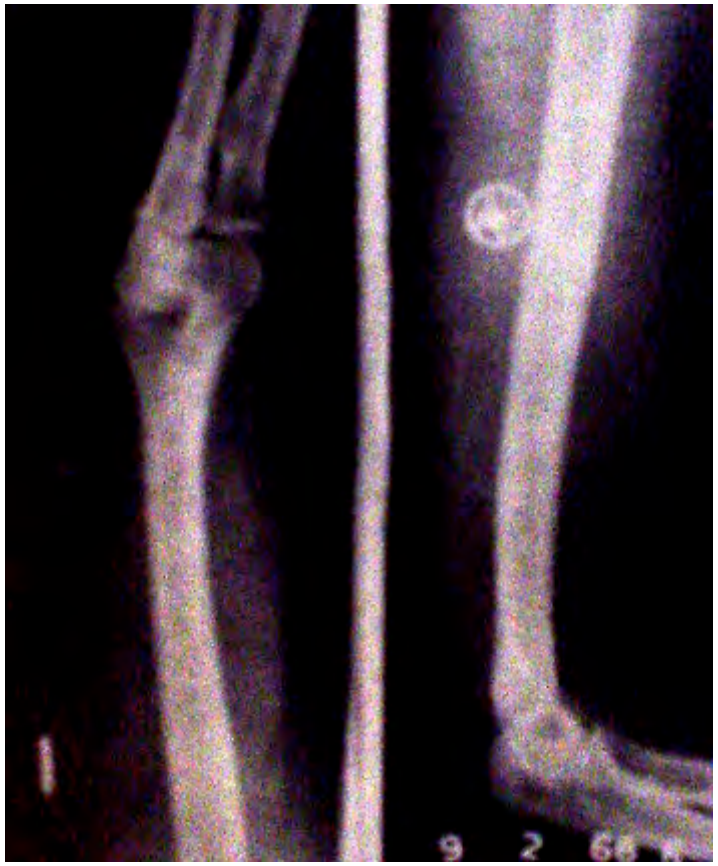
Peripheral Nerve Stimulation

Konstantin Slavin, MD
Professor, Department of Neurosurgery
University of Illinois at Chicago

Peripheral Nerve Stimulation

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



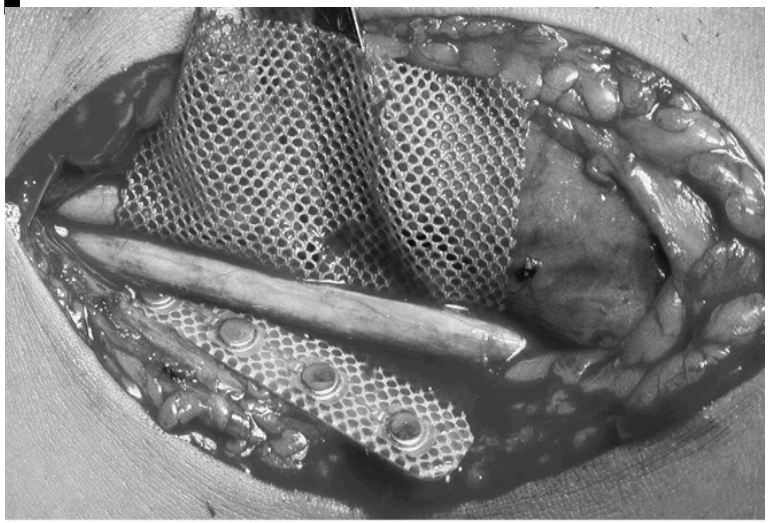
White & Sweet, 1969

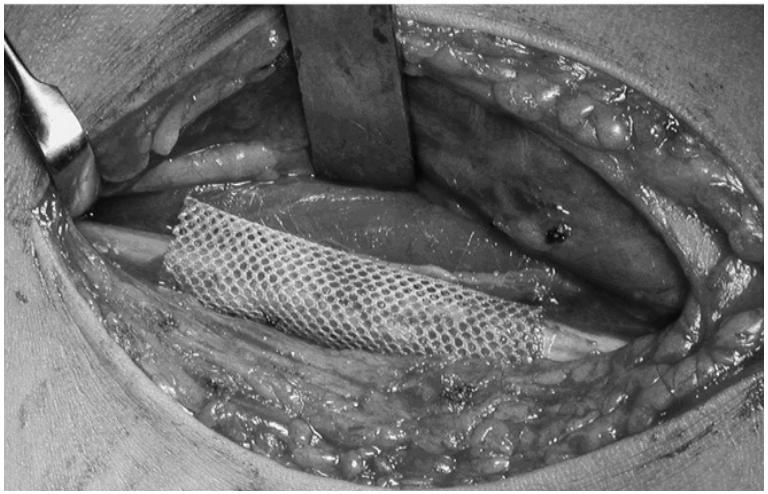
Traditional (old) approach

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:

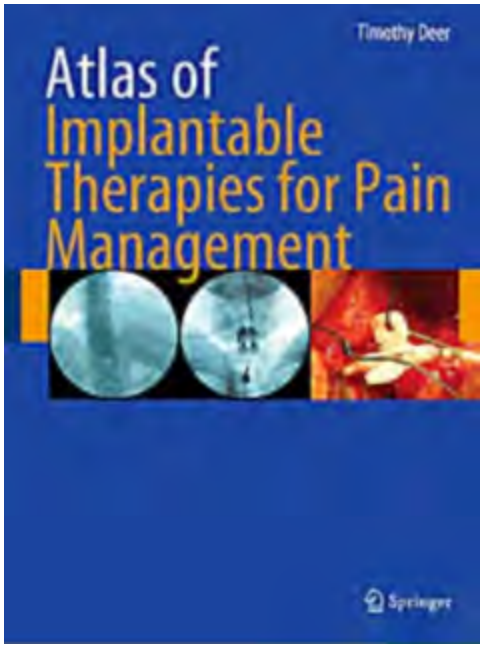
- TENS
- PENS
- PNS
- PNFS
  - PSNS, STS, SubQS

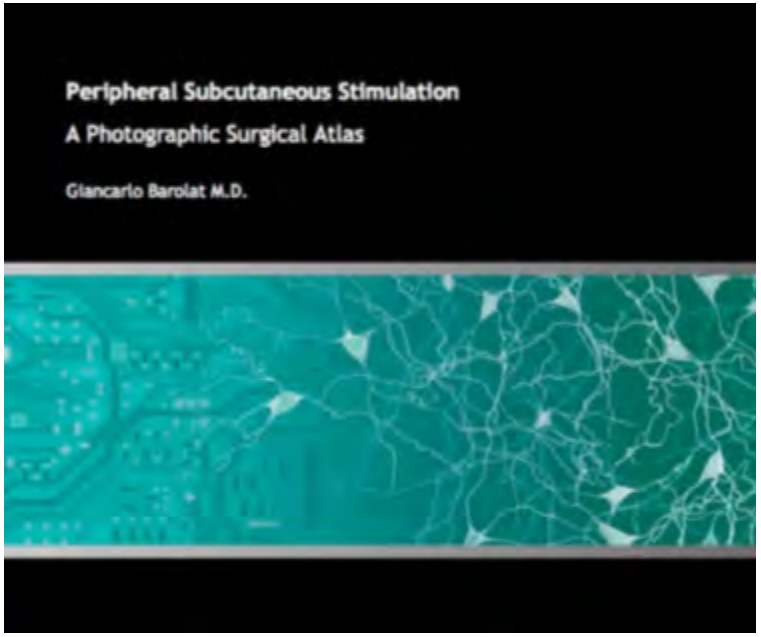
Differentiating the Leaves From the Branches in the Tree of Neuromodulation: The State of Peripheral Nerve Field Stimulation

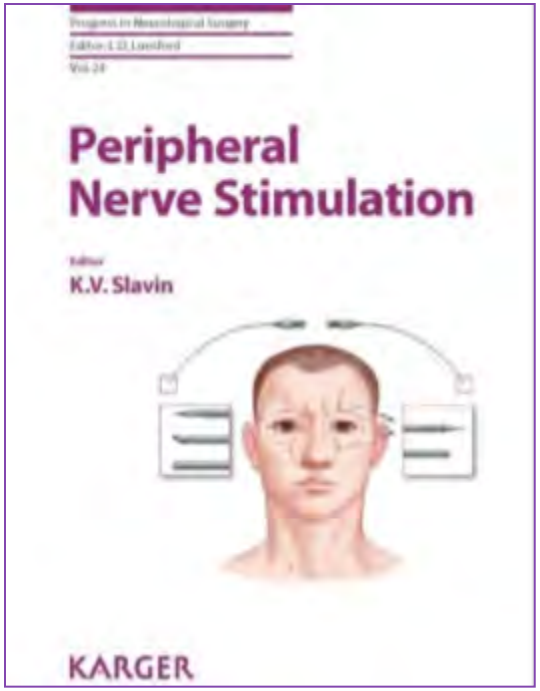
Robert M. Levy, MD, PhD

Neuromodulation 2011; 14: 201–205

Recent PNS Books







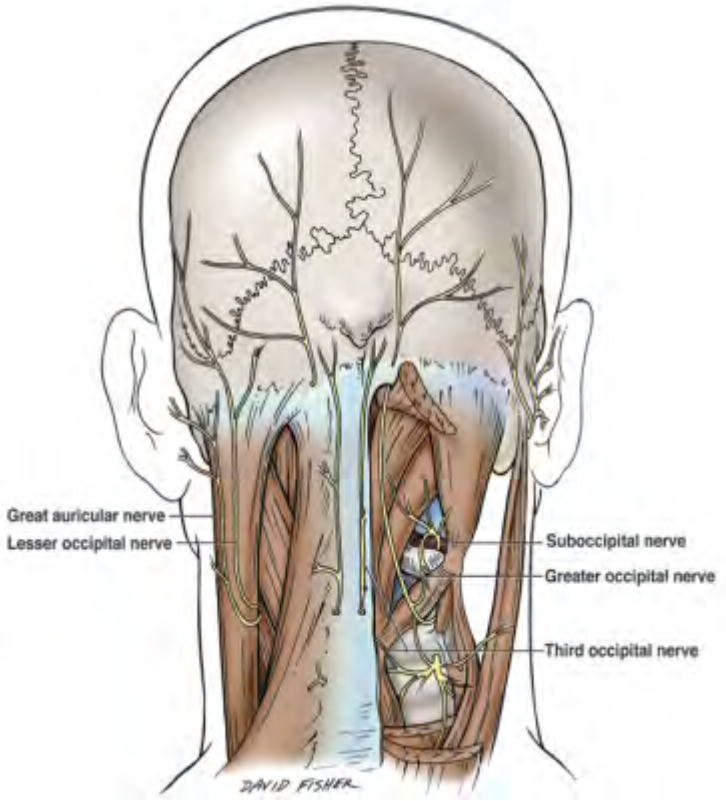
Craniofacial PNS indications

- Postsurgical neuropathic pain
- Postherpetic neuralgia

- Occipital neuralgia
- Cervicogenic headaches

- Cluster headaches
- Migraine headaches

Occipital Neuralgia

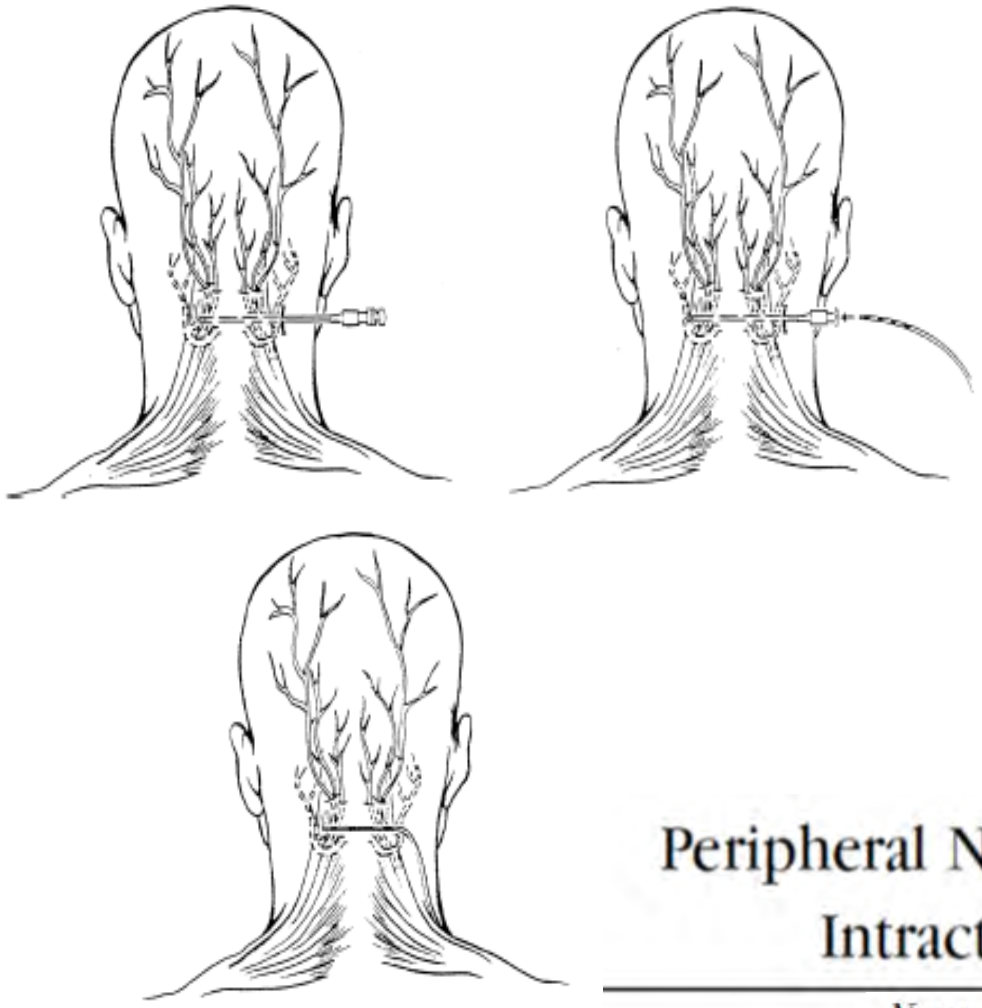


Anatomical study of the third occipital nerve and its potential role in occipital headache/neck pain following midline dissections of the craniocervical junction

J Neurosurg Spine 15:71–75, 2011

R. Shane Tubbs, M.S., P.A.-C., Ph.D.,[1] Martin M. Mortazavi, M.D.,[1] Marios Loukas, M.D., Ph.D.,[2] Anthony V. D'Antoni, Ph.D.,[3] Mohammadali M. Shoja, M.D.,[4] Joshua J. Chern, M.D., Ph.D.,[1] and Aaron A. Cohen-Gadol, M.D., M.Sc.[5]

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.

