



NORTHWEST
SPINE & PAIN MEDICINE

Neuromodulation

Spinal Cord Stimulation

Peripheral Stimulation

Dorsal Root Ganglion Stimulation

How, When and Why





Objectives

1. How to identify candidates for neuromodulation
2. Identify the different types of neuromodulation
3. Understand the patient selection for each type





Introduction

- I am Howard Grattan, MD
- I am double board certified in pain management and physical medicine and rehabilitation
- I am the main spinal cord stimulation specialist at Northwest Spine and Pain in Spokane, WA
- I have been trained in the 3 main pain neuromodulations
 - Peripheral
 - Spinal cord
 - Dorsal Root Ganglion





Disclosures

- None
- Unfortunately...
- If a company is in the audience that would like to give me lots of money, I am all ears.





How does neuromodulation work

Simple and yet complex.

- Simple part: Nerves carry pain signals to the brain using electricity
- We can create electricity to interrupt nerve transmission!
- Complex part: We need to use specific stimulation patterns in specific areas to override painful signals instead of increasing signals.
- Nerves also control muscles, endocrine, heart... well... everything.
- So we need to avoid activating the wrong nerves while modulating the right nerves.





Three most common targets

- Peripheral nerves
- Dorsal Column of the Spinal Cord
- Dorsal Root Ganglions





Peripheral Stimulation

- Basically a super TENS unit
- Companies hate it when you call it that, but it is what it is.
- By placing a lead directly on an injured nerve or in the subcutaneous tissue surrounding a painful area, the effectiveness of stimulation is superior to TENS which passes electricity through the skin and subcutaneous fat.





Peripheral Stimulation

- Common diagnoses
 - Localized post-surgical pain such as
 - Hernia surgery
 - Knee replacement
 - Burns
 - Trauma
 - CRPS
 - Peripheral Neuropathy
 - Occipital neuralgia
 - or any neuralgia really





Peripheral Stimulation

- Some Evidence

- Implantable Peripheral Nerve Stimulation for Peripheral Neuropathic Pain: A Systematic Review of Prospective Studies
- [Biomedicines](#). 2022 Oct; 10(10): 2606.
- Published online 2022 Oct 17
- [Steven Char](#),¹ [Max Y. Jin](#),² [Vinicius Tieppo Francio](#),³ [Nasir Hussain](#),⁴ [Eric J. Wang](#),⁵ [Mahmoud Morsi](#),⁶ [Vwaire Orhurhu](#),^{7,8} [Larry J. Prokop](#),⁹ [Adam Fink](#),¹⁰ and [Ryan S. D'Souza](#)^{11,*}
- “This review highlighted low-quality GRADE evidence supporting the use of PNS therapy to treat peripheral neuropathic pain. Further, studies highlight promising data on improvement in neurological function, quality of life, satisfaction, and emotional functioning after PNS therapy for peripheral neuropathic pain.”





Peripheral Stimulation

- Why low-quality evidence in studies?
- Difficult to blind
- Small size studies
- Variable neuropathic pain conditions limit size of studies
- However, the studies included in the review had between 50-80% of patients report greater than 50% pain improvement at 6-12 months.





Peripheral Stimulation

- How is it done?
- Just poke the needle in there and leave a wire behind



Ua = Ulnar artery
Un = Ulnar Nerve



FCU = Flexor carpi ulnaris muscle
FDP = Flexor digitorum profundus muscle

FDS = Flexor digitorum superficialis muscle





Peripheral Stimulation

- How is it done?
- Just poke the needle in there and leave a wire behind



Longitudinal view of a 8 contact lead peripheral nerve stimulator (shown with red arrows), above the median nerve.



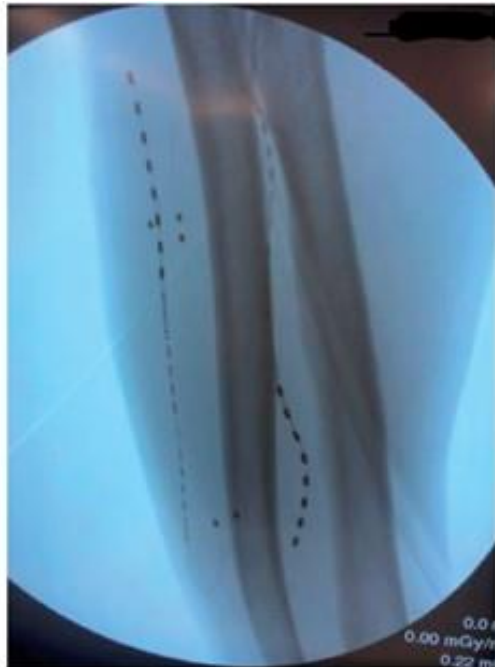
Cross sectional view of the tip of the peripheral nerve stimulator (shown with red arrow) medial to the median nerve.





Peripheral Stimulation

- How is it done?
- Just poke the needle in there and leave a wire behind



Fluoroscopic image of the leads during trial (8 contact leads with no anchor). Tail end is outside the skin as seen in Figure 4.



