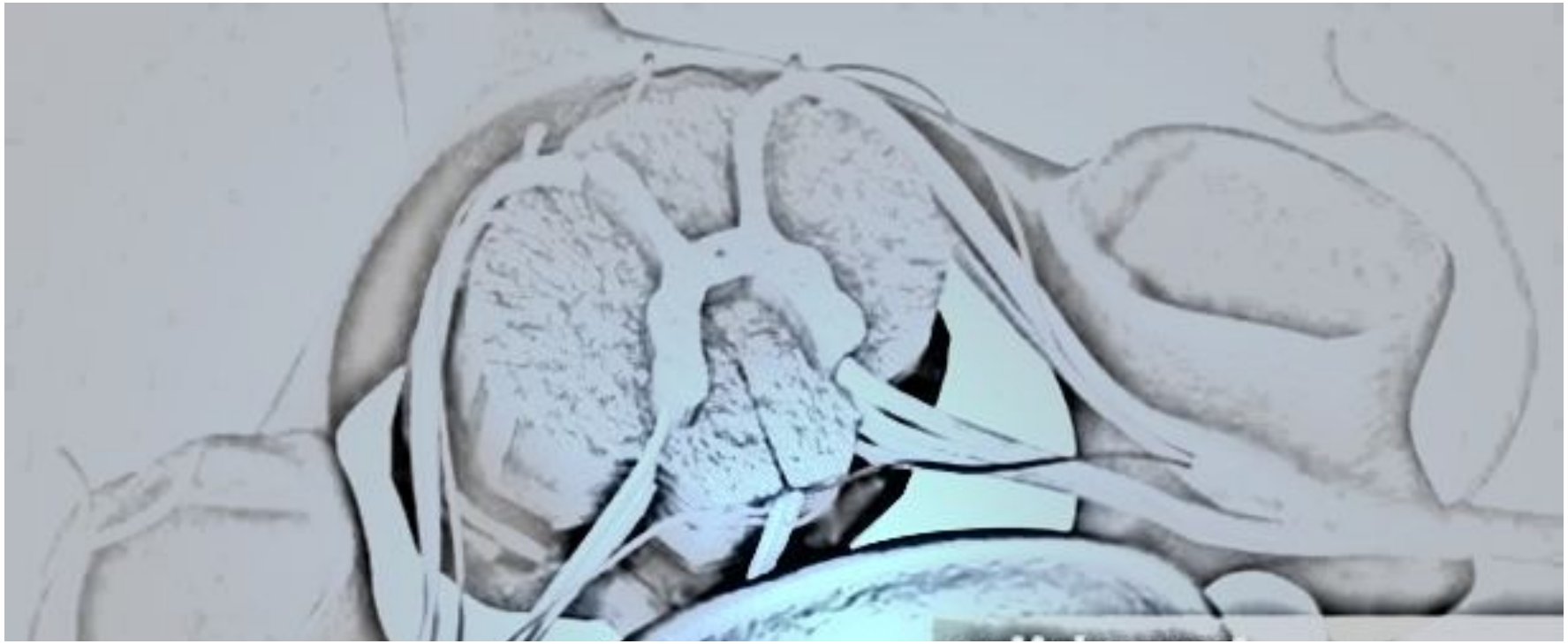


Dorsal Root Ganglion (DRG) Anatomy and Application

David W. Lee, M.D.

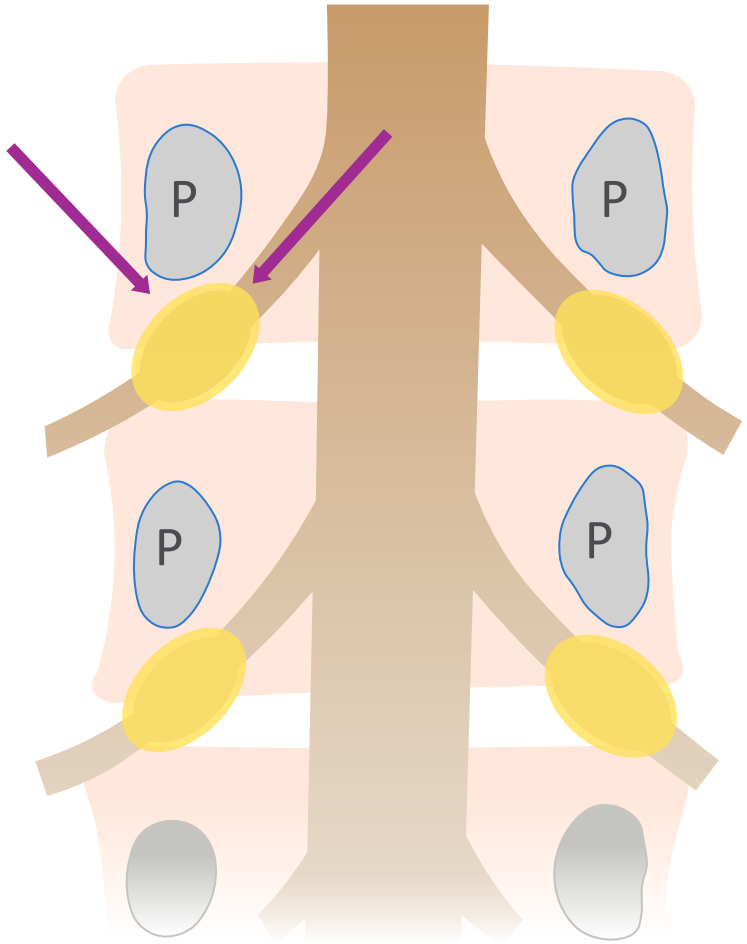
Patient Selection

Indications

- Neuropathic pain after surgical procedure (causalgia)
  - Hernia repair
  - Total knee and hip replacement
  - Foot and ankle surgery
  - Pelvic pain after trauma or surgery
  - Lowe extremity amputation
- Causalgia from traumatic injury of hip, knee, ankle or foot
- CRPS I of the LE

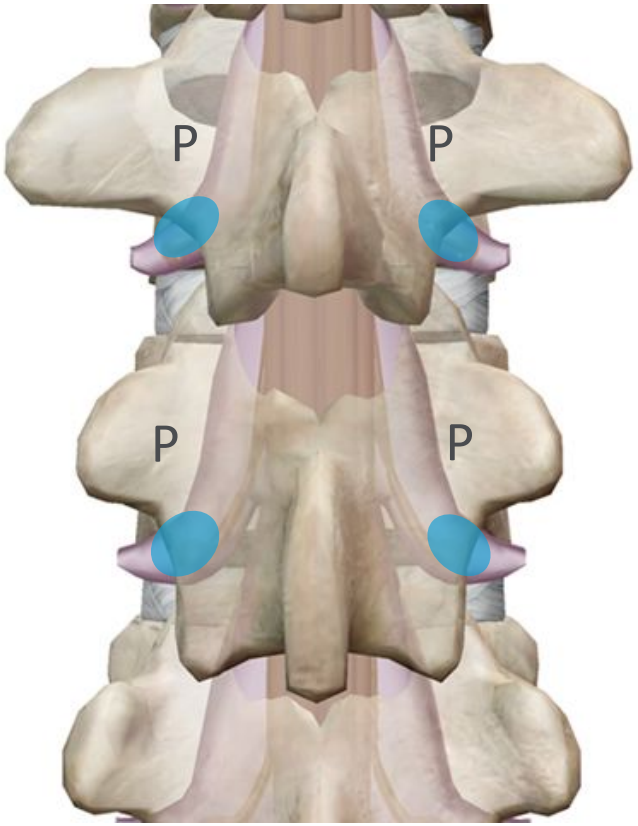
Contraindications

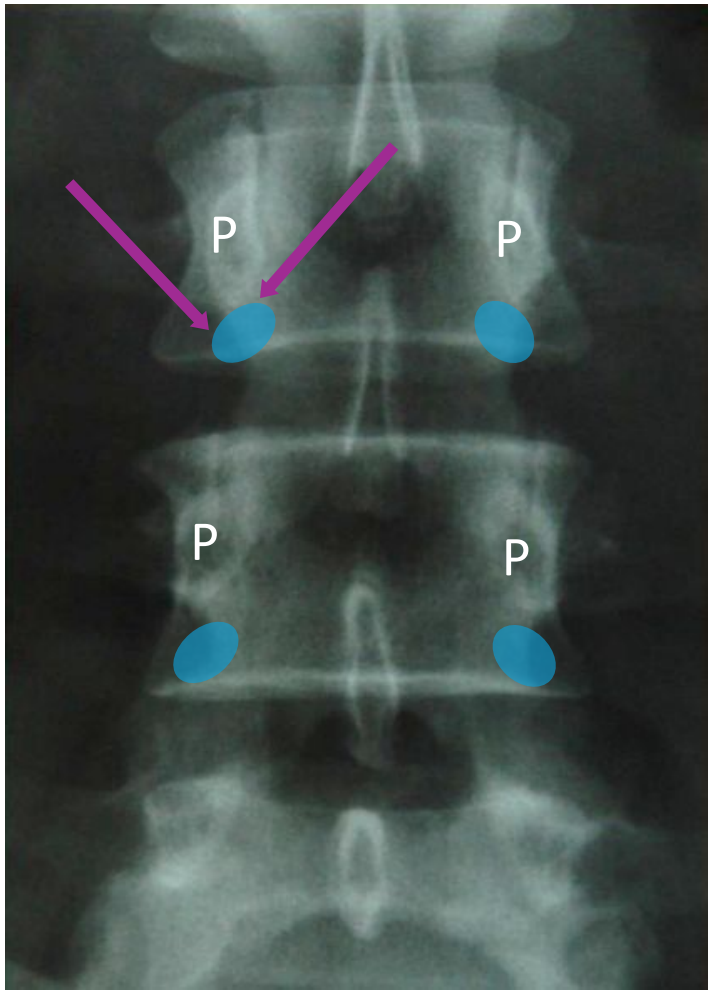
- Poor surgical risk
  - Discontinuation of anticoagulation
  - Hgb A1C > 8% (64 mmol/mol)
  - Ischemic heart disease
  - Autonomic neuropathy
  - Renal failure
  - Compliance concerns
- Pediatrics, pregnancy
- Infection
- Neuroforaminal stenosis
- Psychiatric condition or unable to operate system



