



Peripheral Nerve Stimulators: The Swiss Army Knife for Chronic Pain

Grant H. Chen, MD, MBA, FASA

October 25, 2025

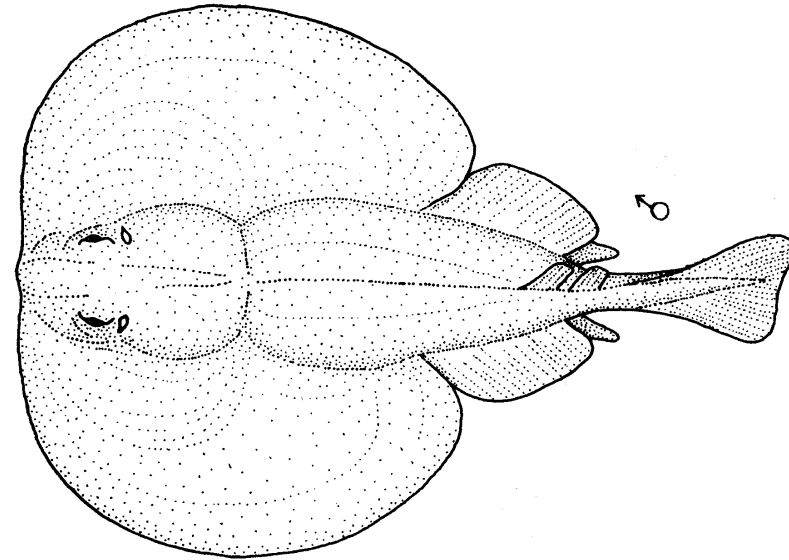
Disclosure:
SPR Therapeutics
Stratus Medical
Skyler Health

THE HISTORY OF ELECTRICAL STIMULATION FOR PAIN



Scribonius Largus

46 AD



Black Torpedo Fish

THE HISTORY OF ELECTRICAL STIMULATION FOR PAIN

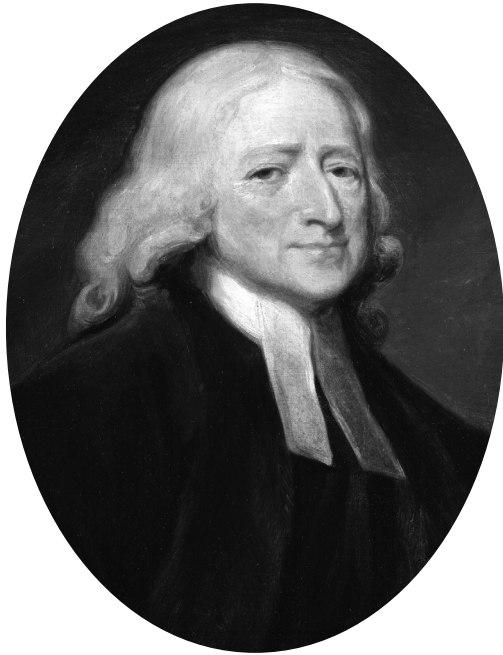


Baghdad Batteries
225 – 640 AD

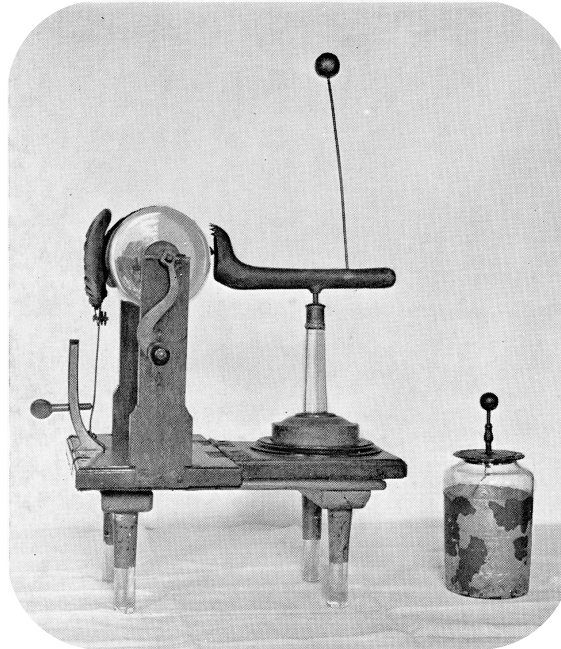


Leyden Jar
1700s

THE HISTORY OF ELECTRICAL STIMULATION FOR PAIN

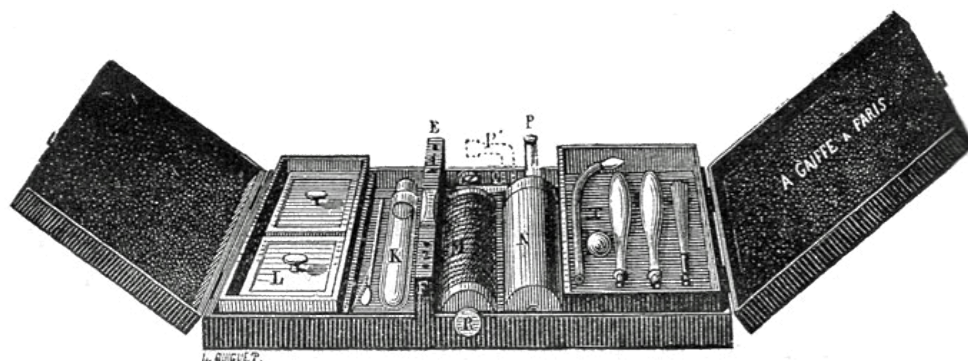


John Wesley
1703 – 1791



Faradic Electrifier
1850

THE HISTORY OF ELECTRICAL STIMULATION FOR PAIN



Gaiffe Unit
1863

SHOOTING ELECTRICITY IN, FORCES THE PAIN OUT

1. How to Start
Muscle Building, Lung Development, Improves Circulation

2. Sponge (+) Relieves Pain
Headache, Earache, Toothache, Neuralgia, Neuritis, Soreness

3. Sponge (-) Roller (+)
Tonsillitis, Catarrh, Asthma, Goitre, Voice, Throat

4. Roller (+)
Pleurisy, Chest Pains, Reducing, Making Lihesome

5. Roller (+)
Breaks Up Congestion, Lumbago and Backache

6. Sponge and Roller
Regulating Internal Organs, Stomach, Indigestion, Bowels, Constipation

7. Spinal Treatment
Tonic, Up Current, Debility, Nervousness, Liver, Kidneys, Spine

8. Electric Hand Massage
The Touch That Soothes—Electricity and Personal Magnetism

9. Concentrated Application
Rheumatism, Stiff Joints, Breaking Up Chronic Conditions

10. Sponge (-) Stimulates
Electric Bath, Poor Circulation, Tired Feet, Improving Dry Chapped Skin

11. Scalp Brush
Falling Hair, Dandruff, Itchy Scalp, Brain Stimulation, Restfulness

12. Beautifying Hair
Enlivens the Hair, Enriches the Color, Stimulates Luxuriant Growth

Electreat
Mechanical Heart
Relieves Pain
Needed in Every Home

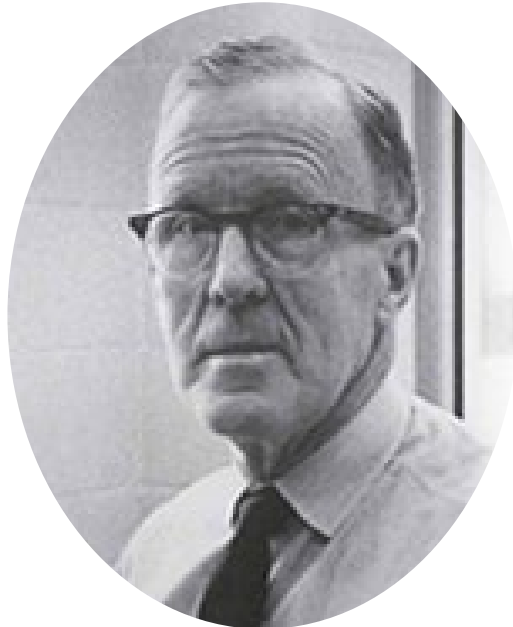
Free Trial Demonstration
No Charges.

MRS. MARION PARKER
For Free Demonstration Write or Phone
343 TULSA, OKLA.
PHONE 3-5502

ELECTREAT MECHANICAL HEART GIVES NEW LIFE TO YOUR VEINS AND RELIEVES YOUR PAINS

Electreat
Patented 1919

WHAT IS THE GATE THEORY FOR PAIN?



Ronald Melzack

1965

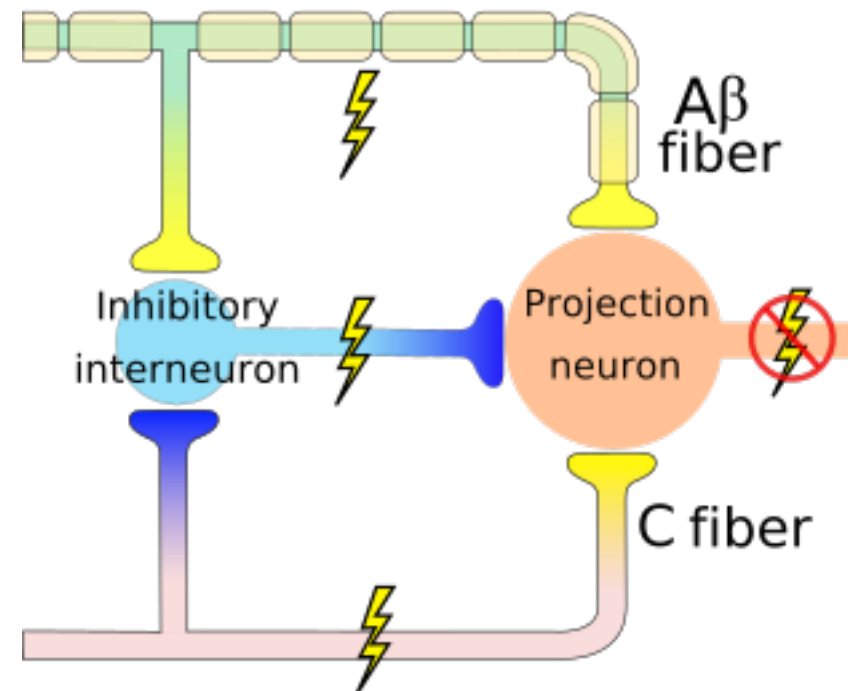


Patrick Wall

Pain Mechanisms: A New Theory

A gate control system modulates sensory input from the skin before it evokes pain perception and response.

Ronald Melzack and Patrick D. Wall



WHAT IS THE GATE THEORY FOR PAIN?



William H. Sweet



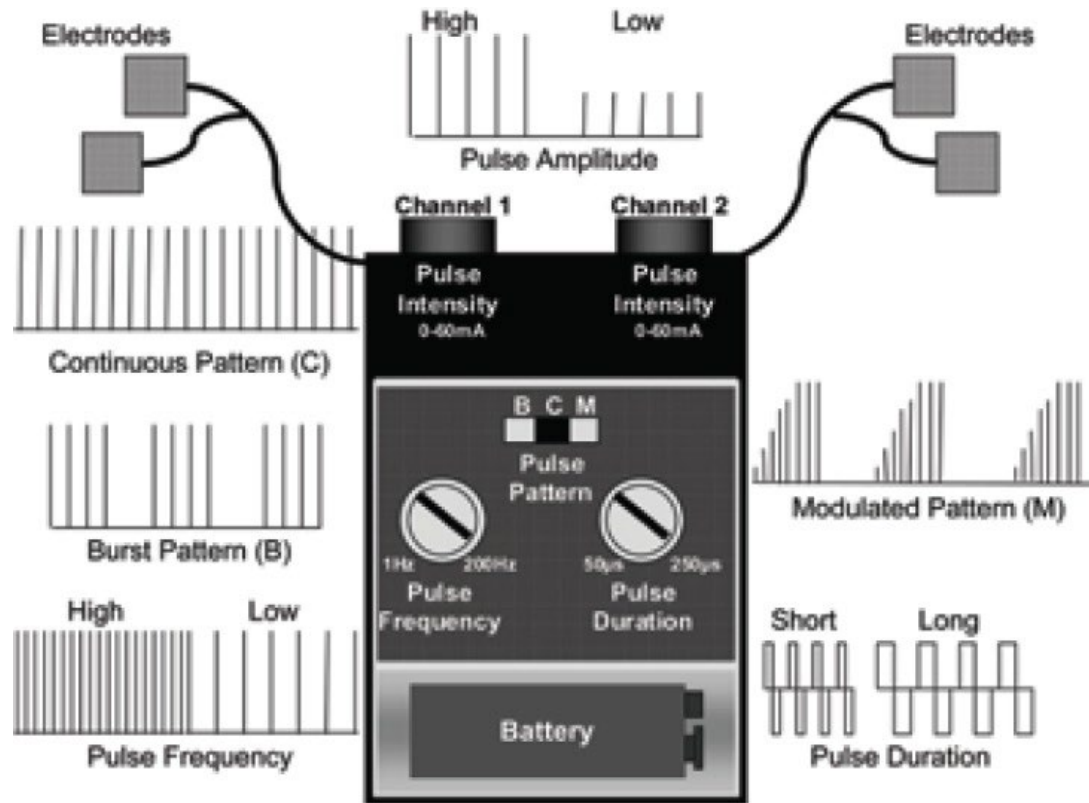
Patrick Wall

1967

Temporary Abolition of Pain in Man

Abstract. In eight patients with intense chronic cutaneous pain, sensory nerves or roots supplying the painful area were stimulated. Square-wave 0.1-millisecond pulses at 100 cycles per second were applied, and the voltage was raised until the patient reported tingling in the area. During this stimulation, pressure on previously sensitive areas failed to evoke pain. Four patients, who had diseases of their peripheral nerves, experienced relief of their pain for more than half an hour after stimulation for 2 minutes.

