Peripheral Nerve Stimulation

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Peripheral Nerve Stimulation

- New (?) approach
- Neuropathic pain syndromes
- “Off label” use of devices
- Limited clinical experience

White & Sweet, 1969
Traditional (old) approach

Direct exposure of the nerve
Placement of electrode next to the nerve trunk

Perineural fibrosis
Nerve manipulation
Large incisions

Published experience – ~350 cases (1969-2007)

Mobbs RJ, et al.
J Clin Neuroscience
2007 14:216–221
Percutaneous electrode insertion

Placement of electrode next to the nerve trunk
Epifascial plane

No nerve manipulation
Smaller incisions

Published experience – ~350 cases (1999-2007)

Weiner & Reed, Neuromodulation 1999
Current PNS indications

- Postsurgical neuropathic pain
- Inguinal pain
- Low back pain
- Postherpetic neuralgia
- Occipital neuralgia
- Cervicogenic headaches
- Cluster headaches
- Migraine headaches
- Fibromyalgia
Peripheral Nerve Stimulation

Definitions:

- TENS
- PENS
- PNS
- PNFS
  - PSNS, STS, SubQS
Recent PNS Books

- *Atlas of Implantable Therapies for Pain Management* by Timothy Deer
- *Peripheral Subcutaneous Stimulation: A Photographic Surgical Atlas* by Giancarlo Barolat M.D.
- *Peripheral Nerve Stimulation* by K.V. Slavin
Craniofacial PNS indications

- Postsurgical neuropathic pain
- Postherpetic neuralgia
- Occipital neuralgia
- Cervicogenic headaches
- Cluster headaches
- Migraine headaches
Occipital Neuralgia
Occipital Neuralgia

Peripheral Neurostimulation for Control of Intractable Occipital Neuralgia

Neuromodulation, Volume 2, Number 3, 1999, 217–221
Richard L. Weiner, MD, FACS* • Kenneth L. Reed, MD†
Occipital Neuralgia

Konstantin V. Slavin, M.D.
Hrachya Nersesyan, M.D., Ph.D.
Christian Wess, M.D.

Peripheral Neurostimulation for Treatment of Intractable Occipital Neuralgia

CONCLUSION: Overall, the beneficial effect from chronic stimulation in our series persisted in more than half of the patients for whom procedure was considered and in 80% of those who significantly improved during the trial and proceeded with internalization. Thus, chronic PNS may be a safe and relatively effective method for long-term treatment of chronic pain syndrome in patients with medically intractable ON.
Trigeminal Neuropathy
Post-Traumatic Neuropathy
(trigeminal branch stimulation)

Trigeminal Branch Stimulation for Intractable Neuropathic Pain: Technical Note
Neuromodulation, Volume 8, Number 1, 2005 7-13
Konstantin V. Slavin, MD ▪ Christian Wess, MD
Department of Neurosurgery, University of Illinois at Chicago, Chicago, Illinois
Supraorbital Neuralgia

Peripheral nerve stimulator for the treatment of supraorbital neuralgia: a retrospective case series

S Amin, A Buvanendran, K-S Park, JS Kroin & M Moric
Department of Anesthesiology, Rush Medical College at Rush University Medical Center, Chicago, IL, USA
Trigeminal Neuropathic Pain
(Gasserian Ganglion Stimulation)
Cluster Headaches
Cluster Headaches
(deep brain stimulation)

M. Leone • A. Franzini • G. Felisati • E. Mea • M. Curone • V. Tullo • G. Broggi • G. Bussone

Deep brain stimulation and cluster headache

doi:10.1093/brain/awh411

Hypothalamic stimulation in chronic cluster headache: a pilot study of efficacy and mode of action

J. Schoenen,1,2 L. Di Clemente,1 M. Vandenheede,1 A. Fumal,1,2 V. De Pasqua,1 M. Mouchamps,3 J.-M. Remacle3 and A. Maertens de Noordhout1
Cluster Headaches
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Cluster Headaches

Treatment of medically intractable cluster headache by occipital nerve stimulation: long-term follow-up of eight patients

Brian Burns, Laurence Watkins, Peter J Goadsby

Lancet 2007; 369: 1099-106

Occipital nerve stimulation for drug-resistant chronic cluster headache: a prospective pilot study

Delphine Magis, Marta Allena, Monica Boila, Victor De Pasqua, Jean-Michel Ramadre, Jean Schoenen

Lancet Neurol 2007; 6: 314-21

Therapeutic neurostimulation in chronic headaches: problems of patient selection

Massimo Leone · Alberto Proietti Cecchini · Eliana Mea · Domenico D’Amico · Vincenzo Tullo · Licia Grazzi · Gennaro Bussone

Cluster Headaches

Supraorbital Nerve Electric Stimulation for the Treatment of Intractable Chronic Cluster Headache: A Case Report

Samer N. Narouze, MD, MS; Leonardo Kapural, MD, PhD

We describe a patient with intractable chronic cluster headache that responded well to supraorbital nerve electric stimulation.