CLINICAL STUDIES

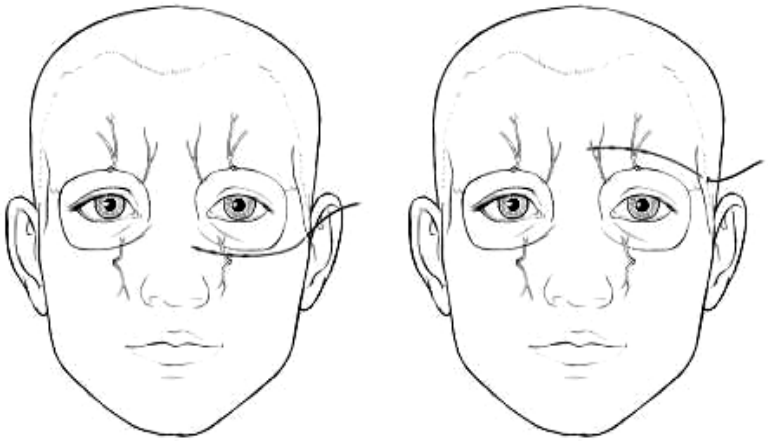
Neurosurgery 58:112-119, 2006

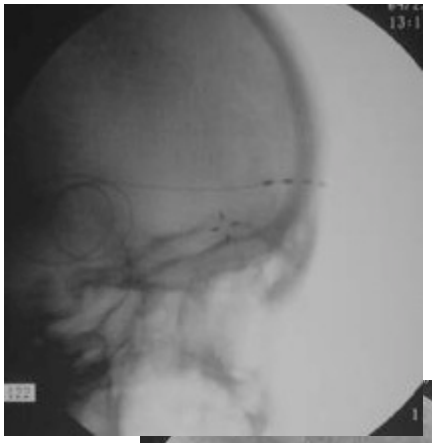
PERIPHERAL NEUROSTIMULATION FOR TREATMENT OF INTRACTABLE OCCIPITAL NEURALGIA

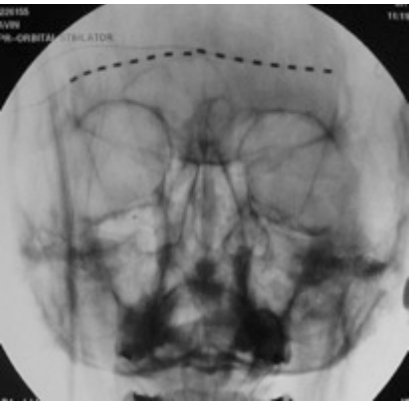
CONCLUSION: Overall, the beneficial effect from chronic stimulation in our series persisted in more than half of the patients for whom procedure was considered and in 80% of those who significantly improved during the trial and proceeded with internalization. Thus, chronic PNS may be a safe and relatively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

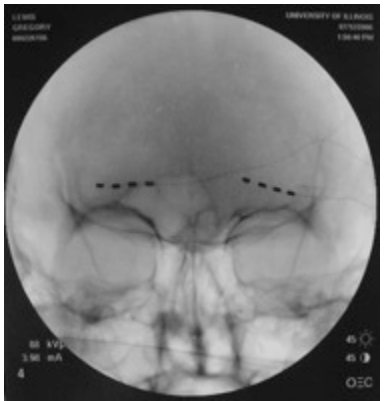
Trigeminal Neuropathy

Post-Traumatic Neuropathy (trigeminal branch stimulation)









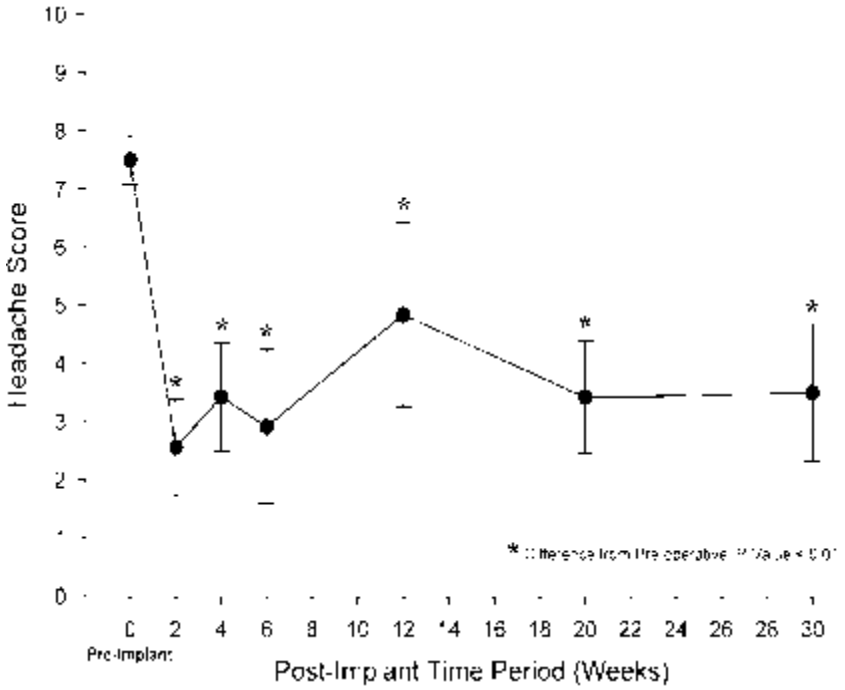
Trigeminal Branch Stimulation for Intractable Neuropathic Pain: Technical Note

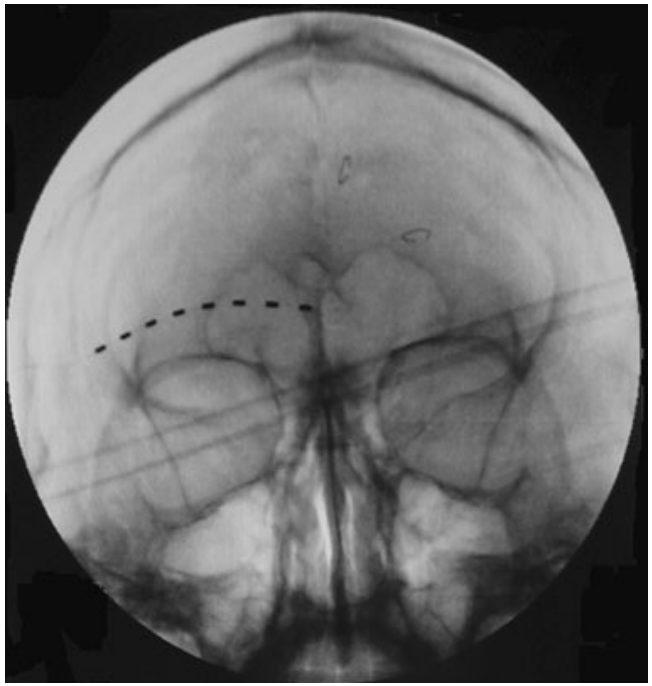
Neuromodulation, Volume 8, Number 1, 2005 7-13

Konstantin V. Slavin, MD ▪ Christian Wess, MD

Department of Neurosurgery, University of Illinois at Chicago, Chicago, Illinois

Supraorbital Neuralgia





Cephalalgia

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

Cephalalgia 2008; 28:355–359.

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)

Chronic Stimulation of the Gasserian Ganglion in patients with Trige… Neuropathy: A Case Series.

www.neurosurgicalreview.com

JNR 2011; 1(S1)

Jean-Pierre Van Buyten[1] & Caroline Hens[1]

Abstract: Between 2009 and 2011 we implanted 8 patients with refractory Trigeminal Neuropathic Pain (TNP) with a custom, tined, percutaneous, tripolar electrode to stimulate the Gasserian Ganglion (TGS). The electrode was positioned with the help of a three dimensional (3D), real-time, tip-tracked, electromagnetic (EM) guidance system. This technique reduced operating time, and augmented electrode targeting and procedural safety. Six of the eight patients had pain relief of at least 30%, all significantly tapered medication-intake (4 stopped opiods completely), two had minor dislocations, and none suffered any major complication. This EM stimulation technique is a valuable, reversible, minimally invasive method to treat refractory TNP.

Cluster Headaches

Cluster Headaches (deep brain stimulation)

Neurol Sci (2005) 26:S138–S139
DOI 10.1007/s10072-005-0427-4

HEADACHES: FOCUS ON NEW TREATMENTS

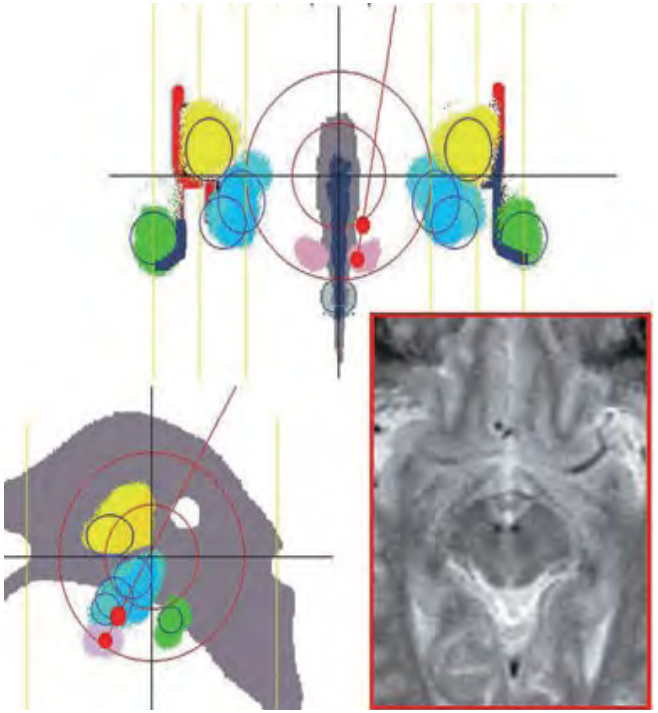
M. Leone • A. Franzini • G. Felisati • E. Mea • M. Curone • V. Tullo • G. Broggi • G. Bussone

Deep brain stimulation and cluster headache

doi:10.1093/brain/awh411 *Brain* (2005), **128**, 940–947

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. Remacle[3] and A. Maertens de Noordhout[1]



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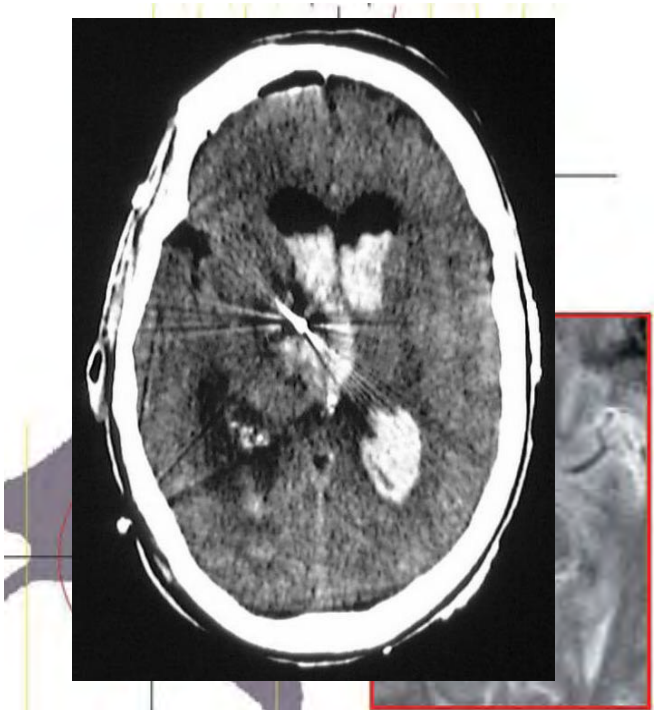


Cluster Headaches

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

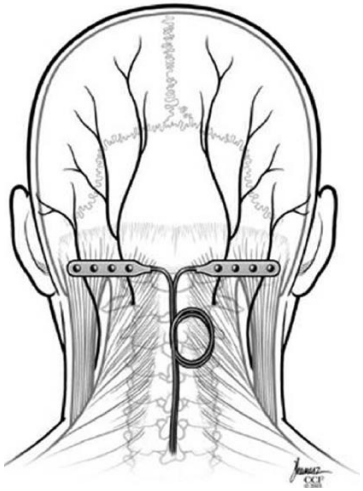
Lancet Neurol 2007; 6: 314–21

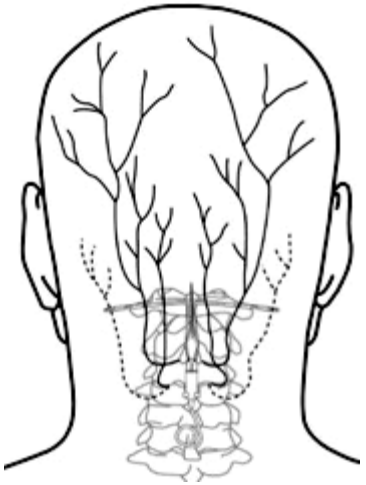
Delphine Magis, Marta Allena, Monica Bolla, Victor De Pasqua, Jean-Michel Remacle, Jean Schoenen