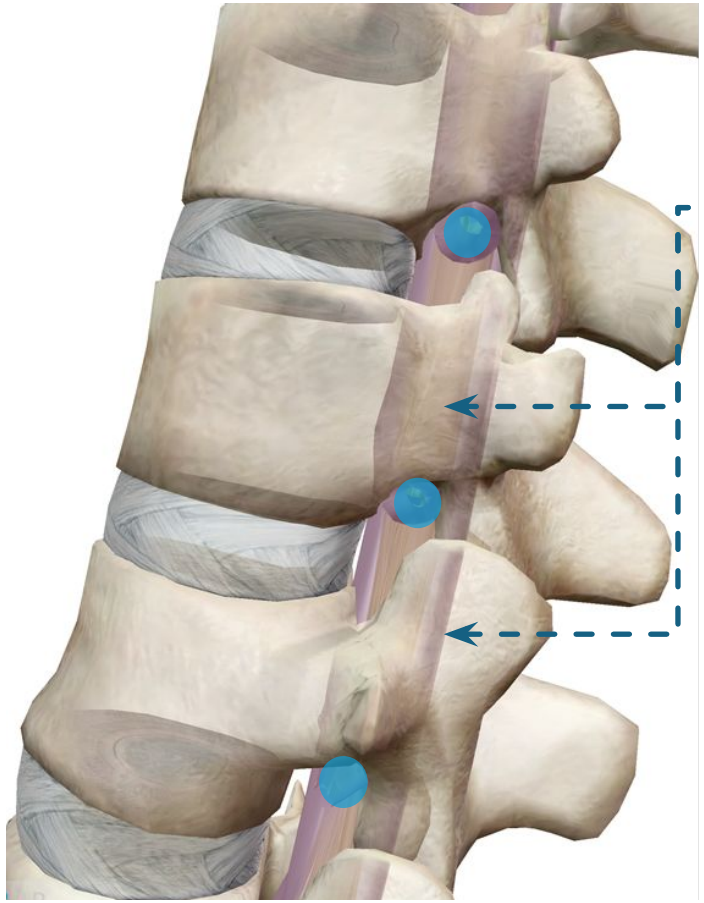
P – Pedicle

– DRG



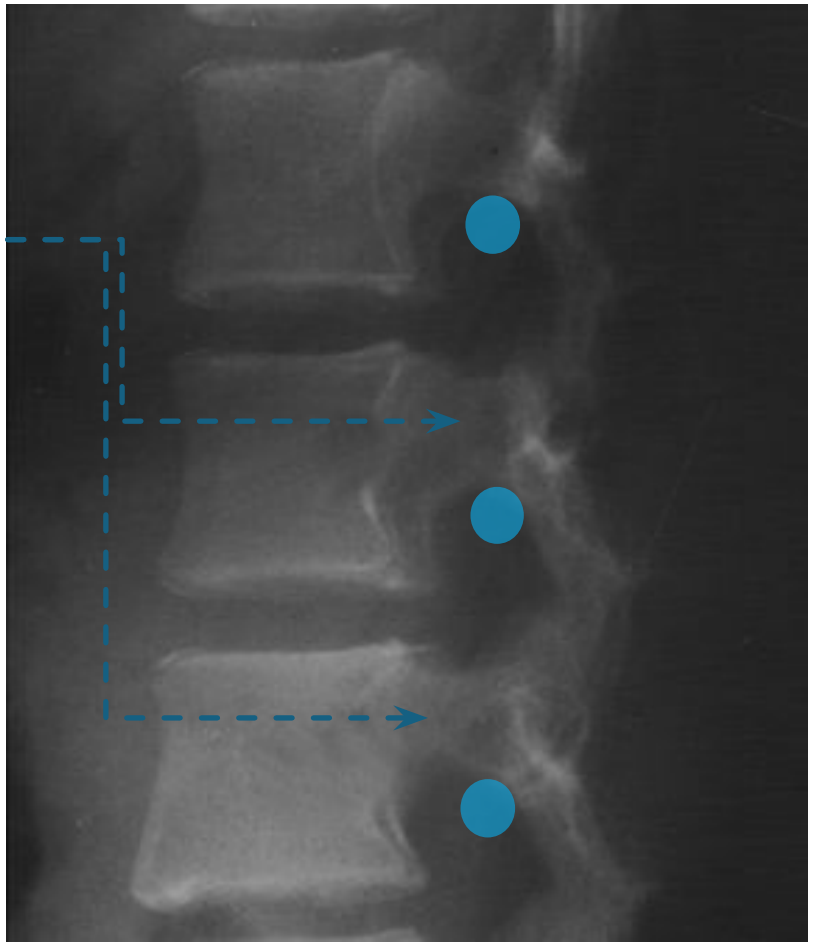


LATERAL LOCATION OF THE DRG



Pedicle

– DRG



PATIENT HISTORY & NATURE OF THE PAIN

PATIENTS WITH **PERSISTENT FOCAL** PAIN RESULTING FROM CRPS I OR AN INJURY TO A SPECIFIC NERVE MAY BE DRG CANDIDATES

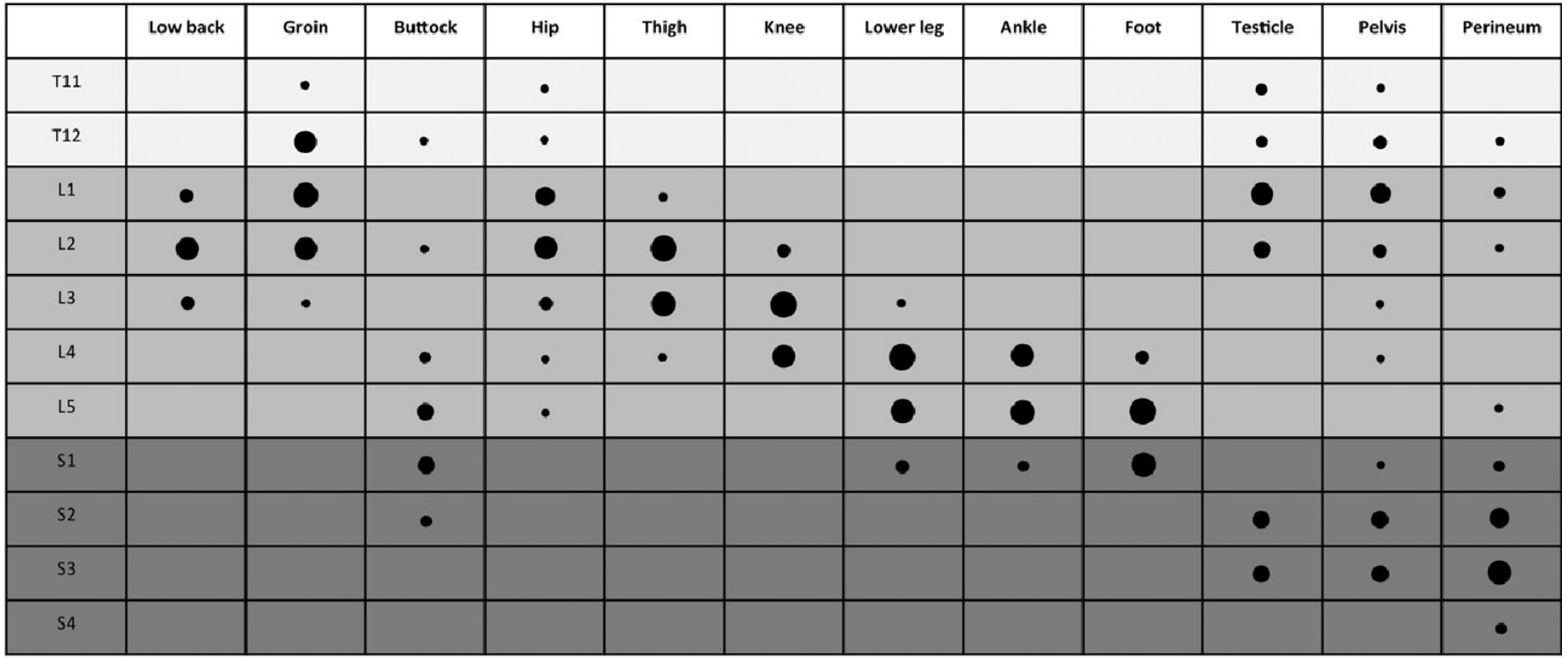
Hunter CW, Yang A. Dorsal Root Ganglion Stimulation for Chronic Pelvic Pain: A Case Series and Technical Report on Novel Lead Configuration. *Neuromodulation*. 2019 Jan;22(1):87-95

Major Nerves of the Pelvic Region and the Spinal Segments They Are Derived From. Gray Illustrates Extent of Coverage by Simultaneously Stimulating L1 and S2.