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

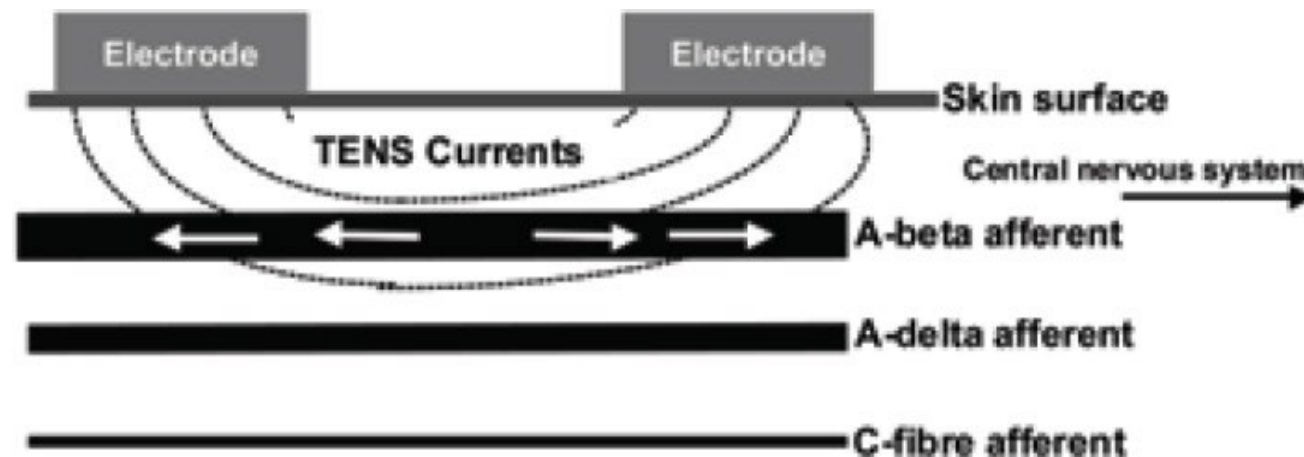


Conventional TENS
(low-intensity, high-frequency)



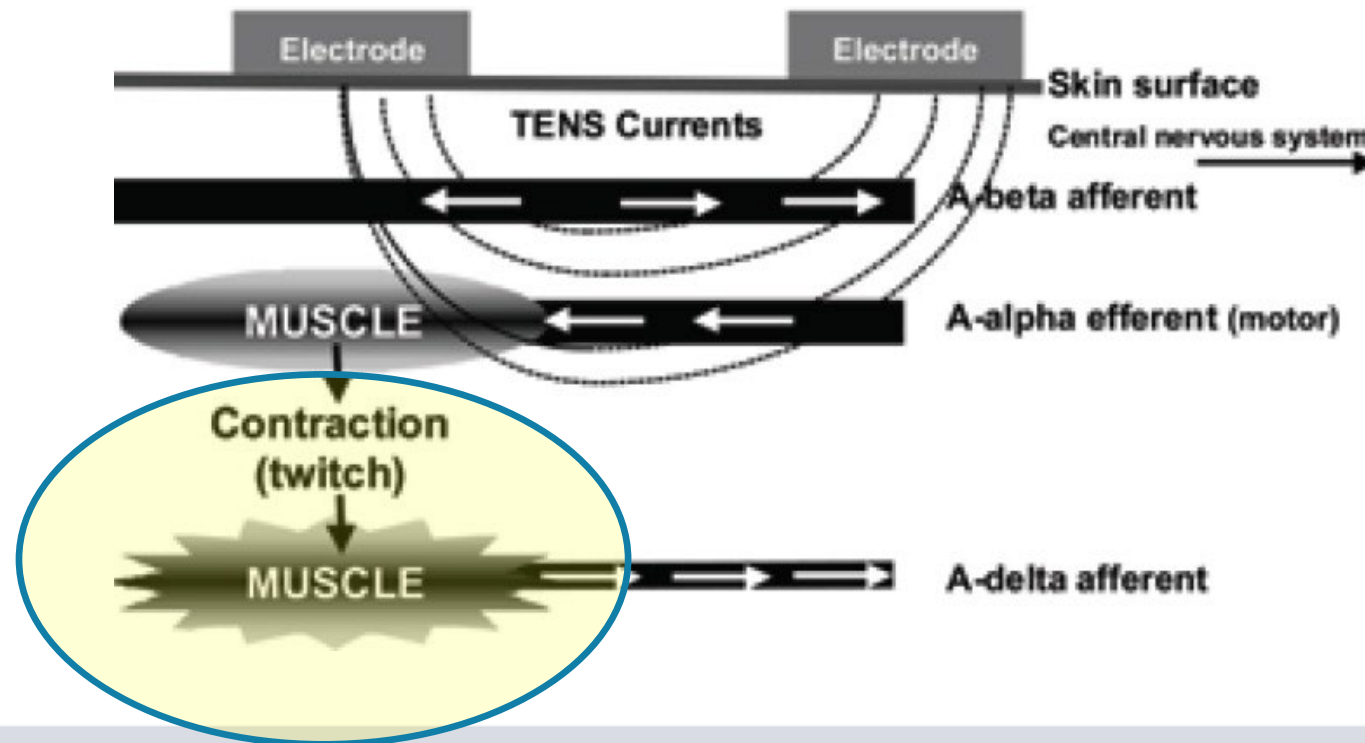
DOES FREQUENCY MATTER?

Conventional TENS
(low-intensity, high-frequency)



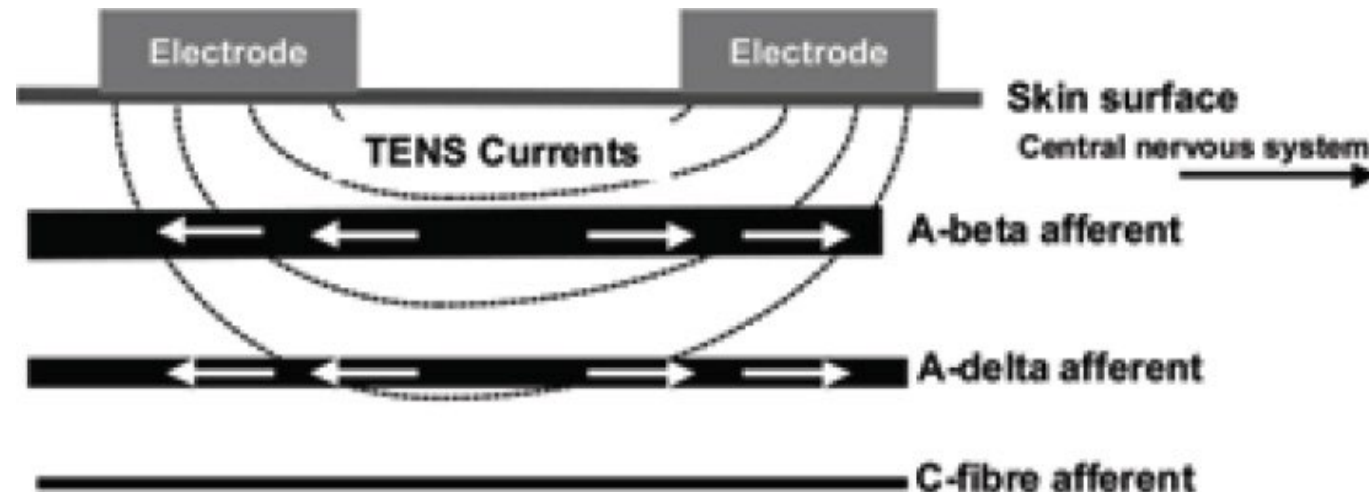
DOES FREQUENCY MATTER?

Acupuncture-like TENS
(high-intensity, low-frequency)



DOES FREQUENCY MATTER?

Intense TENS
(high-intensity, high-frequency)

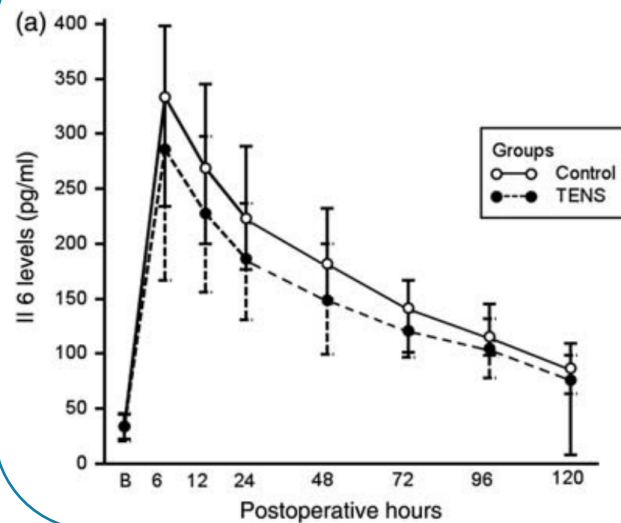


TENS

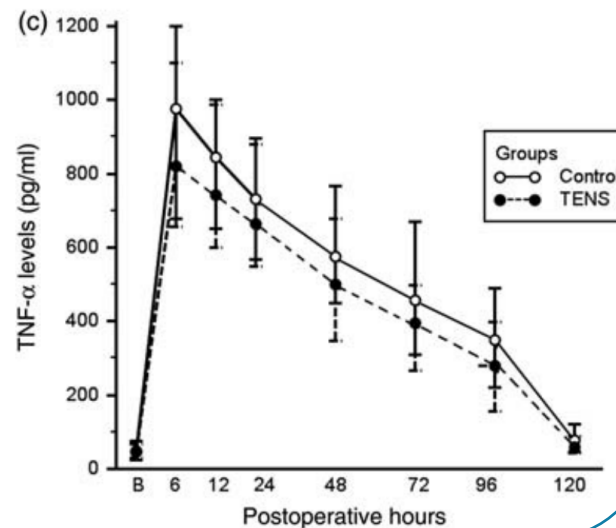
Posterior thoracotomy

- 50 patients
- 2 dorsal pads 2 cm from incision
- 80 Hz, 250 milliseconds
- 30 minutes q 4 hours for 5 days