Fluoroscopic image of the final implanted leads (4 contact leads with anchor)





Peripheral Stimulation

- How is it done?
- Just poke the needle in there and leave a wire behind
- Wire is affixed to skin under sterile conditions usually under a Tegaderm with external stimulator attached or some systems stimulate wirelessly with induction without a wired battery pack.
- After a week trial the leads are removed. If the patient has significant benefit (usually at least 50%) the patient is scheduled for a surgical implantation with new wires.





Peripheral Stimulation

- Risks
- Pain, bleeding, infection (it is a needle after all)
- Injuring the nerve that you are trying to get near
- Irritating stimulation
- Lead migration in very active people
- Waning benefit as brain becomes accustomed to stimulation.





Peripheral Stimulation

- Benefits
 - Localized pain relief
 - Often less procedure risk than other neuromodulation placement
 - Not in epidural space so bleeding and infection is not as dangerous if it were to occur





Spinal Cord Stimulation

- The most common neuromodulation
- Leads are placed under fluoroscopic guidance through an epidural needle and advanced to intended target.
 - Common targets:
 - T8 covers low back and legs
 - C3 covers most of neck and arms





Spinal Cord Stimulation

- The most common neuromodulation
- Several device companies to choose from
 - Boston Scientific
 - Medtronic
 - Abbott
 - Nevro
 - Likely others that I don't know about





Spinal Cord Stimulation

- First systems used “tonic” stimulation
- Simple wave form that cause stimulation of the dorsal columns
- The brain prioritizes the proprioception carried in the dorsal column and ignores the C-fiber mediated pain
- Patients reported that the vibration sensations were more pleasant than the pain... but still sometimes annoying





Spinal Cord Stimulation

- Several years ago, “paresthesia free” systems emerged
- 2 main ideas
 - Blast the nerves with high frequency so they cannot transmit signals well and pain is suppressed. Ie. 10 khz that Nevro developed
 - Massage the nerves with patented wave forms that send inhibitory signals to the brain to ignore pain. Ie Burst DR that Abbott developed





Spinal Cord Stimulation

- Medtronic and Boston scientific have combo systems that do similar signals but not the exact patented wave forms of Abbott or Nevro.
- Does it matter?
- I asked the reps of the device companies, and they all said YES ours is the best!
- However, no official head-to-head studies.



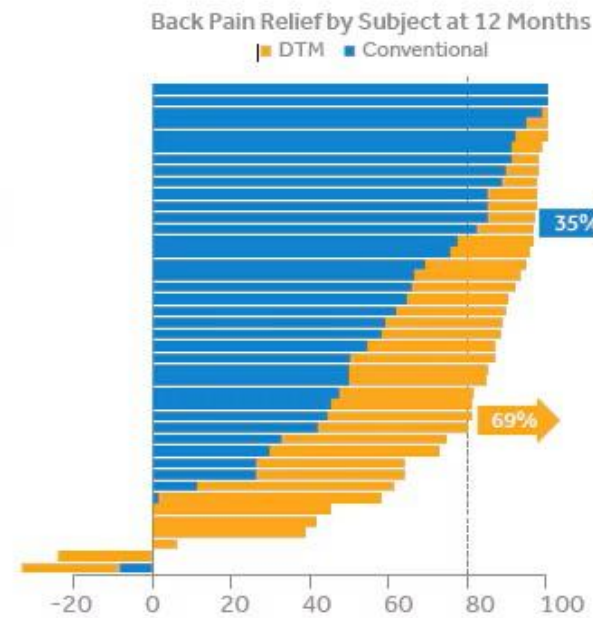
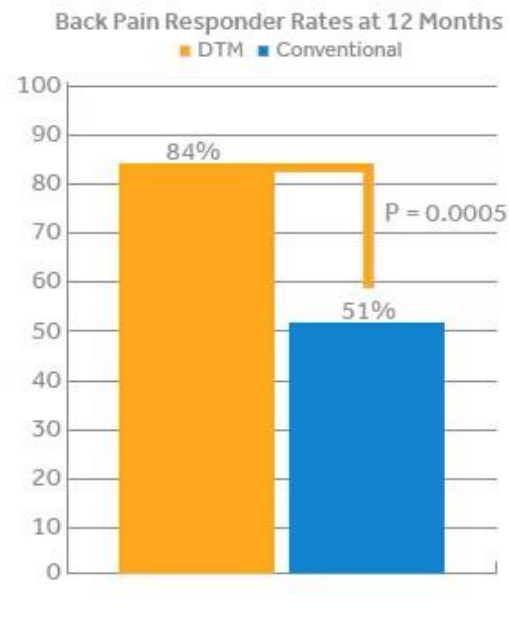


Spinal Cord Stimulation

- Medtronic webpage reports

84%

Highest back pain responder rate reported at 12 months in similar RCTs*
(*> 50% improvement*).