Therapeutic neurostimulation in chronic headaches: problems of patient selection

Neurol Sci (2008) 29:S59–S61

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





Cluster Headaches

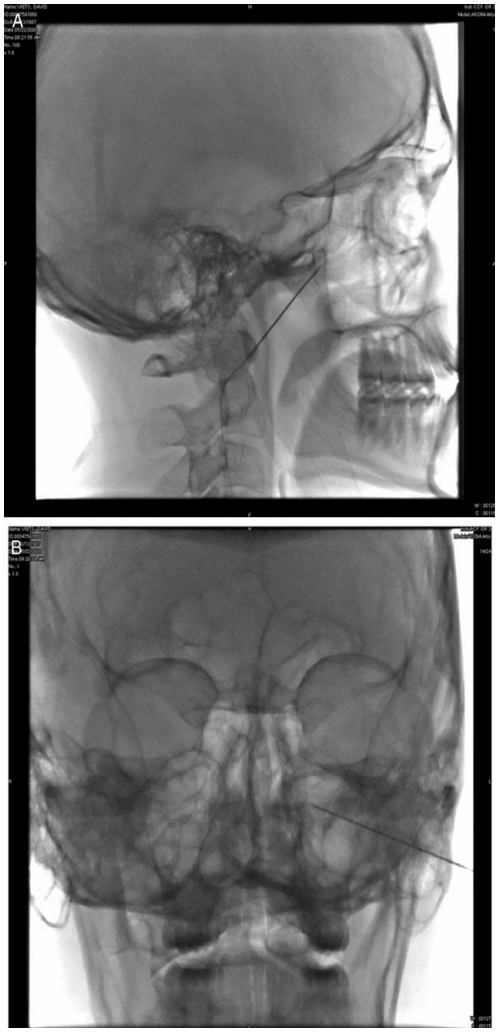
Supraorbital Nerve Electric Stimulation for the Treatment of Intractable Chronic Cluster Headache: A Case Report

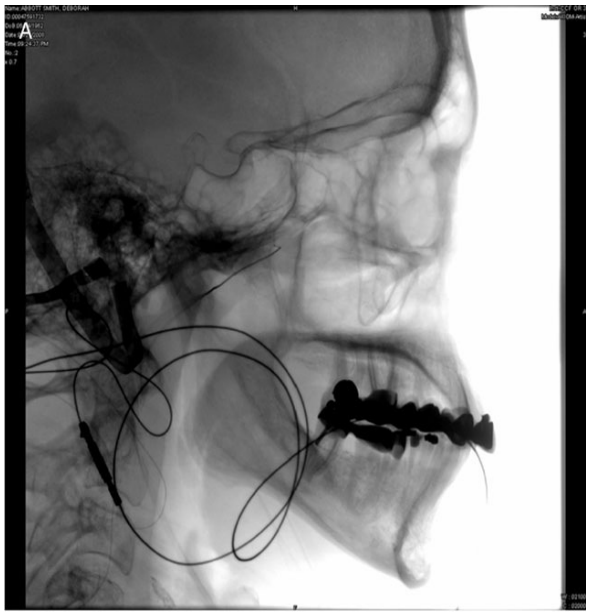
Samer N. Narouze, MD, MS; Leonardo Kapural, MD, PhD

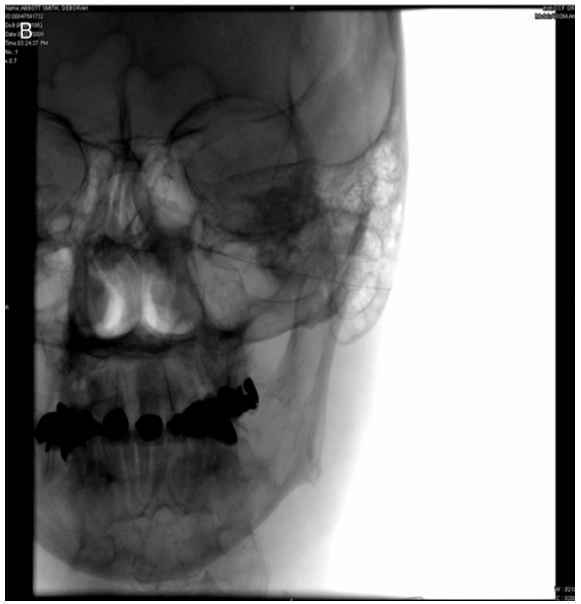
We describe a patient with intractable chronic cluster headache that responded well to supraorbital nerve electric stimulation.

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

Cluster Headaches





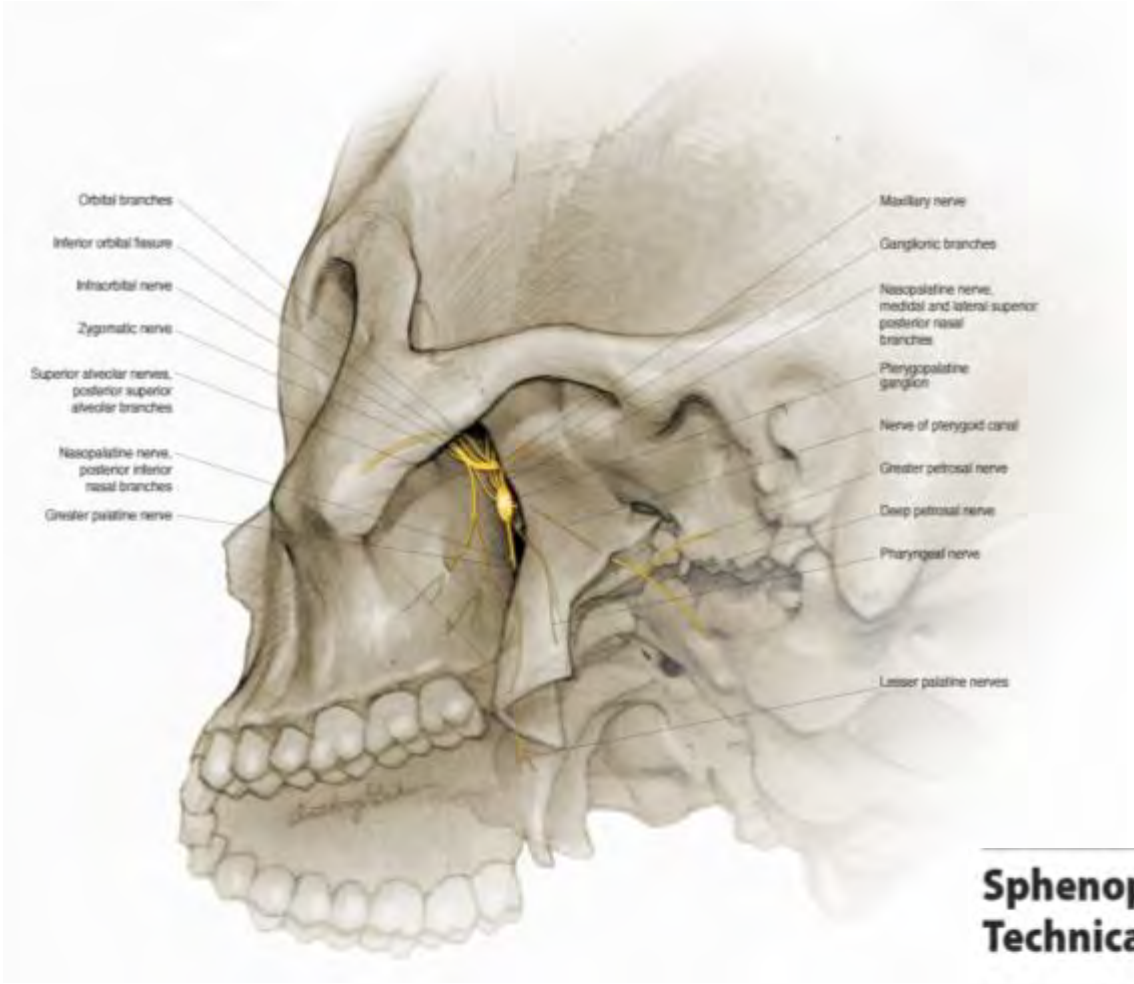


Electrical Stimulation of Sphenopalatine Ganglion for Acute Treatment of Cluster Headaches

(*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

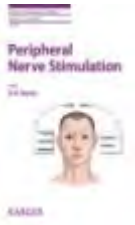
Sphenopalatine Ganglion Stimulation



Sphenopalatine Ganglion Interventions: Technical Aspects and Application

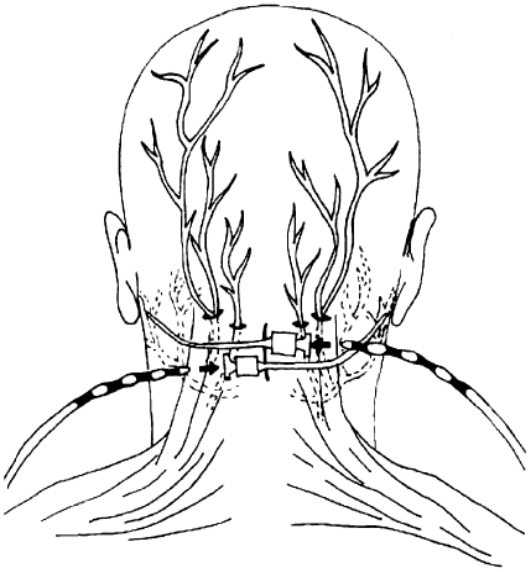
Chima O. Oluigbo[a] · Girma Makonnen[a] · Samer Narouze[b] · Ali R. Rezai[a]

Slavin KV (ed): Peripheral Nerve Stimulation.
Prog Neurol Surg. Basel, Karger, 2011, vol 24, pp 171–179



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 68.7%, 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:

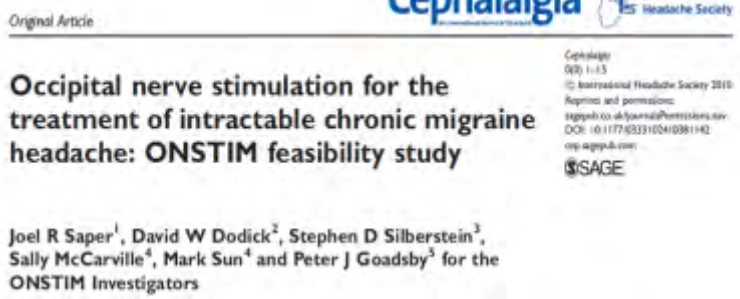
- Medtronic – Occipital Nerve Stimulation for Treatment of Intractable Migraine (ONSTIM) – completed
- Boston Scientific - Occipital Nerve Stimulation for Drug-Refractory Migraine (PRISM study) – completed
- St. Jude Medical (ANS) - A Clinical Evaluation for the Management of Chronic Migraine Headaches 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


Original Article

Cephalalgia

International Headache Society

Occipital nerve stimulation for the treatment of intractable chronic migraine headache: ONSTIM feasibility study

SAGE

Joel R Saper[1], David W Dodick[2], Stephen D Silberstein[3], Sally McCarville[4], Mark Sun[4] and Peter J Goadsby[5] for the ONSTIM Investigators

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

PRISM study: occipital nerve stimulation for treatment-refractory migraine *Cephalalgia*, **29** (Suppl. 1) (2009) 1–166
Lipton RB[1], Goadsby PJ[2], Cady RK[3], Aurora SK[4], Grosberg BM[1], Freitag FG[5], Silberstein SD[6], Whiten DM[7] and Jaax KN[7]

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?