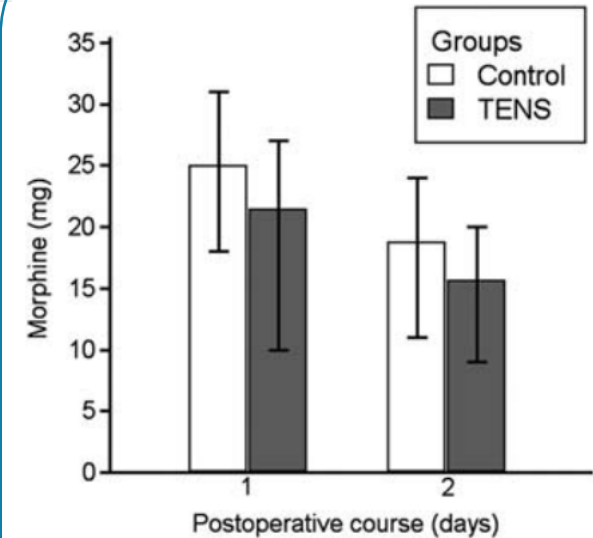
interleukin-6



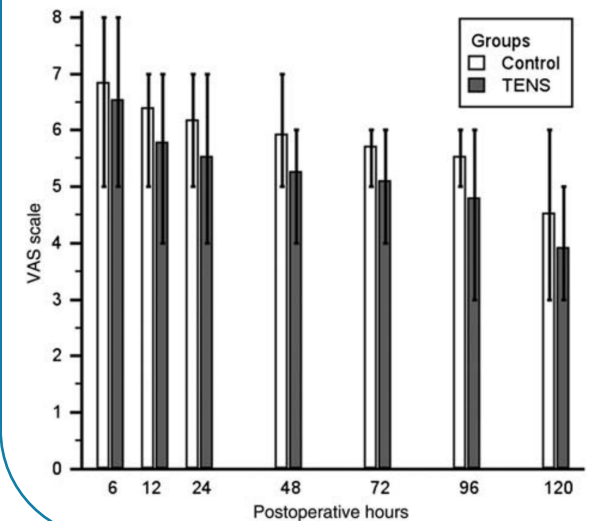
tumor necrosis factor alpha



Morphine Intake



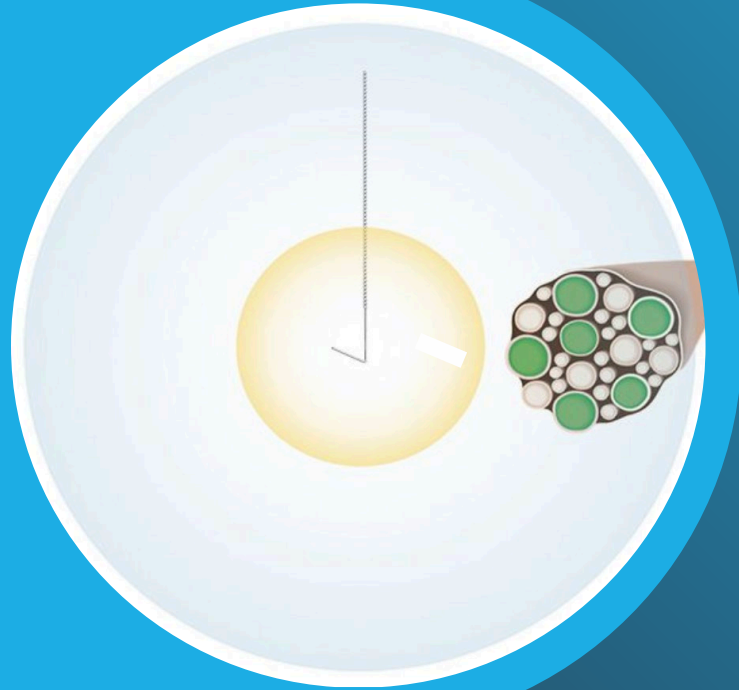
VAS



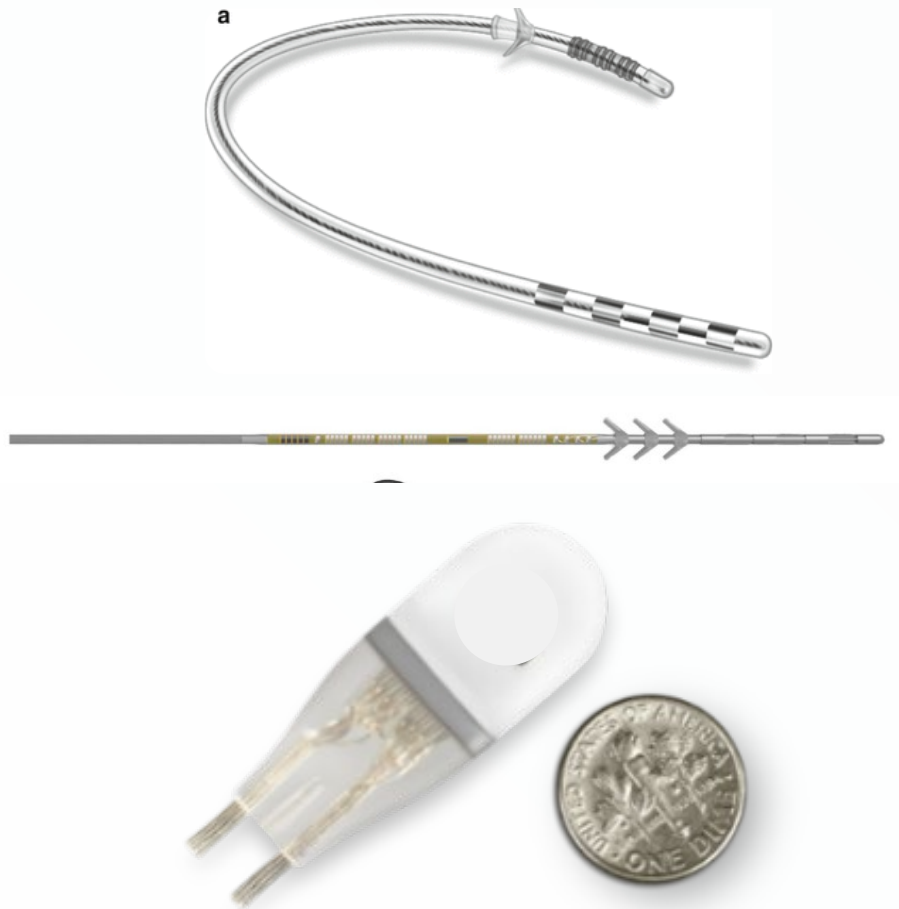
Peripherally Induced Reconditioning of the Central Nervous System: A Proposed Mechanistic Theory for Sustained Relief of Chronic Pain with Percutaneous Peripheral Nerve Stimulation

Timothy R Deer ¹, Sam Eldabe ², Steven M Falowski ³, Marc A Huntoon ⁴, Peter S Staats ⁵,
Isaac R Cassar ⁶, Nathan D Crosby ⁶, Joseph W Boggs ⁶

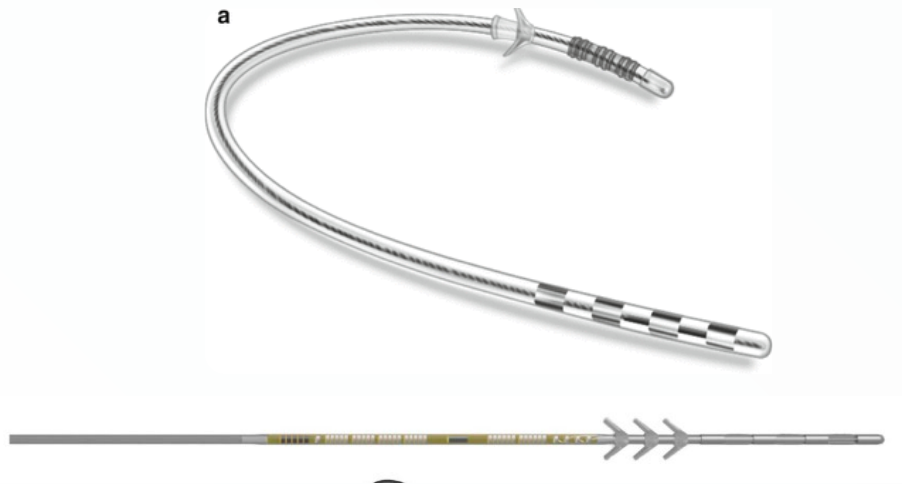
Deer TR. J Pain Res. 2021.



PERIPHERAL NERVE STIMULATOR



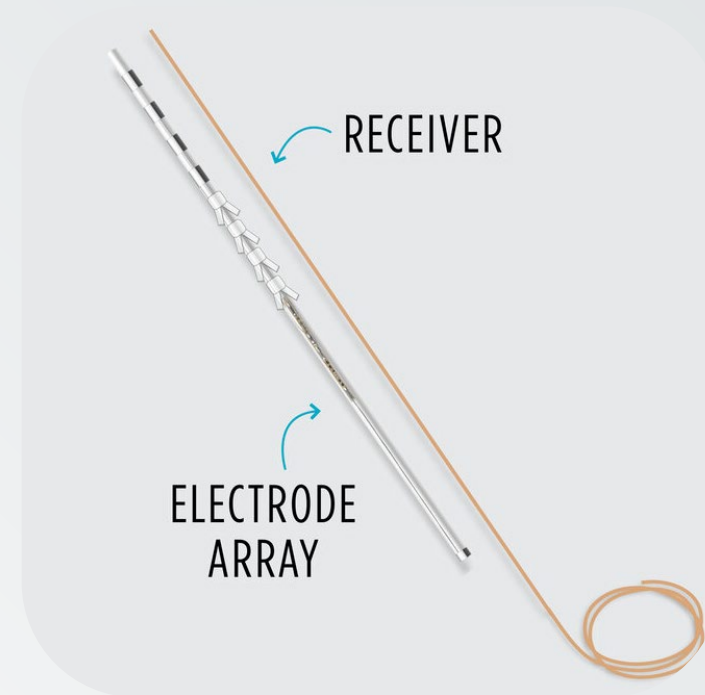
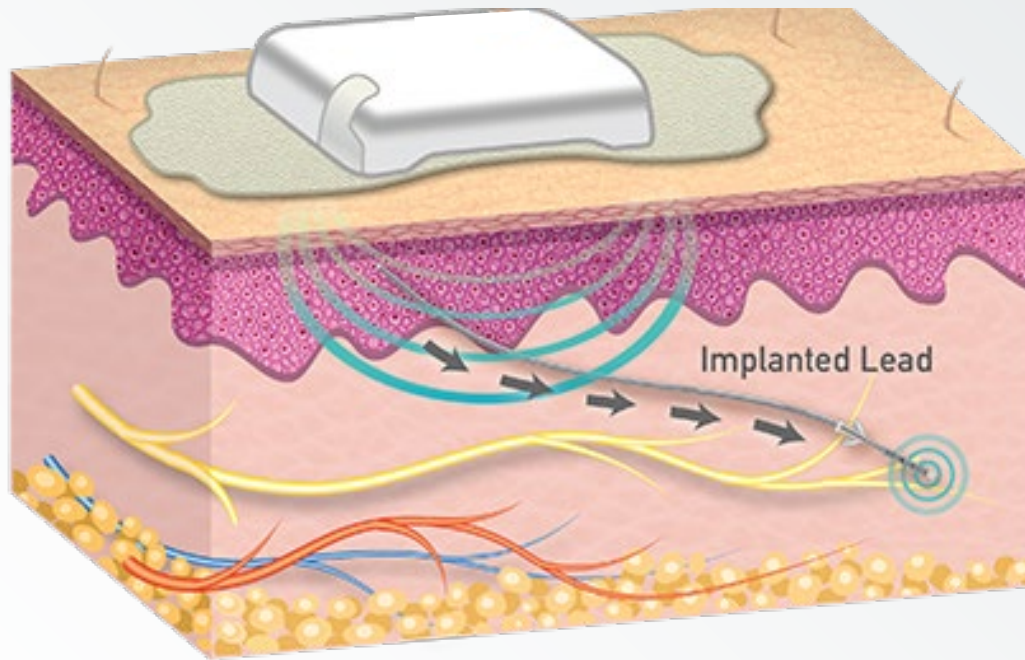
Overcomes the resistance of skin



Permanent



Temporary



Overcomes the resistance of skin

A solid blue horizontal bar with a rounded right end, positioned on the left side of the slide.

Back to some history

N = 30

Long-term results of peripheral nerve stimulation for reflex sympathetic dystrophy

S J Hassenbusch ¹, M Stanton-Hicks, D Schoppa, J G Walsh, E C Covington

J Neurosurg. 1996

Percutaneous Intramuscular Neuromuscular Electric Stimulation for the Treatment of Shoulder Subluxation and Pain in Patients With Chronic Hemiplegia: A Pilot Study

David T. Yu, MD, John Chae, MD, ME, Maria E. Walker, MSE, Zi-Ping Fang, PhD

Arch Phys Med Rehabil. 2001

N = 8

N = 10

Comparing Stimulation-Induced Pain During Percutaneous (Intramuscular) and Transcutaneous Neuromuscular Electric Stimulation for Treating Shoulder Subluxation in Hemiplegia

David T. Yu, MD, John Chae, MD, Maria E. Walker, MS, Ronald L. Hart, MS, Gregory F. Petroski, MS

Arch Phys Med Rehabil. 2001

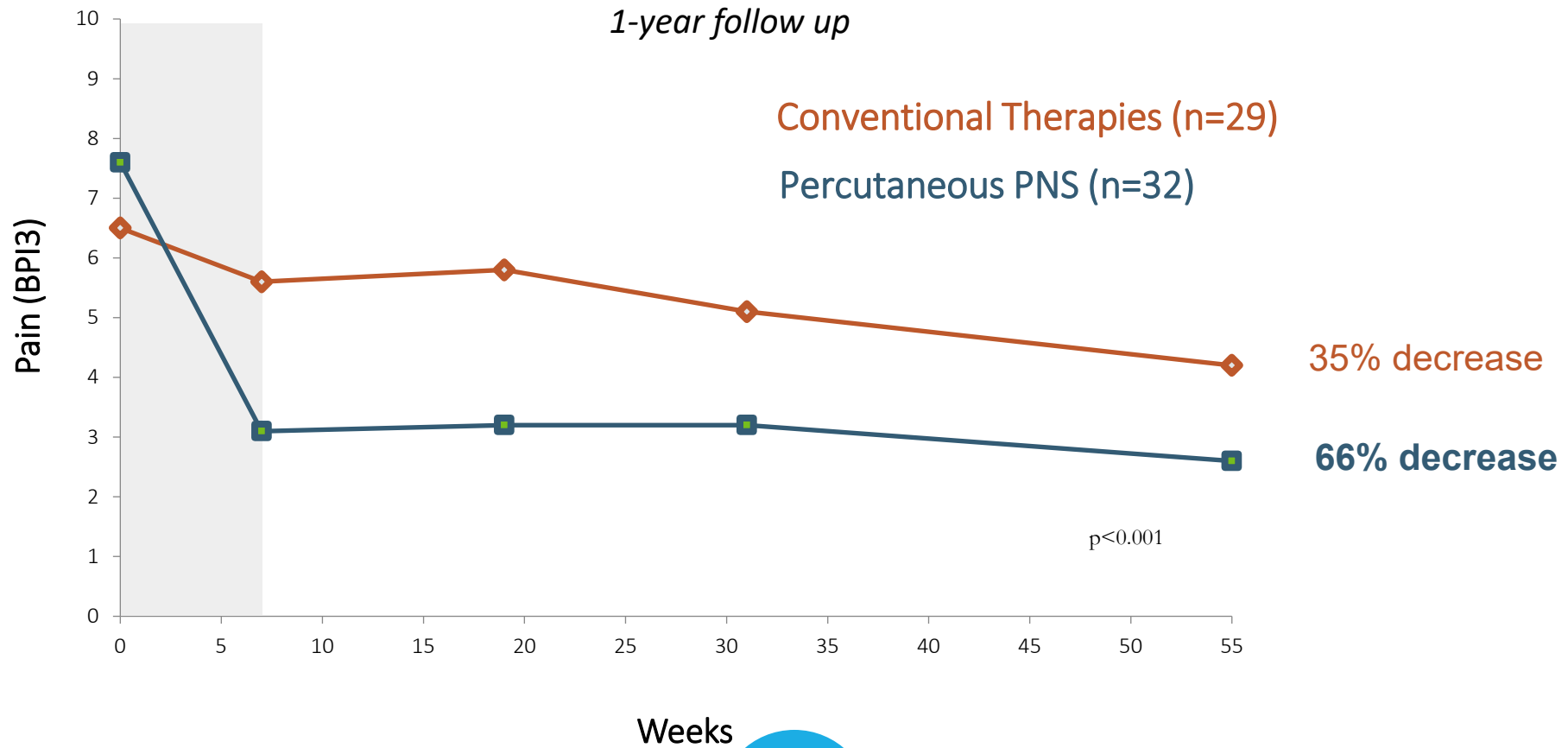
Intramuscular electrical stimulation for hemiplegic shoulder pain: a 12-month follow-up of a multiple-center, randomized clinical trial