Key words: cluster headache, supraorbital nerve neuromodulation, ophthalmic nerve
Cluster Headaches

Electrical Stimulation of Sphenopalatine Ganglion for Acute Treatment of Cluster Headaches

(Headache 2010;50:1164-1174)

Mehdi Ansarinia, MD; Ali Rezai, MD; Stewart J. Tepper, MD; Charles P. Steiner, BS; Jenna Stump, MS; Michael Stanton-Hicks, MD; Andre Machado, MD; Samer Narouze, MD
Sphenopalatine Ganglion Stimulation

Sphenopalatine Ganglion Interventions:
Technical Aspects and Application
Migraines
Migraines

Background.—Up to 5% of the general population suffers from transformed migraine. This study analyzes clinical responses of transformed migraine to cervical peripheral nerve stimulation.

Methods.—Headache frequency, severity, and disability (Migraine Disability Assessment [MIDAS] scores) were independently measured in an uncontrolled consecutive case series of 25 patients with transformed migraine implanted with C1 through C3 peripheral nerve stimulation. All patients met International Headache Society (IHS) criteria for episodic migraine, as well as suggested criteria for transformed migraine, and had been refractory to conventional treatment for at least 6 months. Responses to C1 through C3 peripheral nerve stimulation were recorded.

Results.—Prior to stimulation, all patients experienced severe disability (grade IV on the MIDAS) with 75.56 headache days (average severity, 9.32; average MIDAS score, 121) over a 3-month period.

Following stimulation, 15 patients reported little or no disability (grade I), 1 reported mild disability (grade II), 4 reported moderate disability (grade III), and 5 continued with severe disability (grade IV), with 37.45 headache days (average severity, 5.72; average MIDAS score, 15). The average improvement in the MIDAS score was 88.7%, with all patients reporting their headaches well controlled after stimulation.

Conclusions.—These results raise the possibility that C1 through C3 peripheral nerve stimulation can help improve transformed migraine symptoms and disability. A controlled study is required to confirm these results.

Peripheral Neurostimulation for the Treatment of Chronic, Disabling Transformed Migraine

Charles A. Popeney, DO; Kenneth M. Aló, MD

(Headache 2003;43:369-375)
Migraines

Large Scale Occipital Nerve Stimulation Trials:

- Medtronic – Occipital Nerve Stimulation for Treatment of Intractable Migraine (ONSTIM) – completed

- Boston Scientific - Occipital Nerve Stimulation for Drug-Refractory Migraine (PRISM study) – completed

- St. Jude Medical (ANS) - A Clinical Evaluation for the Management of Chronic Migraine Headaches with Peripheral Nerve Stimulation – completed

- Boston Scientific – Multi-Center Prospective Study of ONS for Migraine Headaches (OPTIMISE) – in preparation
Migraines

Occipital Nerve Stimulation for Treatment of Intractable Migraine (ONSTIM trial)

3 month results
Single-blind randomized trial
110 pts enrolled, 75 treated, 66 w/ 3 months f/u
Adjustable stim (AS) vs. preset stim (PS) vs. med mgmt (MM)
HA improvement 27% AS vs. 9% PS vs. 4% MM
Responder rate: 39% AS, 6% PS, 0% MM

Saper, NANS 08
Migraines

Occipital Nerve Stimulation for Drug-Refractory Migraine (PRISM study)

2 year results
Single-blind randomized sham-controlled trial
140 pts enrolled, 132 treated, 125 w/ 3 months f/u
Difference in reduction of migraine days/month was not significant (-5.5 d/mo in active group vs. -3.9 in sham)
Trend towards greater difference for those not overusing medications vs. overuse group (-5.9 vs. -2.6 and -5.0 vs. -4.0)

Lipton, NANS 09
PNS for Migraines

Occipital Nerve Stimulation for the Management of Chronic Migraine (SJM)

1 year results
Double-blind prospective multi-center randomized sham-Controlled trial (Active or Control groups for 12 weeks)
157 patients
Significant differences in all assessments at 12 weeks
Reduction of migraine days/month, total MIDAS scores, Zung PAD scores, VAS score, QoL improvement
1.0% of serious adverse events