Nerve	T12	L1	L2	L3	L4	S1	S2	S3	S4	S5
Iliohypogastric										
Ilioinguinal										
Genitofemoral										
Obturator										
Posterior Femoral Cutaneous										
Inferior rectal										
Pudendal										
Coccygeal										

PATIENTS WITH **PERSISTENT FOCAL** PAIN RESULTING FROM CRPS I OR AN INJURY TO A SPECIFIC NERVE MAY BE DRG CANDIDATES (need ref)

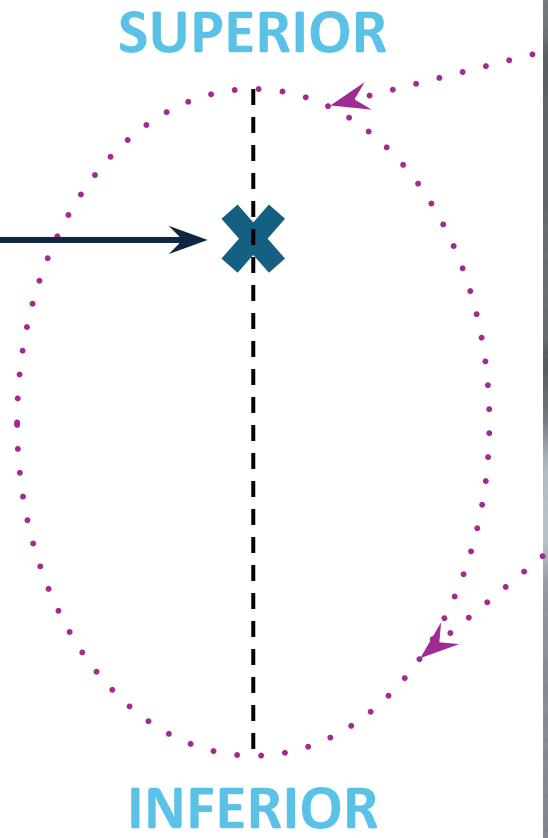
Deer T, et al. The neuromodulation appropriateness consensus committee on best practices for dorsal root ganglion stimulation. *Neuromodulation*. 2019;22(1):1-35

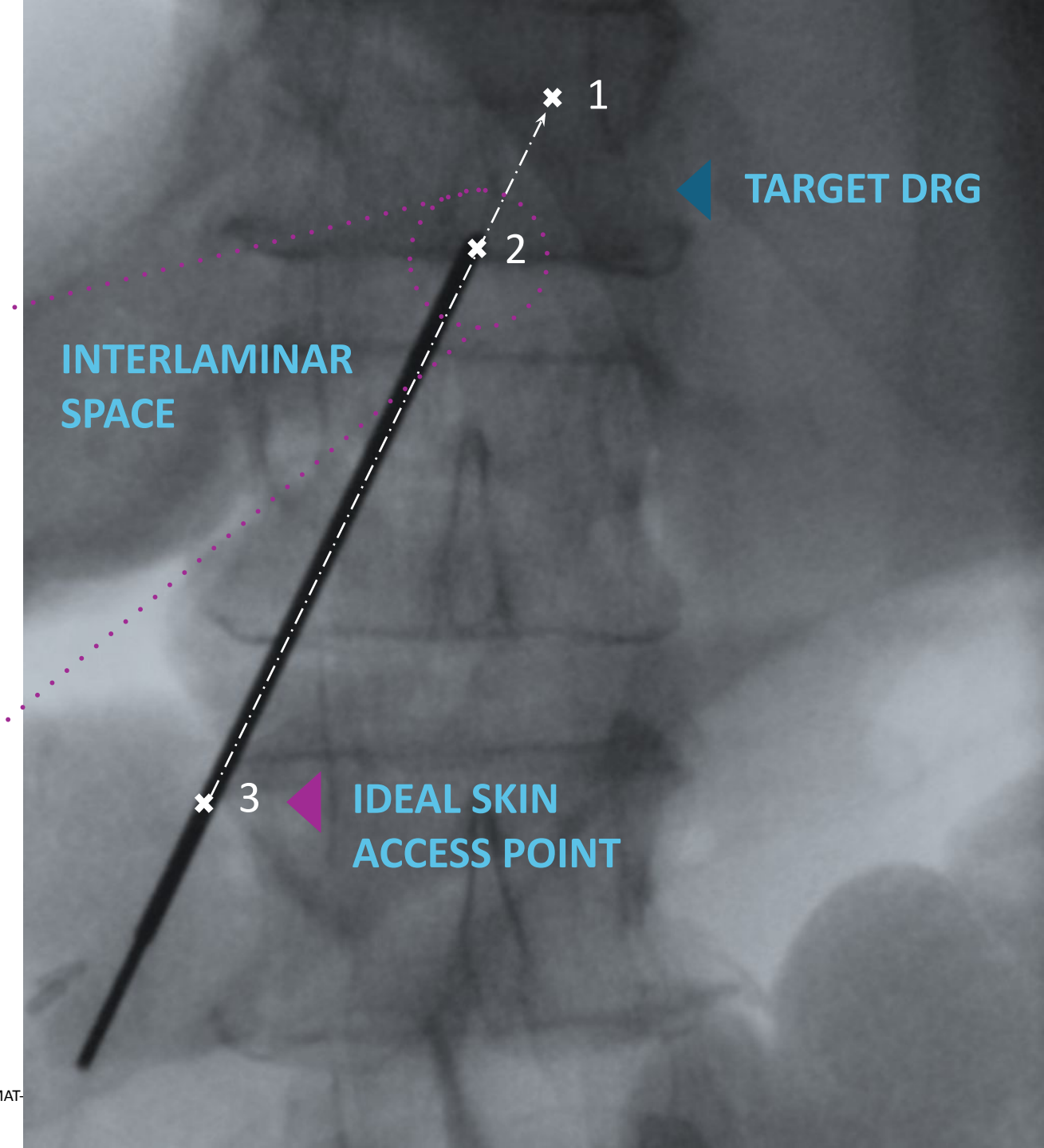


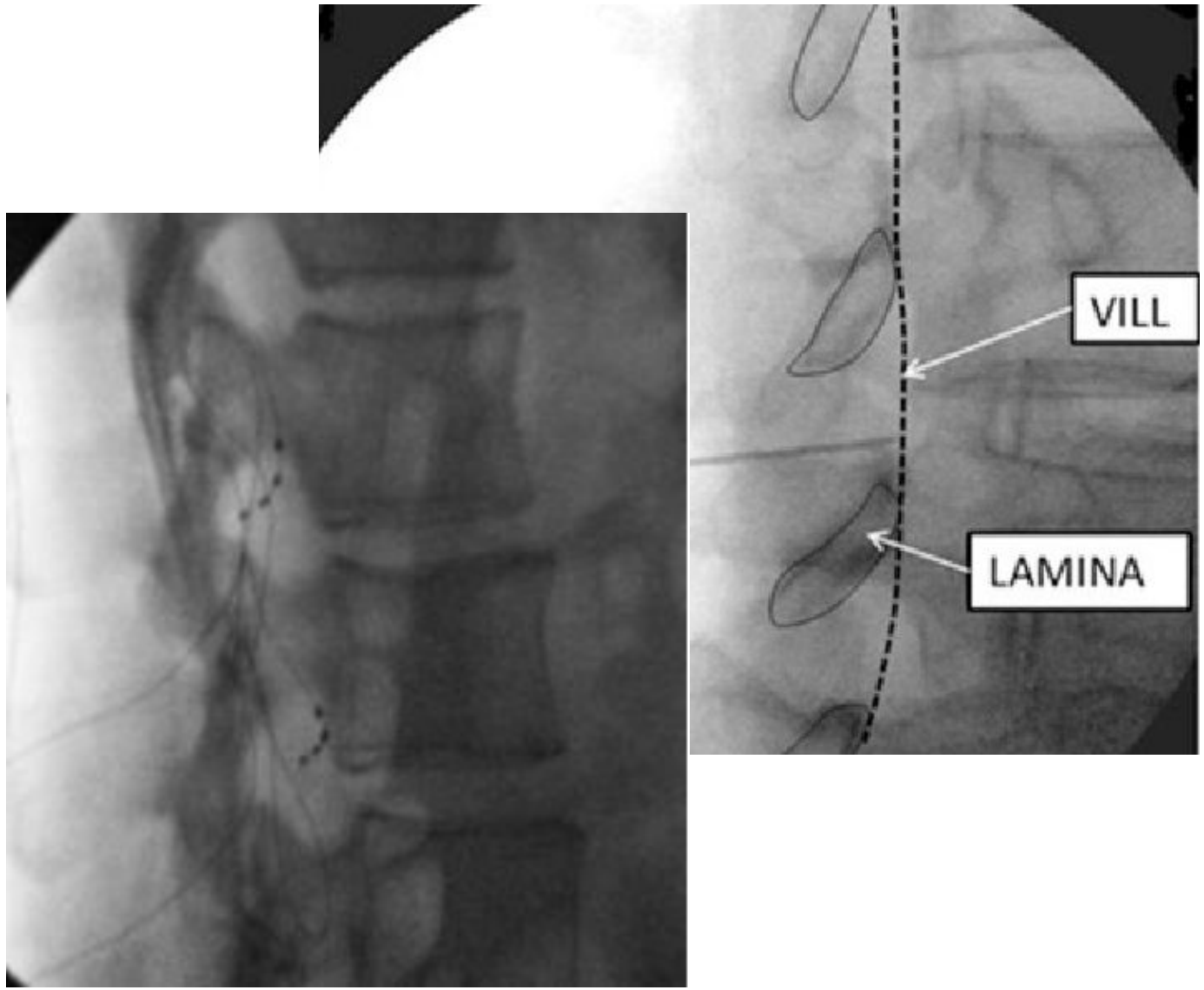
*Abbott's Proclaim DRG Stimulation has approval for T10-S2.