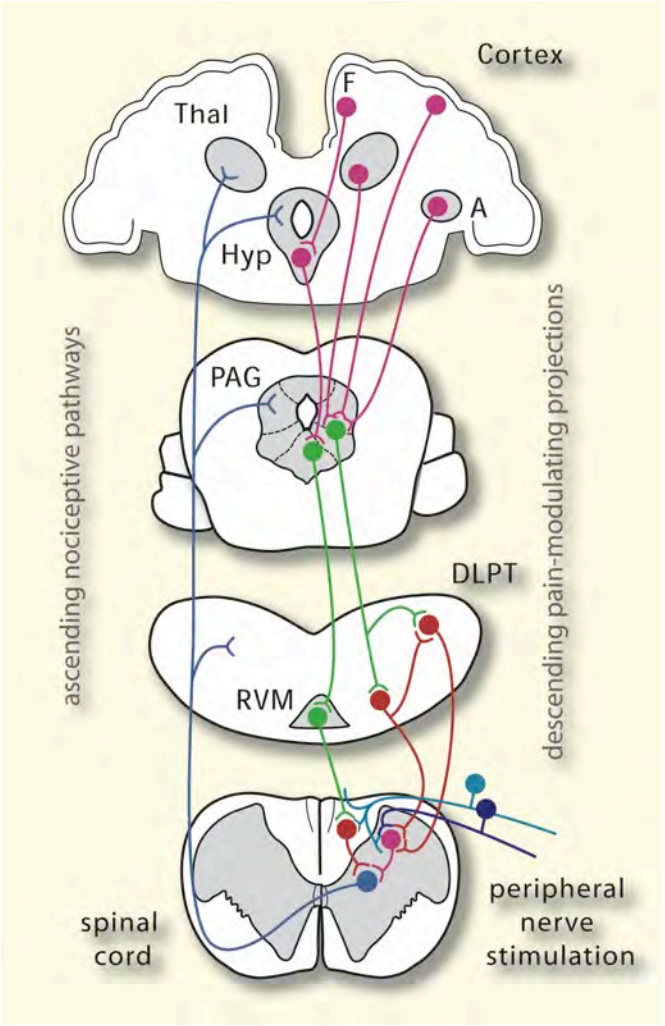
Cephalalgia
An International Journal of Headache
International Headache Society
doi:10.1111/j.1468-2982.2009.01996.x

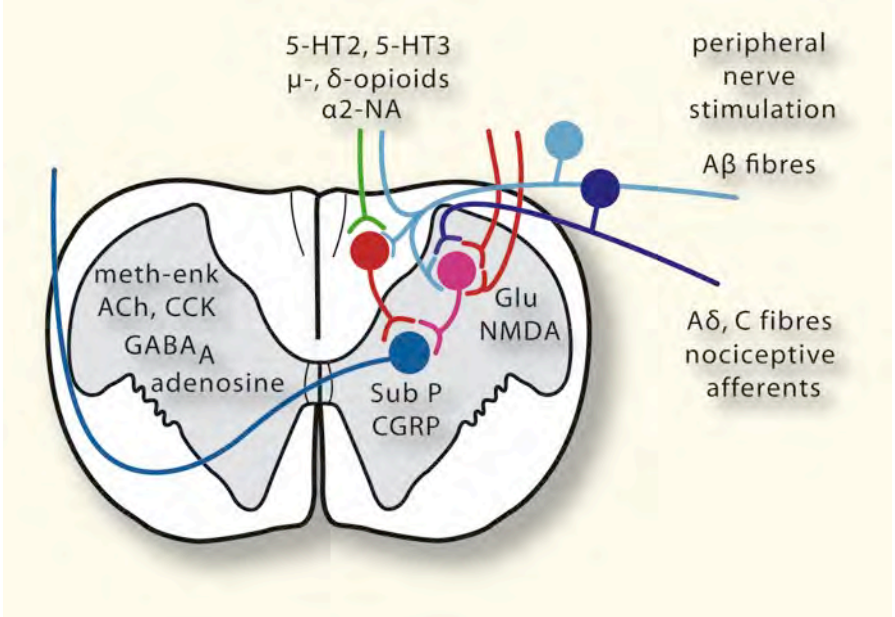
Combined occipital and supraorbital neurostimulation for the treatment of chronic migraine headaches: initial experience

Cephalalgia 2009.

KL Reed[1], SB Black[2], CJ Banta II[3] & KR Will[1]
[1]Department of Anesthesiology, Presbyterian Hospital of Dallas, [2]Medical Director of Neurology, Baylor University Medical Center of Dallas, and [3]Department of Orthopedic Surgery, Presbyterian Hospital of Dallas, Dallas, TX, USA

PNS in headaches: How does it work?





Central Mechanisms of Peripheral Nerve Stimulation in Headache Disorders

Thorsten Bartsch[a] · Peter J. Goadsby[b]

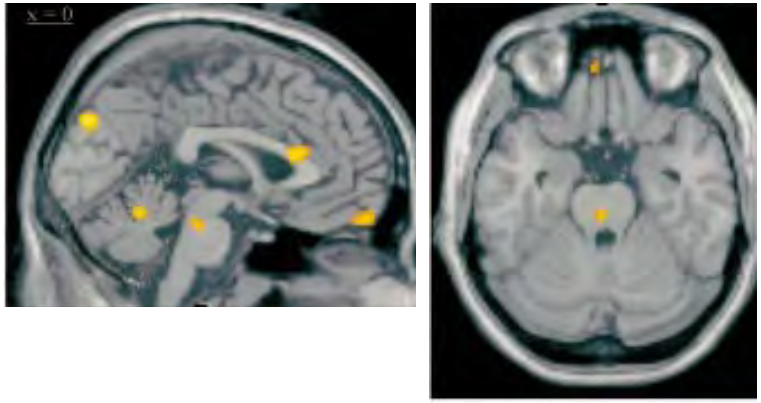
[a]Department of Neurology, University Hospital of Schleswig Holstein, University of Kiel, Kiel, Germany; [b]Headache Group, Department of Neurology, University of California, San Francisco, San Francisco, Calif., USA

Slavin KV (ed): Peripheral Nerve Stimulation.
Prog Neurol Surg. Basel, Karger, 2011, vol 24, pp 16–26

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)

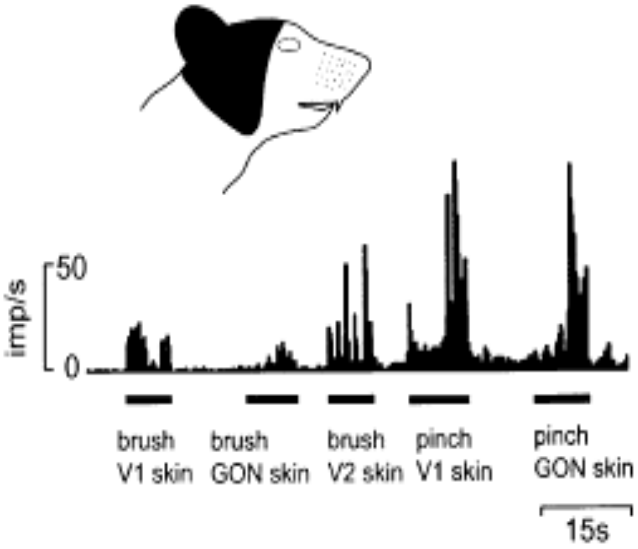


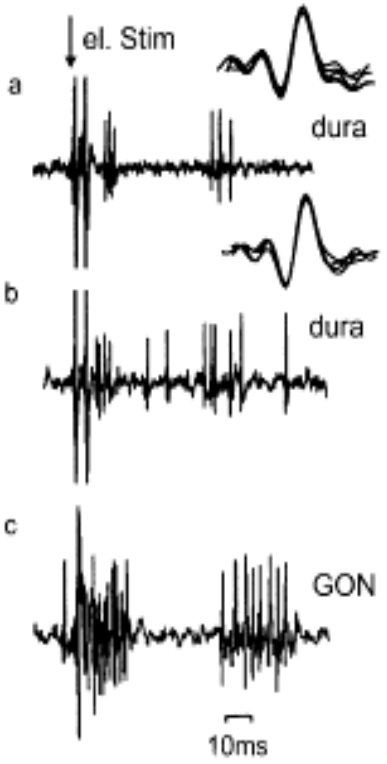
DOI: 10.1093/brain/awh022 Advanced Access publication November 7, 2003 *Brain* (2004), **127**, 220–230

Central neuromodulation in chronic migraine patients with suboccipital stimulators: a PET study

Manjit S. Matharu,[1] Thorsten Bartsch,[1] Nick Ward,[2] Richard S. J. Frackowiak,[2] Richard Weiner[3] and Peter J. Goadsby[1]

PNS in headaches: How does it work?





Brain (2002), **125**, 1496–1509

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

NEUROMODULATION: TECHNOLOGY AT THE NEURAL INTERFACE

Volume 10 • Number 3 • 2007
http://www.blackwell-synergy.com/loi/ner

ORIGINAL ARTICLE

Peripheral Nerve Field Stimulation for the Treatment of Chronic Low Back Pain: Preliminary Results of Long-Term Follow-up: A Case Series

Richard M. Paicius, MD* • Clifford A. Bernstein, MD† • Cheryl Lempert-Cohen, MD‡

Low Back Pain

"Subcutaneous Peripheral Nerve Stimulation"

1 patient, short-term

Krutsch. 2008

NEUROMODULATION: TECHNOLOGY AT THE NEURAL INTERFACE

Volume 11 • Number 2 • 2008
http://www.blackwell-synergy.com/loi/ner

ORIGINAL ARTICLE

A Case Report of Subcutaneous Peripheral Nerve Stimulation for the Treatment of Axial Back Pain Associated With Postlaminectomy Syndrome

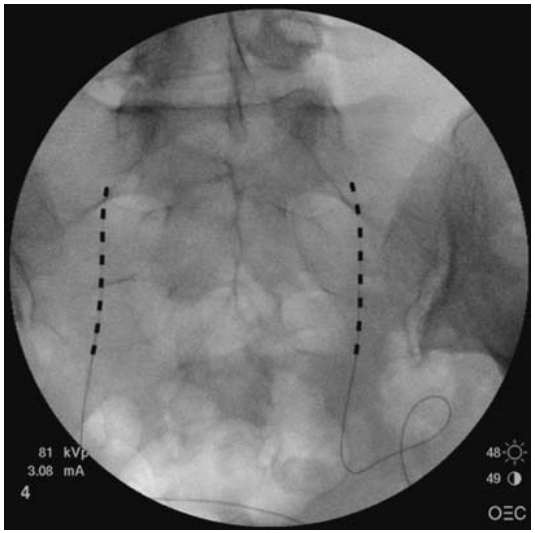
Jason P. Krutsch, MD[A] • Michael H. McCeney, MD[T] • Giancarlo Barolat, MD[‡] • Mazin Al Tamimi, MD, FIPP[¶] • Andrew Smolenski, MD[‖]

Low Back Pain

"Peripheral Nerve Stimulation"

14 patients, long-term

Verrills, 2009



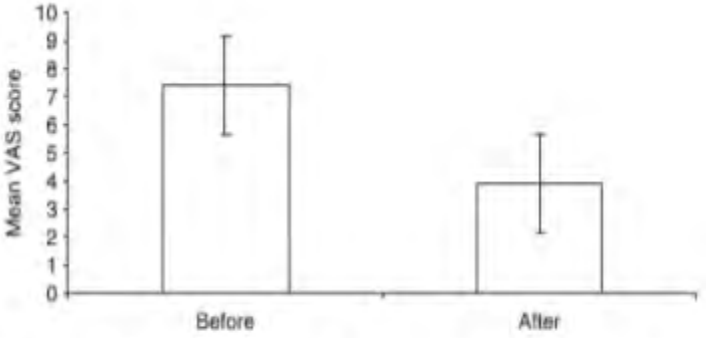


FIGURE 3. Patient pain relief as a result of peripheral nerve stimulation (PNS), where pain relief is expressed as the mean visual analog scale (VAS) recorded both pre- and post-PNS.

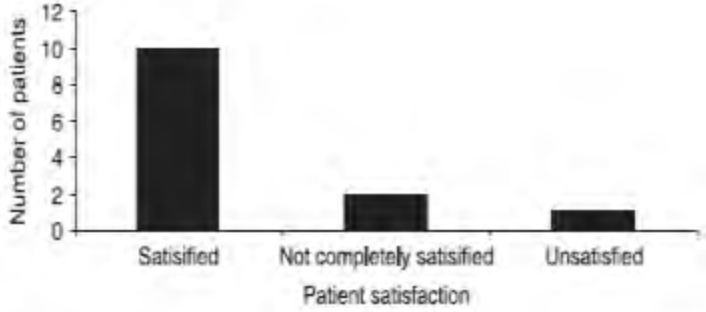


FIGURE 5. Patient satisfaction following peripheral nerve stimulation.

NEUROMODULATION: TECHNOLOGY AT THE NEURAL INTERFACE

Volume 12 • Number 1 • 2009
http://www.blackwell-synergy.com/loi/ner

ORIGINAL ARTICLE

Peripheral Nerve Stimulation: A Treatment for Chronic Low Back Pain and Failed Back Surgery Syndrome?

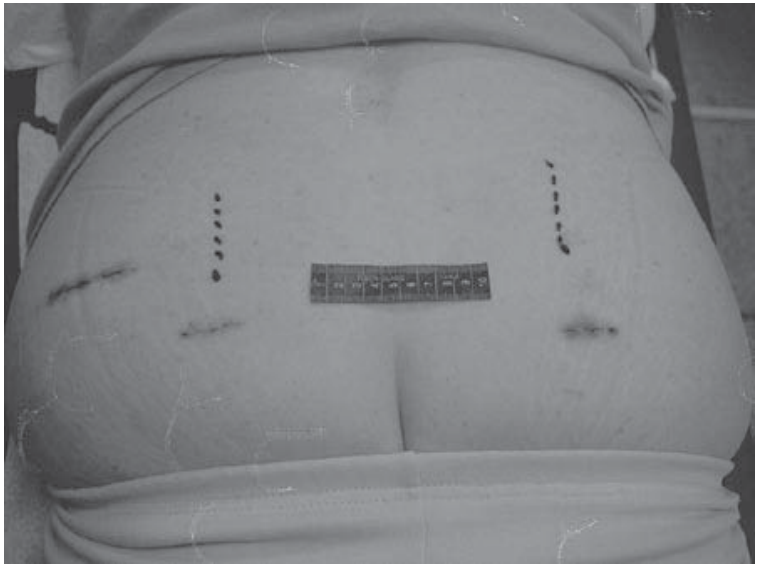
Paul Verrills, MD • Bruce Mitchell, MD • David Vivian, MD • Chantelle Sinclair, PhD

