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Introduction

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Disclosures

- Salaried employment at Joondalup and SCGH
  - Almost all neuomodulation is at Joondalup
- Co-director of PainScience
  - Private consulting rooms & glengarry
  - Don’t accept - honorariums / travel / accomodation
- Do accept sponsored meals and education

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Outline

- History of neuromodulation and SCS
- Indications for neuromodulation
- How its done
- Where its going

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History of Neuromodulation

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What is neuromodulation?

"The alteration of nerve activity through targeted delivery of a stimulus to specific neurological sites in the body."

Stimulus can be of any nature:

- Commonly taken to mean electrical ("Spinal cord stimulation")
- Also includes chemical (eg intrathecal drug delivery)

- Can include other mechanisms (eg magnetic/TMS)

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Features of neuromodulation

General features of all neuromodulation approaches:

- Targeted anatomically

- Reversible in nature

- Provide continuous treatment.

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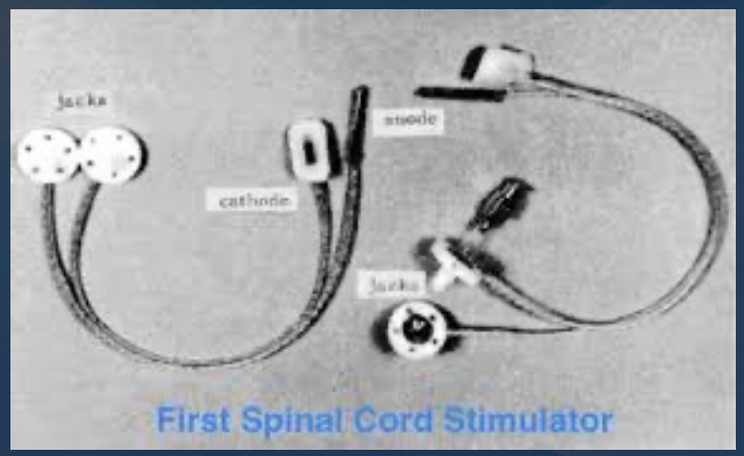
History



First Spinal Cord Stimulator

This has been going for a long time.

Followed on from gate theory of pain in 1965

Spinal cord stimulation first done in 1967.

Originally came from pacemaker companies and technologies.

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History of neuromodulation

1967

Parasthesia based stimulation

1977

Intrathecal opioids

Dorsal column stimulation

1980's

1981
First IPG

DBS
IT Pumps
TMS

2000's

2004
Recharge systems

2010's

MRI conditional systems

Subperception modes

DRG stimulation

2020's

New modes

More indications

Technology improvements

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Indications & Evidence Base

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Cardiac Ischaemia

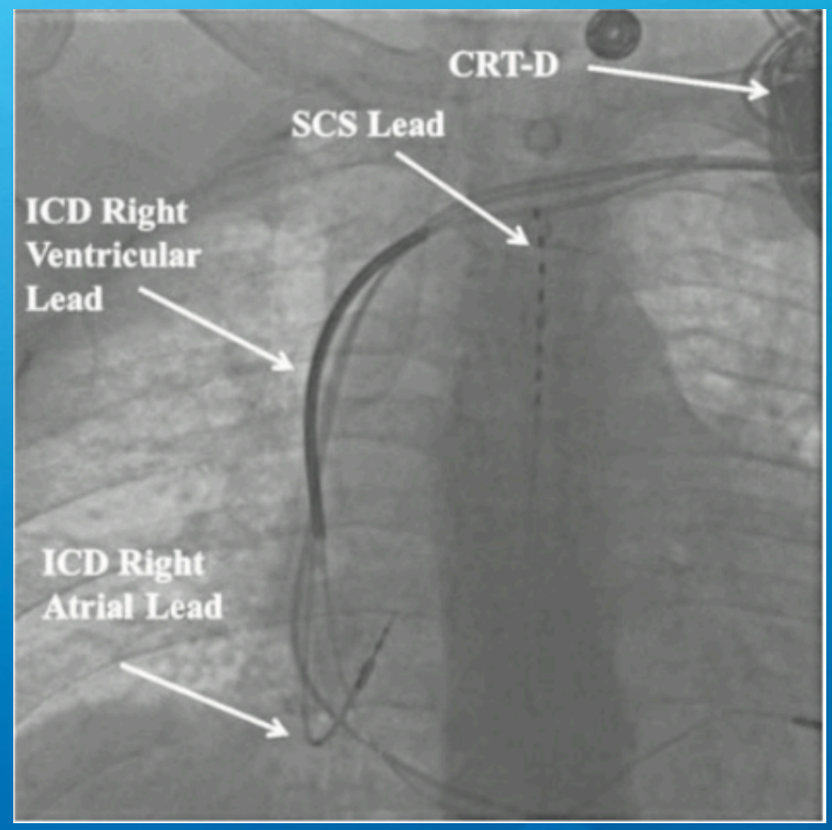
Early evidence in ischaemic cardiac pain - ESBY study

Mannheimer et. al. Circulation 1998; 97:1157-1163

104 patients, randomised to CABG vs SCS.

Treatment benefit: CABG 79.5%, SCS 83.7%

Much lower mortality (7 vs 1 p=0.02) and cerebrovascular events (8 vs 2 p=0.03). Overall morbidity not different.



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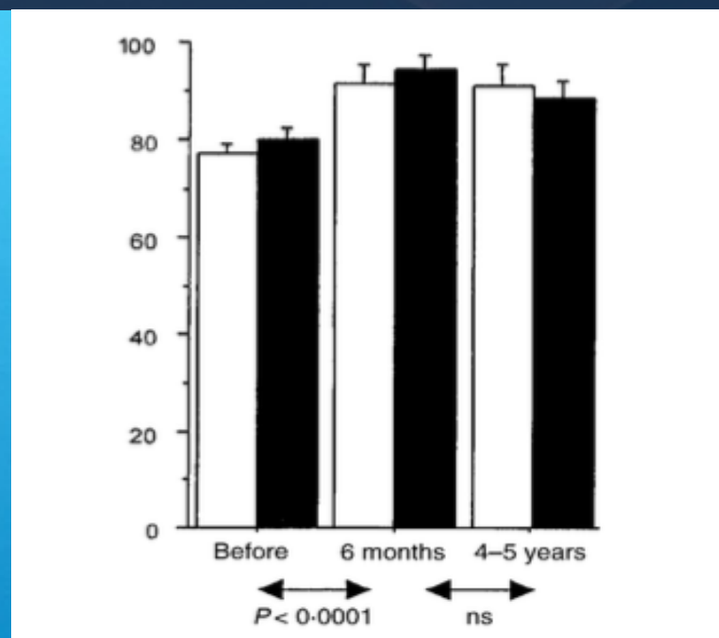
Longer Term Cardiac Ischaemia

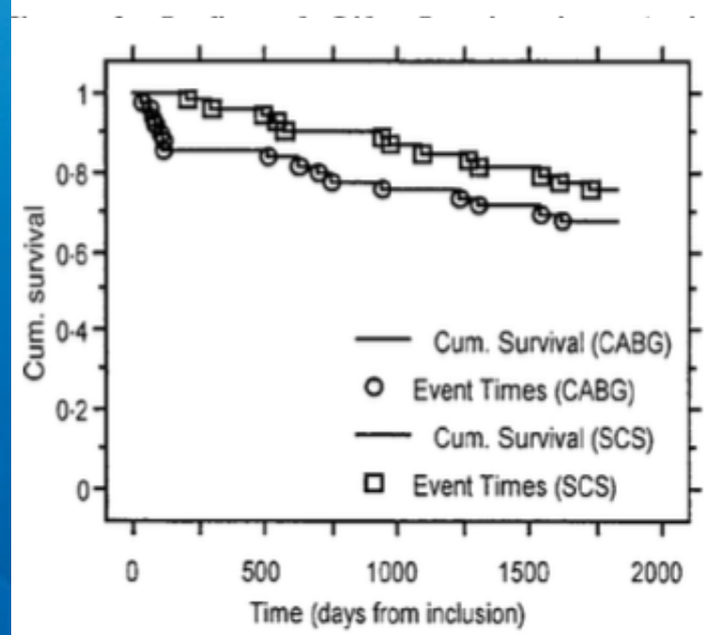
Long-term effects of spinal cord stimulation and coronary artery bypass grafting on quality of life and survival in the ESBY study
Ekre et al.
Eur Heart J, 2002; 23: 1938–1945, doi:10.1053/euhj.2002. 3286)

5 year followup of ESBY study:

Both groups showed sustained improvement in their quality of life

No mortality difference in either group (28%)





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Cardiac Ischaemia

Efficacy of spinal cord stimulation as an adjunct therapy for chronic refractory angina pectoris
Imran et al
International Journal of Cardiology. 2017. Vol 227: 535-542