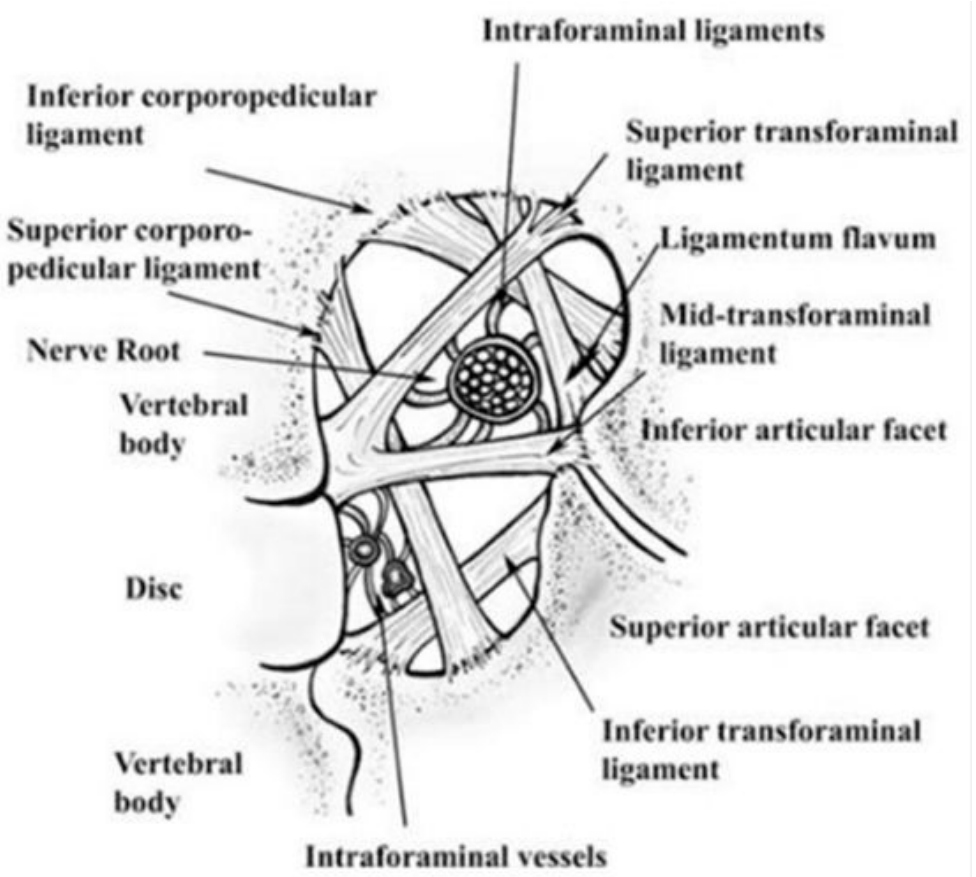
ACCESSING THE EPIDURAL SPACE

IDEAL NEEDLE TIP LOCATION:
Midline and superior in the interlaminar space



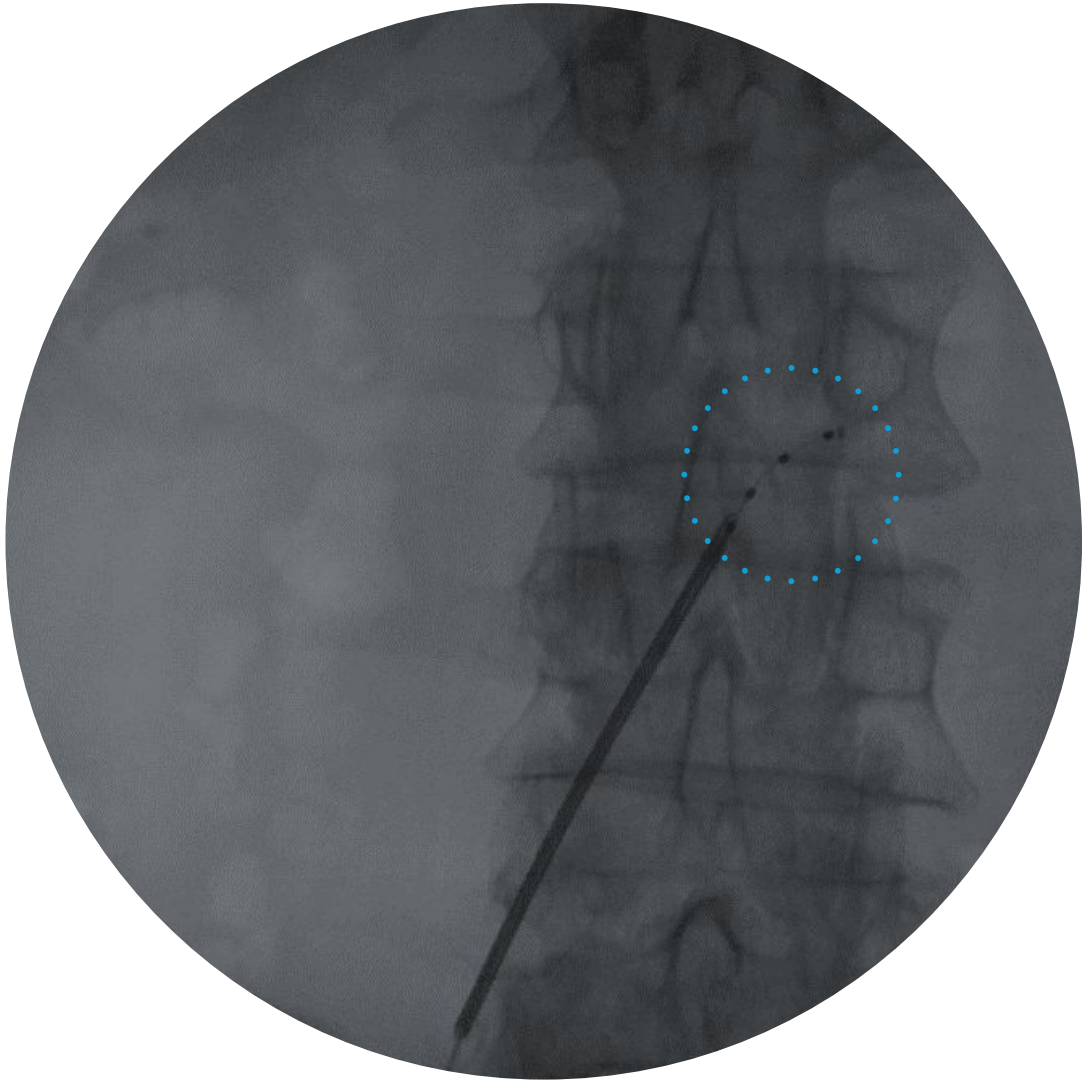



VILL
LAMINA

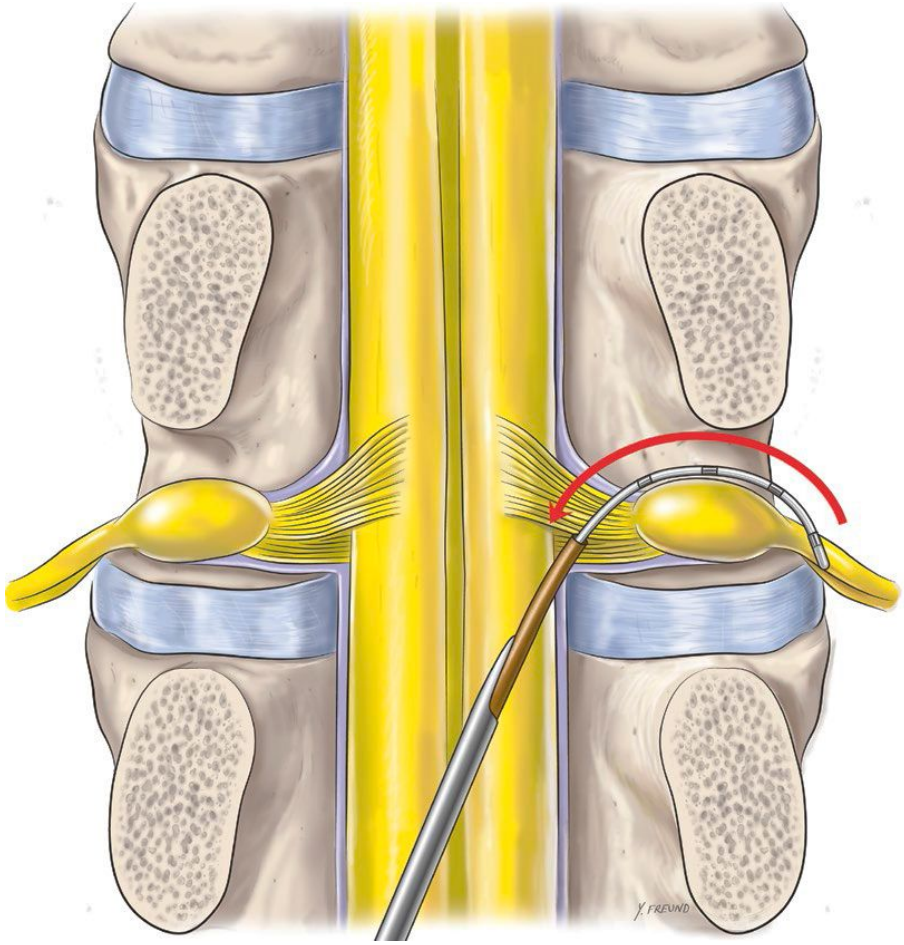

Intraforaminal ligaments
Inferior corporopedicular ligament
Superior transforaminal ligament
Superior corporo-pedicular ligament
Ligamentum flavum
Mid-transforaminal ligament
Nerve Root
Vertebral body
Inferior articular facet
Disc
Superior articular facet
Inferior transforaminal ligament
Vertebral body
Intraforaminal vessels