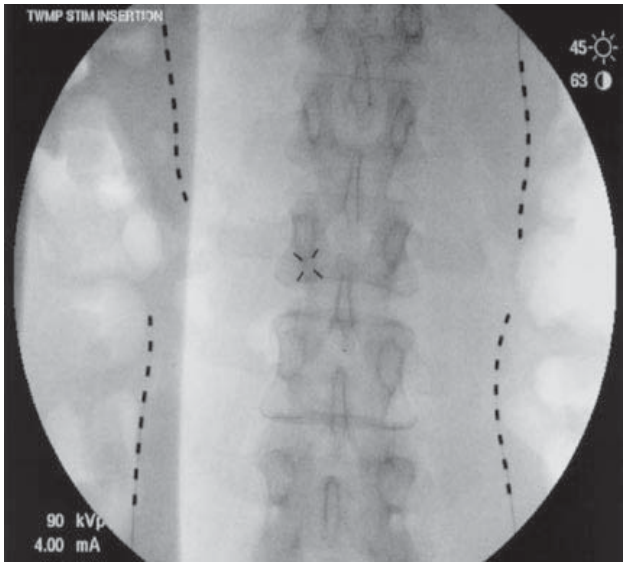
Low Back Pain

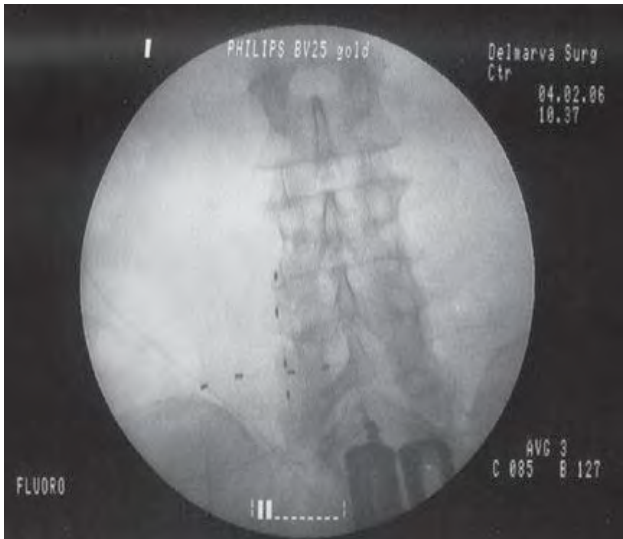
"Cross Talk

PNS concept"

Falco, 2009







Pain Physician 2009; 12:965-983 • ISSN 1533-3159

Observational Report

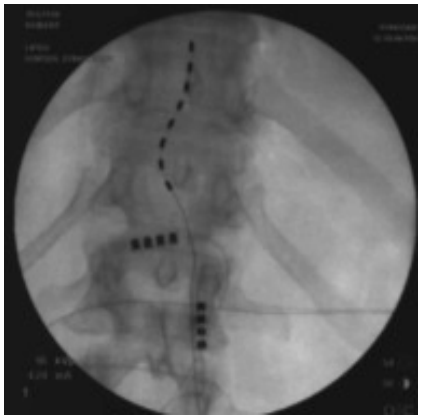
Cross Talk: A New Method for Peripheral Nerve Stimulation. An Observational Report with Cadaveric Verification

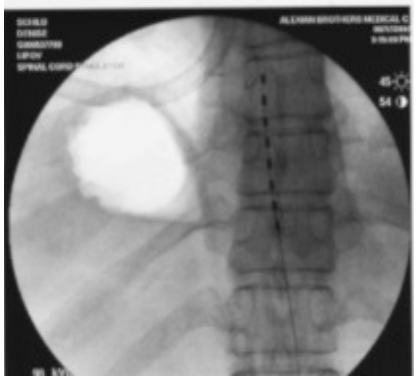
Frank JE Falco, MD[1,2], Jeffrey Berger, MD[2], Alan Vrable, MD[2], Obi Onyewu, MD[1,2], and Jie Zhu, MD[1,2]

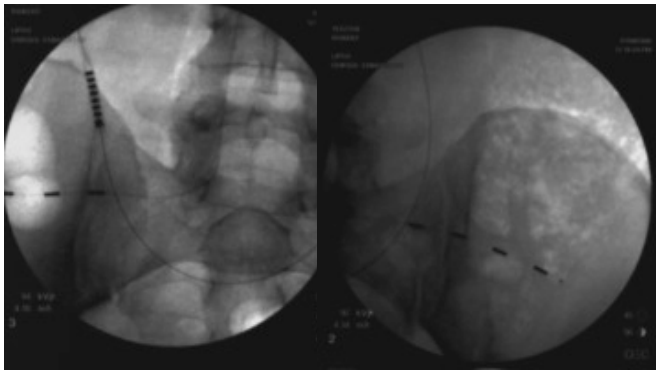
Hybrid neurostimulation

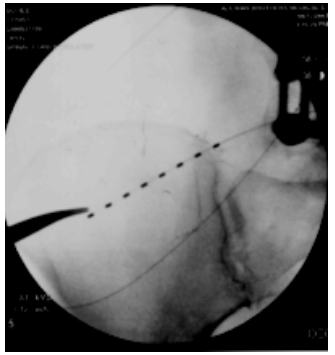
Combination of SCS and PNS

Our experience – 12 patients









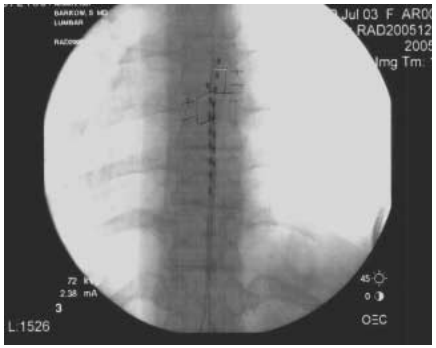
Lipov/Slavin, ASSFN - Vancouver, 2008

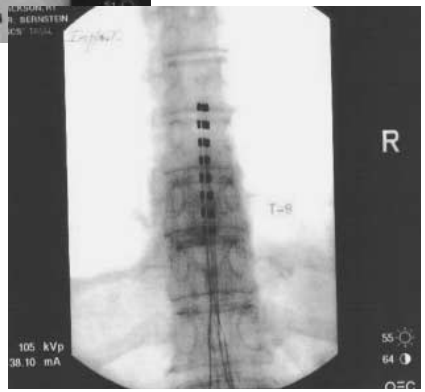
Hybrid neurostimulation

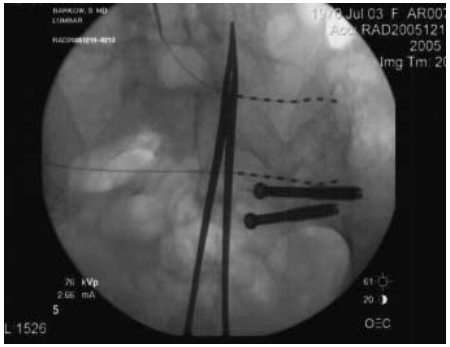
Combination of SCS and PNS

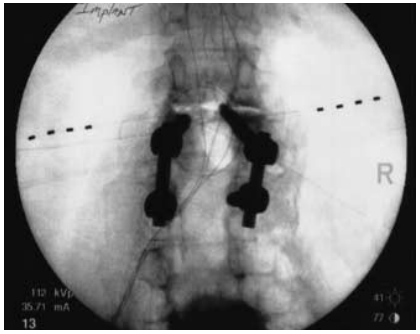
20 patients

Bernstein, 2008









NEUROMODULATION: TECHNOLOGY AT THE NEURAL INTERFACE

ORIGINAL ARTICLE

Spinal Cord Stimulation in Conjunction With Peripheral Nerve Field Stimulation for the Treatment of Low Back and Leg Pain: A Case Series

Clifford A. Bernstein, MD[a] • Richard M. Paicius, MD[T] • Stephen H. Barkow, MD, DABPM[1-3] • Cheryl Lempert-Cohen, MD[a]

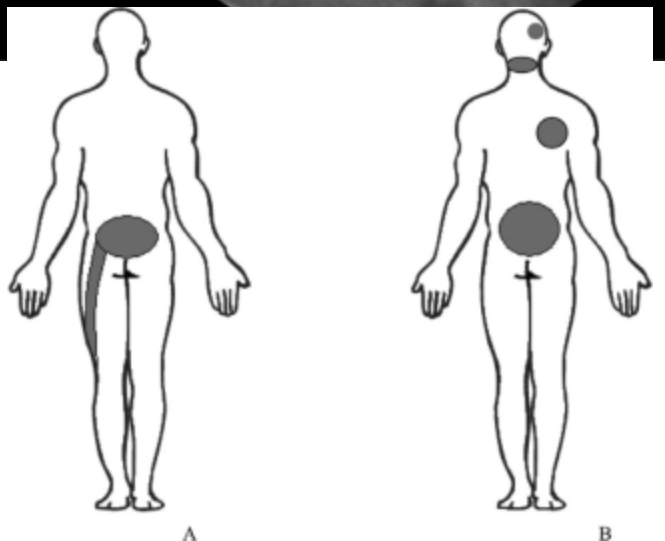
Low Back Pain

Multi-center European study

(111 patients)

Sator-Katzenschlager, et al.

2010



ORIGINAL ARTICLE

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 Ilias, MD¶; Eva-Maria Mozes-Balla, MD**; Michaela Pinter, MD††; Nadja Loining, MD†; Wolfgang Fuchs, MD§; Georg Heinze, PhD‡‡; Rudolf Likar, MD§§

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

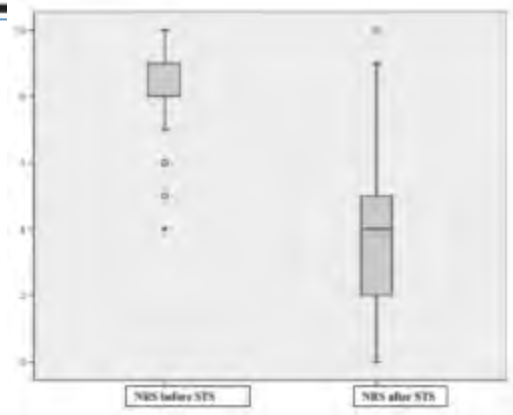
Table 2. Diagnostic Classification According to International Classification of Diseases (ICD)-10-Code (WHO)[20] and Average Pain Intensity (Numerical Rating Scale [NRS]) before and after Implantation of Patients Included into the Analysis.

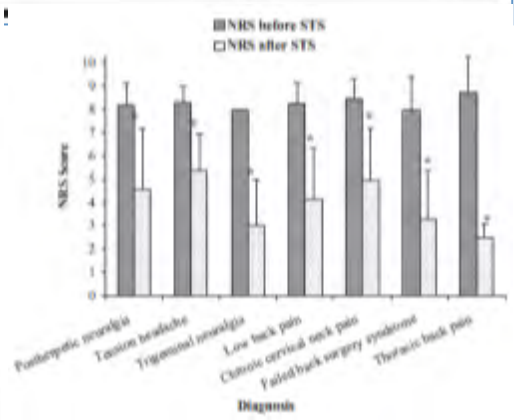
Diagnosis	ICD-10-Code	$N = 111$	Mean (SD) NRS before Implantation	Mean (SD) NRS after Implantation	Corrected P Value
Failed back surgery syndrome	M96.1	37	8.0 (1.4)	3.3 (2.1)	<0.0001
Low back pain	M54.5	29	8.3 (0.9)	4.2 (2.2)	<0.0001
Chronic cervical or neck pain	M54.92	15	8.4 (0.9)	4.9 (2.2)	0.0313
Postherpetic neuralgia	B02.2	12	8.2 (1.0)	4.5 (2.7)	0.0059
Tension headache	G44.2	10	8.3 (0.7)	5.4 (1.6)	0.0313
Trigeminal neuralgia	G50.0	4	8.0 (0.0)	3.0 (2.0)	0.7500
Thoracic back pain	R07.4	4	8.8 (1.5)	2.5 (0.6)	0.7500

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

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

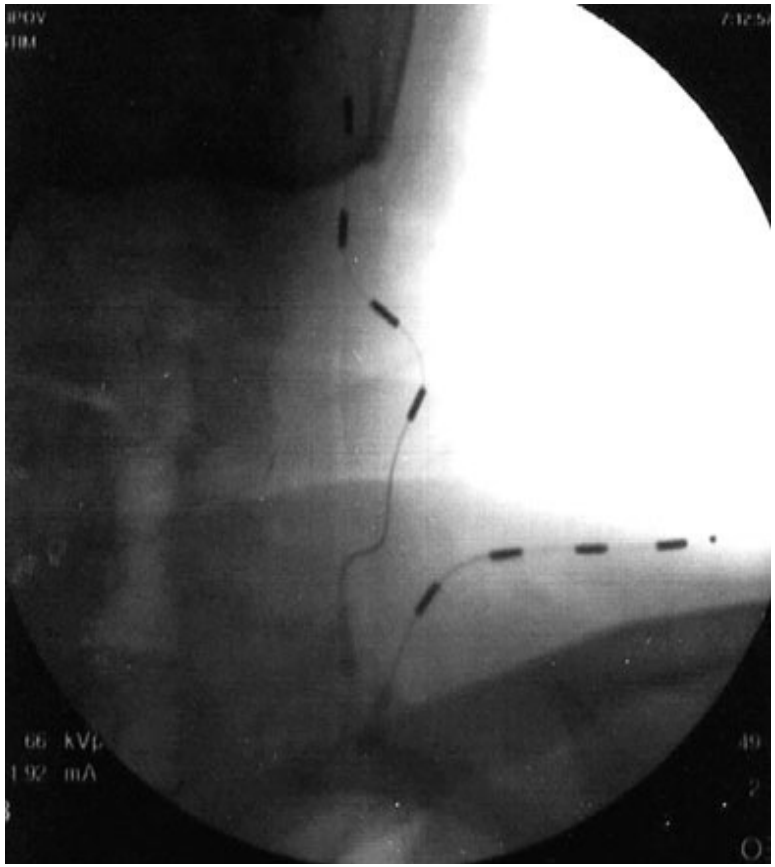
Sabine Sator-Katzenschlager, MD*; Katharina Fiala, MD*; Hans G. Kress, MD, PhD*; Alexandra Kofler, MD†; Josef Neuhold, MD‡; Herwig Kloimstein, MD§; Wilfried Ilias, MD¶; Eva-Maria Mozes-Balla, MD**; Michaela Pinter, MD††; Nadja Loining, MD†; Wolfgang Fuchs, MD§; Georg Heinze, PhD‡‡; Rudolf Likar, MD§§