Meta analysis, n=518 from 14 studies

SCS for refractory angina was associated with

- Higher exercise duration

- Lower angina severity and frequency

- Lower use of nitrates

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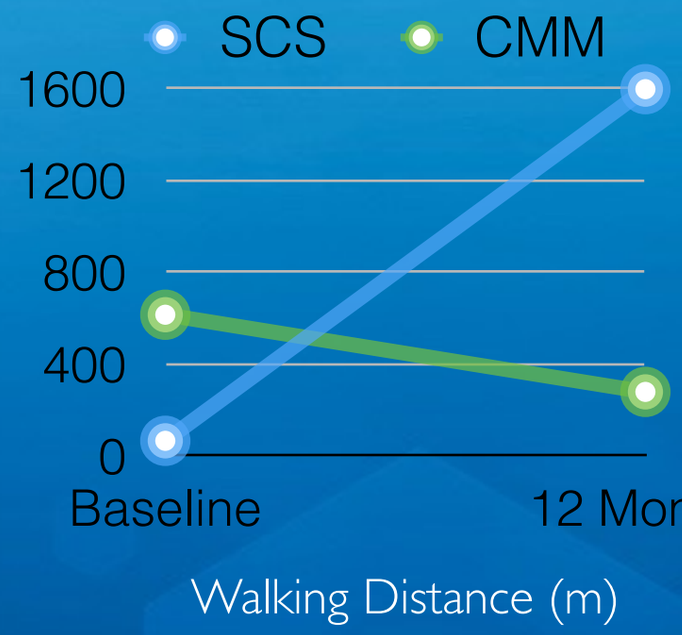
Limb Ischaemia

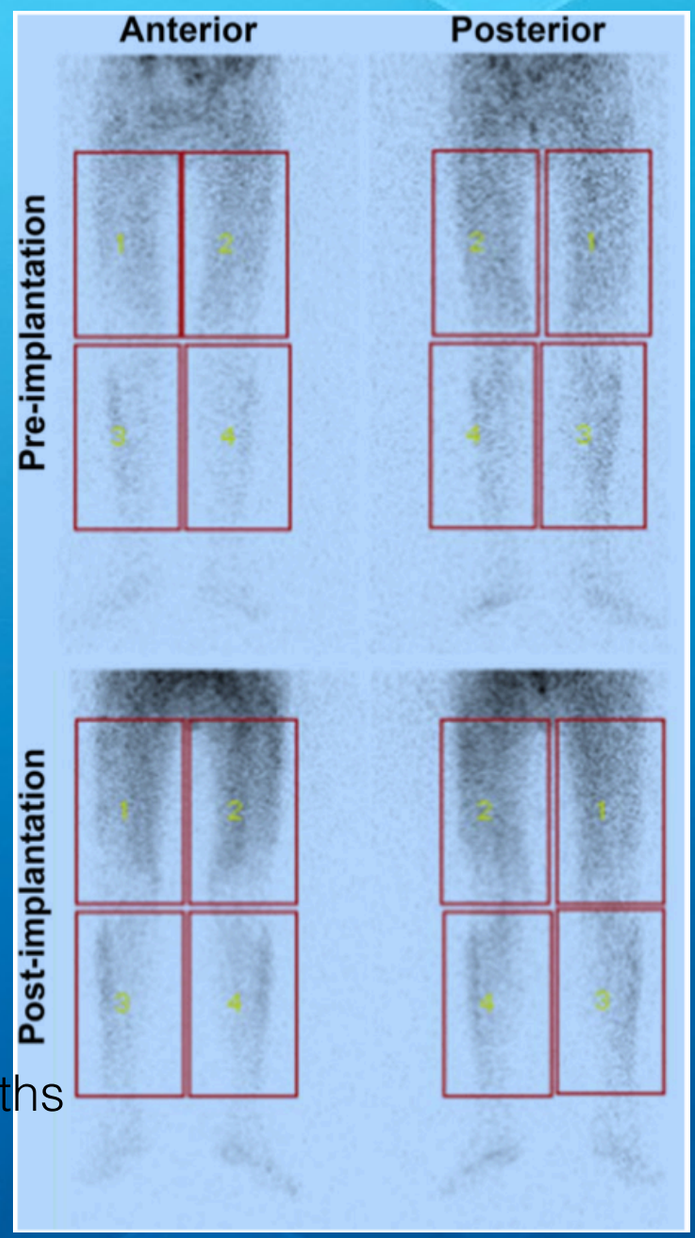
Spinal Cord Stimulation Improves the Microvascular Perfusion Insufficiency Caused by Critical Limb Ischemia

Liu JT, et al.
Neuromodulation 2018; 21: 489–494

Not a randomised study - self select

n= 37 SCS
n= 41 CMM





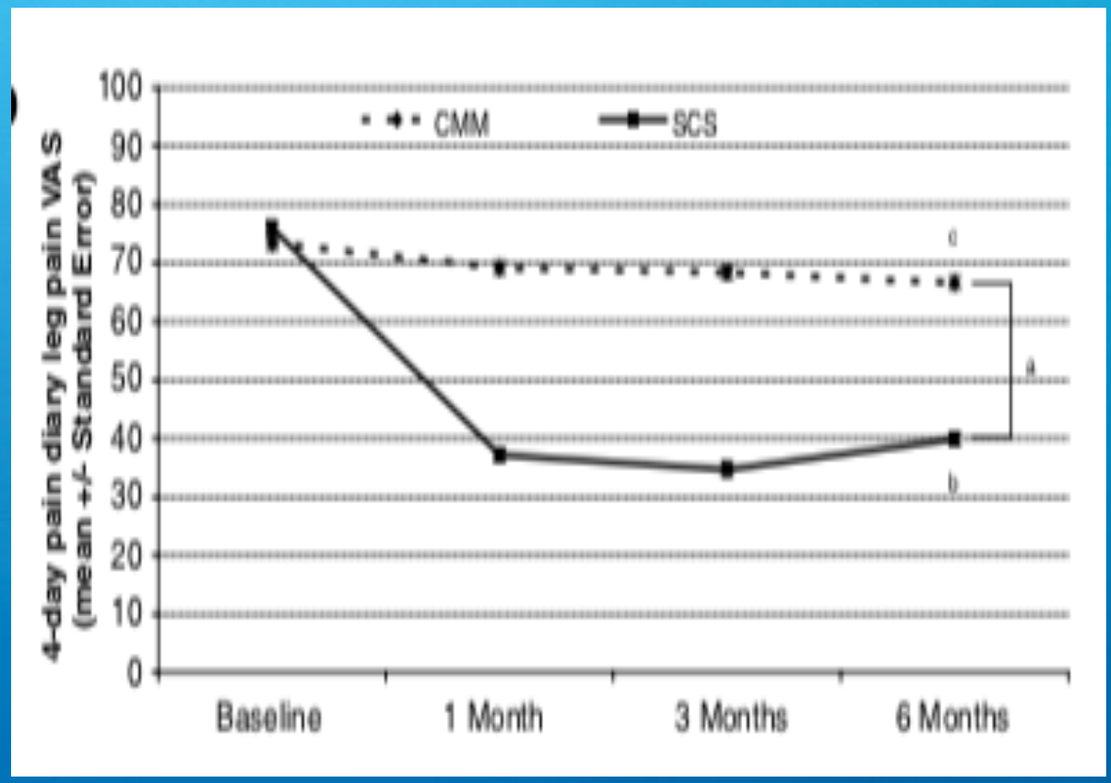
Back pain

Long standing indication for SCS.

Strong evidence base.

North et al 2005 RCT FBSS - 52% success @ 3 yr (19% surg)

Kumar et al 2008 RCT FBSS - Improvement in leg pain



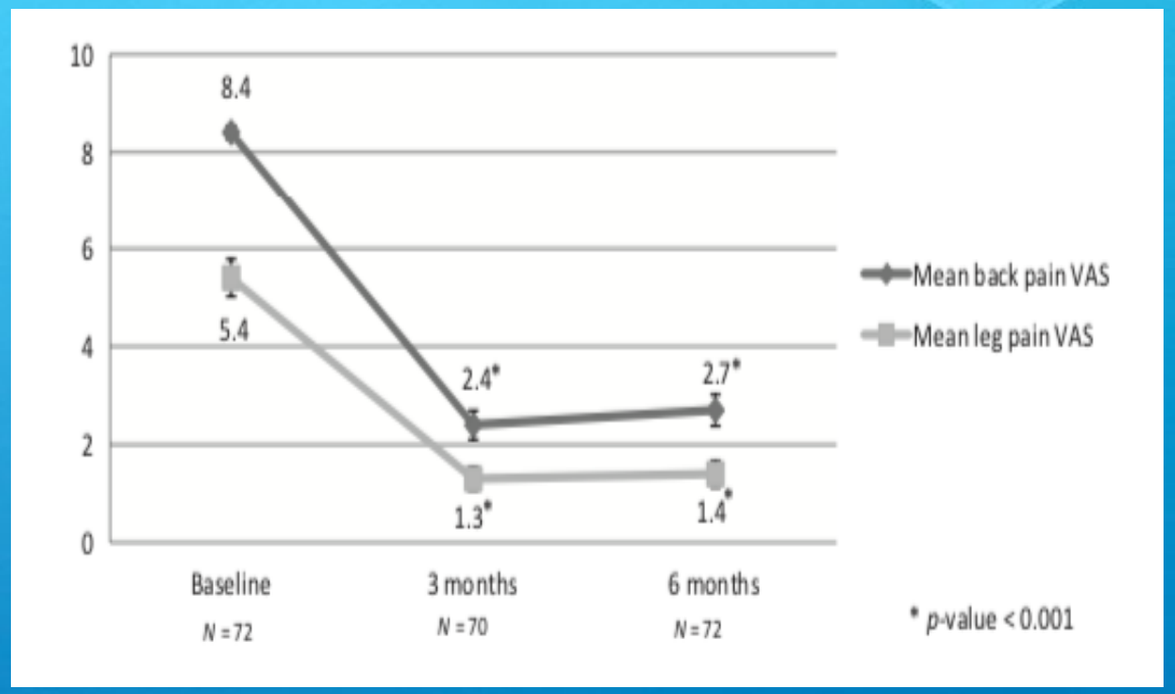
Back Pain - Newer Modes

High-Frequency Spinal Cord Stimulation for the Treatment of Chronic Back Pain Patients: Results of a Prospective Multicenter European Clinical Study
Van Buyten et al Neuromodulation 2013; 16: 59–66