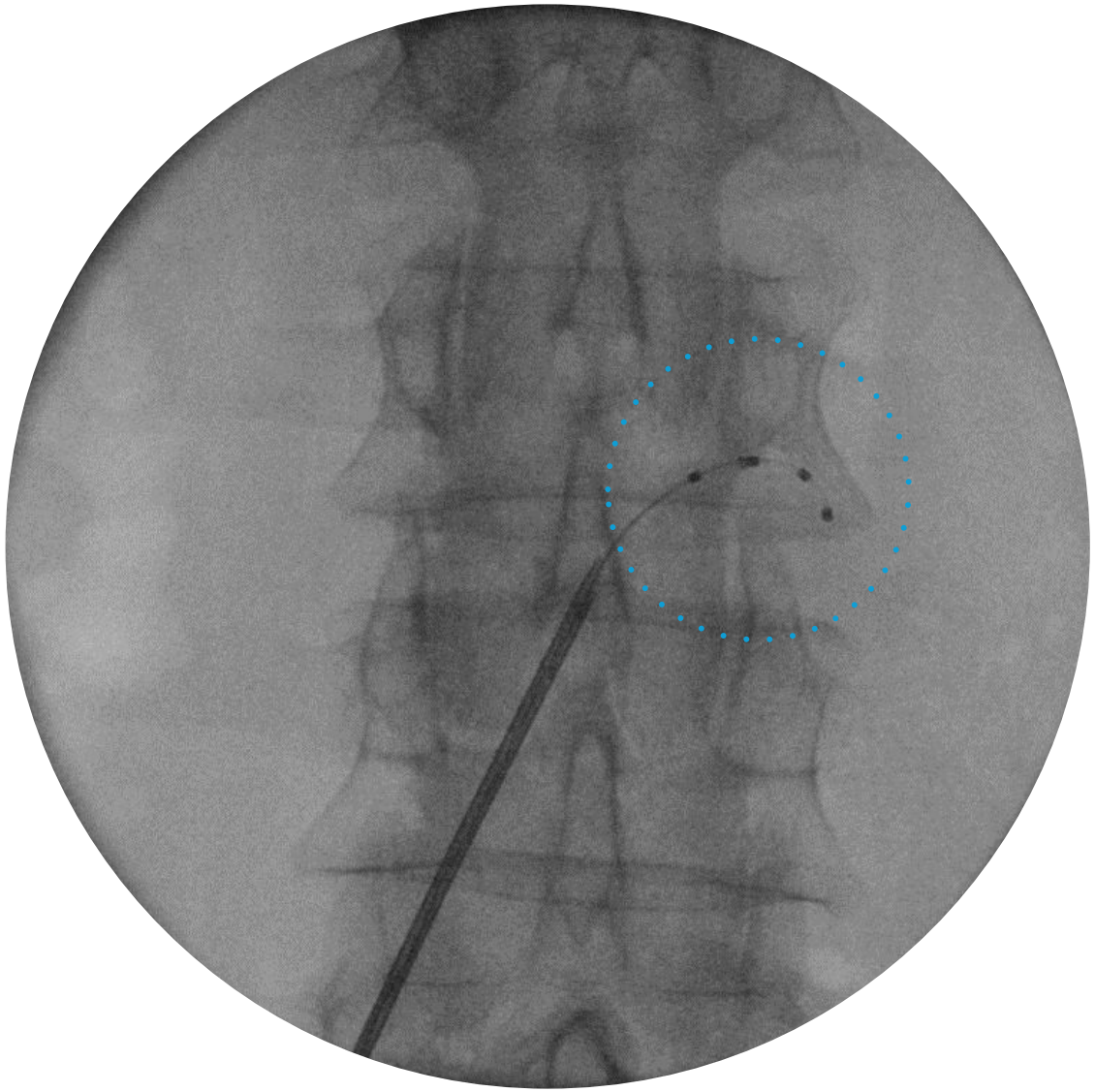
SHEATH DELIVERY (CONTINUED)

- **AS THE SHEATH IS ADVANCED TOWARD THE TARGET FORAMEN**
  - Makes contact with the inferior aspect of the target pedicle
  - Brushes past the target pedicle and into the neural foramen
  - Passes through the intraforaminal ligaments



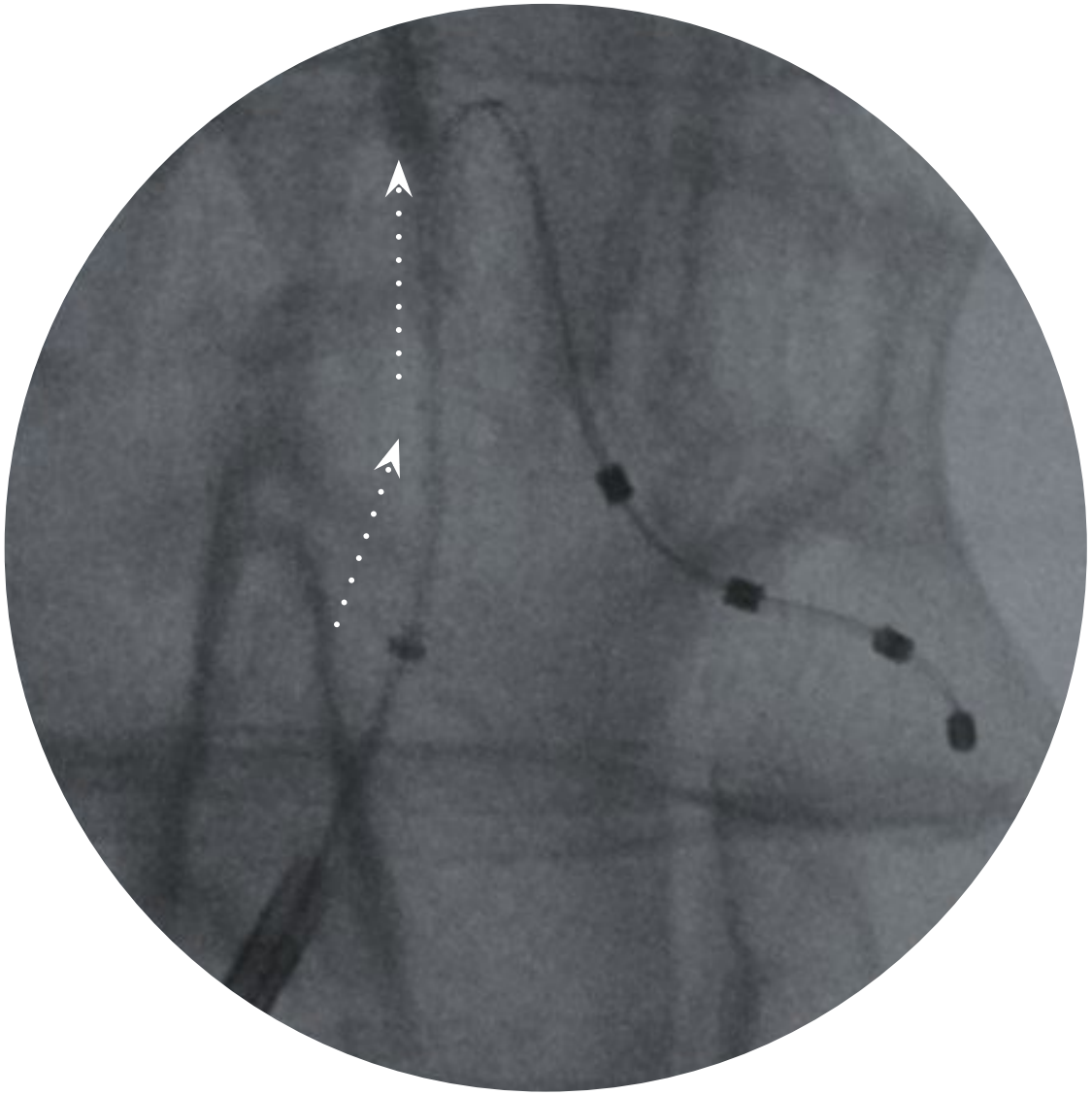
LEAD DELIVERY





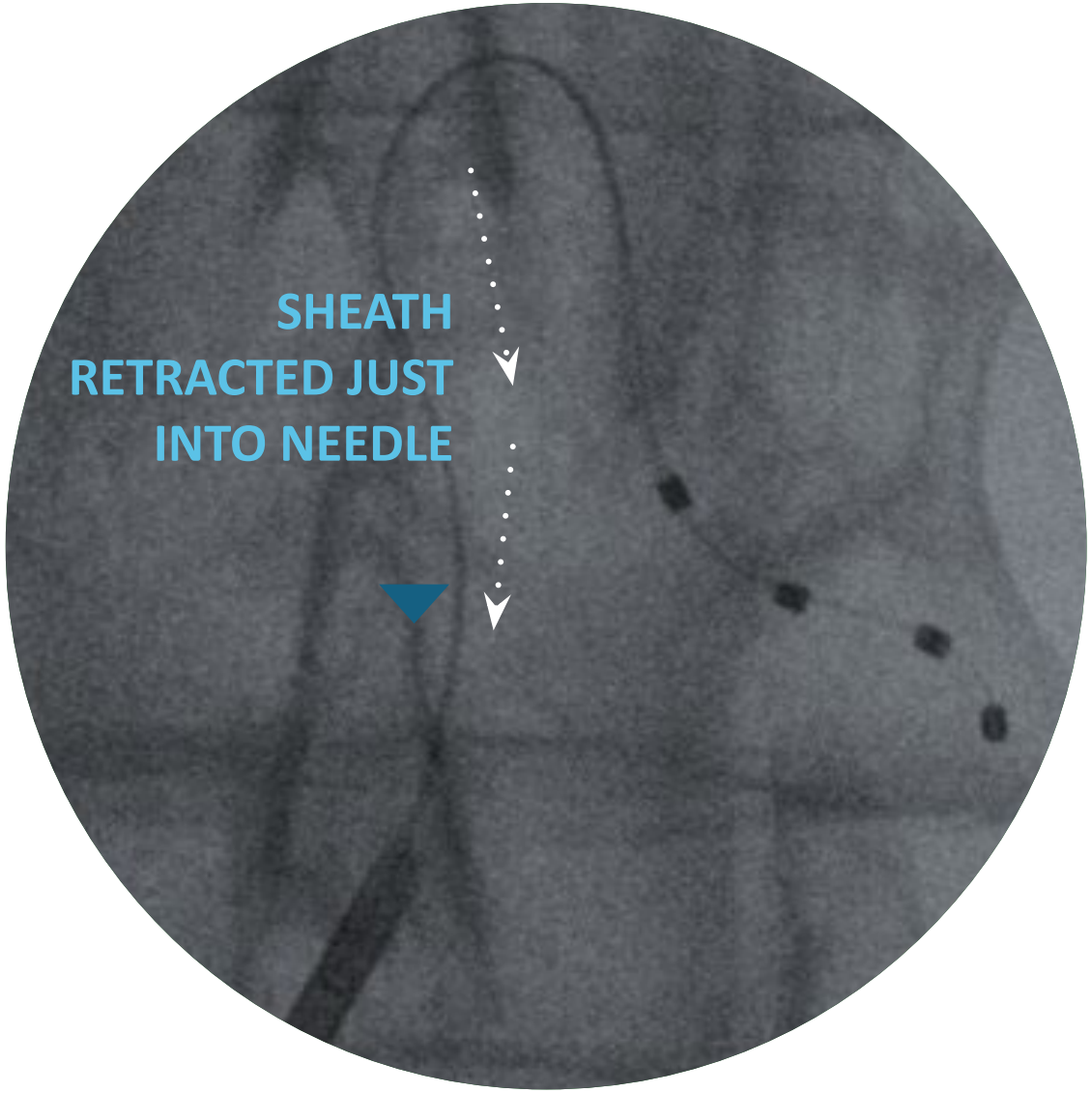
CREATION OF EPIDURAL LEAD STRAIN RELIEF (CONTINUED)