[John Chae¹](#), [David T Yu](#), [Maria E Walker](#), [Andrew Kirsteins](#), [Elie P Elovic](#), [Steven R Flanagan](#), [Richard L Harvey](#), [Richard D Zorowitz](#), [Frederick S Frost](#), [Julie H Grill](#), [Zi-Ping Fang](#)

Am J Phys Med Rehabil. 2005

N = 61

78% Reported Relief 12 months after Treatment



Single-lead percutaneous peripheral nerve stimulation for the treatment of hemiplegic shoulder pain: a case report

Richard D Wilson ¹, Maria E Bennett, Tina E Lechman, Kathryn W Stager, John Chae

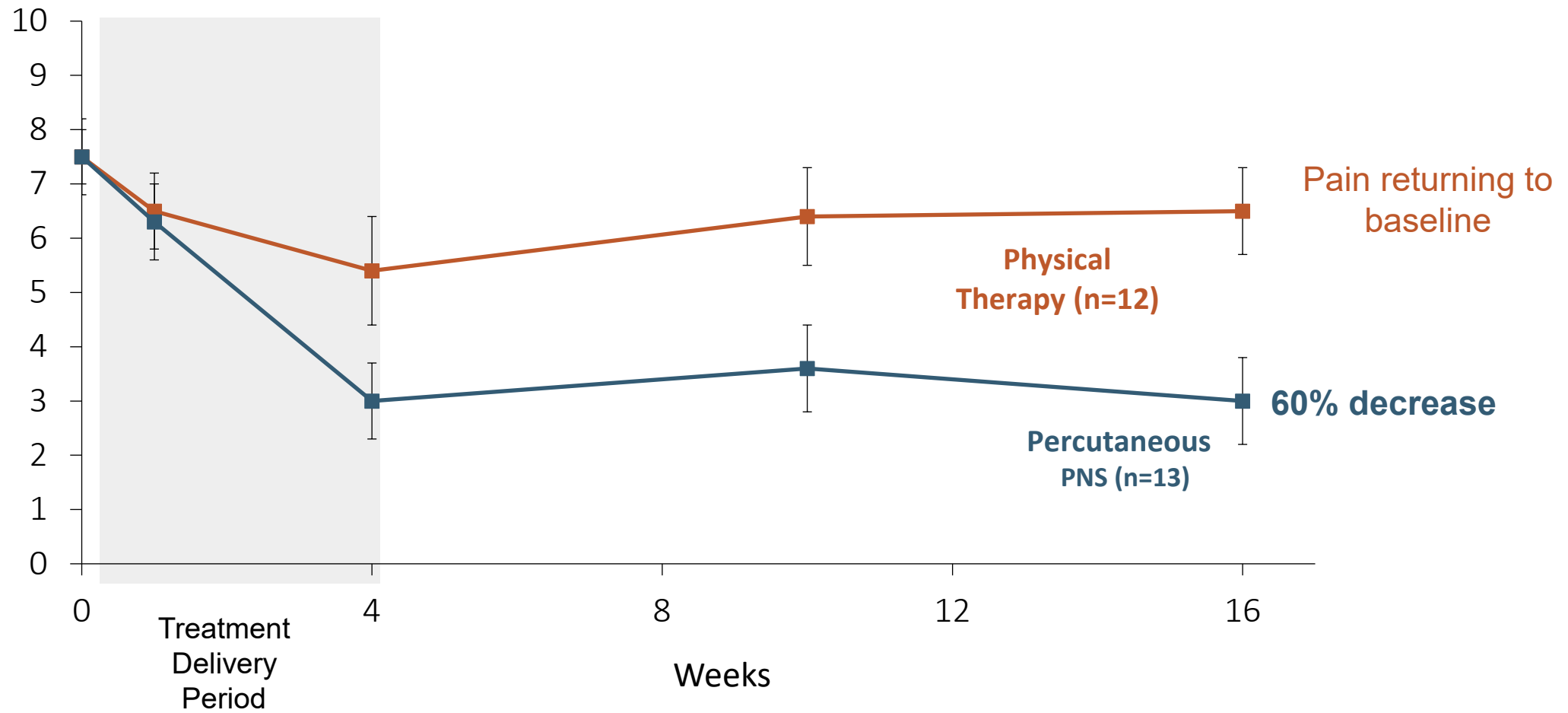
Arch Phys Med Rehabil. 2011

Peripheral nerve stimulation compared with usual care for pain relief of hemiplegic shoulder pain: a randomized controlled trial

Richard D Wilson ¹, Douglas D Gunzler, Maria E Bennett, John Chae

Arch Phys Med Rehabil. 2014

N = 25



Prospective, Multicenter, Randomized, Double-Blinded, Partial Crossover Study to Assess the Safety and Efficacy of the Novel Neuromodulation System in the Treatment of Patients With Chronic Pain of Peripheral Nerve Origin

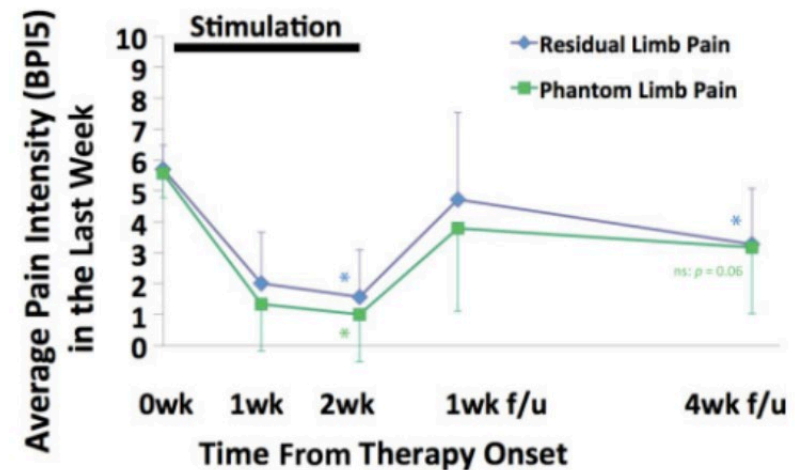
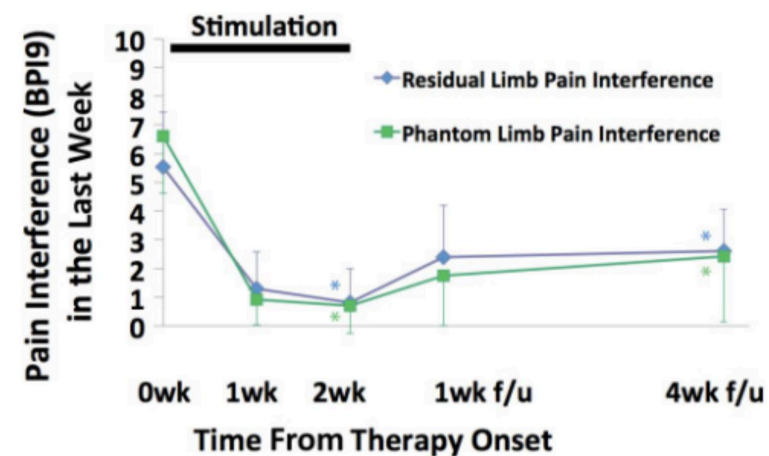
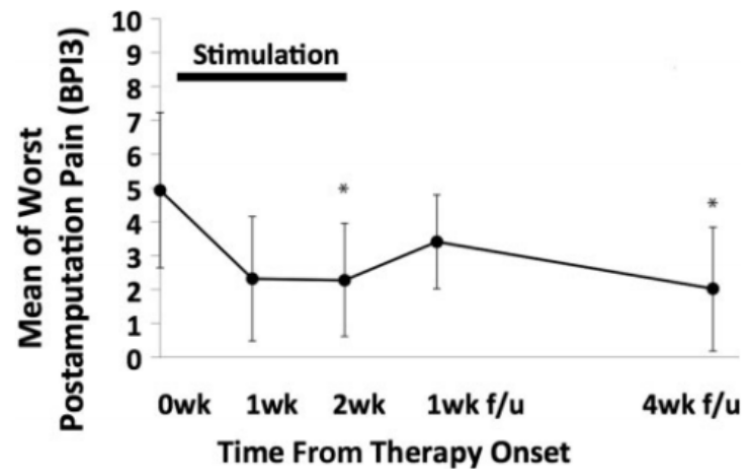
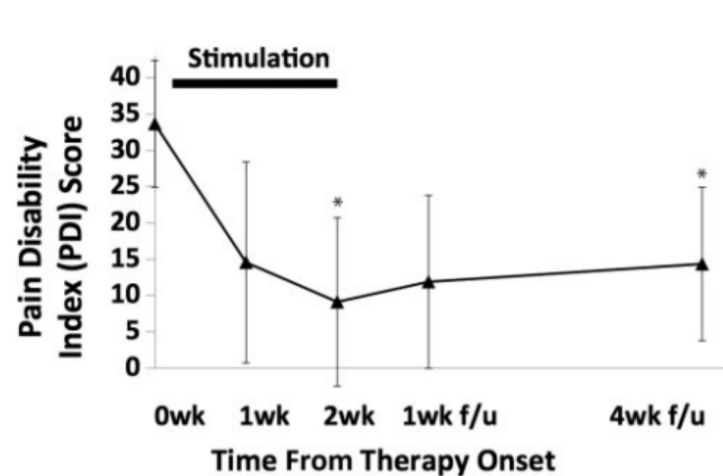
Timothy Deer ¹, Jason Pope ², Ramsin Benyamin ³, Ricardo Vallejo ⁴, Andrew Friedman ⁵, David Caraway ⁶, Peter Staats ⁷, Eric Grigsby ⁸, W Porter McRoberts ⁹, Tory McJunkin ¹⁰, Richard Shubin ¹¹, Payam Vahedifar ¹², Daryoush Tavanaiepour ¹³, Robert Levy ¹⁴, Leonardo Kapural ¹⁵, Nagy Mekhail ¹⁶

Neuromodulation. 2016

Neuromodulation

Technology at the Neural Interface

Post Amputation Pain



Percutaneous 60-day peripheral nerve stimulation implant provides sustained relief of chronic pain following amputation: 12-month follow-up of a randomized, double-blind, placebo-controlled trial

Christopher A Gilmore¹,
Corey W Hunter²,
Nathan D Crosby³,
Reg Anesth Pain Med

Percutaneous Peripheral Nerve Stimulation for the Treatment of Chronic Pain Following Amputation

Steven P Cohen¹, Christopher A Gilmore², Richard L Rauck², Denise D Lester³,
Robert J Trainer³, Thomas Phan³, Leonardo Kapural², James M North², Nathan D Crosby⁴,
Joseph W Boggs⁴