69%

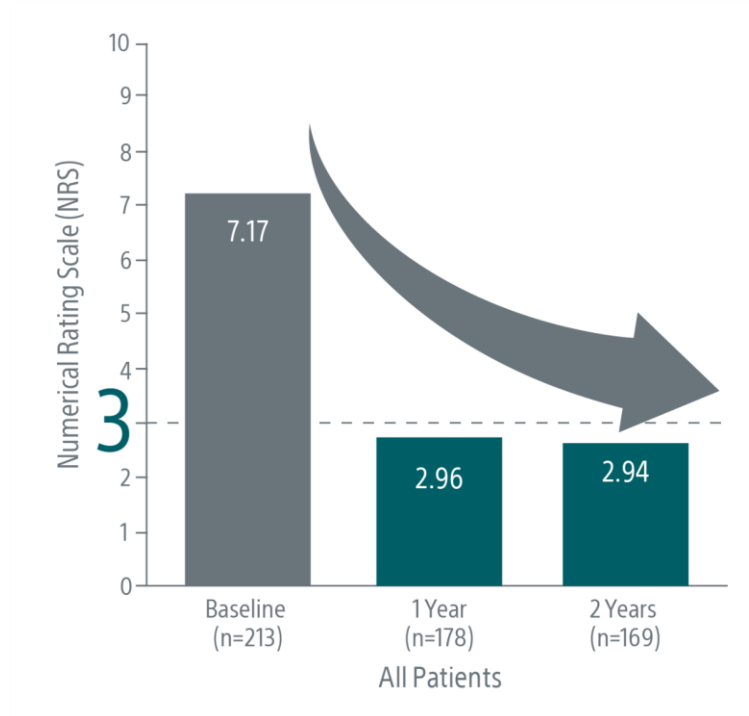
7 out of 10 patients were profound back pain responders (*$\geq 80\%$ pain relief*).





Spinal Cord Stimulation

- Boston scientific webpage reports





Spinal Cord Stimulation

- Abbott webpage reports
- 91.4% of patients significantly responded to the numerical rating scale (NRS) or Oswestry Disability Index (ODI) (\geq 50% NRS or \geq 13-point decrease or score $<$ 20% at follow-up on ODI).



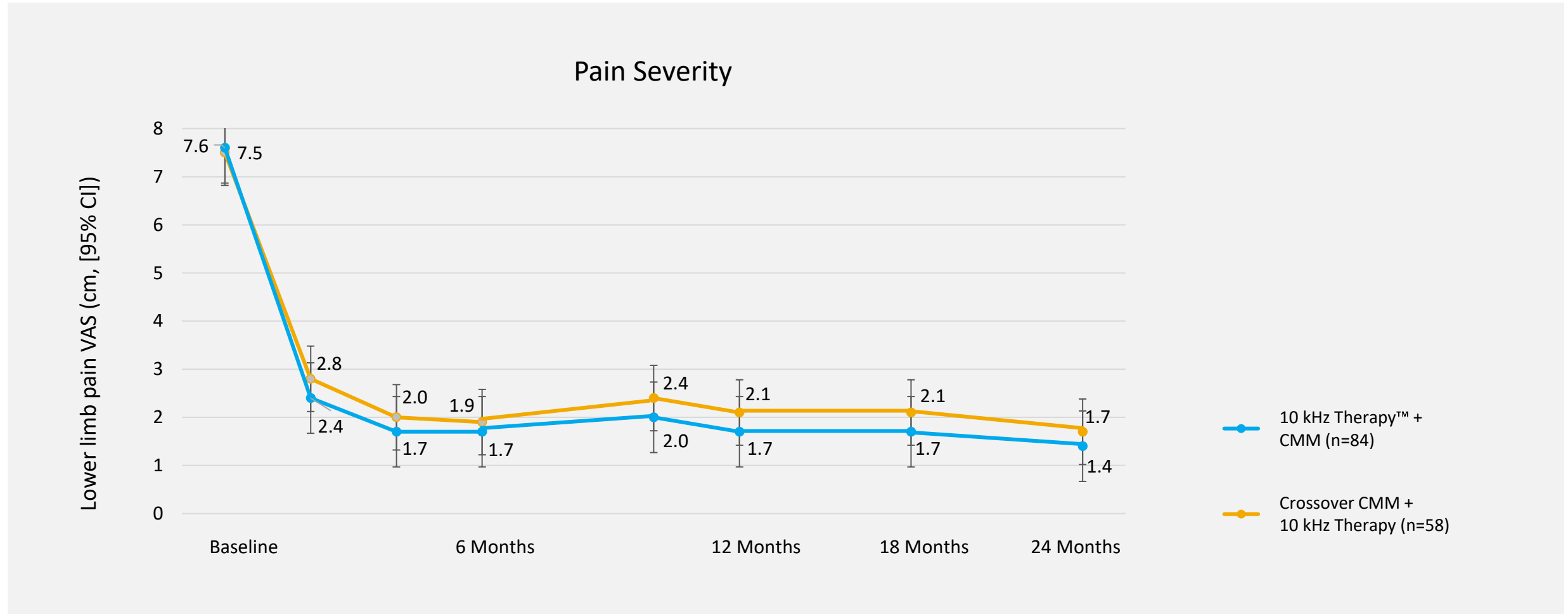


Spinal Cord Stimulation

- Nevro



Pain Relief Over 24 Months



*Error Bars: 95% CI

Petersen, E., et al. (2023). Long-Term Efficacy of High-Frequency (10 kHz) Spinal Cord Stimulation for the Treatment of Painful Diabetic Neuropathy: 24-Month Results of a Randomized Controlled Trial. *Diabetes Research and Clinical Practice*, 110865.