- Retract the stylet 5–10 cm from the tip of the lead
- Rotate the needle and sheath from
  3 o’clock to 12 o’clock
- Gently advance the lead and sheath combination into the epidural space OR feed the lead into the epidural space
- IMPORTANT: The lead should ideally wrap around the medial aspect of the pedicle as it advances superiorly
- This creates the upward curve of the S-curve



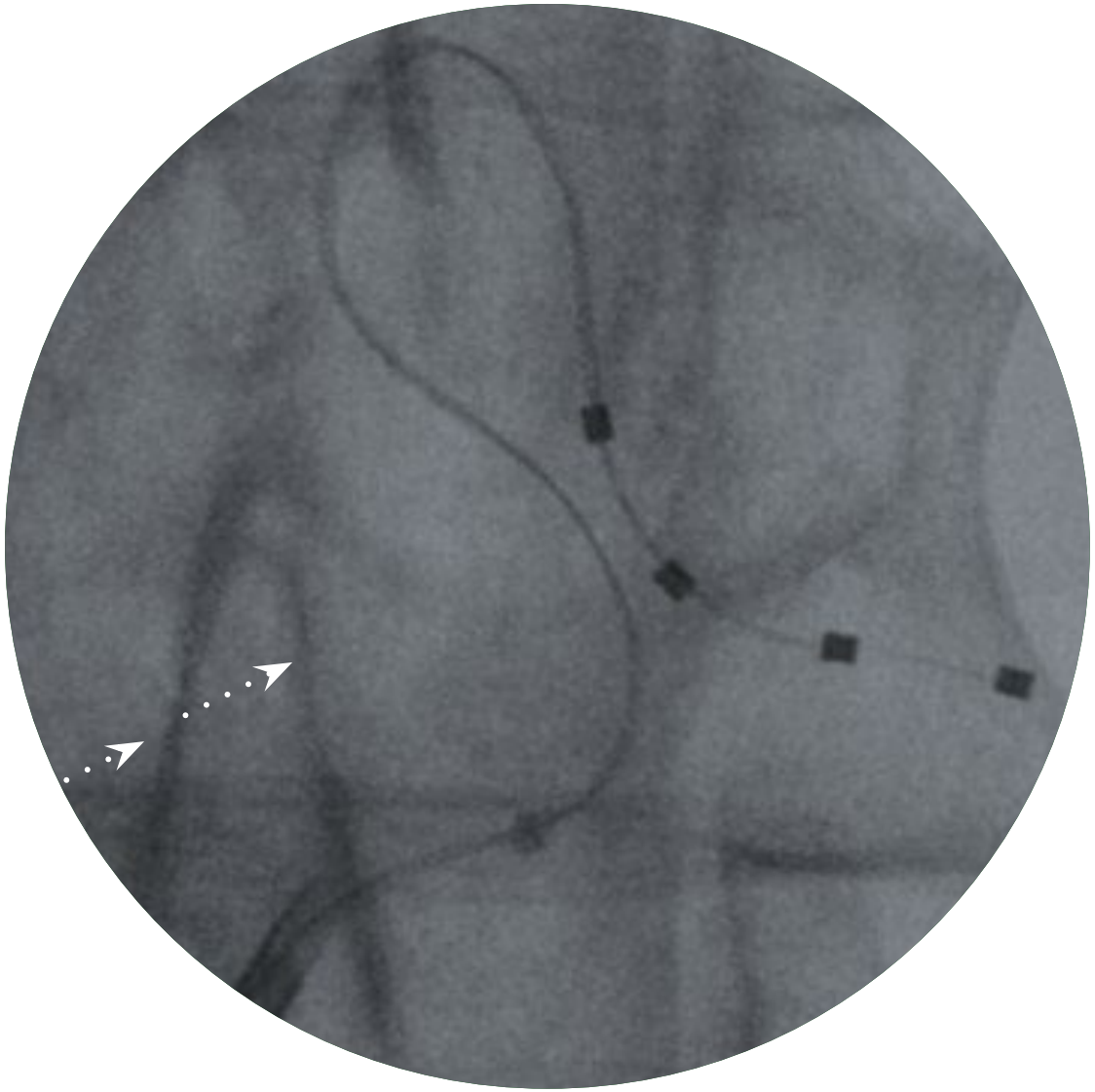
CREATION OF EPIDURAL LEAD STRAIN RELIEF (CONTINUED)

- Retract the sheath just into the needle
- Rotate the sheath to 3 o’clock



CREATION OF EPIDURAL LEAD STRAIN RELIEF (CONTINUED)

- Advance the sheath and lead (as one) or feed the lead into the epidural space in a lateral direction to form the lower part of the S-curve



Management of Complications

Have a plan/team *BEFORE THEY OCCUR*

- Neurologic
  - Epidural Hematoma – emergency decompression & evacuation
  - Neuritis vs neural injury
- Infection
  - Educate & re-educate patient to be vigilant of signs
  - Do not aspirate surgical sites
  - Immediately explant
    - Consider MRI to assess extent of infection & guide surgical planning
- Lead or IPG migration
  - Prevention through proper technique

Thoracic Percutaneous SCS

Brian Anderson, MD

Percutaneous Thoracic Leads

Indications

- Failed back syndrome
- Complex regional pain syndrome
- Diabetic neuropathy
- Non-surgical back pain
- Post thoracotomy pain
- Post herpetic pain
- Phantom limb pain

Brian Anderson, MD, MHA
Summit Brain Spine and Orthopedics

Percutaneous Thoracic Leads

Contraindications

- Previous epidural surgery*
- Heterotopic ossification*
- Active infection
- Coagulopathy/thrombocytopenia
- Immunodeficiency*

* *Relative contraindication*

Brian Anderson, MD, MHA
Summit Brain Spine and Orthopedics

Percutaneous Thoracic Leads

Complications

- CSF leak
  - Flat, caffeine, hydration, blood patch
- Infection
  - Abx, surgical intervention
- Anterior/Intrathecal placement
  - Remove
- Epidural hematoma
  - Surgical evacuation
- Lead fracture
  - Surgical removal

Pearls

- Consider entrance angle
- Perfect LOR technique
- Consider introducers
- Stylets can be manipulated to serve a purpose
- Consider the pathology to guide placement

Brian Anderson, MD, MHA
Summit Brain Spine and Orthopedics

ECAP-Controlled, Closed-Loop SCS Therapy Indications and Procedural Best Practices

PSPS Cadaver Lab

February 24, 2024

Pain Conditions Treated in the EVOKE Study

EVOKE Study

Pain Etiology *	Closed-Loop (n=67)	Open-Loop (n=67)
Arachnoiditis	0 (0%)	2 (3.0%)
Complex Regional Pain Syndrome (CRPS) 1	0 (0%)	1 (1.5%)
Degenerative Disc Disease	**33 (49.3%)**	**42 (62.7%)**
Failed Back Surgery Syndrome (FBSS)	**38 (56.7%)**	**41 (61.2%)**
Internal Disc Disruption or Tear / Discogenic Pain	7 (10.4%)	10 (14.9%)
Lumbar Facet-Mediated Pain	8 (11.9%)	8 (11.9%)
Mild-Moderate Spinal Stenosis	**26 (38.8%)**	**27 (40.3%)**
Neuropathic Pain	1 (1.5%)	1 (1.5%)
Radiculopathy	**61 (91.0%)**	**59 (88.1%)**
Sacroiliac Joint-Mediated pain	9 (13.4%)	5 (7.5%)
Spopndylolishesis	6 (9.0%)	5 (7.5%)
Spondylosis with Myelopathy	2 (3.0%)	3 (4.5%)
Spondylosis without Myelopathy	**26 (38.8%)**	**24 (35.8%)**
Other Chronic Pain	6 (9.0%)	3 (4.5%)