Mil Med. 2019

Amputation pain with peripheral

James M North, Leonardo Kapural,

**nerve stimulation for the
ropathic postamputation
omized, placebo-controlled**

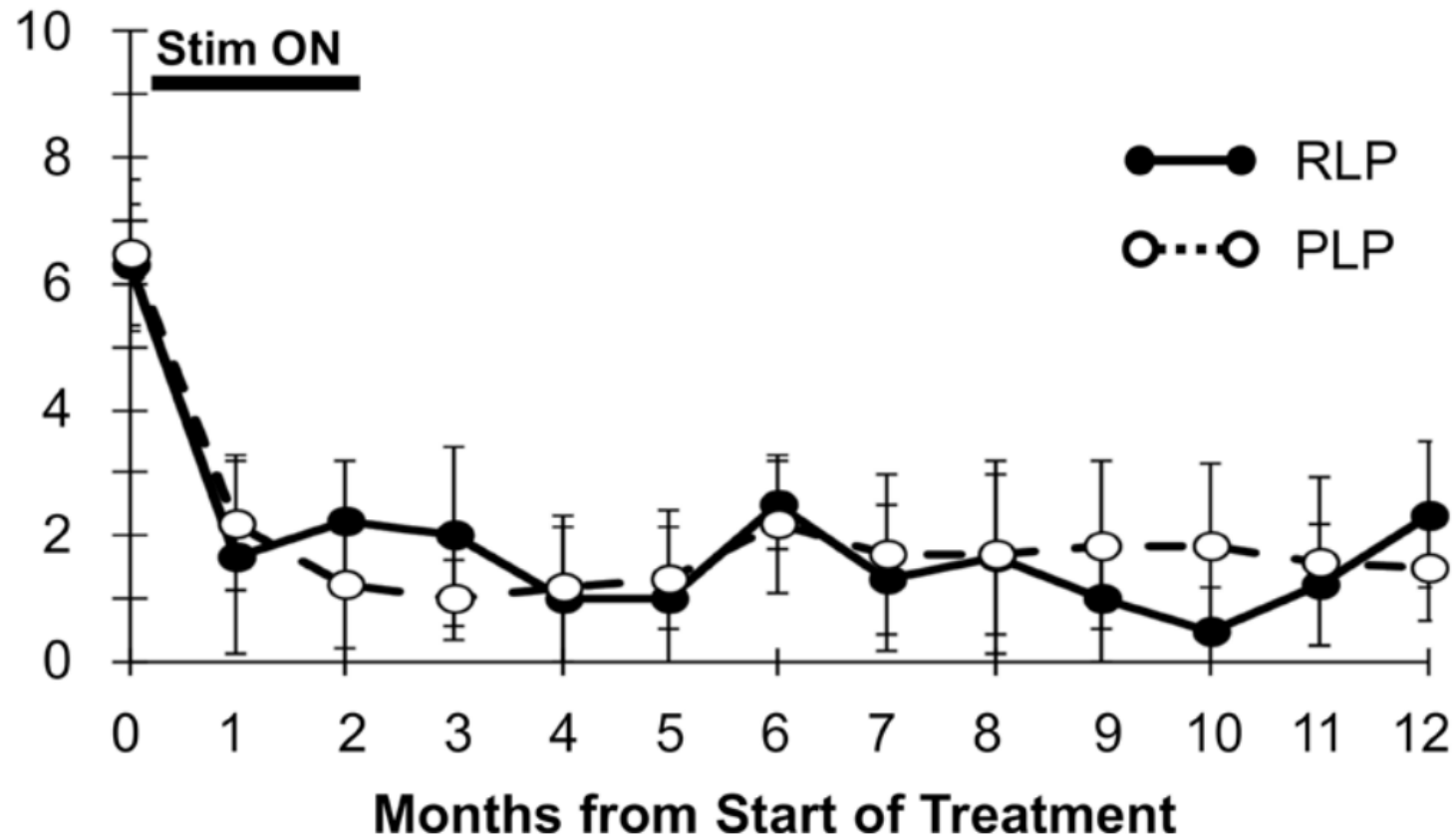
Christopher Gilmore¹, Brian Ilfeld², Joshua Rosenow³, Sean Li⁴, Mehul Desai⁵,
Corey Hunter⁶, Richard Rauck⁷, Leonardo Kapural⁷, Antoun Nader⁸, John Mak⁴,
Steven Cohen⁹, Nathan Crosby¹⁰, Joseph Boggs¹⁰

Reg Anesth Pain Med. 2019

Post Amputation
Pain

B

Average Post-Amputation Pain in
Group 1 Responders (SD)



Post Amputation
Pain

Reg Anesth Pain Med. 2019

Percutaneous Peripheral Nerve Stimulation of the Medial Branch Nerves for the Treatment of Chronic Axial Back Pain in Patients After Radiofrequency Ablation

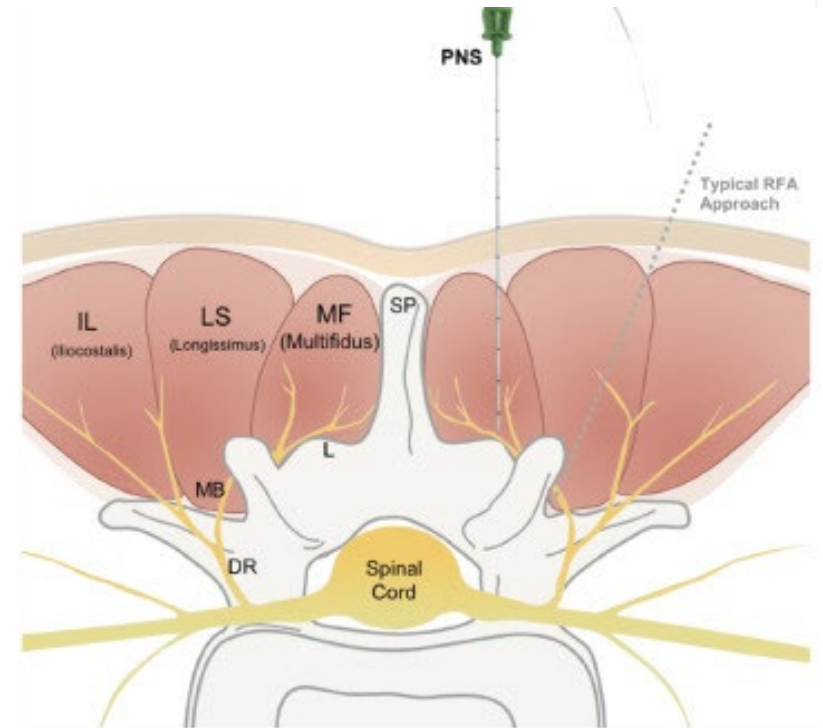
Timothy R Deer ¹, Christopher A Gilmore ², Mehul J Desai ³, Sean C Li ⁴, Michael J DePalma ⁵, Thomas J Hopkins ⁶, Abram H Burgher ⁷, David A Spinner ⁸, Steven P Cohen ⁹, Meredith J McGee ¹⁰, Joseph W Boggs ¹⁰

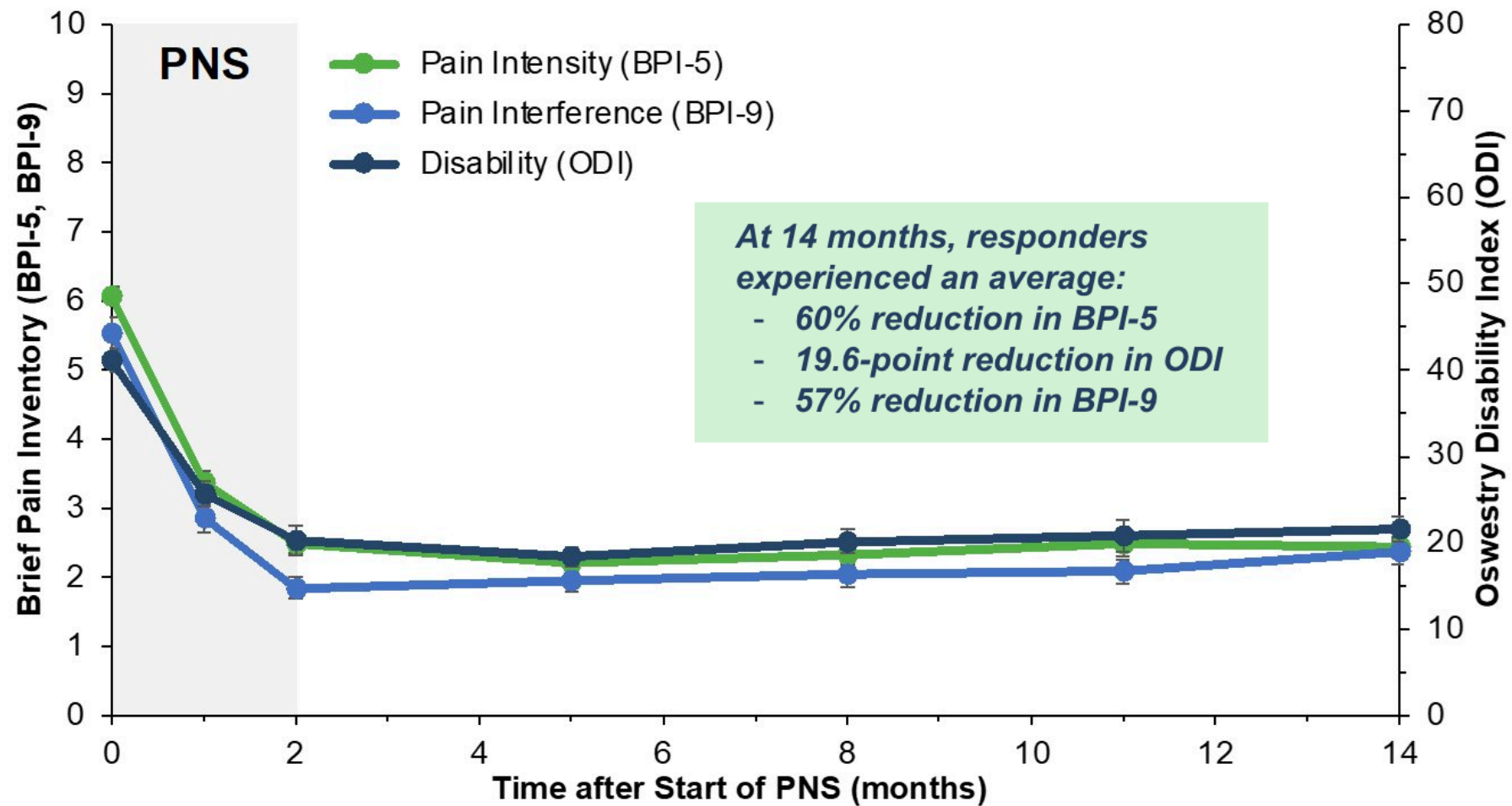
Pain Med. 2021

Treatment of chronic axial back pain with 60-day percutaneous medial branch PNS: Primary end point results from a prospective, multicenter study

Christopher A Gilmore ¹, Mehul J Desai ², Thomas J Hopkins ³, Sean Li ⁴, Michael J DePalma ⁵, Timothy R Deer ⁶, Warren Grace ⁶, Abram H Burgher ⁷, Puneet K Sayal ², Kasra Amirdelfan ⁸, Steven P Cohen ⁹, Meredith J McGee ¹⁰, Joseph W Boggs ¹⁰

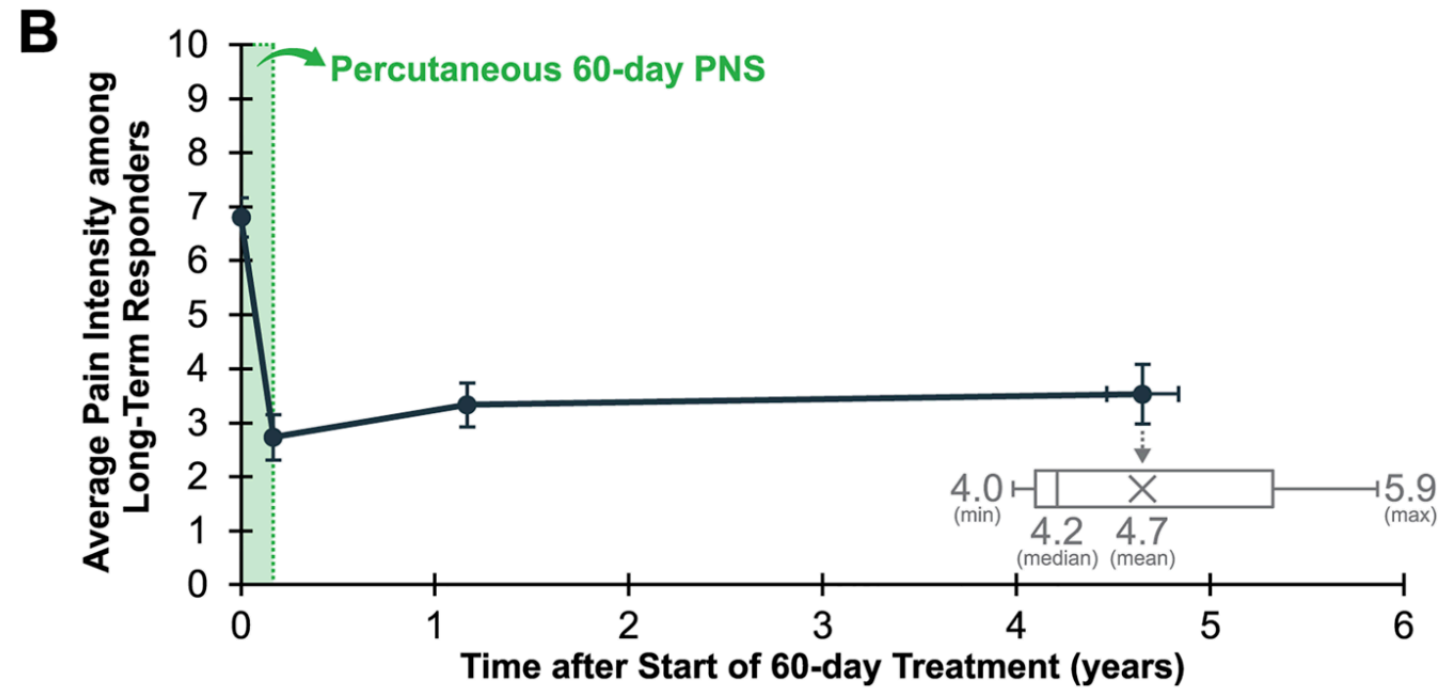
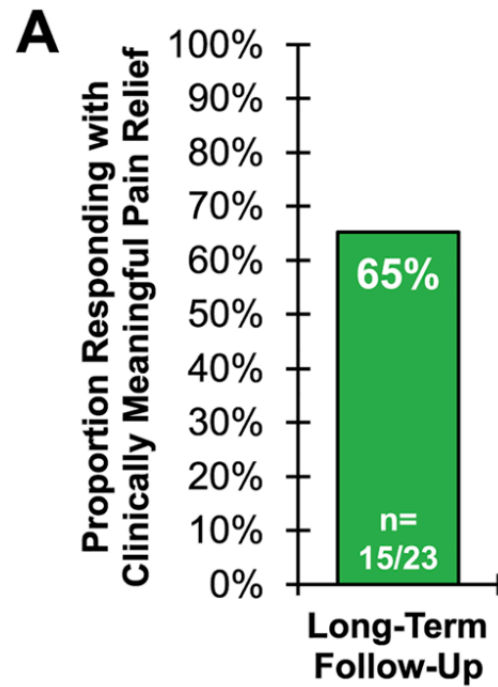
Pain Pract. 2021