Spinal Cord Stimulation

- All quite good and within the same general range of relief
- Spinal cord stimulation is generally very effective for neuropathic pain
- Commonly used for
 - DPN
 - Post-laminectomy syndrome
 - Phantom Pain
 - CRPS
- Radiculopathy in patients that are not surgical candidates





Spinal Cord Stimulation

- Less commonly used for
- Peripheral artery disease related pain
- Chronic anginal pain
- Generalized low back pain
- Fibromyalgia
- After all other options have been tried.





Spinal Cord Stimulation

The process

- First trial period ~ 1week.
 - Can extend trial with same leads to use a different company's system if failed one brand.
 - Generally, patients are on antibiotics for the entire trial and off of blood thinners for the entire trial.
 - Infection and bleeding are the two scariest risks but are very rare if the above are followed. Big problems if there is an epidural hematoma or infection.





Spinal Cord Stimulation

- My goals to meet before recommending implantation
 - 70% pain improvement
 - Some functional improvement
 - Ie, better sleep
 - Walking or exercise tolerance
 - Less pain medication need
 - Patient wants to have the implant





Spinal Cord Stimulation

- Next step is permanent implantation
- Typically, spinal surgeons do the implantation based on the imaging of the lead placement during the trial
- Some pain doctors do their own particularly if they have a surgery center or block time in a hospital OR.
 - I have neither at this time. I previously implanted my own but was frequently bumped out of my slot
 - Can be a fairly simple surgery





Spinal Cord Stimulation

2 types of implantable leads

- Percutaneous (same as trial leads)
 - Lower impact surgery, more likely to shift over time
- Paddle (surgically placed through a laminectomy)
 - Requires small laminectomy to slide paddle up but less likely to shift
 - Only spine surgeons do the paddle implants

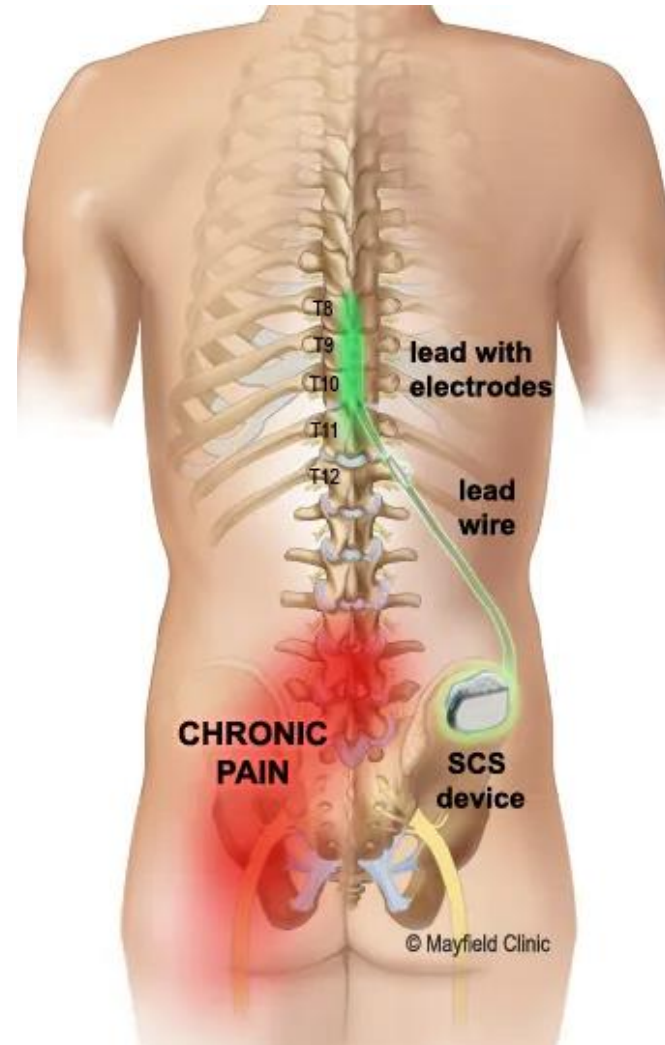
Battery pack can basically be placed anywhere the wire will reach. Usually in the back fat.

Needs to be somewhat superficial so the battery can communicate and charge via induction. Too much adipose blocks the signal.





Spinal Cord Stimulation





Spinal Cord Stimulation





Spinal Cord Stimulation

When to consider spinal cord stimulation

- Neuropathic or chronic pain
- Failure of conservative care such as PT and medications
- No reasonable surgical options to correct the problem
 - Multilevel fusions in a stable spine for pain symptoms are not generally considered a reasonable option to do instead of SCS
- No increased risks for implantable devices in the spine such as active infection, bleeding disorder or a clotting disorder that can not stop blood thinners for the entire trial period.
- No severe psychological contraindications.