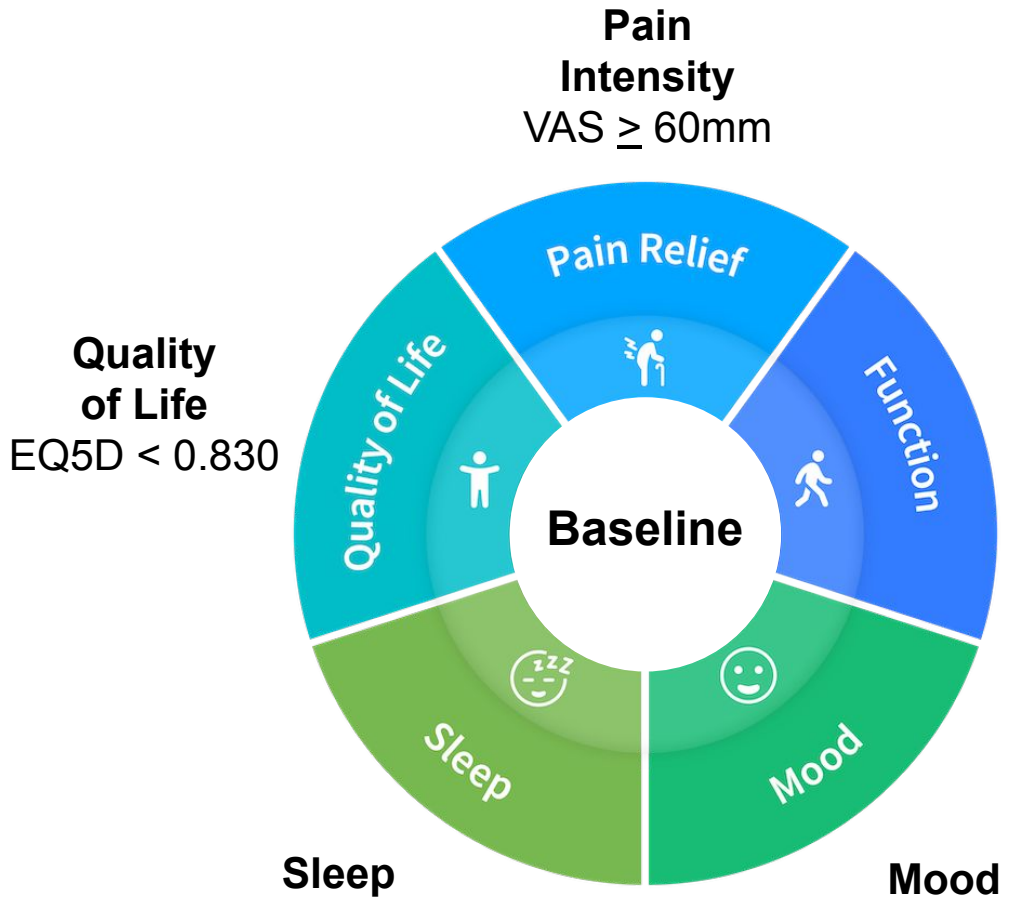
No notable difference across the two treatment groups

The ECAP-Controlled, Closed-Loop SCS Therapy is indicated as an aid in the management of **chronic intractable pain of the trunk and/or limbs**, including unilateral or bilateral pain associated with the following: **failed back surgery syndrome, intractable low back pain and leg pain**.

Mekhail N, Levy RM, Deer TR, et al. Durability of Clinical and Quality-of-Life Outcomes of Closed-Loop Spinal Cord Stimulation for Chronic Back and Leg Pain; A Secondary Analysis of the Evoke Randomized Clinical Trial. JAMA Neurol. 2022;79(3):1-10.

Identifying ECAP-Controlled, Closed-Loop Therapy candidates beyond baseline pain intensity

100% of EVOKE Study patients had baseline **dysfunction** in **Pain, Sleep, Mood, Function,** or **Quality of Life**

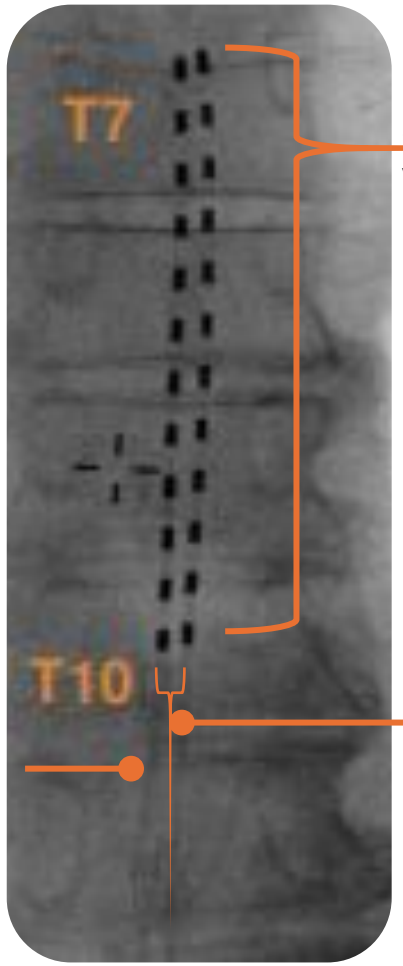


Mekhail N, Levy RM, Deer TR, et al. Durability of Clinical and Quality-of-Life Outcomes of Closed-Loop Spinal Cord Stimulation for Chronic Back and Leg Pain; A Secondary Analysis of the Evoke Randomized Clinical Trial. JAMA Neurol.

Lead Placement and Programming with Neurophysiology

12-contact lead designed for ECAP signal optimization

In-vivo visualization of real time activation of the spinal cord guides objective programming



PNS

Jake Measom, MD

Indications

- Symptomatic relief of chronic, intractable pain, post-surgical and post-traumatic acute pain
- Symptomatic relief of post-traumatic pain
- Symptomatic relief of post-operative pain
- Most PNS systems are not intended to be placed in the region innervated by the cranial and facial nerves.

- Low back/neck pain
- Neuropathic mononeuropathy
- Post-amputation pain
- Nerve or plexus trauma
- Complex regional pain syndrome
- Meralgia paresthetica
- Occipital neuralgia
- Inoperable joint pain
- Post-operative joint/joint-replacement pain
- Post-herniorrhaphy pain
- Post decompression/transposition surgery
- Leg, ankle, or foot pain

Patient Selection

- Healthy nerve target and/or ability to stimulate proximal to an injured nerve or region of pain
- Little to no history of psychological problems or disorders (depression, bipolar disorder, pain catastrophizing, etc.)
- No opioid use or low-dose opioid use (daily use <90 mg morphine equivalent, MME)
- No history of recurrent skin infections and no increased risk for infection
- Patient has caregiver or can adequately maintain and care for system (cleaning, charging, operating remote) and bandages
- No history of allergy to band-aids or adhesives
- Low body mass index (BMI), ideally < 30 BMI
- No confounding pain (significant pain in another area of the body, or pain of another cause in the same area)
- No prior surgeries that may have altered anatomy and/or impede lead placement or use of system
- No recent anesthetic injections which may interfere with stimulation
- No ablation of target nerve
- No secondary gains issues (pending workman's compensation or disability claims, where the patient is disincentivized to report improvement)
- andages or skin adhesives used (gel pads, bandages, etc.)

Contraindications

- Lead placement over the heart or across the thoracic volume.
- Lead placement in the front or side of the neck.Lead placement on the top of the head.
- Patients who have a Deep Brain Stimulation (DBS) system.
- Patients who have an implanted active cardiac implant (e.g. pacemaker or defibrillator).
- Patients who have any other implantable neuro-stimulator whose stimulus current pathway may overlap with that of the PNS System.
- Patients who require Magnetic Resonance Imaging (MRI).
- Patients who have epilepsy, if the leads are intended to be placed in the head or neck.
- Patients who have a tape or adhesive allergy.

Complications

Skin irritation

- Suspected or confirmed superficial infection treated with lead pull and/or antibiotics
- Active infection at target site
- Painful/uncomfortable stimulation
- Pain at the lead exit site
- Serious adverse events, including but not limited to infection requiring intervention, have been rare and have been reported in 0.11% of patients.

CERVICAL SCS TIPS

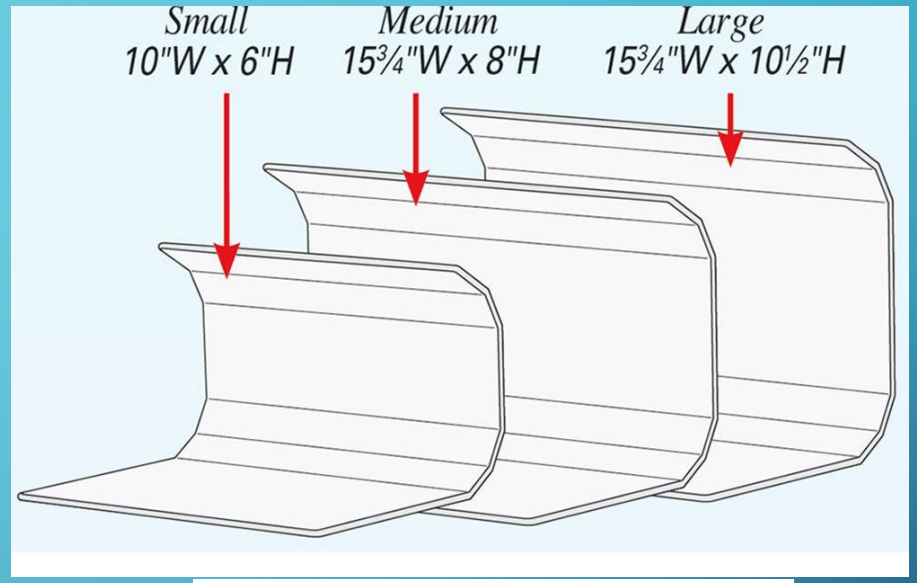
- Flat back…just like in thoracolumbar cases
- Build up the abdomen
  - 2-3 pillows
- Build up the chest
  - 1-2 pillows