Used 10 KHz stimulus (sub perception)

n=83, significant improvements

Backpain 8.4 -> 2.7
Leg pain 5.4 -> 1.4



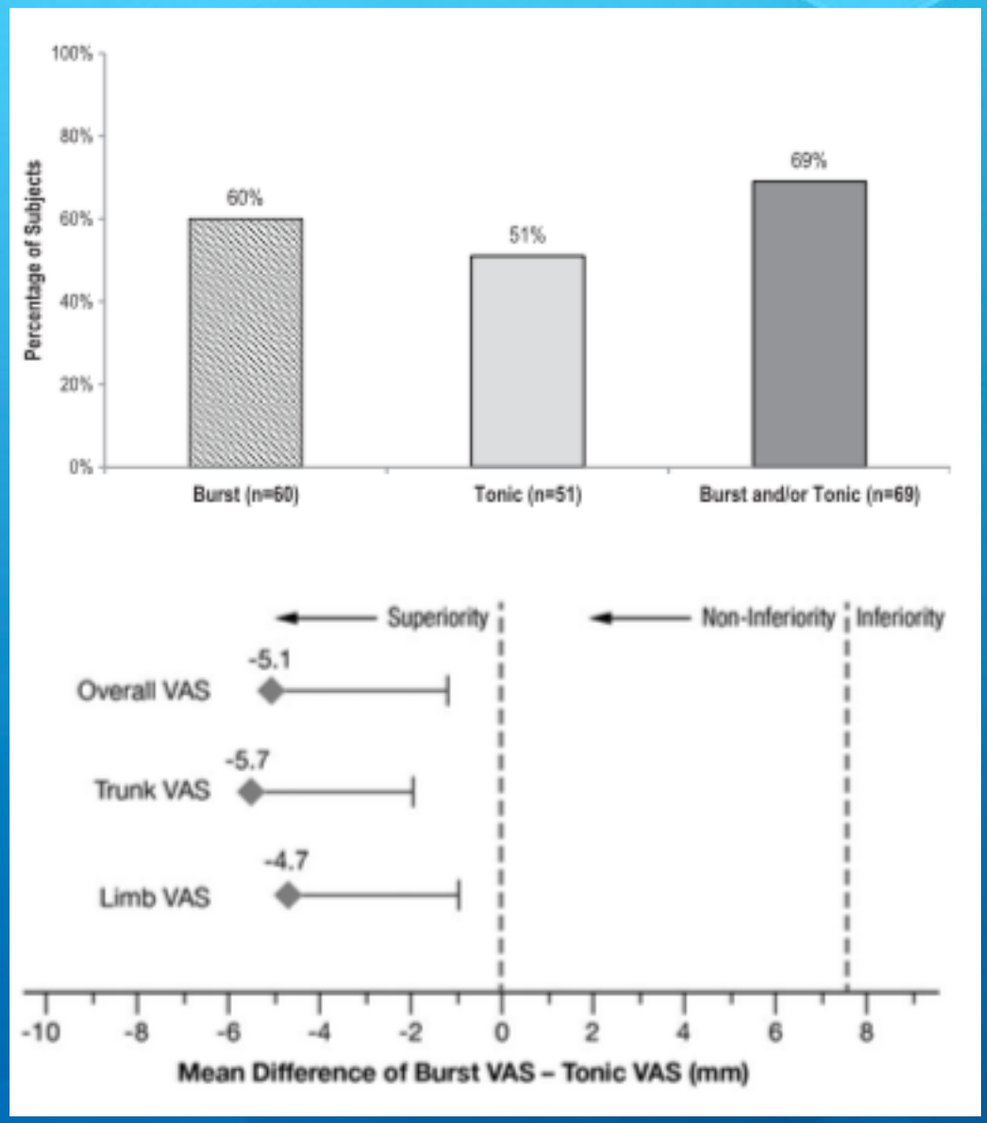
Back pain - Newer modes

Success Using Neuromodulation With BURST (SUNBURST) Study: Results From a Prospective, Randomized Controlled Trial Using a Novel Burst Waveform
Deer et al. Neuromodulation 2018; 21: 56–66

Randomized crossover study, n=100

12 weeks Tonic, 12 weeks Burst.

Improved responder rate to 69%



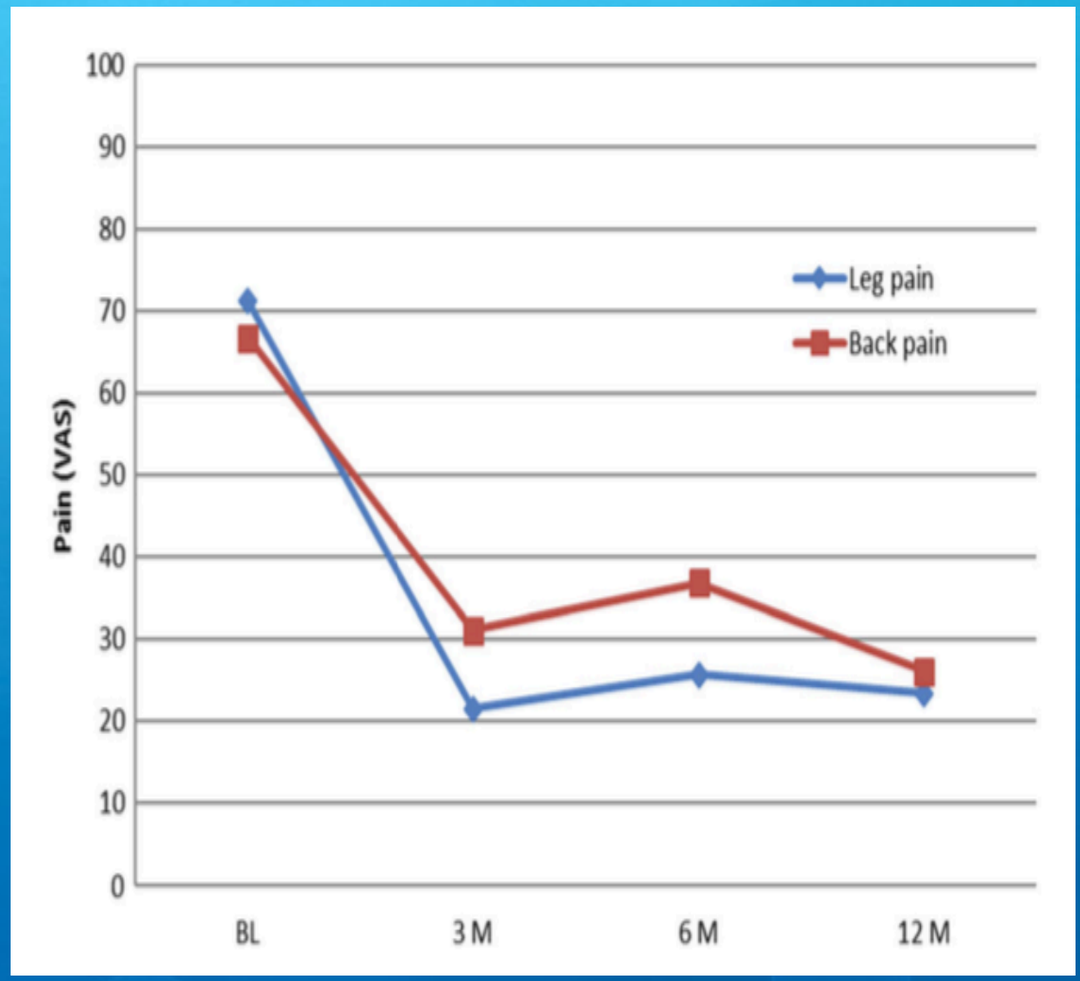
Back Pain - Newer Modes

High-Dose Spinal Cord Stimulation for Treatment of Chronic Low Back Pain and Leg Pain in Patients With FBSS, 12-Month Results: A Prospective Pilot Study
Hamm-Faber et al Neuromodulation 2020; 23: 118–125

High density mode

n=11 (Pilot study)