Dorsal Root Ganglion Stimulation

Directly stimulates the sensory ganglion of the nerve roots

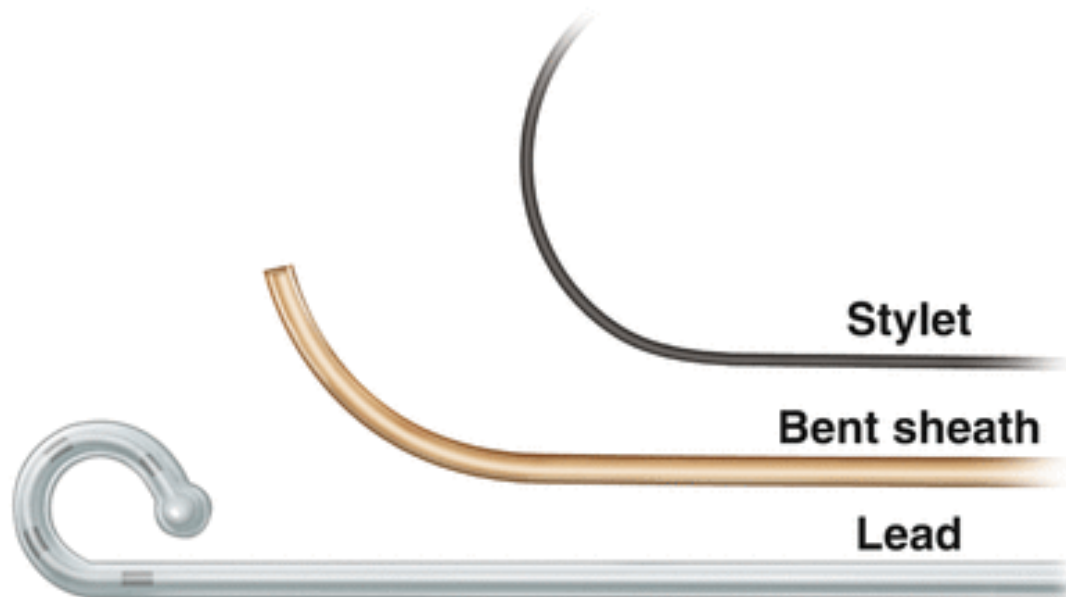
- Excellent for dermatomal pain or localized pain
 - DPN
 - CRPS
 - Ilioinguinal neuropathy
 - Lower extremity neuropathy
- Not for levels where the spinal cord is (~T12 and above)
 - Risk of spinal cord injury because of the complexity of lead placement





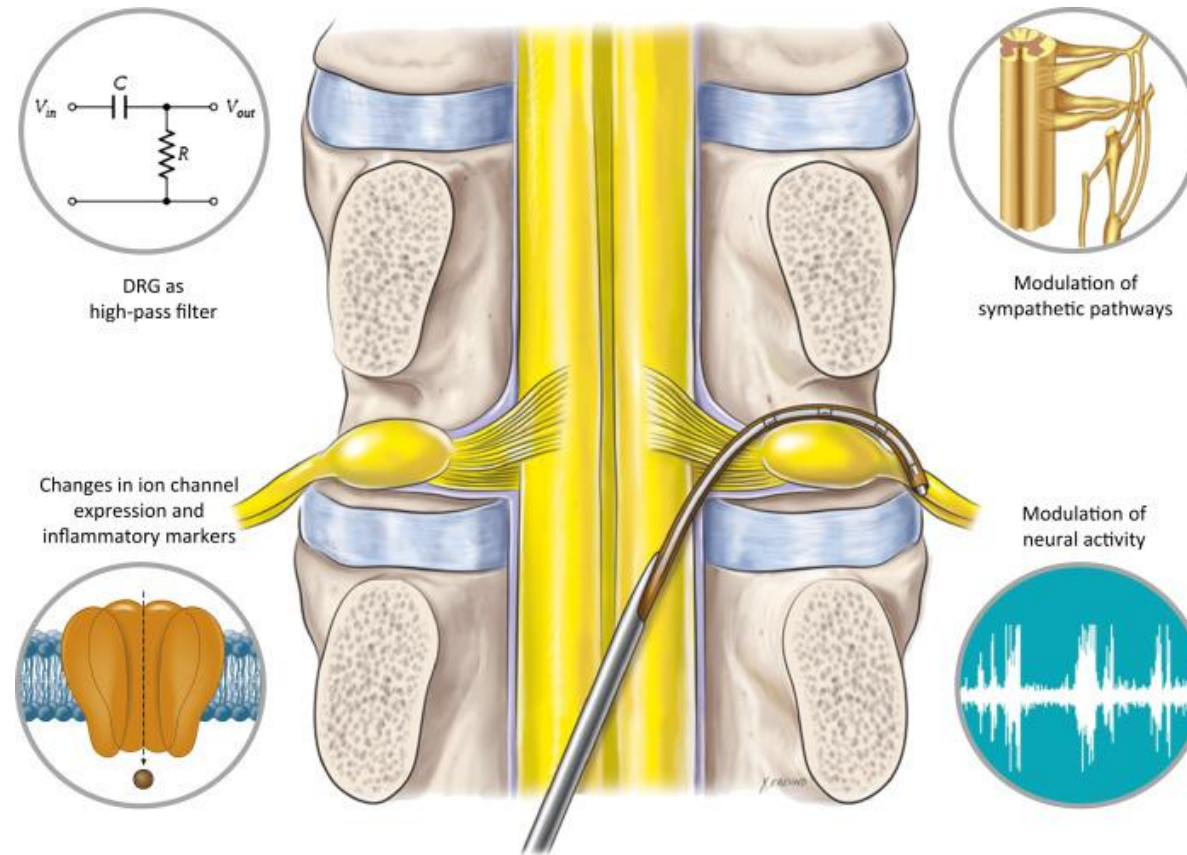
Dorsal Root Ganglion Stimulation

The most fun
and elegant of
stimulators to
place!