Silberstein, IHC 2011
Migraines

A novel approach to the treatment of chronic migraine headaches based on neurostimulation of both occipital and supraorbital nerves was developed and reduced to clinical practice in a series of patients with headaches unresponsive to currently available therapies. Following positive trials, seven patients with chronic migraine and refractory chronic migraine headaches had permanent combined occipital nerve-supraorbital nerve neurostimulation systems implanted. The relative responses to two stimulation programs were evaluated: one that stimulated only the occipital leads and one that stimulated both the occipital and supraorbital leads together. With follow-up ranging from 1 to 35 months all patients reported a full therapeutic response but only to combined supraorbital–occipital neurostimulation. Occipital nerve stimulation alone provided a markedly inferior and inadequate response. Combined occipital nerve-supraorbital nerve neurostimulation systems may provide effective treatment for patients with chronic migraine and refractory chronic migraine headaches. For patients with chronic migraine headaches the response to combined systems appears to be substantially better than occipital nerve stimulation alone.

Is the solution in combining occipital and supraorbital PNS?
PNS in headaches: How does it work?
PNS in headaches: How does it work?

Mechanism of action

- Central modulatory effect linked to the convergence of C2 afferents and trigeminal afferents at the second order neurons in the trigeminocervical complex (Bartsch, 02, 03)
- Activation of thalamus and cingulate cortex in response to occipital nerve stimulation (Matharu, 04)
PNS in headaches: How does it work?

Stimulation of the greater occipital nerve induces increased central excitability of dural afferent input

Thorsten Bartsch and Peter J. Goadsby
Low Back Pain
Low Back Pain

“Peripheral Nerve Field Stimulation”

6 patients, short-term
Paicius, 2007
Low Back Pain

“Subcutaneous Peripheral Nerve Stimulation”

1 patient, short-term
Krutsch. 2008
Low Back Pain

“Peripheral Nerve Stimulation”

14 patients, long-term
Verrills, 2009
Low Back Pain

“Cross Talk
PNS concept”

Falco, 2009
Hybrid neurostimulation

Combination of SCS and PNS

Our experience – 12 patients

Lipov/Slavin, ASSFN - Vancouver, 2008
Hybrid neurostimulation

Combination of SCS and PNS

20 patients
Bernstein, 2008
Low Back Pain

Multi-center European study
(111 patients)
Sator-Katzenschlager, et al.
2010

Subcutaneous Target Stimulation (STS) in Chronic Noncancer Pain: A Nationwide Retrospective Study
Pain Practice, Volume 10, Issue 4, 2010 279–286
Low Back Pain

Table 1. Subcutaneous Target Stimulation: Exclusion Criteria

1. A pathophysiologic contraindication (eg, a chief complaint of mechanical low back pain)
2. Abnormal pain behavior
3. Unresolved psychiatric illness
4. Unresolved issues of secondary gain
5. Another coexisting chronic pain problem or chronic neurologic disease
6. A coexisting condition that would increase procedural risk (eg, sepsis, coagulopathy)
7. Inappropriate use of medication
8. Patients who applied for litigation

Table 2. Diagnostic Classification According to International Classification of Diseases (ICD)-10-Code (WHO) and Average Pain Intensity (Numerical Rating Scale [NRS]) before and after Implantation of Patients Included into the Analysis.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>ICD-10-Code</th>
<th>N</th>
<th>Mean (SD) NRS before Implantation</th>
<th>Mean (SD) NRS after Implantation</th>
<th>Corrected P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed back surgery syndrome</td>
<td>M96.1</td>
<td>37</td>
<td>8.0 (1.4)</td>
<td>3.3 (2.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Low back pain</td>
<td>M54.5</td>
<td>29</td>
<td>8.3 (0.9)</td>
<td>4.2 (2.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Chronic cervical or neck pain</td>
<td>M54.92</td>
<td>15</td>
<td>8.4 (0.9)</td>
<td>4.9 (2.2)</td>
<td>0.0313</td>
</tr>
<tr>
<td>Postherpetic neuralgia</td>
<td>B02.2</td>
<td>12</td>
<td>8.2 (1.0)</td>
<td>4.5 (2.7)</td>
<td>0.0059</td>
</tr>
<tr>
<td>Tension headache</td>
<td>G44.2</td>
<td>10</td>
<td>8.3 (0.7)</td>
<td>5.4 (1.6)</td>
<td>0.0313</td>
</tr>
<tr>
<td>Trigeminal neuralgia</td>
<td>G50.0</td>
<td>4</td>
<td>8.0 (0.0)</td>
<td>3.0 (2.0)</td>
<td>0.7500</td>
</tr>
<tr>
<td>Thoracic back pain</td>
<td>R07.4</td>
<td>4</td>
<td>8.8 (1.5)</td>
<td>2.5 (0.6)</td>
<td>0.7500</td>
</tr>
</tbody>
</table>