Neck Pain

Paraspinal Subcutaneous Stimulation



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

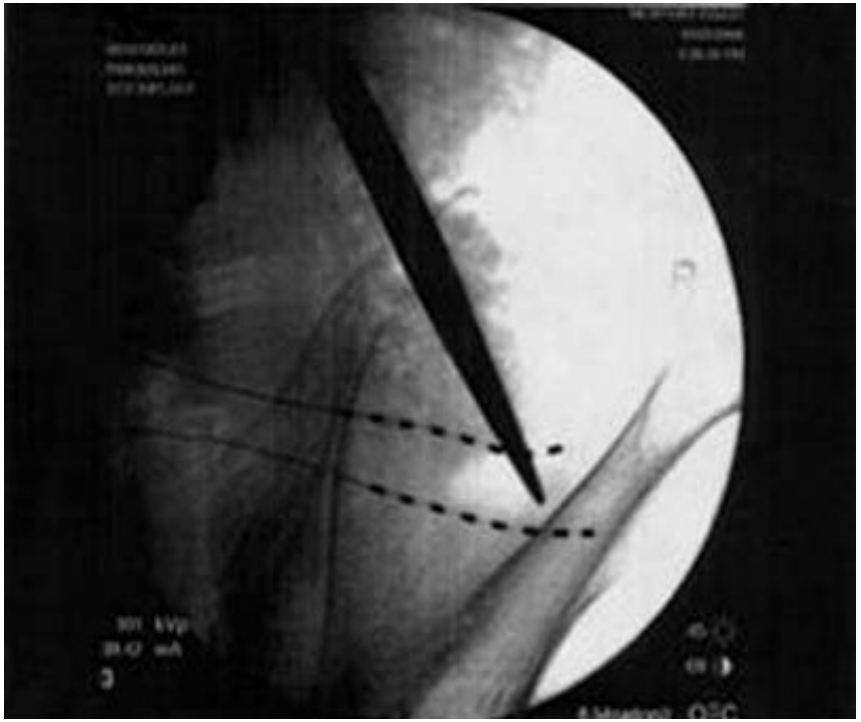
Eugene G. Lipov, MD* • Jaydeep R. Joshi, MD* • Sarah Sanders, PA-C* •
Konstantin V. Slavin, MD†

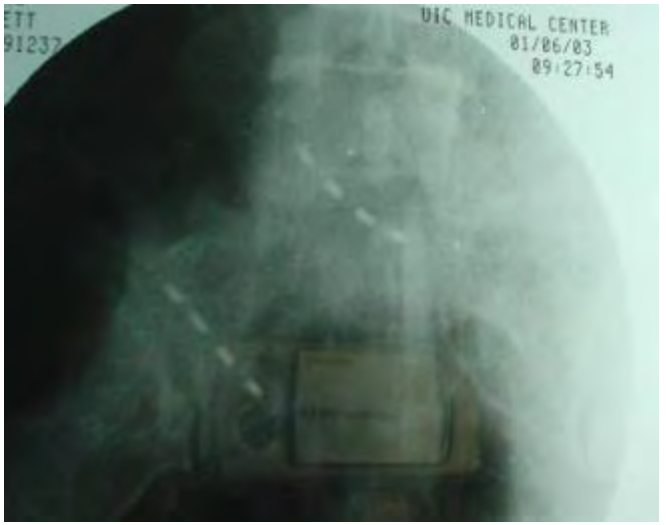
NEUROMODULATION: TECHNOLOGY AT THE NEURAL INTERFACE

Volume 12 • Number 4 • 2009

Abdominal / Inguinal Pain

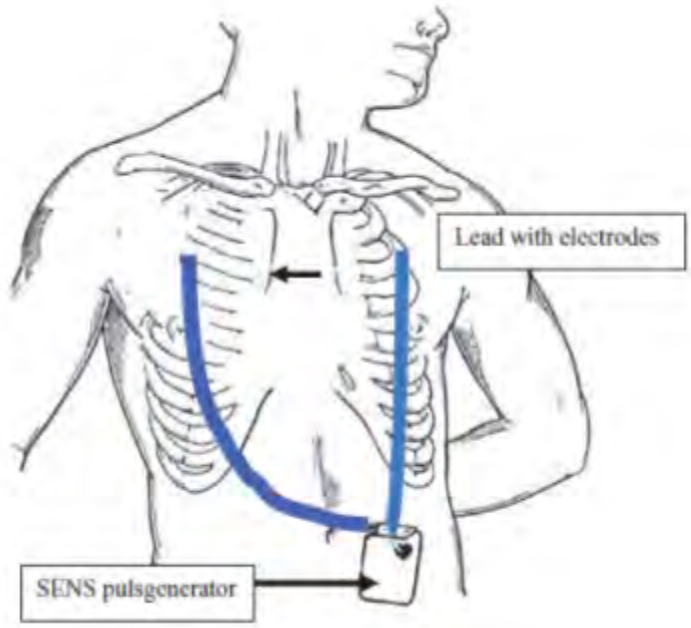
Abdominal Stimulation (post-herniorrhaphy)

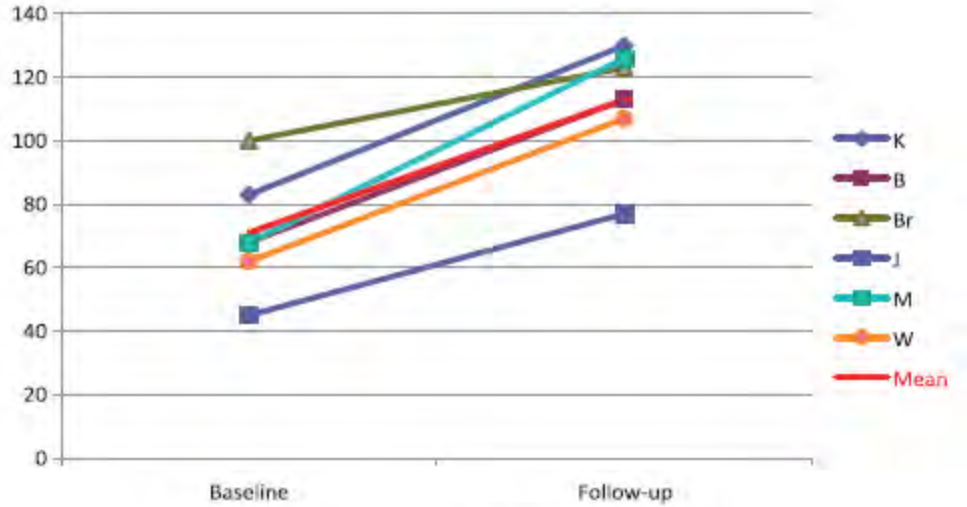




Chest Pain / Angina Pectoris

Chest Wall Stimulation (angina pectoris)





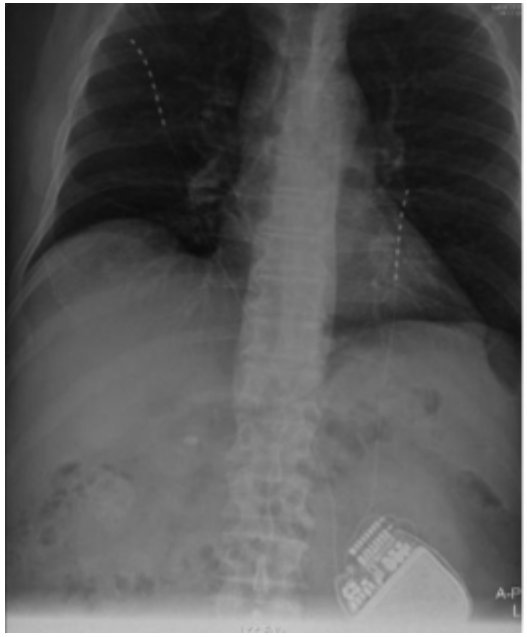
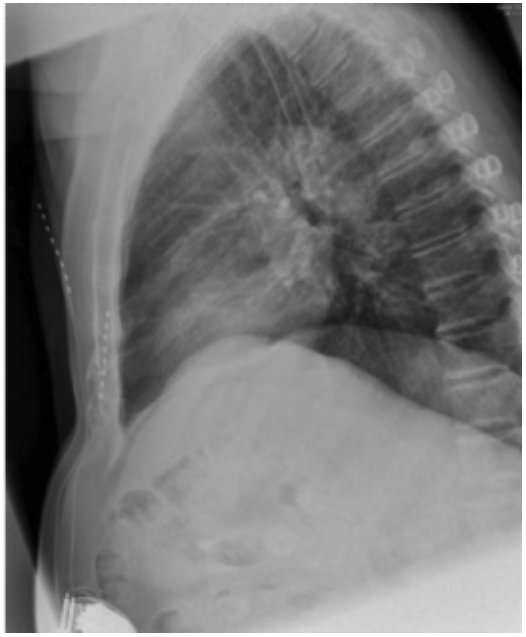
Exercise capacity (Watts).

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

Maurits S. Buiten, 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)

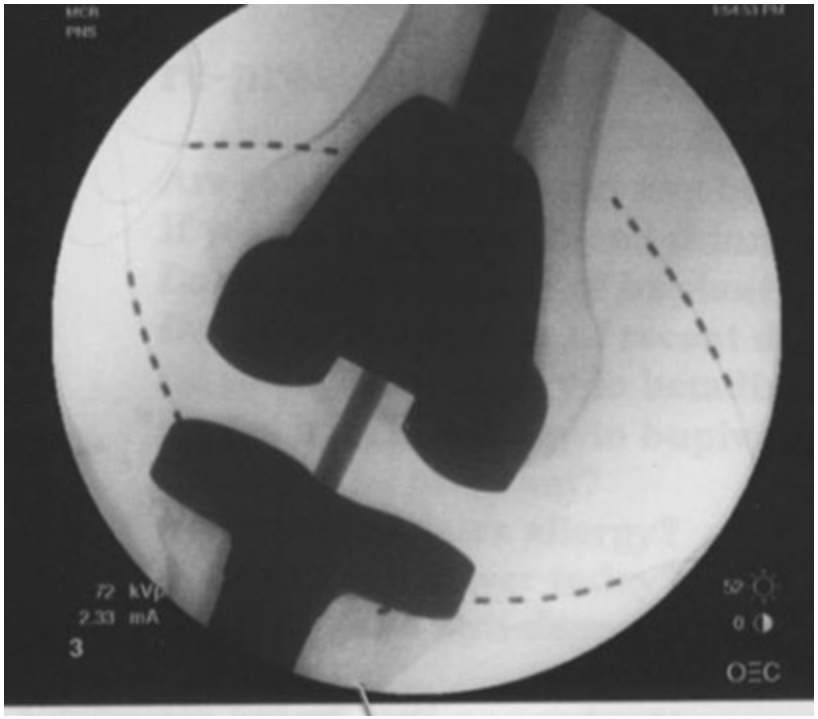
Subcutaneous Electrical Nerve Stimulation: A Feasible and New Method for the Treatment of Patients With Refractory Angina

Maurits S. Buiten, BSc*, Mike J.L. DeJongste, MD†, Uli Beese, MD‡, Cor Kliphuis, PA§, Ans Durenkamp NP‡, Michiel J. Staal, MD§

Neuromodulation 2011; 14: 258–265

Pain in Extremities

Post-arthroplasty knee pain

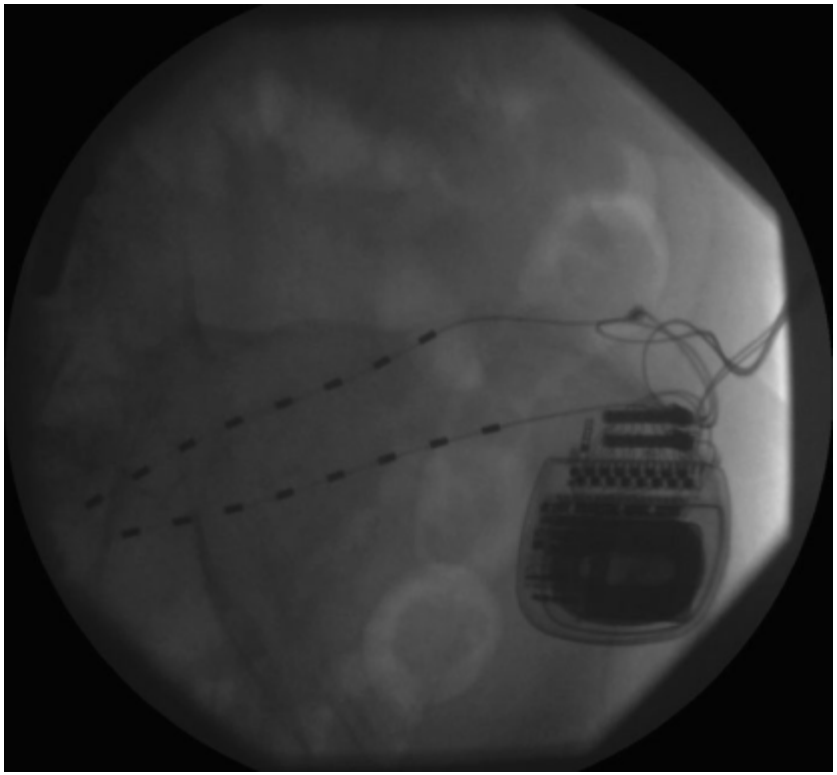


Novel approach for peripheral subcutaneous field stimulation for the treatment of severe, chronic knee joint pain after total knee arthroplasty