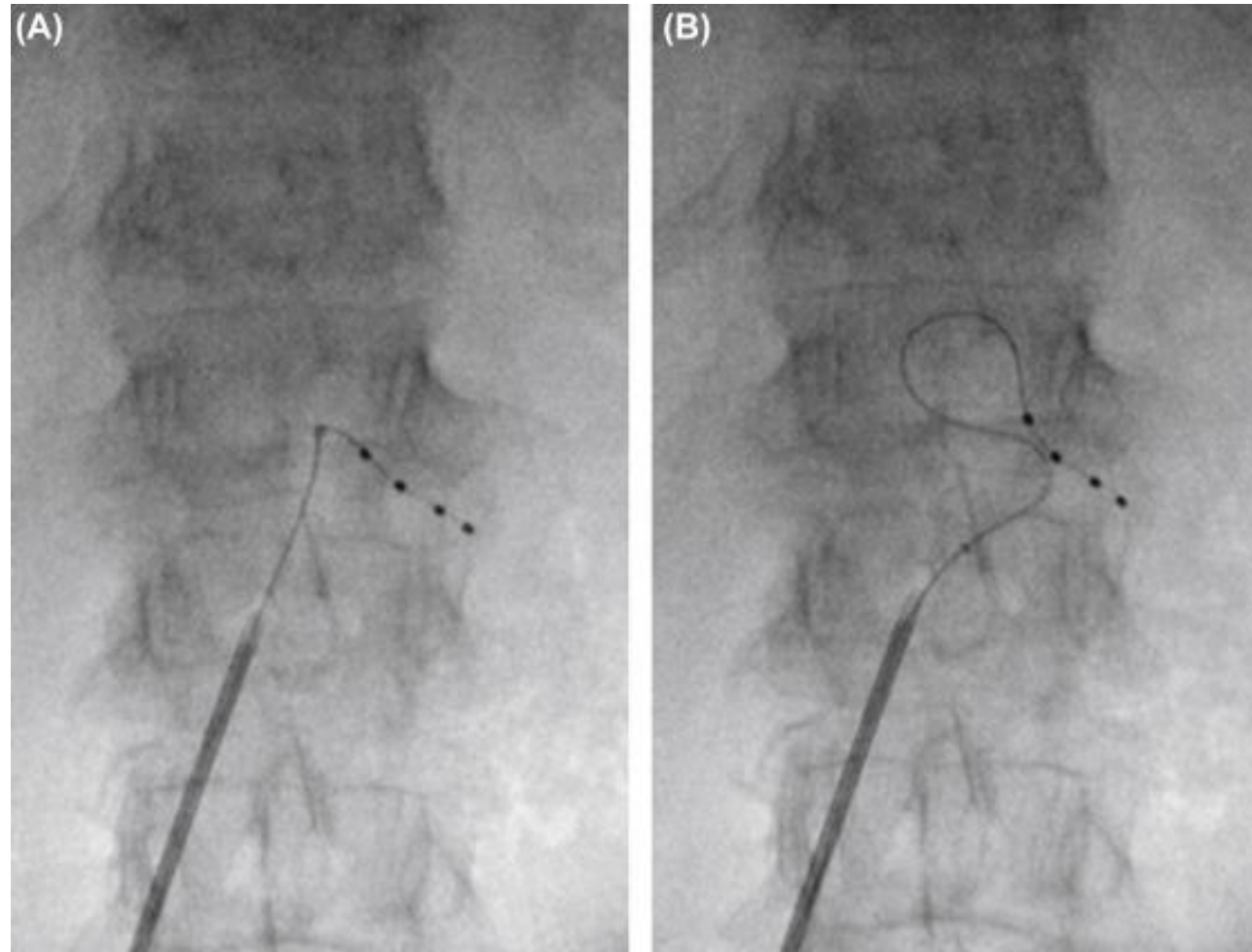


Dorsal Root Ganglion Stimulation





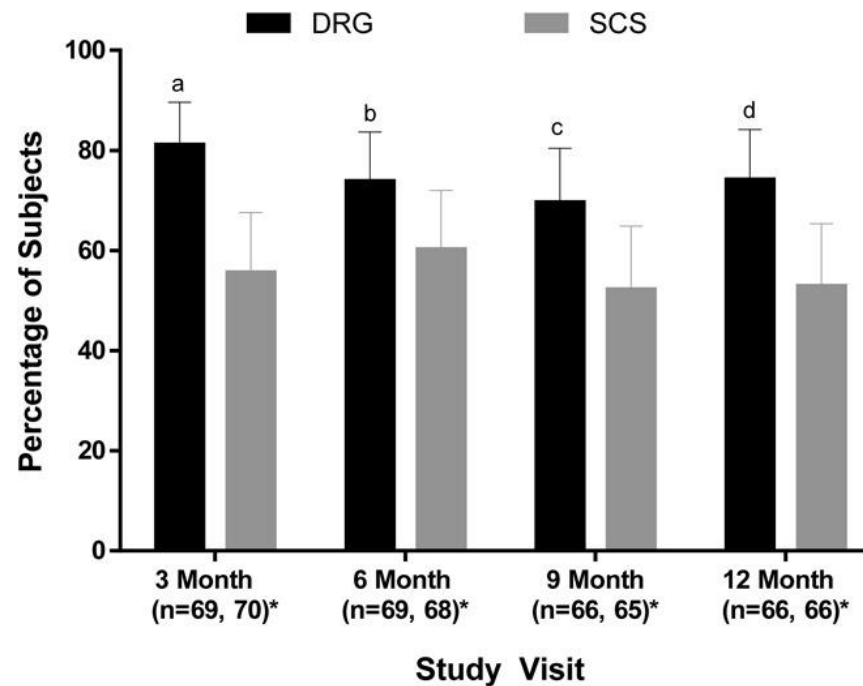
Dorsal Root Ganglion Stimulation





Dorsal Root Ganglion Stimulation

- Why do DRG if it covers less area than a traditional spinal cord stimulation with greater skill needed by the physician?
- You get RESULTS!



- 2017 study in CPRS patients SCS vs DRG
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5359787/>





Dorsal Root Ganglion Stimulation

- Risks
- Similar to spinal cord stimulation as it is an epidural placement.
 - Dural puncture
 - Epidural hematoma
 - Epidural abscess
- Bonus risks!
 - Lots of twisting and turning of the lead, needle, and stylet which increases pressure on the epidural structures which is why it is not recommended at the levels where the spinal cord lives. There have been catastrophic spinal cord injuries with cervical placement
 - Some people still do them because they are so effective!





Dorsal Root Ganglion Stimulation

Neuromodulation: Technology at the Neural Interface

Volume 26, Issue 8, December 2023, Pages 1781-1787

Efficacy and Safety of Cervical and High-Thoracic Dorsal Root Ganglion Stimulation Therapy for Complex Regional Pain Syndrome of the Upper Extremities