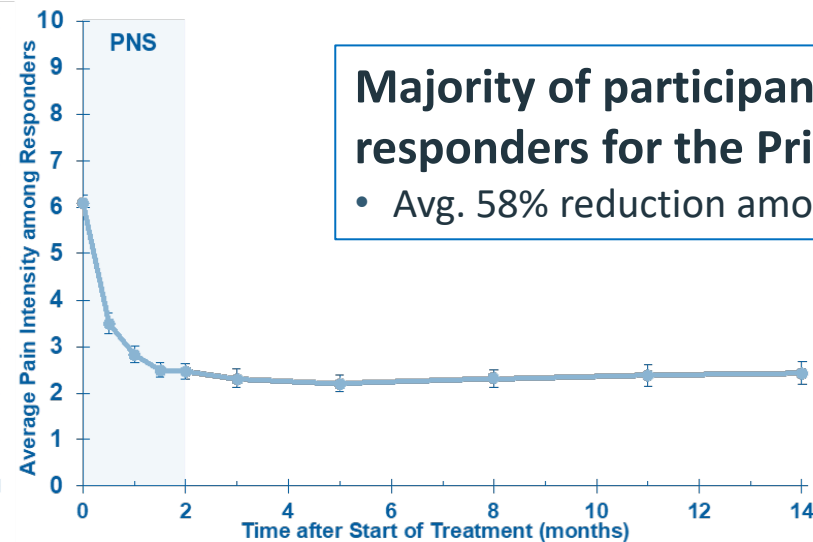
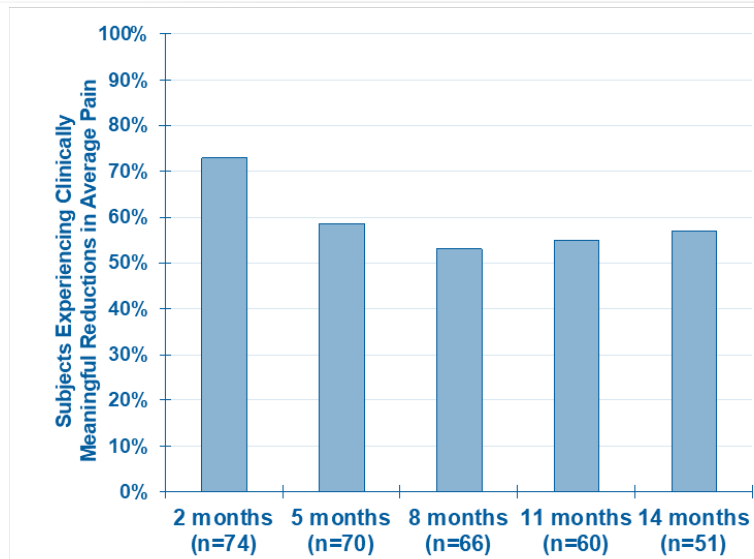




N = 74

Lumbar Pain

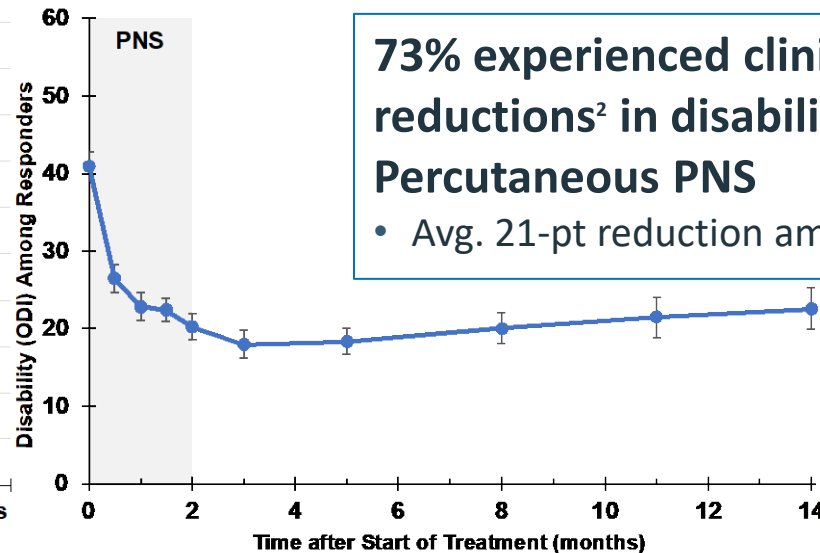
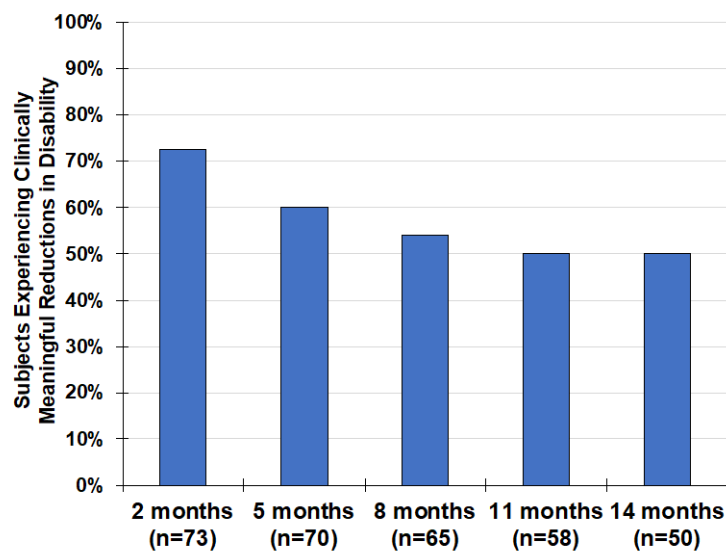




Majority of participants, (73%) were responders for the Primary Endpoint¹

- Avg. 58% reduction among responders

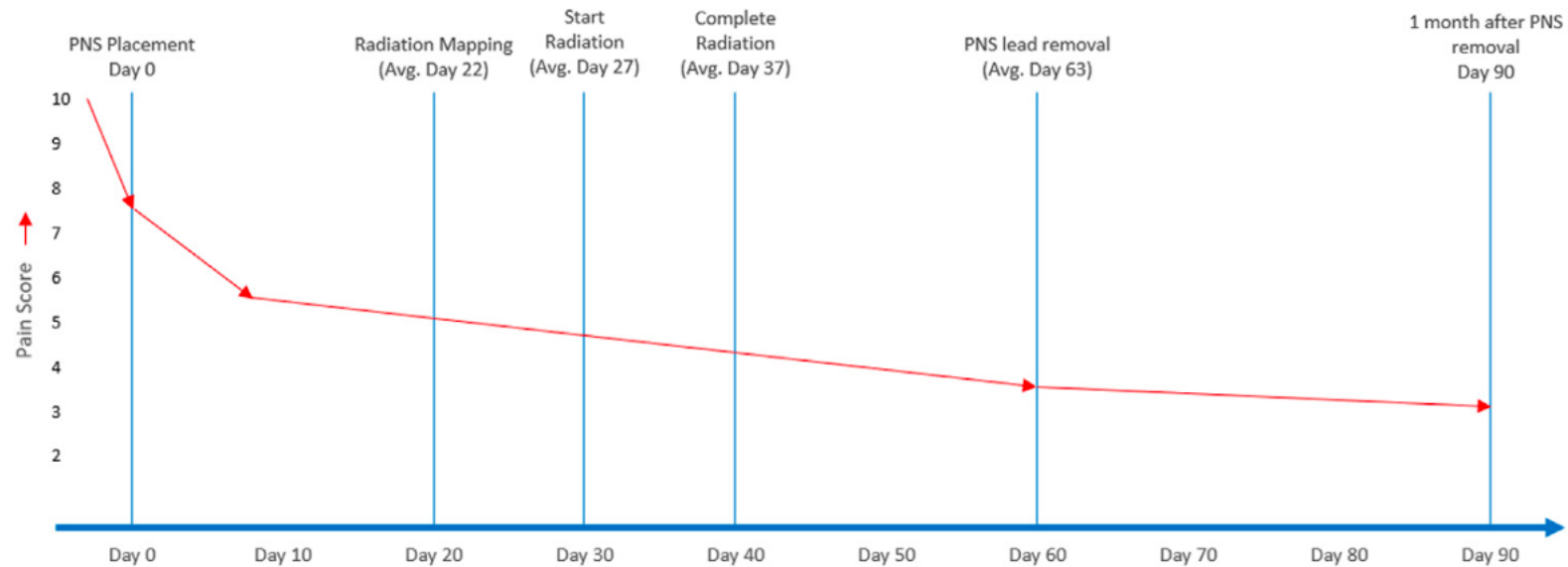
Reductions in Average Pain Intensity (BPI-5):



73% experienced clinically meaningful reductions² in disability after 2 months of Percutaneous PNS

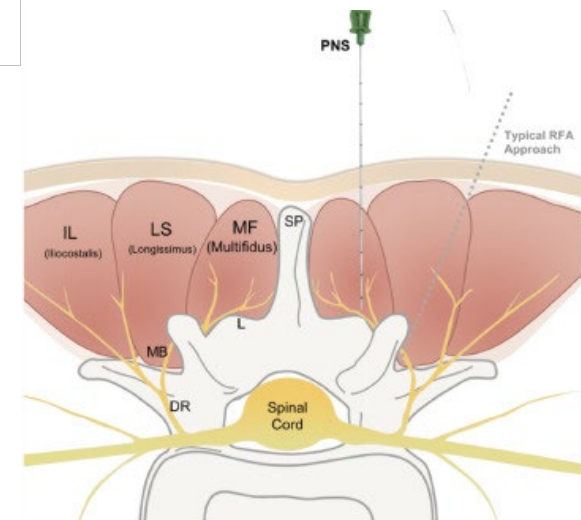
- Avg. 21-pt reduction among responders

Reductions in Disability (ODI):



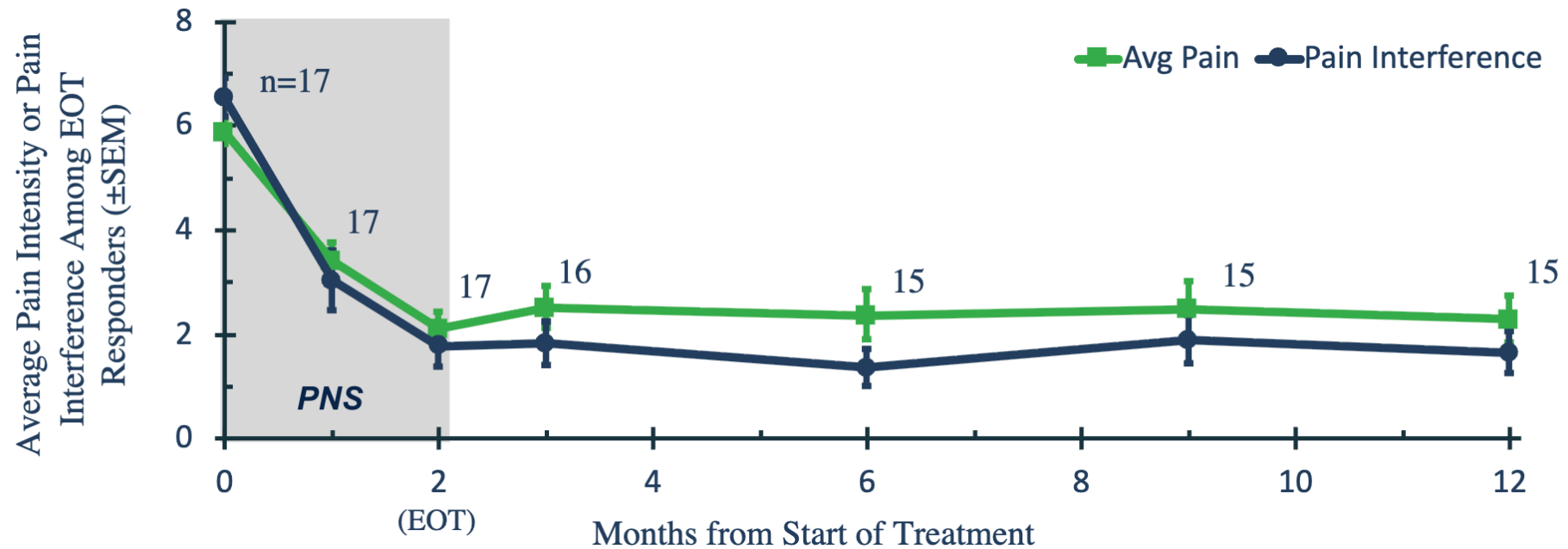
Peripheral Nerve Stimulation for Back Pain in Patients With Multiple Myeloma as Bridge Therapy to Radiation Treatment: A Case Series

