier Ltd. All rights reserved.

1. Introduction

Chronic non-cancer pain may affect up to one in five adults in the general community,1,2 and is often inadequately treated.3

While many patients with chronic pain are managed with a range of pharmacological, physical, and psychological modalities, the development of non-destructive surgical strategies known broadly as “neuromodulation” may offer hope to many patients with refractory pain. Neuromodulation, the reversible and adjustable blockade or manipulation of pain pathways to modify physiological function, may be applied to the spinal cord,4,5 deep brain structures,6 motor cortex,7 and peripheral nerves.8

We review the evidence pertaining to the use of peripheral nerve stimulation for the treatment of intractable headache and facial pain, neuropathic limb and trunk pain, and lower back pain.

2. Headache and facial pain

Peripheral nerve stimulation is utilised to ameliorate pain due to migraine, occipital neuralgia, cervicogenic headaches, cluster headache, as well as neuropathic facial pain. The most common nerves of the head and neck that are targeted are the occipital, supraorbital and supratrochlear nerves.

2.1. Transformed migraine

Transformed migraine, the most common cause of chronic daily headache, may affect up to 5% of the population,9 with significant pain and suffering as well as economic consequences. Data from two small, retrospective, uncontrolled studies suggest that occipital nerve stimulation results in less frequent, less severe, and less disabling headaches. The benefit is almost always partial, and seems to be maintained for at least 18 months of follow-up.

Schwedt et al. retrospectively studied a mixed group of 15 patients with chronic headache.10 Eight had chronic migraine and two suffered from hemicrania continua. The mean follow-up was 19 months. Although the results were not specified for each condition, headache frequency was reduced from 89 to 64 per 90 days. Headache severity on a visual analogue scale (VAS) decreased from 7.1 pre-operatively to 4.7 post-operatively, and the migraine disability score (MIDAS) was reduced by 39%.

Popeney and Aló performed occipital nerve stimulation on 25 patients with medically refractory transformed migraine, and retrospectively analysed their data.11 At a mean follow-up of 18
months, they observed a reduction in headache frequency (from 76 to 38 per 90 days) and severity (9.3 pre-operatively versus 5.7 post-operatively). The MIDAS score decreased by 89%.

2.2. Occipital neuralgia

Several small, uncontrolled studies (Class III and IV data) have investigated the use of occipital nerve stimulation in the treatment of occipital neuralgia. A wide range of pain syndromes have been classed as “occipital neuralgia” in these studies, and a frequently used entry criterion for occipital nerve stimulation, a positive response to local anaesthetic blockade of the occipital nerves, has recently been discredited. Nevertheless, encouraging results have been published.

Kapural et al. published a small retrospective series of patients (n = 6) with a very short follow-up of 3 months. They reported that all patients had a successful trial and underwent a permanent implantation. The mean VAS score decreased from 8.7 to 2.5. In a slightly larger retrospective study with a much longer follow-up, Johnstone and Sunderaj reported the outcomes of eight patients with a mean follow-up of 25 months. Seven of the eight patients had a successful trial of stimulation. Of the seven patients receiving a permanent system, a significantly reduced VAS pain score (>50%) was seen in five. Two patients were able to return to work following implantation of permanent occipital nerve stimulation systems.

In a larger series, Slaven et al. performed occipital nerve stimulation on 14 patients with occipital neuralgia. This was a retrospective study with a mean follow-up of 22 months. Ten of the 14 patients had a successful trial and underwent implantation of a permanent system. At follow-up, seven of the 10 patients continued to benefit significantly. Three systems were explanted: two due to complications (infection, neck tightness), and one due to complete resolution of pain. Reduced pain scores of 60% to 90% were documented in the remaining seven patients at follow-up.

2.3. Cervicogenic headache

Cervical spine pathology is an increasingly recognised cause of headaches, and may affect around 4% of the adult population. We are not aware of any published studies that specifically examine occipital nerve stimulation for the treatment of refractory cervicogenic headache. However, about 50% of patients with Slavin’s occipital neuralgia had a history of cervical spine surgery or injury, and about 50% of Sunderaj’s occipital neuralgia patients had significant cervical spine pathology or intervention.

2.4. Cluster headache

Two small uncontrolled studies have examined the efficacy of occipital nerve stimulation for the treatment of cluster headache. Magis et al. performed occipital nerve stimulation on eight patients with cluster headaches, with a mean follow-up of 15 months. One patient experienced no benefit. Two patients were rendered pain-free, with three experiencing around a 90% reduction in the frequency of their attacks. The remaining two patients gained an improvement of about 40% in terms of attack frequency. Headache severity diminished by an average of 50% in the remaining attacks. Burns et al. also performed occipital nerve stimulation on eight patients with cluster headaches, with a slightly longer mean follow-up of 20 months. Six of the eight patients derived an overall benefit, with a mean improvement of 60%. Three patients reduced their triptan intake following surgery.

2.5. Neuropathic facial pain

Amin et al. published a retrospective case series of 16 patients with supraorbital neuralgia, who underwent stimulation of the supraorbital nerve. A relatively short follow-up of 30 weeks was documented. Ten of the 16 patients underwent a successful trial of stimulation, which was followed by implantation of a permanent system. The mean pre-implantation headache score was 7.5; this decreased to 3.5 following implantation. Opioid consumption was reduced by 50% following implantation.