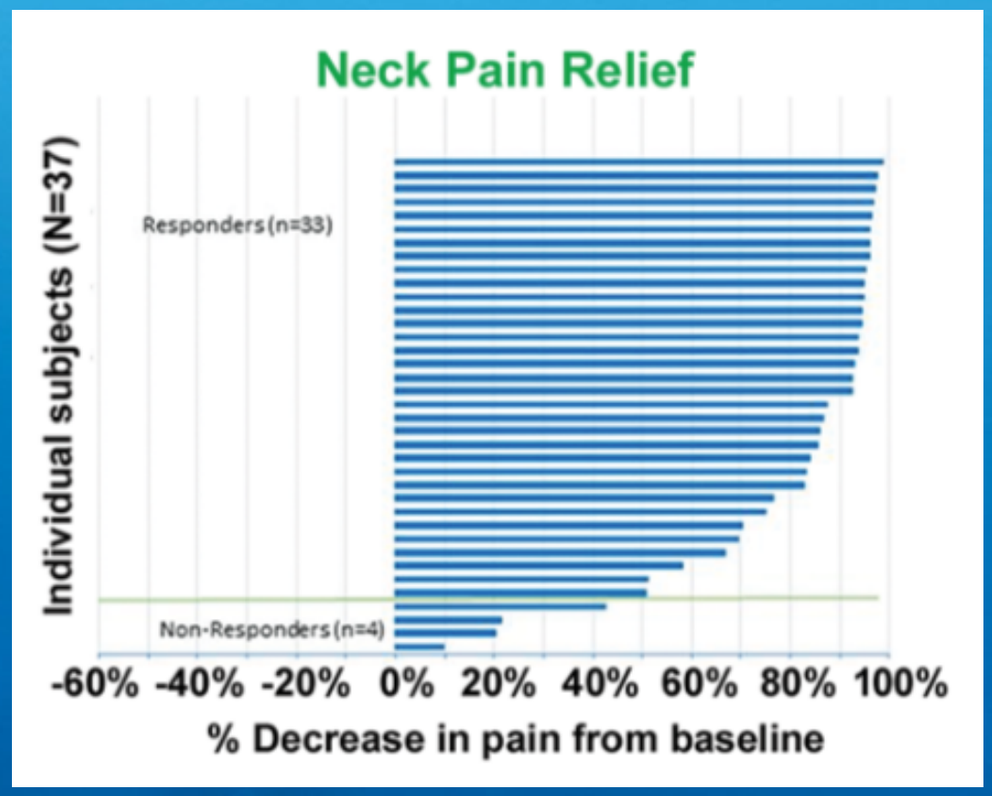
84% responder rate

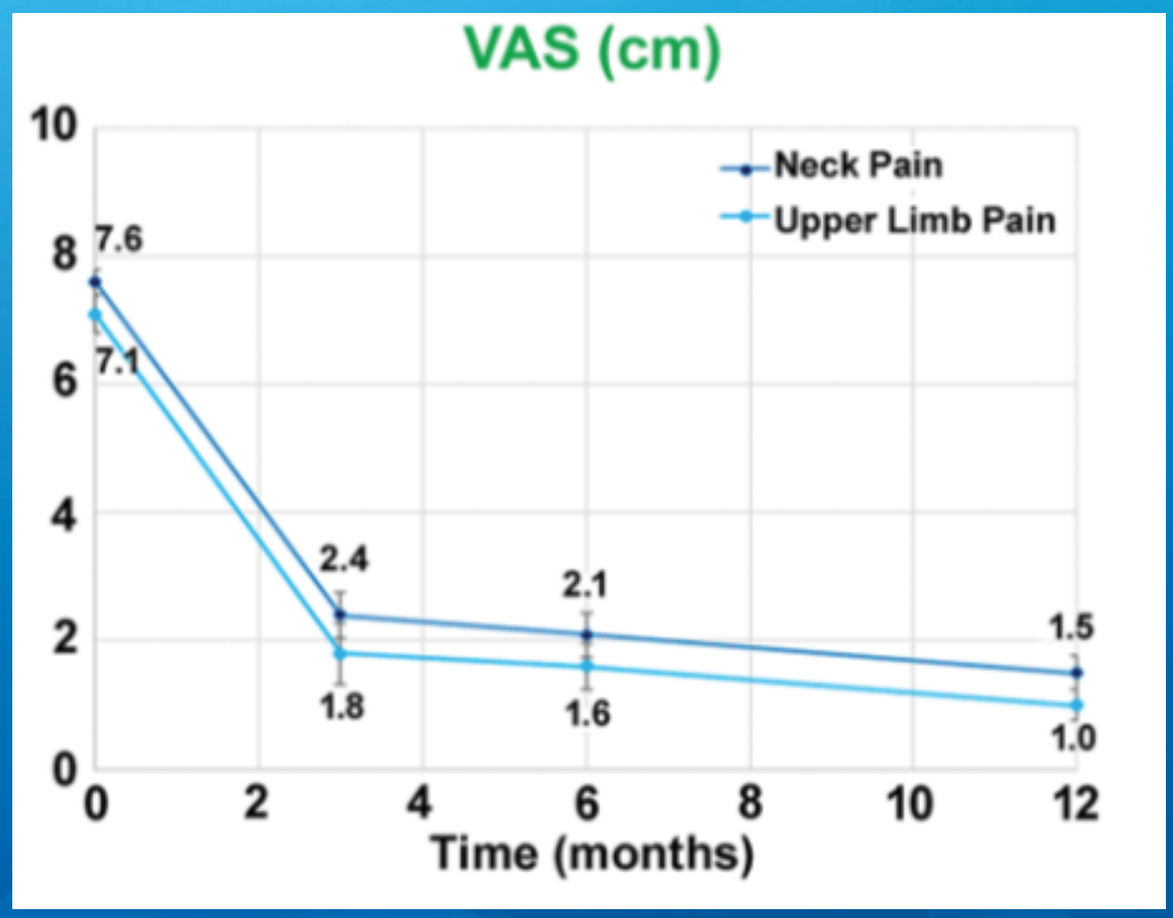


Neck Pain

Less well studied, tonic modes less effective. HF promising.

High-Frequency Spinal Cord Stimulation at 10 kHz for the Treatment of Combined Neck and Arm Pain: Results From a Prospective Multicenter Study
Amirdelfan et al Neurosurgery 0:1–11, 2019





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Complex Regional Pain Syndrome

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CRPS

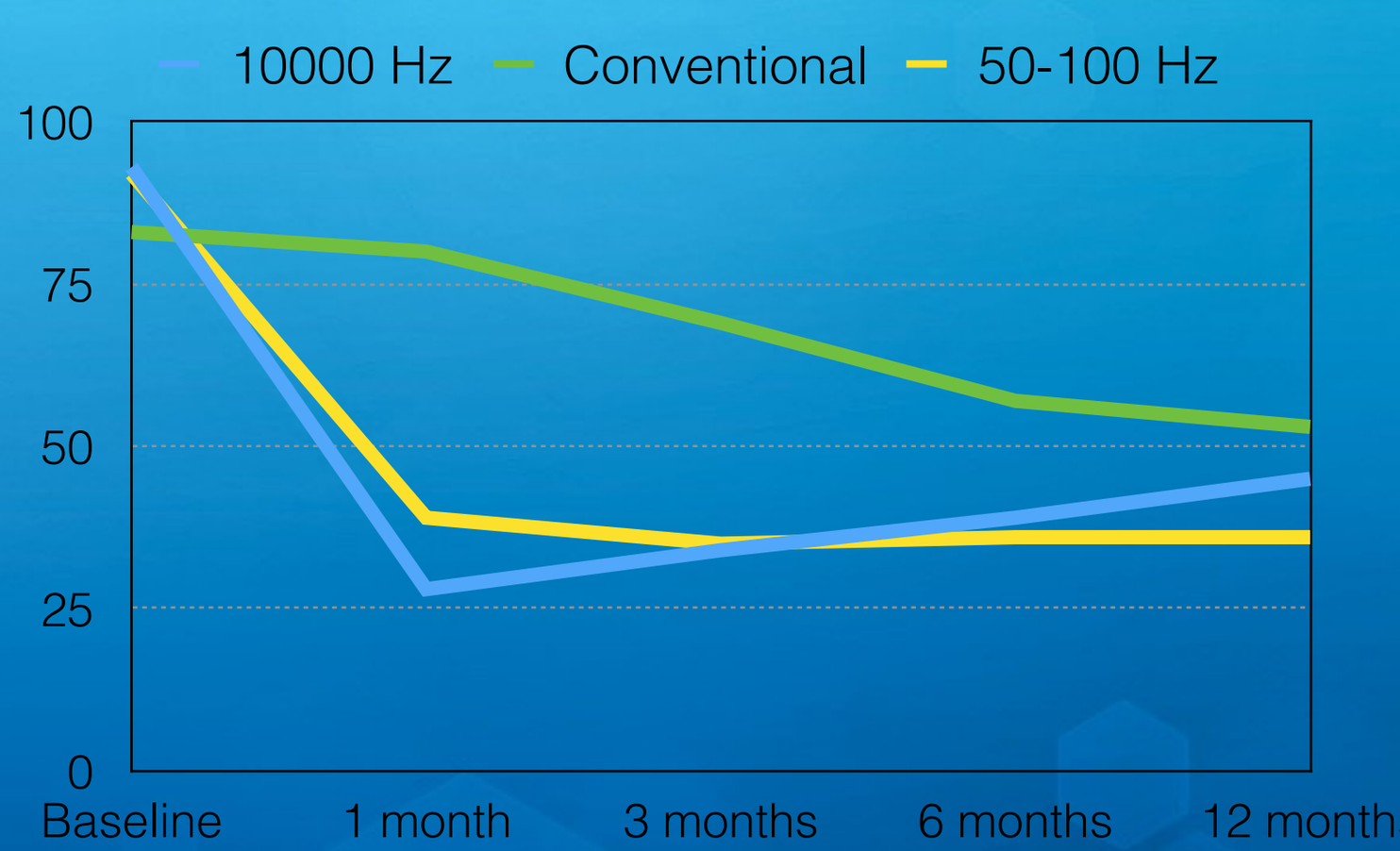
CRPS Response to SCS

Randomized Prospective Study in Patients With Complex Regional Pain Syndrome of the Upper Limb With High-Frequency Spinal Cord Stimulation (10-kHz) and Low-Frequency Spinal Cord Stimulation

Canòs-Verdecho A et al,

Neuromodulation 2021; 24: 448–458

Independent study head to head.