- Results
- After a DRG stimulation trial, 17 of 20 patients (85%) had $\geq 50\%$ improvement in NRS pain and underwent a permanent [pulse generator](#) implant, with 100% endorsing $\geq 50\%$ pain relief at six months. Mean NRS pain scores before DRG neuromodulation were 9.3 ± 1.1 , with a mean reduction of 5.5 (95% CI, 4.5–6.6; $p < 0.001$) at six months. Ten patients were taking opioids at baseline; the median (interquartile range) dose was 45 mg (23 to 120) morphine equivalents (MME), which was reduced to 20 MME (15 to 40) at six months. The median reduction in daily MME use was -25 (95% CI, -100 to 20 ; $p = 0.099$). **Six of 20 patients (30%) experienced a complication:** three had lead migration; two experienced paresthesias; and one had a reduction in shoulder mobility. **One patient had symptoms of a reversible [spinal cord compression](#)** immediately after implant, requiring emergent electrode removal.





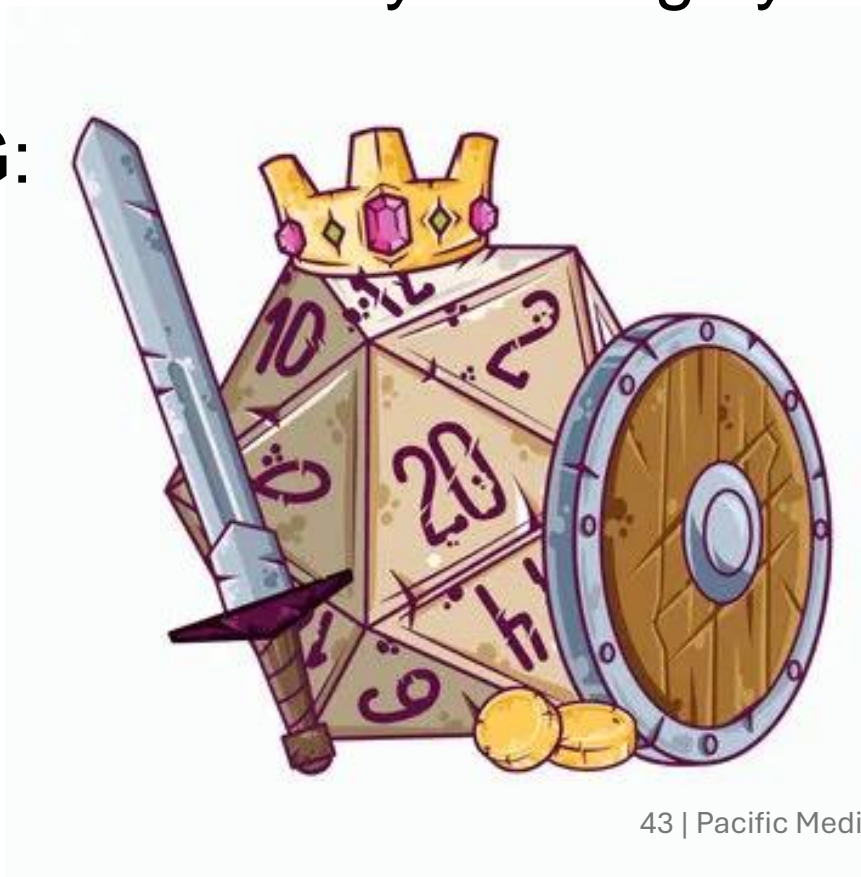
Dorsal Root Ganglion Stimulation

1 in 20 serious complication rate in a study with highly experienced implanters

Best strategy for cervical DRG:

Don't roll a nat 1 D20

for your dexterity check





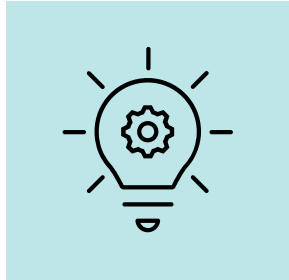
Want to geek out more?