Johnson and Burchiel reported a retrospective case series of 11 patients with trigeminal neuropathic pain following herpetic infection or facial trauma. Intraorbital or supraorbital electrodes were used, according to the distribution of pain. Ten of the 11 individuals had a successful trial and received a permanent system. At 27 months mean follow-up, 80% of patients obtained a reduction in pain severity of more than 50%. Medication use declined in 70% of patients. All patients with traumatic neuropathic pain had a successful result, while only 50% (2/4) of post-herpetic facial pain patients obtained significant benefit.

3. Neuropathic limb and trunk pain

Complex region pain syndromes (CRPS) may occur following an injury to a nerve (CRPS Type 2) or tissues (CRPS Type 1). Several studies have examined the efficacy of peripheral nerve stimulation in this clinical context.

Hassenbusch et al. carried out a prospective, consecutive series of patients with CRPS with symptoms mainly in the distribution of a single major peripheral nerve. Plate-type electrodes were placed surgically on the affected nerves and tested for 2 days to 4 days. Programmable generators were implanted if 50% or more pain reduction as well as objective improvements in physical changes were achieved during the trial. These patients were followed for 2 years to 4 years. Of the 32 patients subjected to a trial of stimulation, 30 (94%) underwent a permanent system placement. Long-term good or fair relief was experienced in nearly two-thirds of patients. In the successfully treated patients, allodynic and spontaneous pain was reduced from 8.3 preimplantation to 3.5 at follow-up. Changes in vasomotor tone and patient activity levels were also markedly improved. Importantly, involvement of more than one major peripheral nerve correlated with a poor outcome.

Mobbs et al. retrospectively studied 45 neuropathic pain patients, with four aetiologic factors: blunt or sharp nerve trauma, iatrogenic injuries from surgery, inadvertent injection of a nerve, and pain following surgery for nerve entrapment or tumour. Their mean follow-up was 31 months. The initial trial failed in four patients. Six patients (15%) required removal of stimulators due to infection or loss of pain control after a good result initially. At follow-up, pain relief was judged as good (>50% reduction) by about 60%, and fair or poor in almost 40%. Nearly 47% of patients reported a significant improvement in their activity levels.

These two larger, albeit non-randomised with no control group (Class III evidence) studies with a reasonably long follow-up, suggest that peripheral nerve stimulation can provide good relief for CRPS that is limited to the distribution of one major nerve. Overall, around 60% of patients derive a benefit.

Case reports and small series have documented the successful application of peripheral nerve stimulation to post-operative neuropathic inguinal pain as well as abdominal pain due to chronic pancreatitis and following liver transplant. Stinson et al. performed peripheral nerve stimulation in three patients with intractable post-operative inguinal pain, and reported 75% to 100% pain relief after 3 months to 12 months follow-up.
4. Peripheral nerve (regional) field stimulation for lower back pain

A relatively recent application of peripheral neuromodulation has been in the treatment of chronic intractable lower back pain. This involves placement of a stimulating electrode subcutaneously in the area of maximum pain, and is known as peripheral nerve field stimulation (PNFS) or regional field stimulation. There are few published results, all of which are Class III or IV.

Paicius et al. performed PNFS for chronic lower back pain in six patients, five of whom previously underwent failed back surgery.25 The stimulation trial was successful in all patients. All patients reported at least a 50% reduction in pain VAS at follow-up, although the follow-up duration was not clearly reported. Krutsch et al. reported the use of PNFS for chronic lower back pain in a patient with failed back surgery.26 They reported a >90% reduction in lower back pain at 12 months follow-up.

In a larger series, Bernstein et al. used both spinal cord stimulation and PNFS in conjunction for lower back and leg pain.27 Twenty patients underwent surgery; however, the methodology varied and detailed results were not reported. They concluded that a combination of the two techniques provided greater benefit than either alone in most patients.

5. Conclusions

There exists a lack of Class I and Class II data relating to peripheral nerve and regional field stimulation. No randomised controlled trial of peripheral neuromodulation has ever been conducted. This creates a serious dilemma for surgeons desiring scientifically valid information on this technology. The available data are mostly anecdotal, Class III and IV. Interpretation of the published studies is difficult, owing to variable patient selection criteria and outcome measurements.

The published studies suggest that a significant proportion (60–70%) of patients with certain intractable pain syndromes will benefit from peripheral nerve stimulation. These include occipital neuralgia, transformed migraine, and neuropathic pain confined to single nerve distribution. Although most patients who undergo successful trial will obtain a long-term benefit from chronic stimulation, the revision rate is high, and the incidence of late loss of efficacy is significant. Other complications, including lead migration, infection, peripheral nerve injury, and hardware failure, may occur, but the risk of serious adverse events is relatively low.

There is a greater volume of evidence supporting the benefits of peripheral nerve stimulation compared to regional field stimulation; however, increasing interest in the latter, predominantly as it applies to the treatment of intractable lower back pain, may see this situation change.

Although the data pertaining to peripheral neuromodulation for pain is encouraging, well-designed, large prospective studies with long-term follow-up are needed if the evidence is to become compelling. Equally as important, cost-benefit analyses will also be imperative to justify the burgeoning use of this expensive technology.

References