CRPS

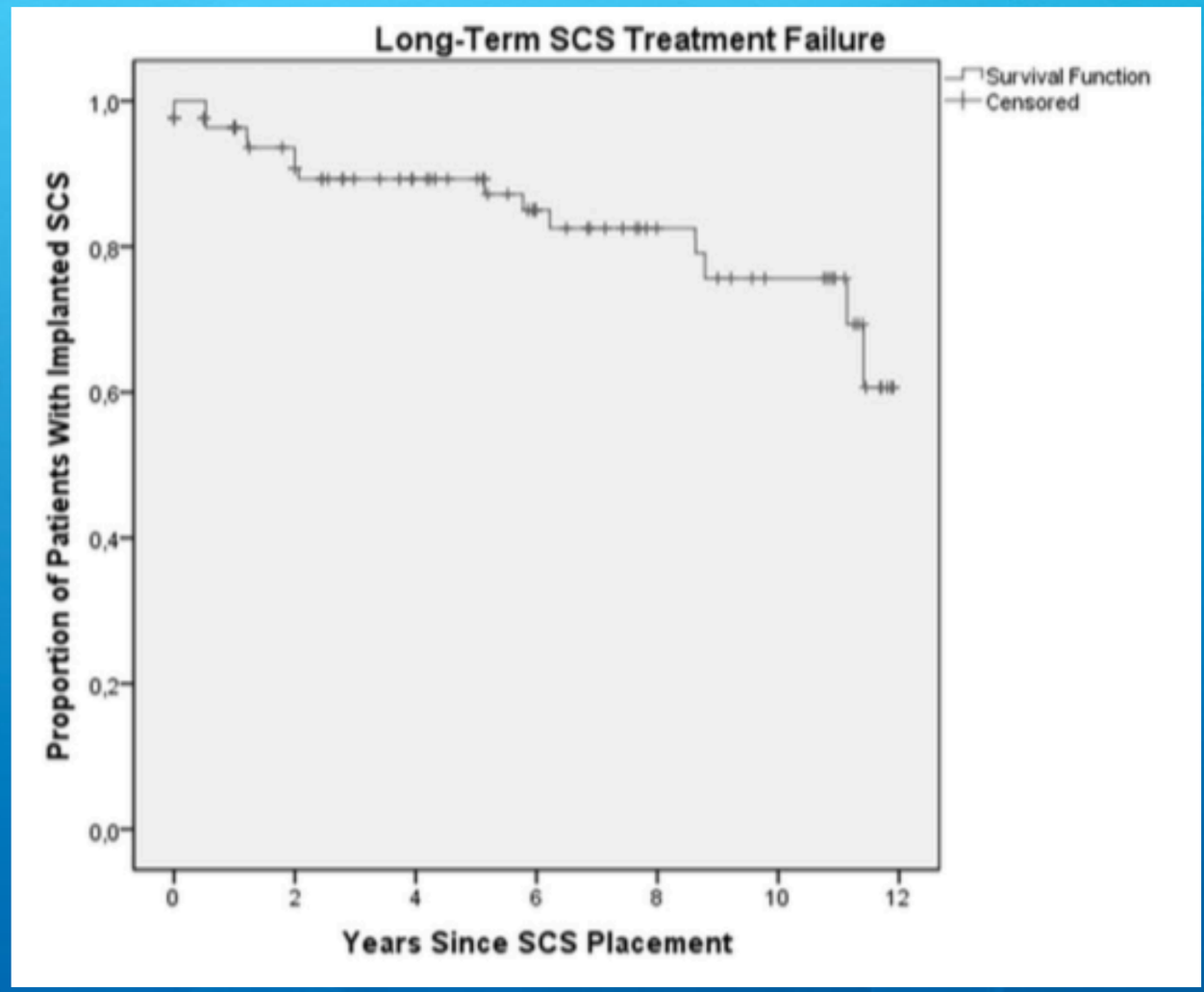
Difficult to treat condition

Strong evidence base for SCS

Spinal Cord Stimulation for Complex Regional Pain Syndrome Type I: A Prospective Cohort Study With Long-Term Follow-Up
Geurts et al Neuromodulation 2013; 16: 523–529

Older study, older technology

Still showed prolonged benefit.



Neuromodulation treats pathophysiology

Neuromodulation isn't just treating the pain

Review of complex regional pain syndrome and the role of the neuroimmune axis

Prasad A, Chakravarthy K
Molecular Pain 2021 Volume 17: 1–10

After SCS:

Decreased expression of pro inflammatory cytokines (except IL-6)

Associated with improved pain, vasomotor and sudomotor signs/symptoms.

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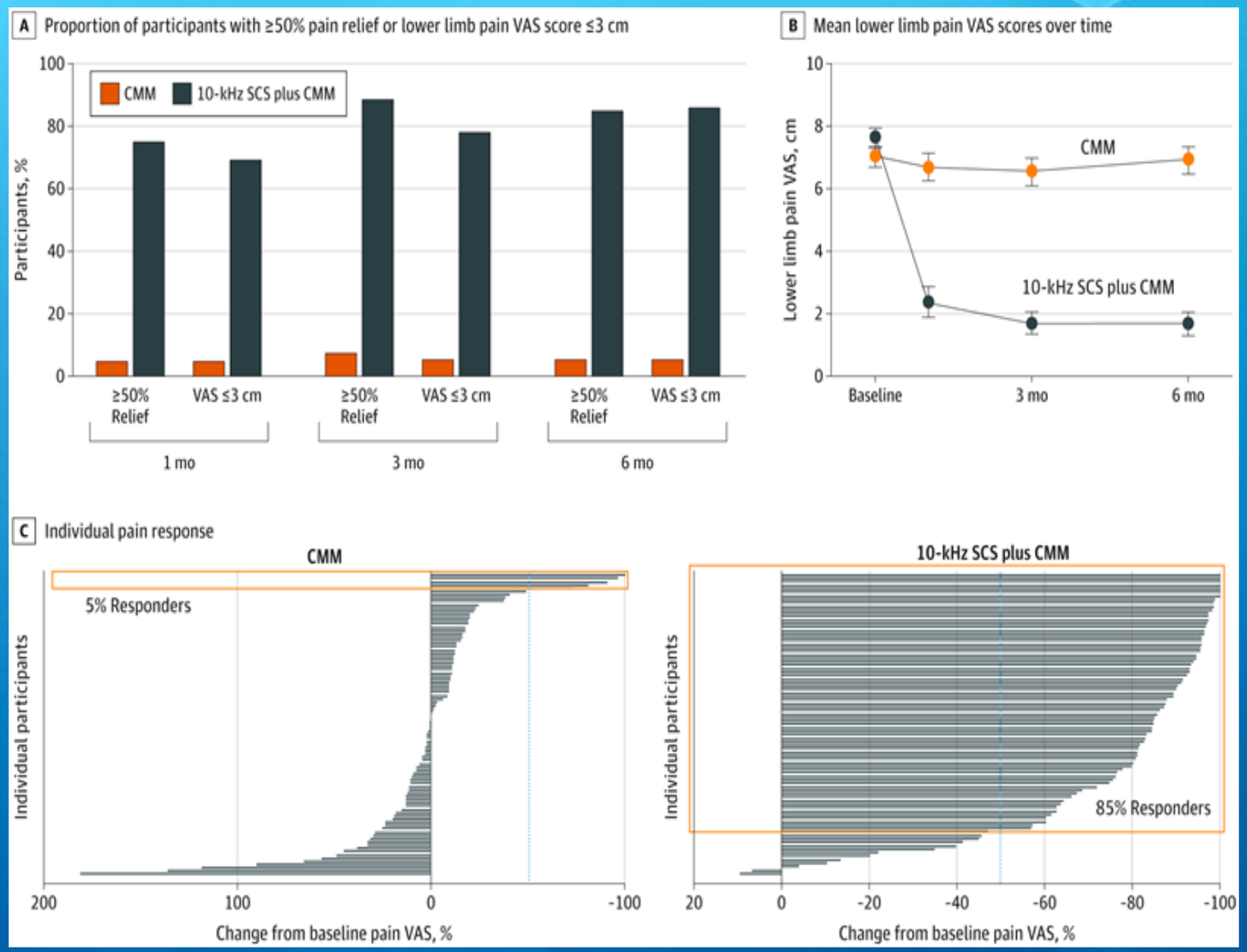
Diabetic Neuropathic Pain

Effect of High-frequency (10-kHz) Spinal Cord Stimulation in Patients With Painful Diabetic Neuropathy

Petersen EA et al.
JAMA Neurol. 2021; 78(6):687-698

Probably treating ischaemia as well as neuropathic pain.