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+

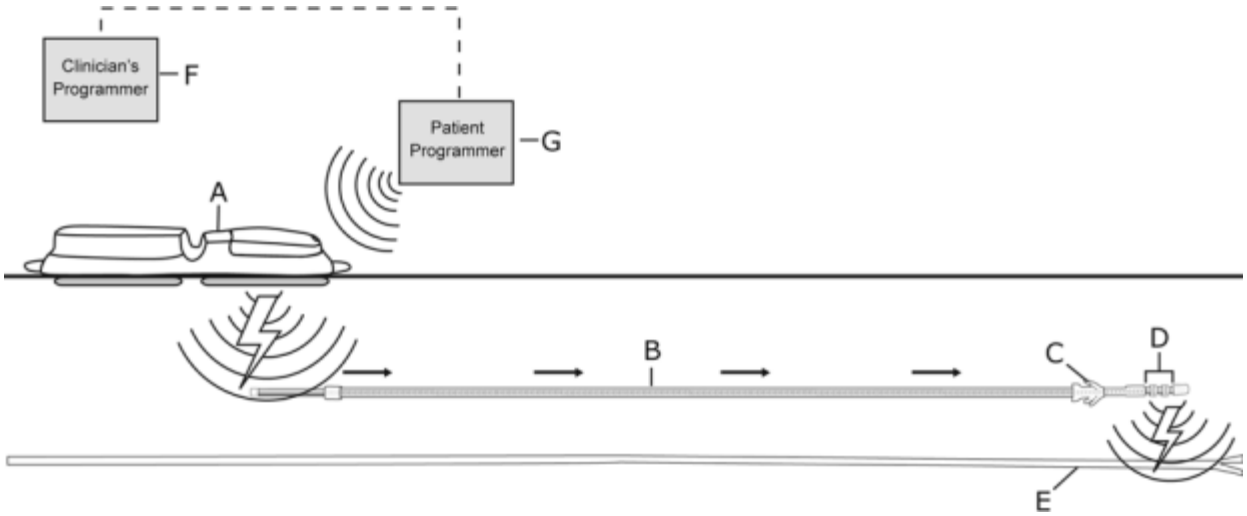
Neuromodulation 2011; 14: 156–159

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



Prospective Clinical Study of a New Implantable Peripheral Nerve Stimulation Device to Treat Chronic Pain

Timothy R. Deer, MD, Robert M. Levy, MD, PhD,† and Evan L. Rosenfeld, MD, JD‡*

(*Clin J Pain* 2010;26:359–372)

PNS complication prevention

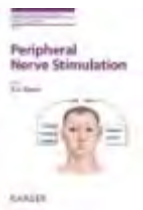
Migration

“Out” migration

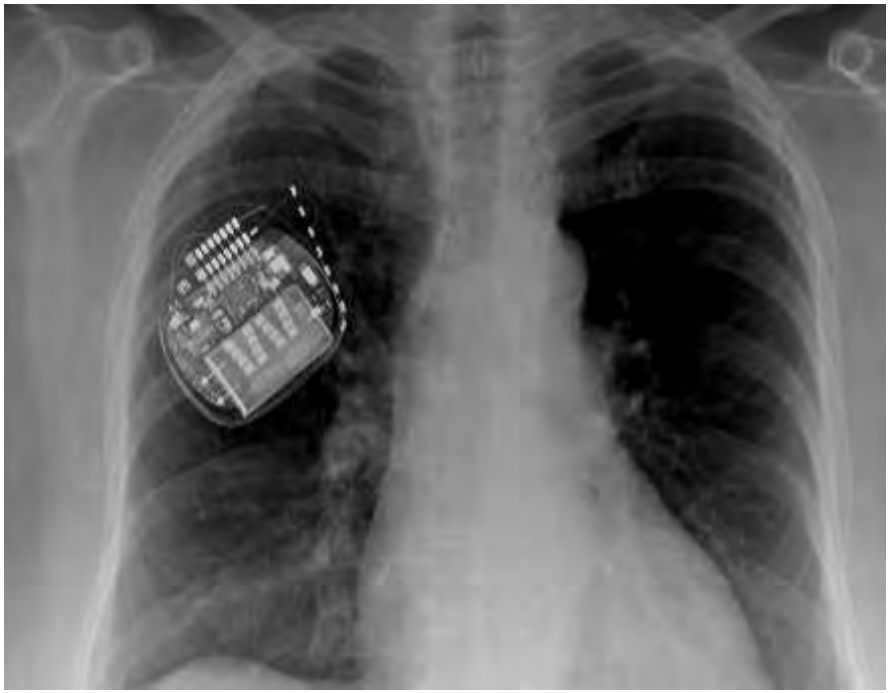
Technical Aspects of Peripheral Nerve Stimulation: Hardware and Complications

Konstantin V. Slavin

Slavin KV (ed): Peripheral Nerve Stimulation.
Prog Neurol Surg. Basel, Karger, 2011, vol 24, pp 189–202



Extreme “out” migration



Technical Aspects of Peripheral Nerve Stimulation: Hardware and Complications

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Slavin KV (ed): Peripheral Nerve Stimulation.
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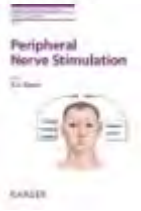
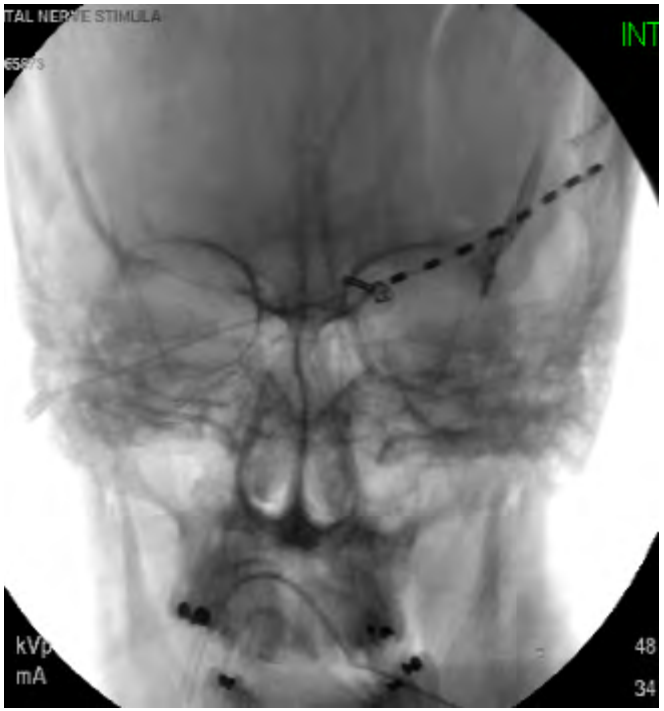


“In” migration



Technical Aspects of Peripheral Nerve Stimulation: Hardware and Complications

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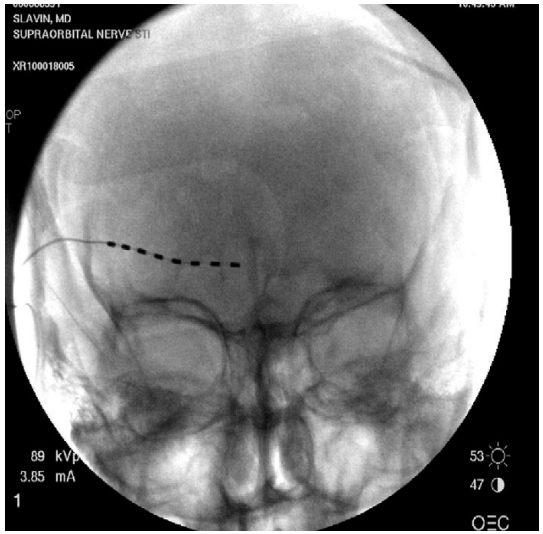
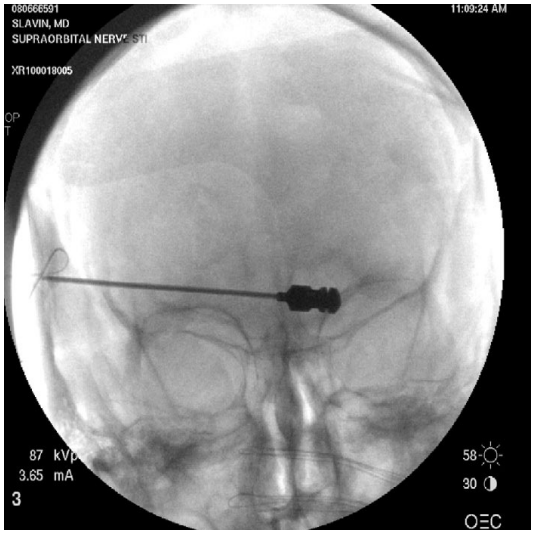
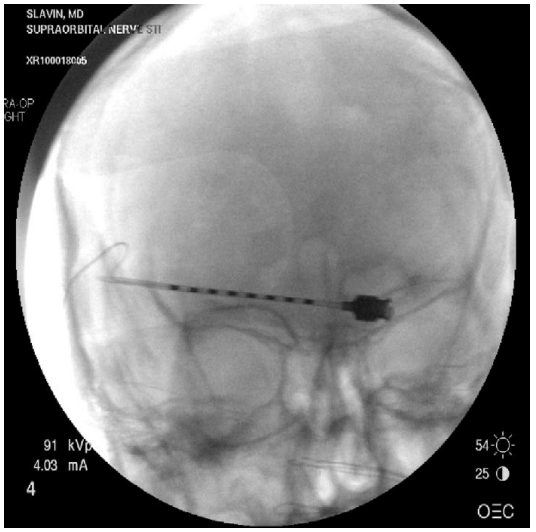
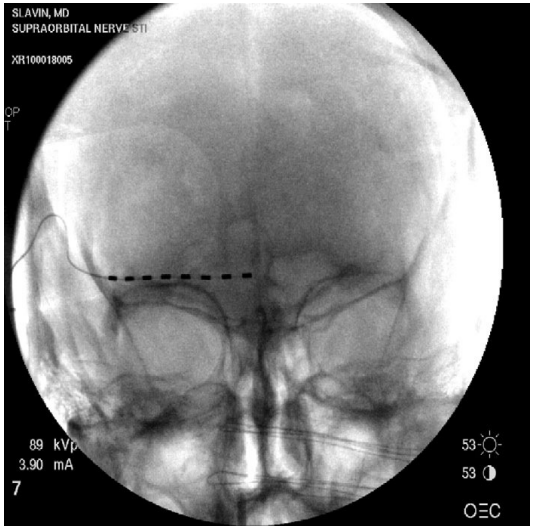
Slavin KV (ed): Peripheral Nerve Stimulation.
Prog Neurol Surg. Basel, Karger, 2011, vol 24, pp 189–202

Simplified revision technique









Neuromodulation: Technology at the Neural Interface

Received: June 7, 2010 First revision: July 24, 2010 Accepted: July 26, 2010

(www.interscience.wiley.com) DOI: 10.1111/j.1525-1403.2010.00315.x

Repositioning of Supraorbital Nerve Stimulation Electrode Using Retrograde Needle Insertion: A Technical Note

Konstantin V. Slavin, MD, Prasad S.S.V. Vannemreddy, MBBS, MS, MCh

PNS complication prevention

Correctness of the electrode depth

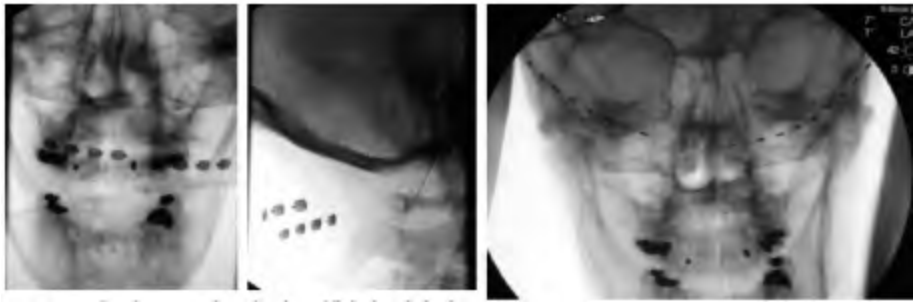
Insertion plane

Too deep

Occipital Neurostimulation-Induced Muscle Spasms: Implications for Lead Placement

Salim M. Hayek, MD, PhD[1], Joseph F. Jasper, MD[2], Timothy R. Deer, MD[3], and Samer N. Narouze, MD[4]