Let's see some patient examples!

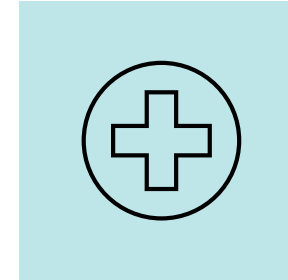




Case Studies



**Could neuromodulation
be an option?**



Which and why?



Case Studies



- 52 y/o male with prior laminectomy at L5/1 3 years prior with radiating leg pain right more than left. MRI with moderate central stenosis at L5/1. Normal neuro examination. Neurosurgeon recommends lumbar fusion at L5/1. Failed PT and multiple medication options.
- Ideas?
- Spinal cord stimulation would be an option to consider. Post laminectomy syndrome is one of the most common diagnoses for SCS
- Peripheral leads would not cover large enough area
- Dorsal root ganglion would not be safe at a post-surgical level



Case Studies



- 64 y/o female with prior open hernia surgery 4 years prior with severe pain radiating to groin on the left. Failed prior injections, topical medications and oral medications.
- Ideas?
- Dorsal root ganglion stimulator would likely be the most effective
- Peripheral stimulator could also be effective but may be difficult to place 2nd to local scar tissue
- Spinal cord stimulator could be effective as well as it would cover this area as it covers the entire low back to groin to toes

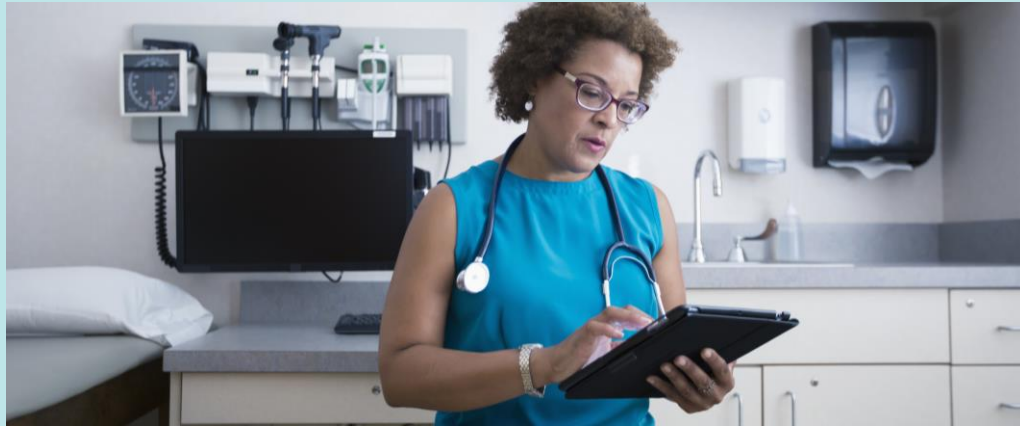




Case Studies

Want to try some more?

82 y/o male with diabetic peripheral neuropathy for 10 years now with well controlled blood sugars and for the past 4 years the burning and numbness has not ascended beyond ankles. Severe sensitivity and unable to sleep because of sheets rubbing on feet. He is gaining weight and losing walking distance because of the pain. No blood thinners or open wounds



What to do?



Dorsal root ganglion stimulation at S1 and L5 bilaterally would likely provide the most benefit.

SCS would cover the area as well and would cover higher if the neuropathy progresses

Peripheral along the sural and/or saphenous would be a third-tier option.



Case Studies



87 y/o female with CRPS of the right knee and hardware loosening. TKA 10 years ago. Failed geniculate nerve radiofrequency ablation last year and it flared her CRPS. Hx of CAD with stenting 2 months ago and on blood thinners that can not be stopped. Taking gabapentin 2400 mg a day with dizziness side effects. Fentanyl patch 50 mcg with constipation side effects. Family reporting confusion and loss of benefit with the patch. She is requesting higher dose.



What to do?

Everything seems like a bad idea!

Not IDEAL for anything



But, peripheral nerve stimulation is still an option that could be considered and weighed with the risks of her current medications in an 87-year-old.

Bleeding risks would be elevated but would be localized and in the superficial tissues which could be compressed post procedure. Some peripheral stimulators do not need an implanted battery pack and are just wires under the skin with an external induction unit. The risks are basically limited to the needle stick (albeit a big long needle)

Do not discount the significant risks of fall this 87 y/o has with the current medications. Neuromodulation frequently leads to reduction in opioids and neuropathic medications





Thank you for your time.

Questions?





Objectives

1. How to identify candidates for neuromodulation
2. Identify the different types of neuromodulation
3. Understand the patient selection for each type





N O R T H W E S T
S P I N E & P A I N M E D I C I N E

Thank You