Indications

Strong indications:

- Complex Regional Pain Syndrome
- Post spinal surgery pain

Evolving indications

- Spinal pain - Lumbar and Cervical
- Diabetic neuropathy.

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How its done (Trials and IPG's)

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Workup

Not a first line treatment generally

Needs good assessment:

- OT / Physio
- Clinical Psychology

The Procedure

Many have significant co-morbidities.

Anaesthetic considerations:

- Most are quite sensitised

- Prone position

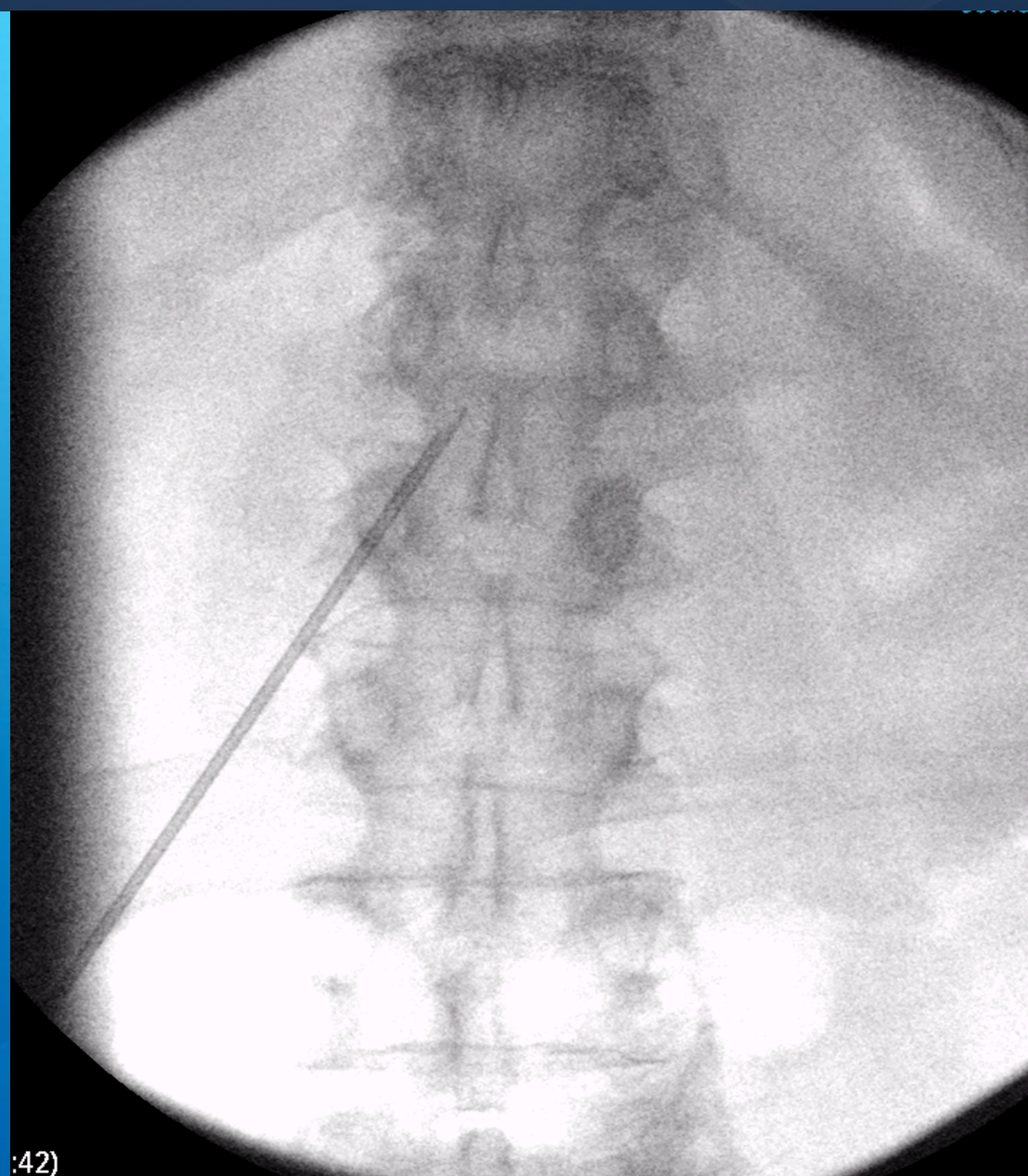
- On table testing.

Technical details - Trials

Shallow approach to epidural space

- Small skin puncture for tunnelling

Entry point usually high lumbar



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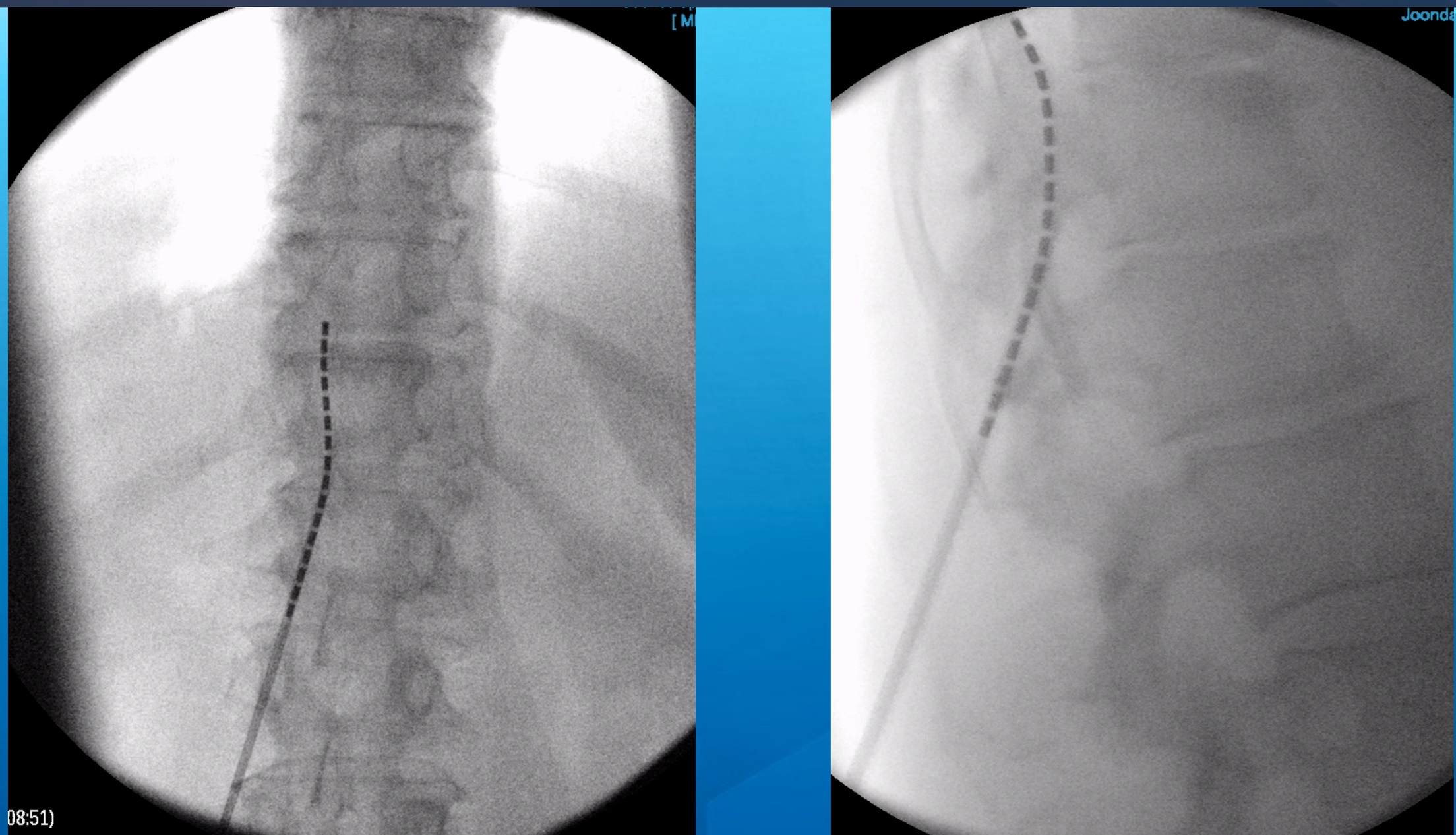
TECHNICAL DETAILS - TRIALS