Steven Mach, MD¹ ; Saba Javed, MD¹; Grant H. Chen, MD²; Billy K. Huh, MD, PhD¹



A multicenter, prospective, single-arm study of 60-day peripheral nerve stimulation of the occipital nerves for the treatment of headache

Genaro G Gutierrez¹, Zachary L McCormick², Mitchell P Engle³, Christopher A Gilmore⁴,
Matthew J Pingree⁵, Jason E Pope⁶, David J DiBenedetto⁷, Narayan R Kissoon^{5 8},
Puneet K Sayal³, Claire A Zurn⁹, Nathan D Crosby⁹, Joseph W Boggs⁹



Clinical study of a micro-implantable pulse generator for the treatment of peripheral neuropathic pain: 3-month and 6-month results from the COMFORT-randomised controlled trial

John Hatheway ¹, Alexander Hersel, ² Jonathan Song, ³ Mitchell Engle, ⁴ Genaro Gutierrez, ⁵ Vishal Khemlani, ⁶ Leonardo Kapural, ⁷ Gregory Moore, ⁸ Reginald Ajakwe, ⁹ Drew Trainor, ¹⁰ Jennifer Hah, ¹¹ Peter S Staats, ¹² Paul Lynch, ¹³ James Makous, ¹⁴ Gary Heit, ¹⁵ Shilpa Kottalgi, ¹⁶ Mehul J Desai ¹⁷

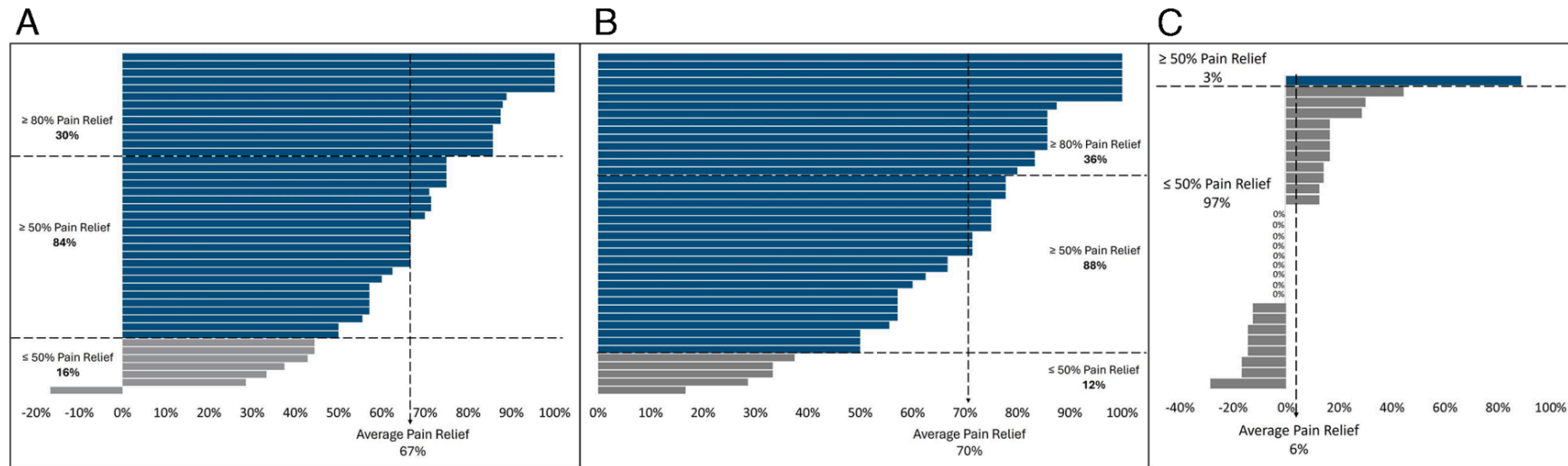
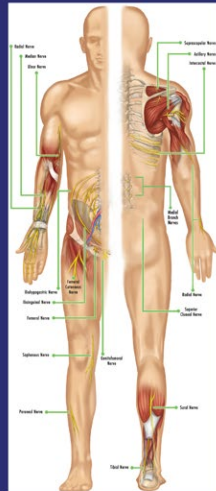


Figure 2 Tornado plot. (A) Active arm at 3 months, (B) active arm at 6 months and (C) control arm at 3 months, showing per cent pain relief in each study subject. Responders were subjects with $\geq 50\%$ pain reduction compared with their baseline NRS pain score. High responders were subjects with $\geq 80\%$ pain reduction compared with their baseline pain score. NRS, numeric rating scale.

Pain Medicine

VOLUME 21, SUPPLEMENT 1, 2020
academic.oup.com/painmedicine

Peripheral Nerve Stimulation: Update for the 21st Century



THE OFFICIAL JOURNAL OF



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ONLINE ISSN: 1526-4637

OXFORD
UNIVERSITY PRESS

Pilot Study in Temporary Peripheral Nerve Stimulation in Oncologic Pain

Ojas Mainkar, MD* ; Che Antonio Sollo, MD[†]; Grant Chen, MD[‡]; Aron Legler, MD[‡]; Amitabh Gulati, MD* 

An Interventional Pain Algorithm for the Treatment of Postmastectomy Pain Syndrome: A Single-Center Retrospective Review

Ajax Yang , MD*,^{†,‡} Danielle Nadav, MD*,[†] Aron Legler, MD* Grant H. Chen , MD* Lee Hingula, MD* Vinay Puttanniah, MD* and Amitabh Gulati, MD*

Sciatic, Femoral, and Lateral Femoral Cutaneous Nerve Ultrasound-Guided Percutaneous Peripheral Nerve Stimulation

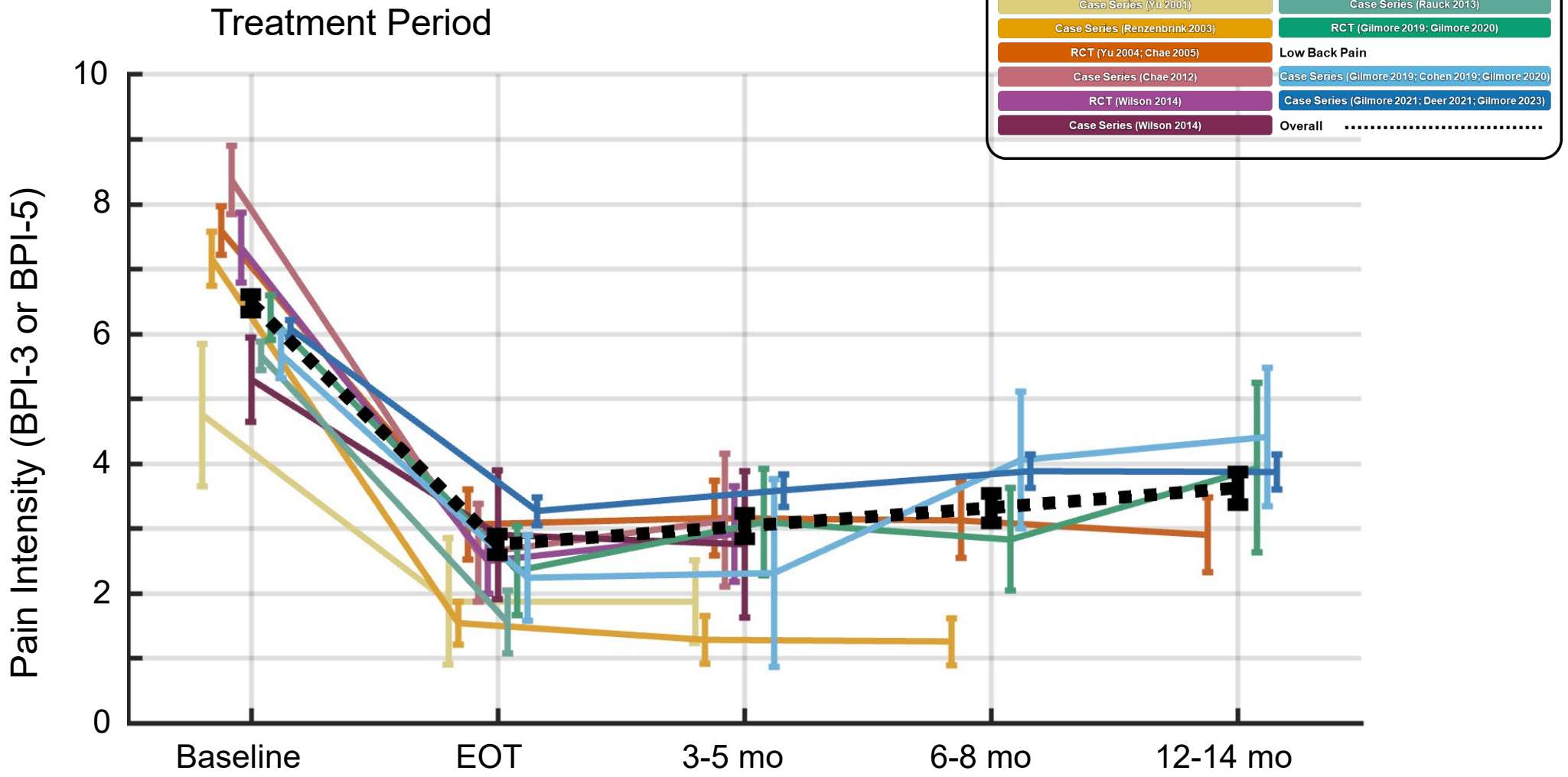
Harmandeep Singh, MD*,^{†,‡} Akshat Gargya, MD*,^{†,‡} Tiffany Lin, MD*,^{†,‡} and Amitabh Gulati, MD, FIPP, CIPS[‡]

Mechanism of Peripheral Nerve Stimulation in Chronic Pain

Tiffany Lin, MD* Akshat Gargya, MD* Harmandeep Singh, MD,* Eellan Sivanesan , MD[†] and Amitabh Gulati, MD[‡]

Extraforaminal Thoracic and Lumbar Spinal Nerve Ultrasound-Guided Percutaneous Peripheral Nerve Stimulation

Akshat Gargya, MD, FIPP, CIPS*,[†] Harmandeep Singh, MD*,[†] Tiffany Lin, MD*,[†] and Amitabh Gulati, MD*



ANESTHESIOLOGY

Percutaneous Peripheral Nerve Stimulation (Neuromodulation) for Postoperative Pain: A Randomized, Sham-controlled Pilot Study

Brian M. Ilfeld, M.D., M.S., Anthony Plunkett, M.D., Alice M. Vijjeswarapu, M.D., Robert Hackworth, M.D., Sandeep Dhanjal, M.D., Alparslan Turan, M.D., Steven P. Cohen, M.D., James C. Eisenach, M.D., Scott Griffith, M.D., Steven Hanling, M.D., Daniel I. Sessler, M.D., Edward J. Mascha, Ph.D., Dongsheng Yang, M.S., Joseph W. Boggs, Ph.D., Amorn Wongsarnpigoon, Ph.D., Harold Gelfand, M.D., on behalf of the PAINfRE Investigators*

ANESTHESIOLOGY 2021; XXX:00–00

Jan 2019- Sept 2020

Types of surgery:

- Rotator Cuff Repair
- Anterior Cruciate Ligament Repair with Patellar Allograph
- Hallux Valgus Correction
- Ankle Arthrodesis

Prior to Surgery

- Leads placed 2 cm away from nerve
- 100 Hz frequency fixed
- Adjustable intensity

ANESTHESIOLOGY

Percutaneous Peripheral Nerve Stimulation (Neuromodulation) for Postoperative Pain: A Randomized, Sham-controlled Pilot Study

Brian M. Ilfeld, M.D., M.S., Anthony Plunkett, M.D., Alice M. Vijjeswarapu, M.D., Robert Hackworth, M.D., Sandeep Dhanjal, M.D., Alparslan Turan, M.D., Steven P. Cohen, M.D., James C. Eisenach, M.D., Scott Griffith, M.D., Steven Hanling, M.D., Daniel I. Sessler, M.D., Edward J. Mascha, Ph.D., Dongsheng Yang, M.S., Joseph W. Boggs, Ph.D., Amorn Wongsarnpigoon, Ph.D., Harold Gelfand, M.D., on behalf of the PAINfRE Investigators*

ANESTHESIOLOGY 2021; XXX:00–00

Daily pain scores first 7 days
(Mean $\pm$ SD)