Subcutaneous Target Stimulation (STS) in Chronic Noncancer Pain: A Nationwide Retrospective Study

Pain Practice, Volume 10, Issue 4, 2010 279–286

Sabine Sator-Katzenschlager, MD; Katharina Fiala, MD; Hans G. Kress, MD, PhD; Alexandra Kofler, MD; Josef Neuhold, MD; Herwig Kloimstein, MD; Wilfried Illias, MD; Eva-Maria Mozes-Balla, MD; Michaela Pinter, MD; Nadja Loining, MD; Wolfgang Fuchs, MD; Georg Heinze, PhD; Rudolf Likar, MD
Neck Pain
Paraspinal Subcutaneous Stimulation

Use of Peripheral Subcutaneous Field Stimulation for the Treatment of Axial Neck Pain: A Case Report

Eugene G. Lipov, MD
Jaydeep R. Joshi, MD
Sarah Sanders, PA-C
Konstantin V. Slavin, MD

NEUROMODULATION: TECHNOLOGY AT THE NEURAL INTERFACE
Volume 12 • Number 4 • 2009
Abdominal / Inguinal Pain
Abdominal Stimulation (post-herniorrhaphy)
Chest Pain / Angina Pectoris
Chest Wall Stimulation (angina pectoris)

Subcutaneous Electrical Nerve Stimulation: A Feasible and New Method for the Treatment of Patients With Refractory Angina

Maurits S. Buitien, BSc, Mike J.L. DeJongste, MD, Uli Beese, MD, Cor Kliphuis, PA, Ans Durenkamp NP, Michiel J. Staal, MD

Neuromodulation 2011; 14: 258–265
Chest Wall Stimulation (angina pectoris)
Pain in Extremities
Novel approach for peripheral subcutaneous field stimulation for the treatment of severe, chronic knee joint pain after total knee arthroplasty

William Porter McRoberts, MD, Martin Roche, MD

Neuromodulation 2010; 13: 131–136
Post-ICBG harvesting
hip pain

Treatment of Chronic Intractable Hip Pain After Iliac Crest Bone Graft Harvest Using Peripheral Nerve Field Stimulation
Alexander E. Yakovlev, MD, Beth E. Resch, APNP+

Neuromodulation 2011; 14: 156–159
Post-amputation neuroma pain

Blocking pain transmission through the use of high frequency alternating current
Post-carpal tunnel pain

“StimRouter”: Implantable PNS device coupled with external transmitter
PNS complication prevention

Migration
“Out” migration
Extreme “out” migration
“In” migration
Simplified revision technique
PNS complication prevention

Correctness of the electrode depth
Insertion plane

Too deep

Too superficial

Occipital Neurostimulation-Induced Muscle Spasms: Implications for Lead Placement
Salim M. Hayek, MD, PhD1, Joseph F. Jasper, MD2, Timothy R. Deer, MD1, and Samir N. Narouze, MD2
Pain Physician 2009; 12:867-876

Percutaneous Occipital Stimulator Lead Tip Erosion: Report of 2 Cases
Terrence L. Trentman, MD, David W. Dodick, MD, Richard S. Zimmerman, MD, and Barry D. Birch, MD
Pain Physician 2008; 11:253-256
Electrode erosion
Erosion prevention

Electrode insertion plane
Erosion prevention

Electrode insertion plane
Electrode erosion

Electrode insertion plane
PNS complication prevention

Infection control
Infection
Prevention of infection

- Perioperative antibiotics
- Avoid excessive tissue dissection
- Meticulous hemostasis
- Appropriate size of incision
  - Not too small
  - Not too large
- Avoid over-tightening of the sutures
- Plan exit site of trial electrodes to avoid crossing the path of permanent device
Infection risk reduction

Trial vs. Permanent Implant
Best electrodes?
Fibromyalgia
(occipital nerve stimulation)

C2 Area Neurostimulation: A Surgical Treatment for Fibromyalgia

Mark Thimineur, MD,* and Dirk De Ridder, MD, PhD†
Thank you!