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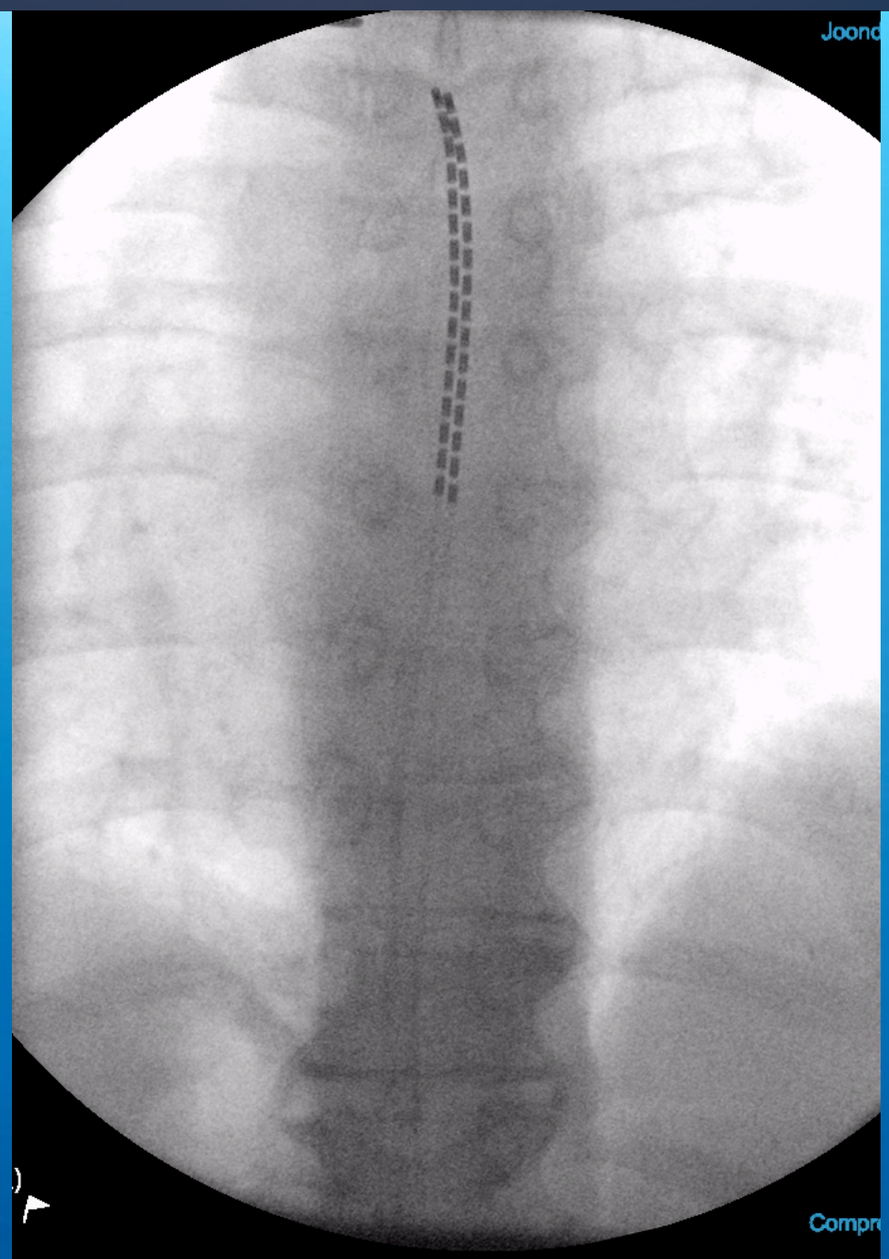
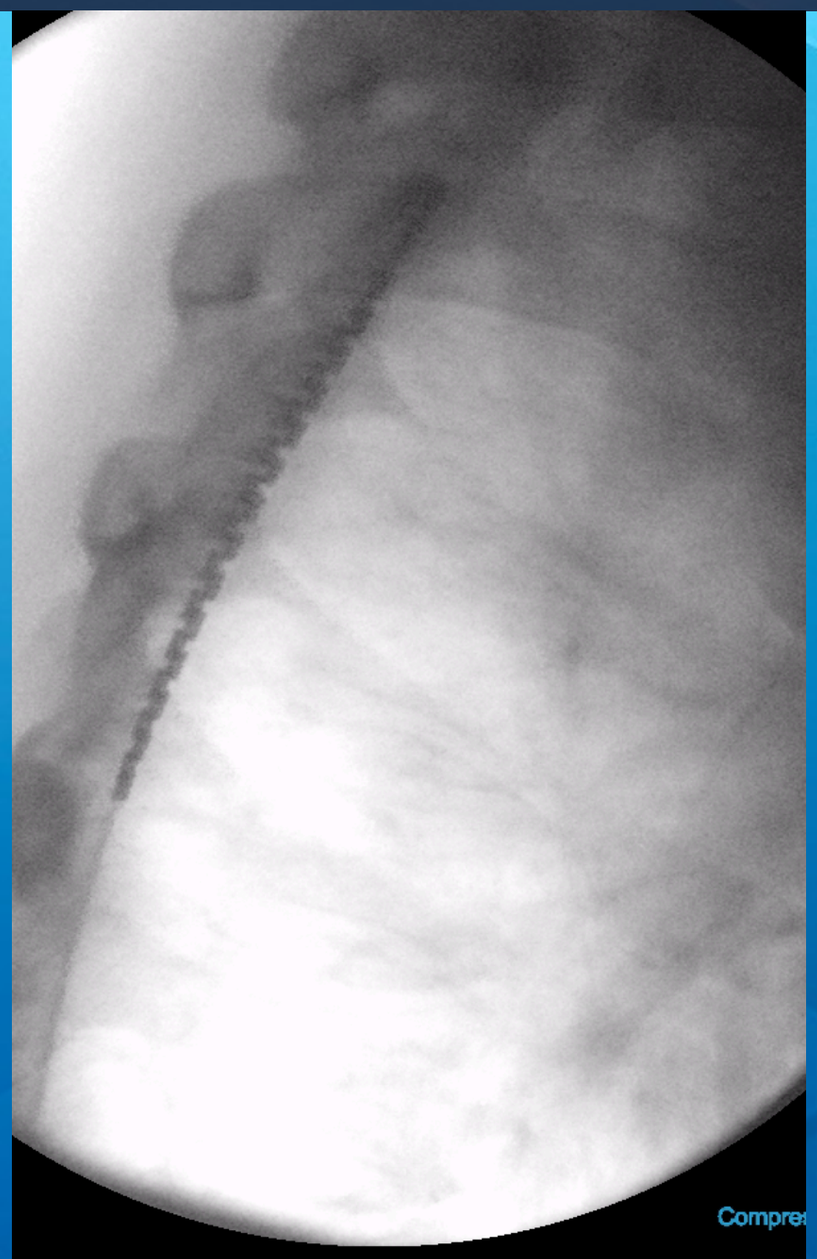
Technical details - Trials





The Trial

Typically 2+ weeks

Trialling multiple modes

Requires teamwork between patient, technician and pain medicine

Try to establish:

- Does the device work (ie., >50% pain relief) in a sustained way.

- Where the target is for the leads

- Can you do a primary cell or do you need rechargeable system

Permanent system

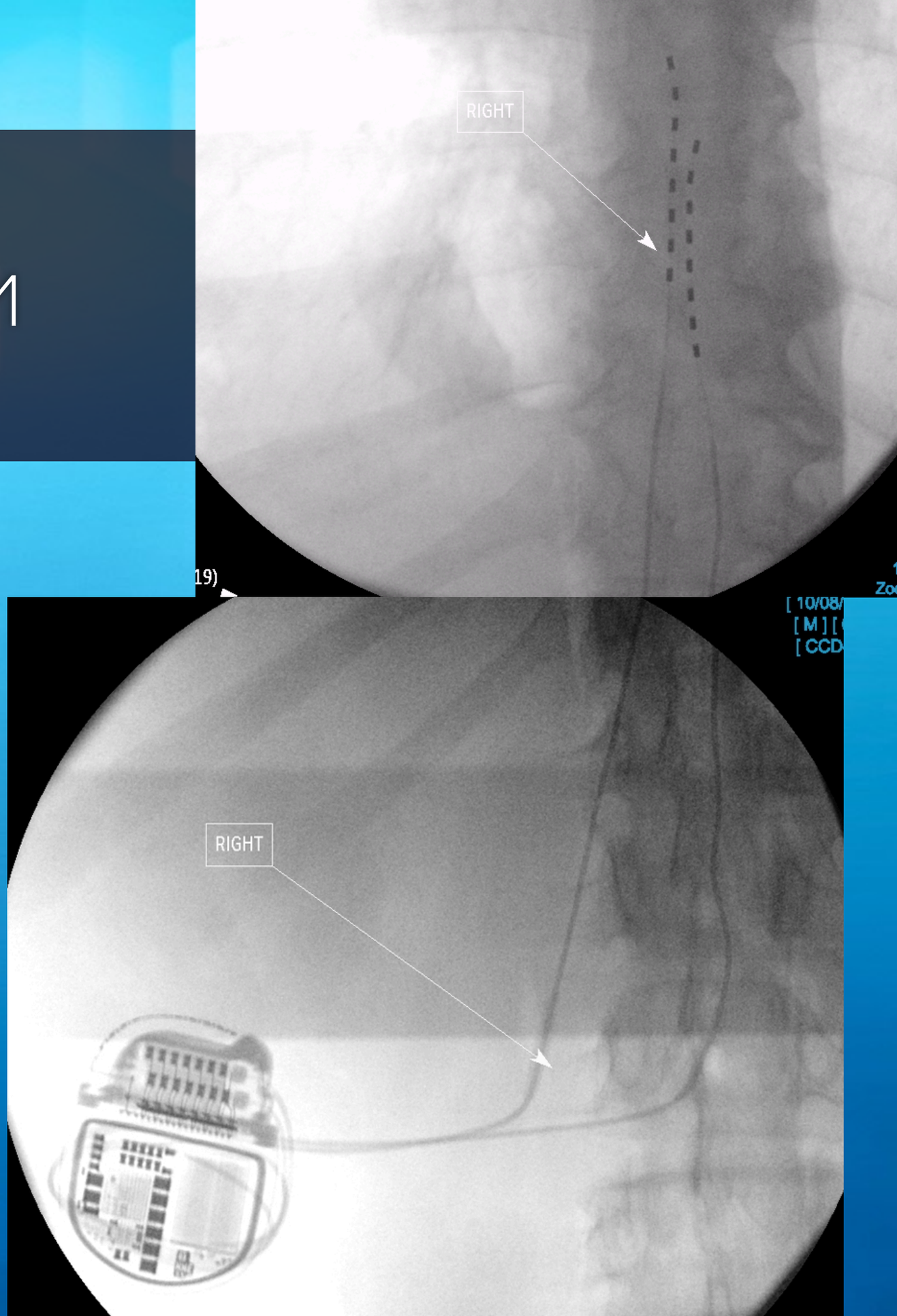
Similar to trial.