Stimulation:

1.1 $\pm$ 1.1

Nonstimulation

3.1 $\pm$ 1.7

Oral morphine equivalent consumption

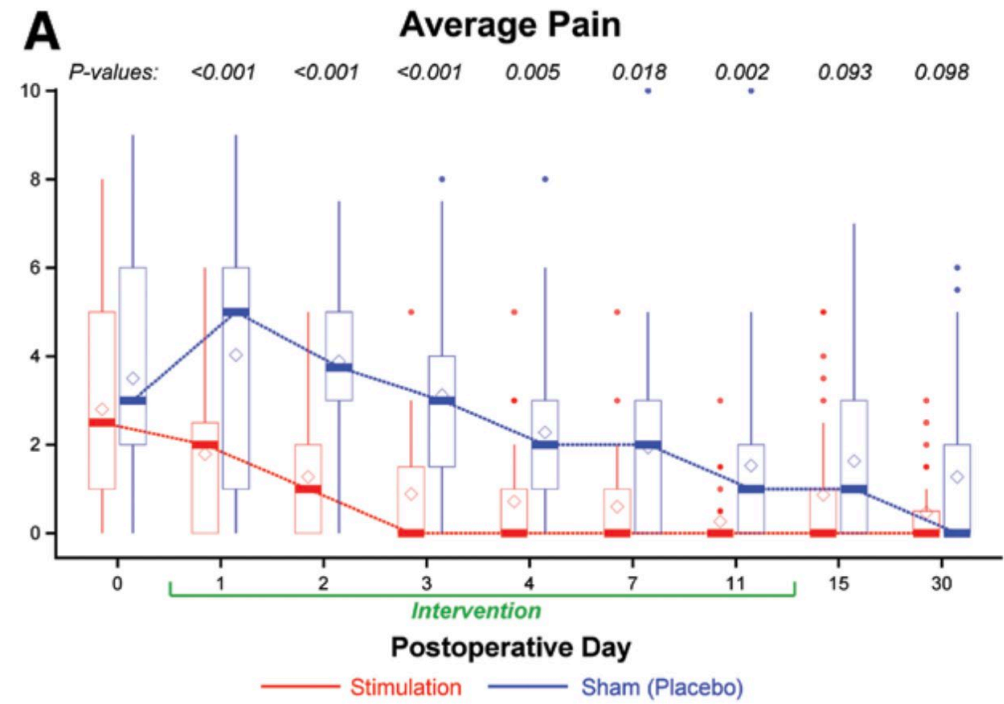
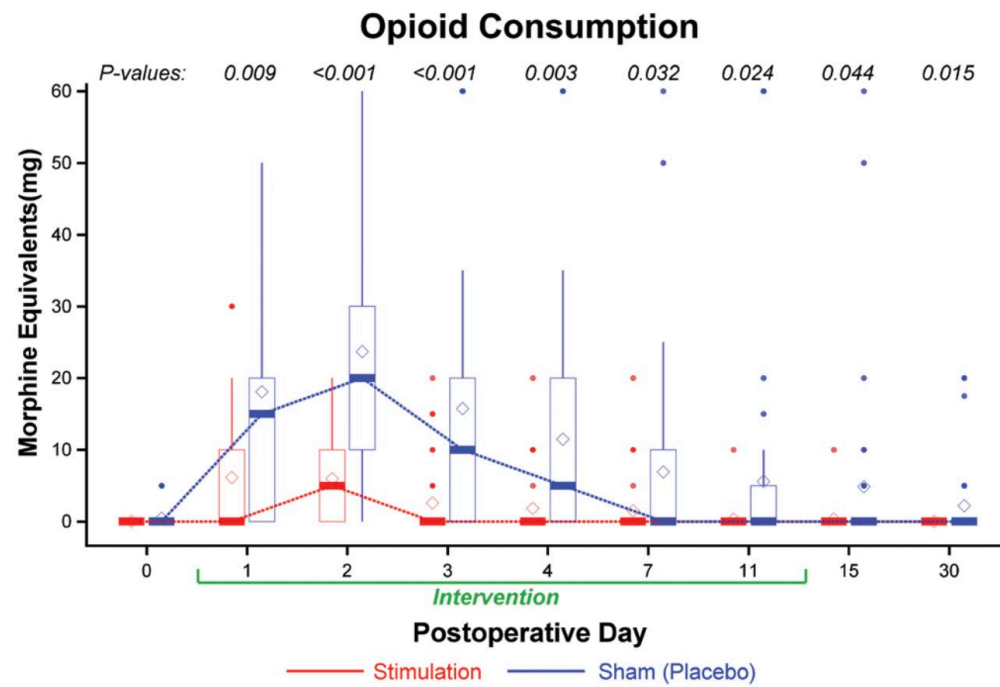
Median (Interquartile Range)

Stimulation:

5 mg (0 to 30 mg)

Nonstimulation

48 mg (25 to 90 mg)



Texas **Pain** Society



Best Practice Guidelines



Guidelines

e Comprehensive Evidence-Based Guidelines for Implantable Peripheral Nerve Stimulation (PNS) in the Management Of Chronic Pain: From the American Society Of Interventional Pain Physicians (ASIPP)



Evidence-Based Clinical Guidelines from the American Society of Pain and Neuroscience for the Use of Implantable Peripheral Nerve Stimulation in the Treatment of Chronic Pain



Table 6 ASPN Best Practices PNS Guidelines

ASPN Best Practices PNS Guidelines	Level of Evidence	Grade
<u>Head/Neck</u> Stimulation of occipital nerves may be offered to patients with chronic migraine headache when conservative treatments have failed. The average effect size for relief of migraine symptoms is modest to moderate. There is insufficient evidence to recommend stimulation of supraorbital and infraorbital nerves for neuropathic craniofacial pain. <u>Upper Extremities</u> PNS may offer modest and short-term pain relief, improved physical function, and better quality of life for chronic hemiplegic shoulder pain. PNS for mononeuropathies of the upper extremity may be offered following a positive diagnostic ultrasound-guided nerve block of the targeted nerve and is associated with modest to moderate pain relief. <u>Low Back/Trunk</u> Subcutaneous peripheral field stimulation and optimal medication management may offer moderate improvement in pain intensity for failed back surgery compared to optimal medication management alone. There is evidence that PNS of lumbar medial branch nerves may improve pain intensity, physical function, and pain interference in patients with axial, mechanical low back pain. There is limited evidence that PNS may alleviate pain in neuropathic pain syndrome involving the trunk and back including radiculopathy and post-herpetic neuralgia. <u>Lower Extremities</u> PNS may be considered for lower extremity neuropathic pain following failure of conservative treatment options and is associated with modest pain relief. PNS may be considered for lower extremity post-amputation pain following failure of conservative treatment options and is associated with modest to moderate pain relief. <u>Other Considerations</u> As a less-invasive modality compared to SCS therapy, PNS may be offered to patients with CRPS Type I or Type II, and may be associated with modest improvement in pain intensity and functional outcomes. However, high-quality evidence is limited and other neuromodulation interventions such as dorsal root ganglion SCS are recommended for CRPS. PNS carries a low-to-intermediate risk for bleeding complications and depends on the proximity of the targeted nerve to critical vessels and invasiveness of PNS implantation.	I II-3 I II-2 I II-2 III I I III III	B C B B B B C B B C I



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EXPERT OPINION

Consensus Guidelines from the American Society of Pain and Neuroscience for the Use of 60-Day Peripheral Nerve Stimulation Therapy. A NEURON Living Guideline Project

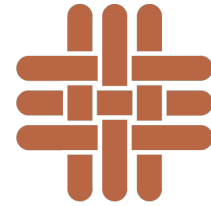


Table 3 Summary of Consensus Opinions Regarding Use of 60-Day PNS

Etiology of Pain	ASPEN Guidelines Panel Statement	Grade	Certainty	Evidence Level
Chronic LBP	Moderate	Grade C	Moderate	Level I-C
Chronic LBP: After facet RFA	Moderate	Grade B	Moderate	Level I-C
Chronic LBP: Centralized contributions	Strong	Grade A	Moderate	Level I-C
Chronic neck pain	Weak	Grade C	Moderate	Level II
Chronic shoulder pain vs shoulder surgery	Weak	Grade C	Low	Level II
Foot and ankle pain: Post-operative refractory	Moderate	Grade C	High	Level I-A
Knee pain: Inoperable	Weak	Grade C	Low	Level II
Knee pain: Post-operative refractory	Strong	Grade B	High	Level I-A
Neuropathic pain	Moderate	Grade C	Moderate	Level I-B
Occipital neuralgia	Moderate	Grade B	Low	Level II
Phantom and residual limb pain	Strong	Grade A	High	Level I-A
Post-amputation pain	Strong	Grade B	High	Level I-C
Shoulder pain: Inoperable	Moderate	Grade C	Moderate	Level I-C
Shoulder pain: Post-operative refractory	Moderate	Grade B	Low	Level II

Abbreviations: ASPEN, American Society of Pain and Neuroscience; PNS, Peripheral nerve stimulation; LBP, low back pain; RFA, radiofrequency ablation.

WHERE HAS PNS BEEN USED IN CHRONIC PAIN AT



&



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Suprascapular

Axillary

Intercostal

Paravertebral

Brachial Plexus

Occipital

Superior Cluneal

Middle Cluneal

Lumbar & Cervical Medial Branch

Radial

Musculocutaneous

Anterior Interosseus

Common Fibular

Sciatic

Popliteal

Ilioinguinal

Ulnar

L3 nerve root

Saphenous

Lateral Femoral Cutaneous

Anterior Tibial

Sural

Pudendal

Superficial Peroneal

Genicular



Complications

Skin pruritus/abrasion/erosion

Lead breakage or migration

Pain after electrode placement

Pulse generator too far from the skin

Uncomfortable motor response

Suboptimal results

MRI conditionality

Infection

Nerve damage

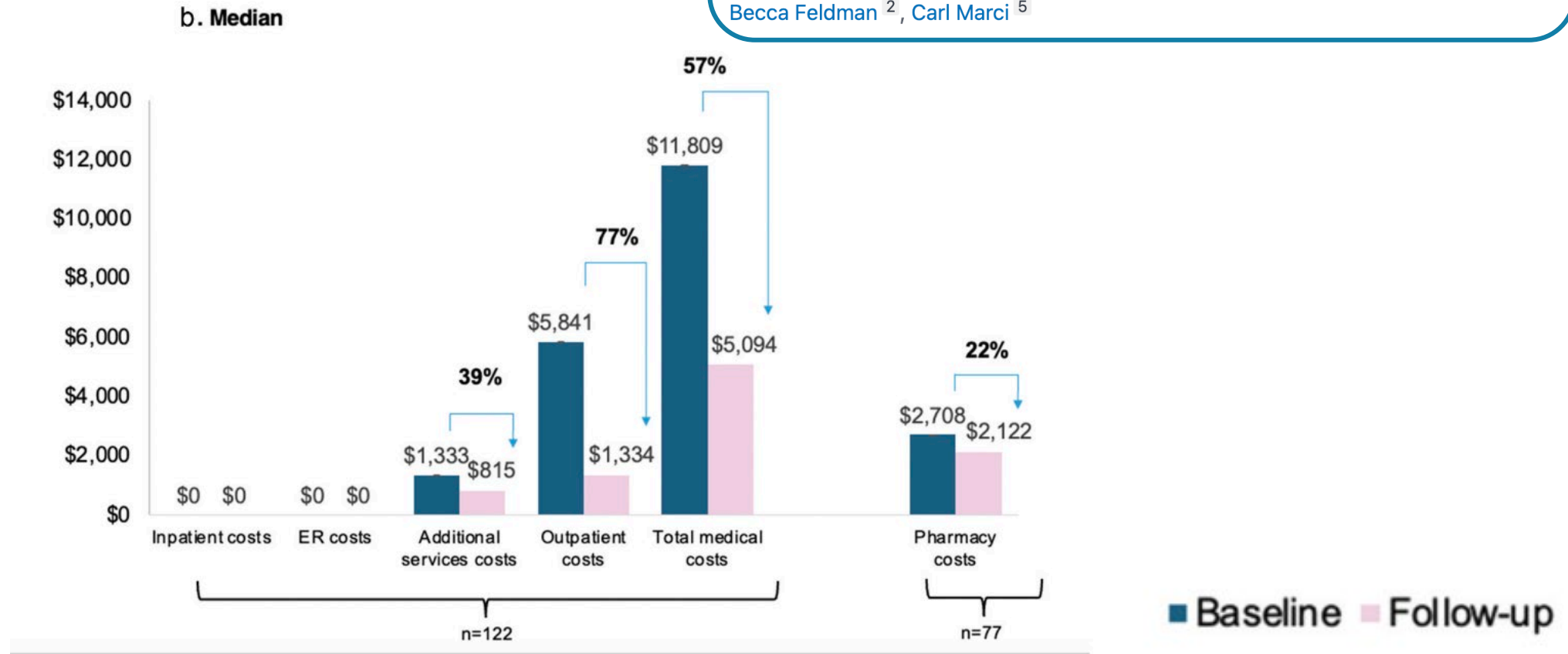
Bleeding



The Future of PNS

Real-world healthcare utilization and costs of peripheral nerve stimulation with a micro-IPG system

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Thank you

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