Pain Physician 2009; 12:867-876



Too superficial

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

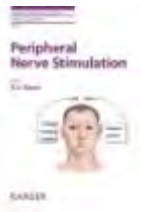
Pain Physician 2008; 11:253-256

Electrode erosion

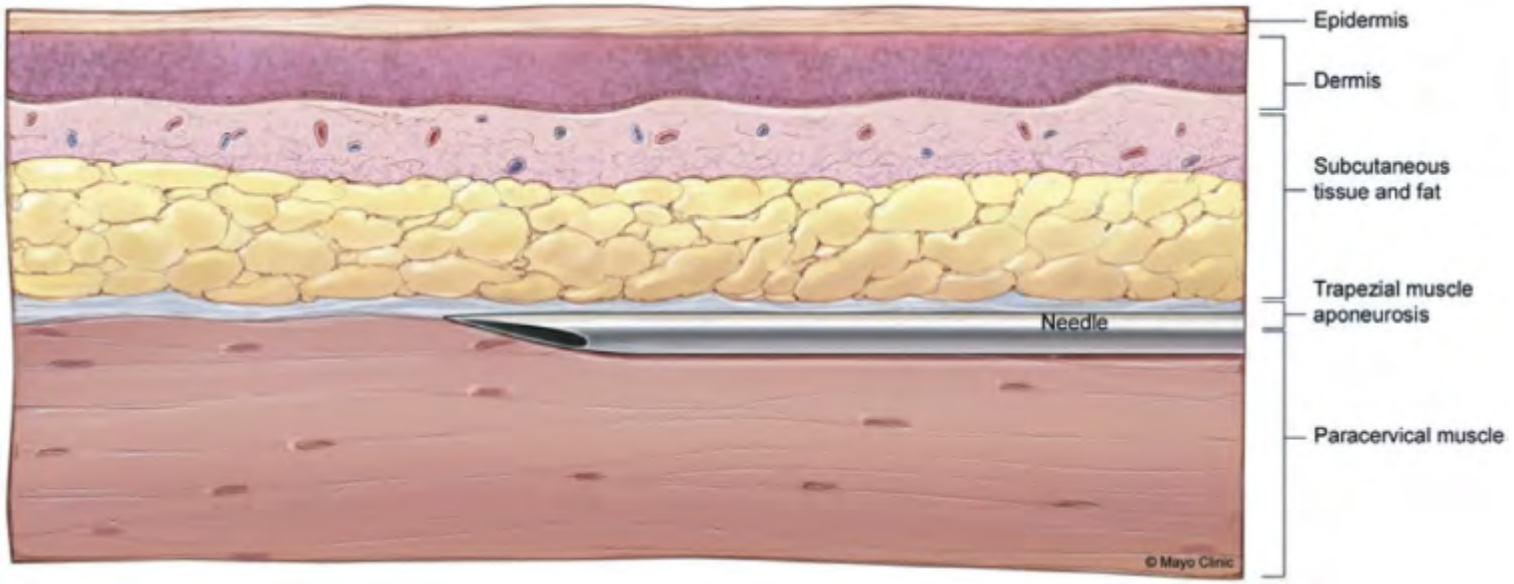
Technical Aspects of Peripheral Nerve Stimulation: Hardware and Complications

Konstantin V. Slavin

Slavin KV (ed): Peripheral Nerve Stimulation.
Prog Neurol Surg. Basel, Karger, 2011, vol 24, pp 189–202



Erosion prevention



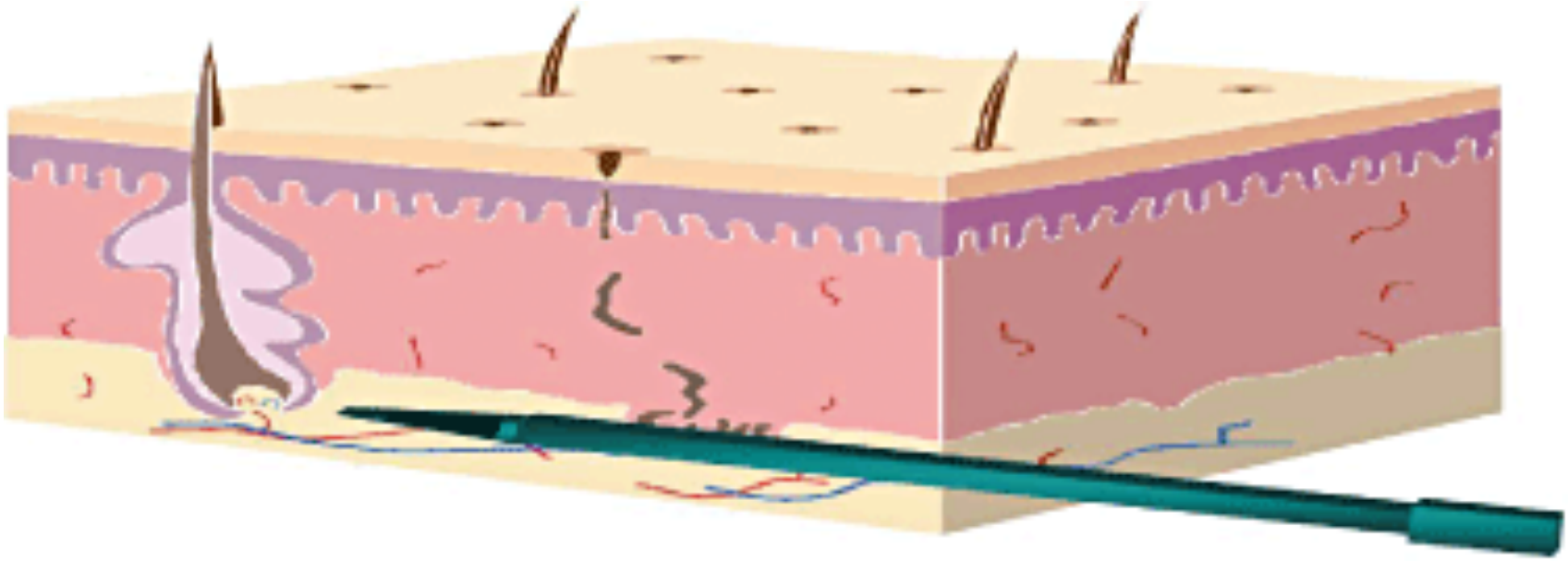
Electrode insertion plane

Occipital Neuromodulation: Ultrasound Guidance for Peripheral Nerve Stimulator Implantation

Jason S. Eldrige, MD*; Jon B. Obray, MD*†; Matthew J. Pingree, MD*; Bryan C. Hoelzer, MD*

Pain Practice, Volume 10, Issue 6, 2010 580–585

Erosion prevention



Electrode insertion plane

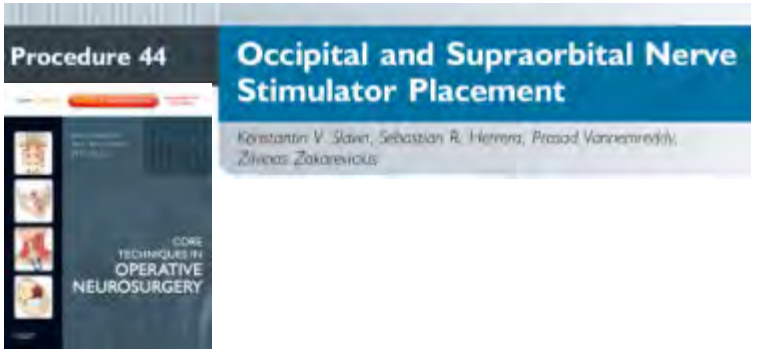
Differentiating the Leaves From the Branches in the Tree of Neuromodulation: The State of Peripheral Nerve Field Stimulation

Robert M. Levy, MD, PhD

Neuromodulation 2011; 14: 201–205

Electrode erosion

Electrode insertion plane



PNS complication prevention

Infection control

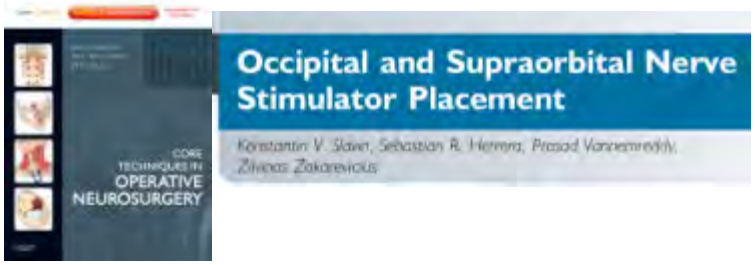
Infection

Prevention of infection

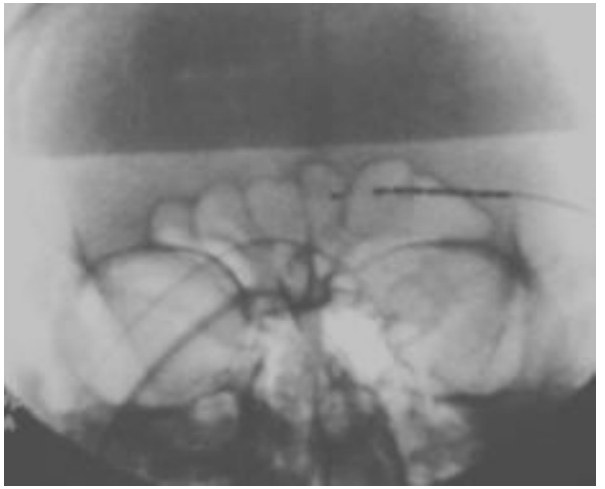
- Perioperative antibiotics
- Avoid excessive tissue dissection
- Meticulous hemostasis
- Appropriate size of incision
  - Not too small
  - Not too large
- Avoid over-tightening of the sutures
- Plan exit site of trial electrodes to avoid crossing the path of permanent device

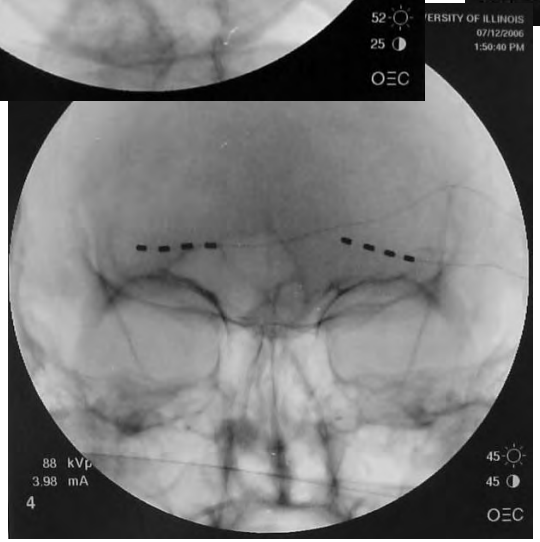
Infection risk reduction

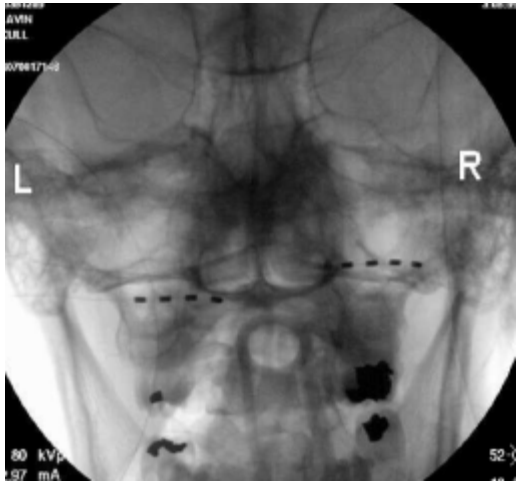
Trial vs. Permanent Implant



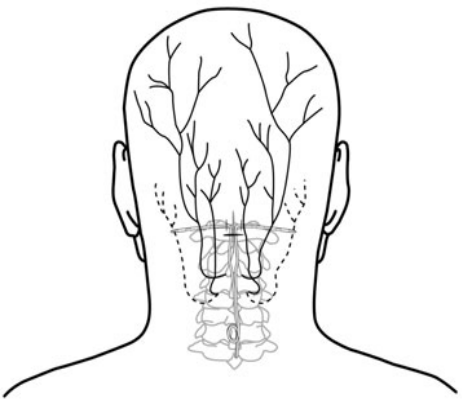
Best electrodes?

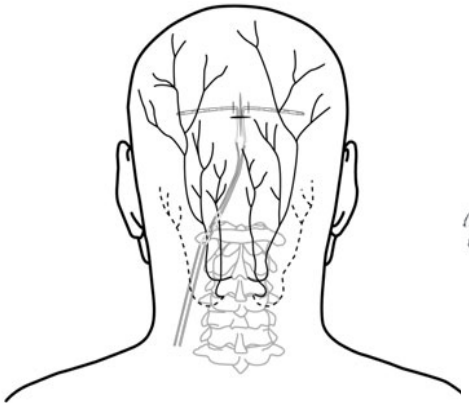


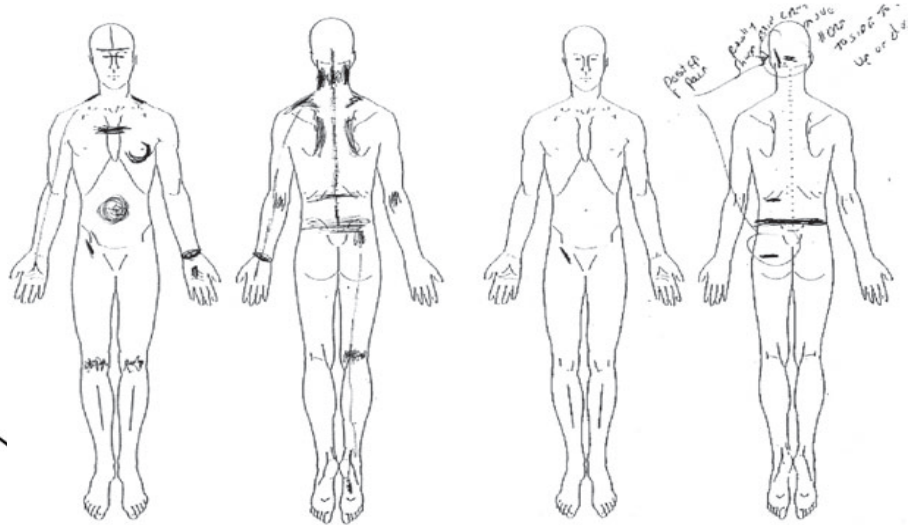




Fibromyalgia (occipital nerve stimulation)







PAIN MEDICINE
Volume 8 • Number 8 • 2007

C2 Area Neurostimulation: A Surgical Treatment for Fibromyalgia

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Thank you!