Can often do under GA.

Surgical incisions for device

- Generally sore

- Overnight admission



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After the IPG

Some limitations for first couple of months.

- Have to recover from surgery

- Hopefully can wind down any opioids or other pain meds.

- Avoid heavy lifting/bending/twisting for 2-3 months.

Rehabilitation begins here.

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The future

For pain management

Increasing number of conditions that will be indicated.

Improved technology

- Better MRI compatibility

- Feedback systems (monitor evoked responses - Eg Saluda systems)

- More primary cell systems & smaller rechargeable systems

- Better algorithms with greater pain reductions.

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PARALYSIS

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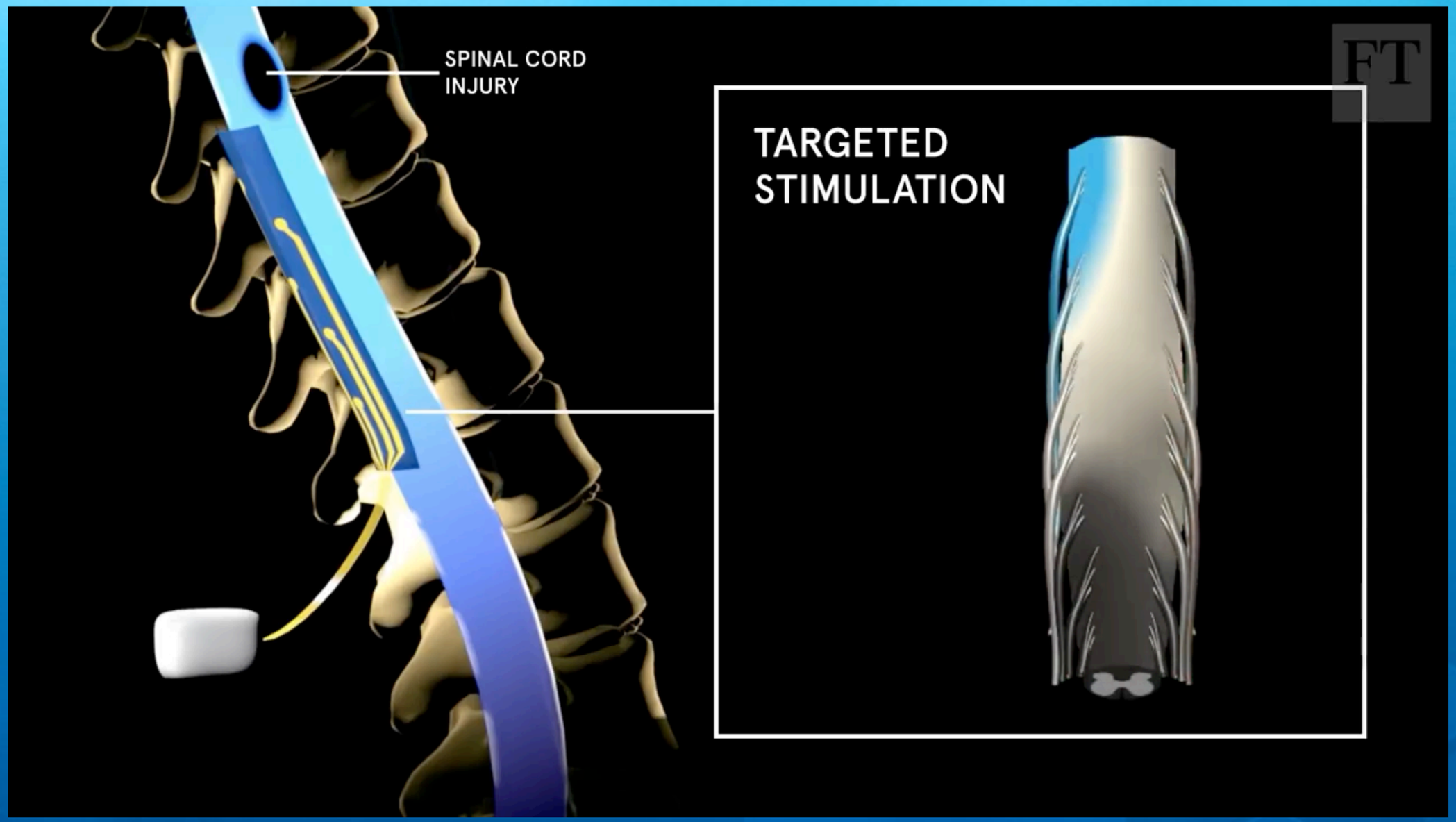
SCS FOR MOTOR CONTROL



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Unexpected results

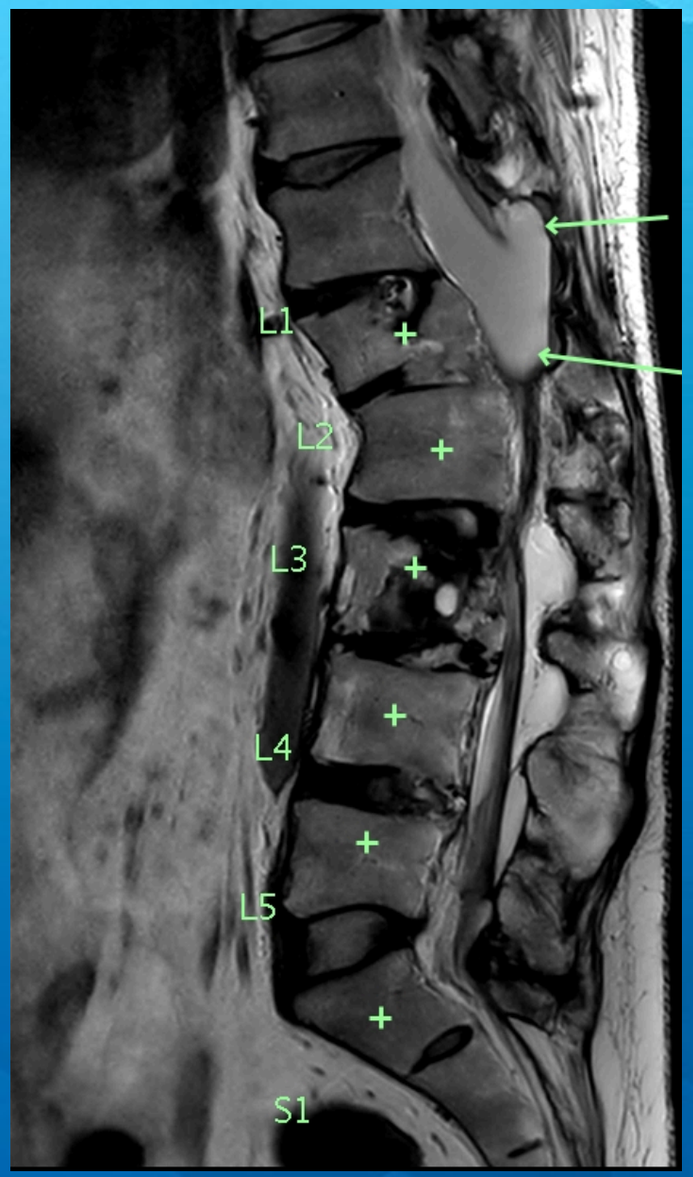
The Future

So probably going to see more of these down the track..

Not just for pain.

- Distal vessel vascular disease

- Spinal cord injury?



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Summary

- History of neuromodulation and SCS
- Indications for neuromodulation
- How its done
- Where its going