PACIFIC SPINE PAIN SOCIETY

PACIFIC SPINE PAIN SOCIETY

CERVICAL SCS TIPS

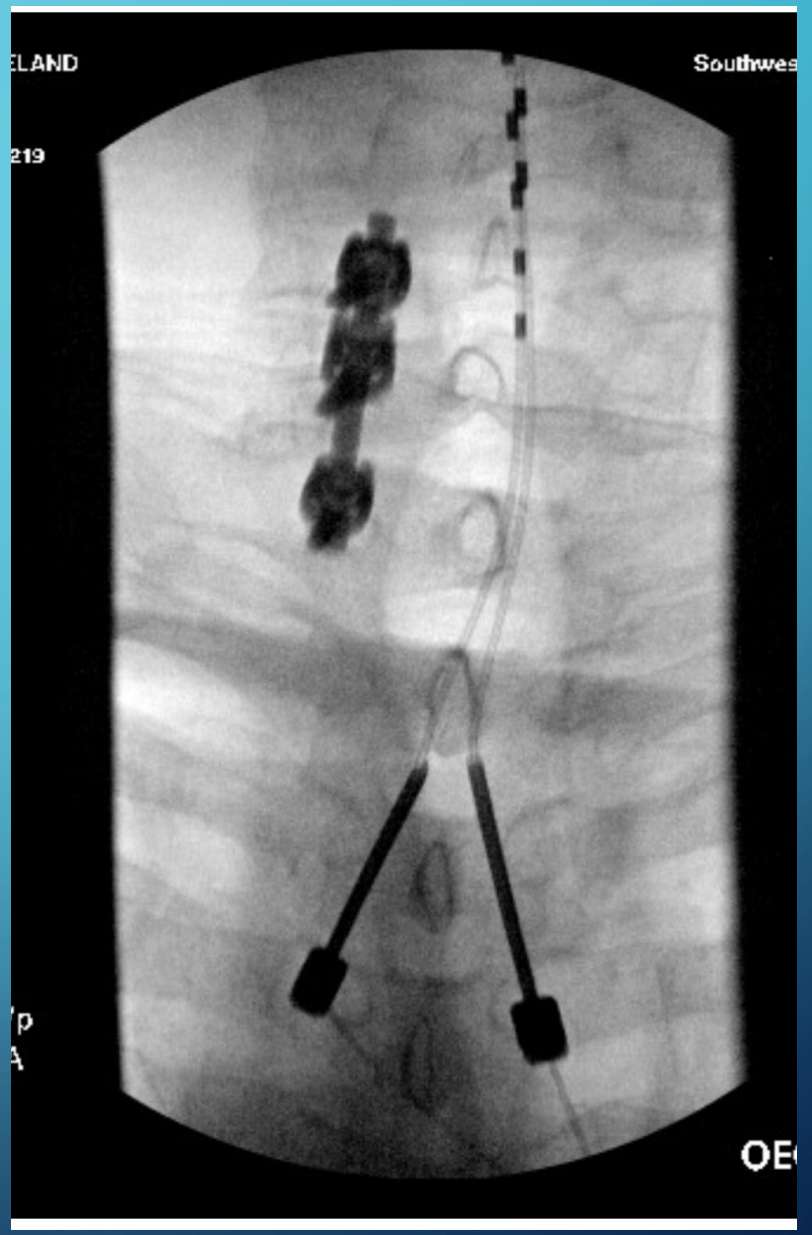
- Arms to the side
- Head Rest



PACIFIC SPINE PAIN SOCIETY

CERVICAL SCS TIPS

- Steeper Angle



PACIFIC SPINE PAIN SOCIETY

Interspinous Spacer for Spinal Stenosis

Jennifer M Lee, MD

Patient Selection

Indications

- Intermittent lower extremity neurogenic claudication secondary to mild-moderate:
  - Central stenosis
  - Neuroforaminal stenosis
  - Lateral recess stenosis
- Presence of functional impairment
- Pain relieved by flexion
- 6 months non-operative treatment
- No more than 2 levels, from L1 to L5

Contraindications

- Allergy to titanium
- Instability, ≥ Grade 1 spondylolisthesis
- Severe osteoporosis (spine or hip > 2.5 S.D.)
- Scoiliosis with Cobb angle ≥ 10 degrees
- Poor surgical risk
  - Unable to discontinue anticoagulation
  - Hgb A1C > 8% (64 mmol/mol)
  - Infection
- Prior fusion or decompression at index level
- Ankylosed index segment
- BMI > 40

Clinical Pearls

- Go Slow to Go Fast
  - Initial alignment is key!!
- Undersize rather than oversize
- Check and double check that lamina is intact
- Plan for adequate anesthetic depth

Management of Complications

Have a plan/team *BEFORE THEY OCCUR*

- Dislodgement or migration of implant
- Pain and discomfort due to presence of implant
- Neurologic
  - Post-op Neuritis
- Infection
  - Educate & re-educate patient to be vigilant of signs
  - Do not aspirate surgical sites

The PILD Procedure

Percutaneous Image-Guided Lumbar Decompression

Decompression Is Required to Effectively Treat LSS with Neurogenic Claudication

Nerve root inflammation[1]

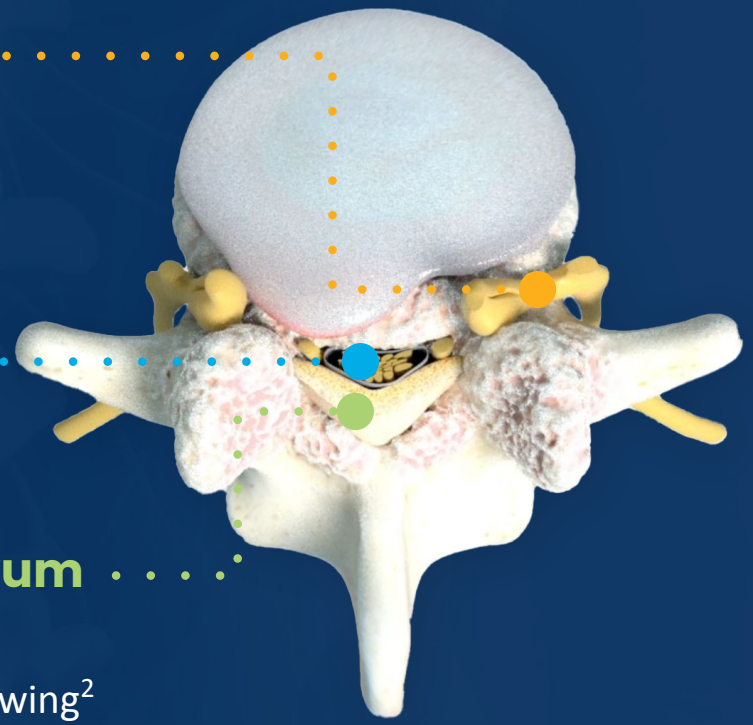
Symptom: radicular pain
Treatment: anti-inflammatory

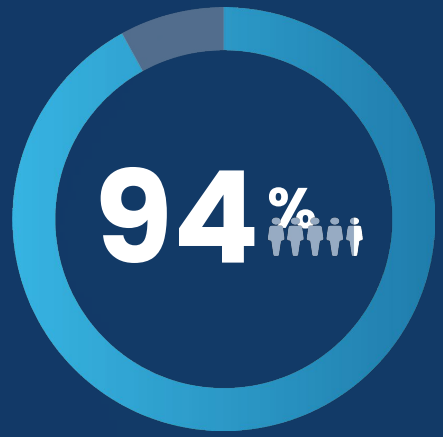
Thecal sac compression / ischemia

Symptom: neurogenic claudication (NC)[1]
Treatment: decompression

Hypertrophic ligamentum flavum (HLF)

Contributes up to 85% of spinal canal narrowing[2]



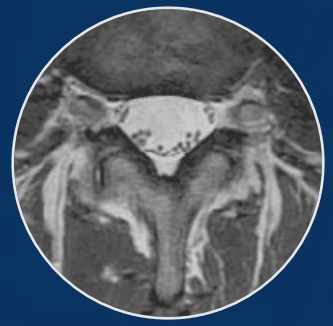


of LSS patients suffer with NC[3]

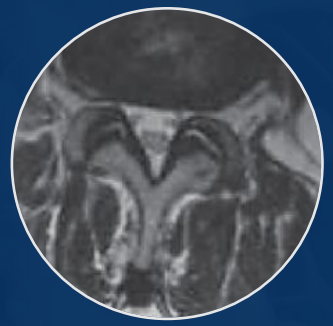
PILD Treats Mild To Severe Stenosis

Radiological quantitative assessment of stenosis

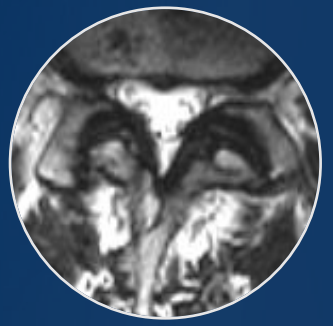
Normal



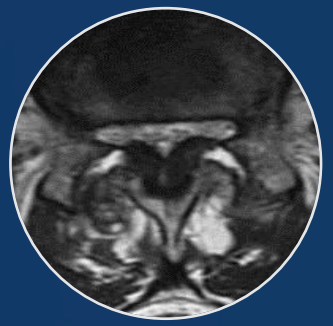
Mild



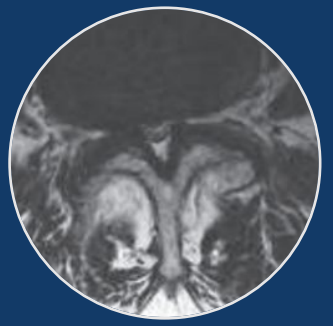
Moderate



Moderate – Severe



Severe



PILD Removes a Major Root Cause of LSS to Improve Back and Leg Pain, and Leaves Nothing Behind[1]

“Remove the kink in the drinking straw”

Safe and Efficient Outpatient Procedure

No General Anesthesia

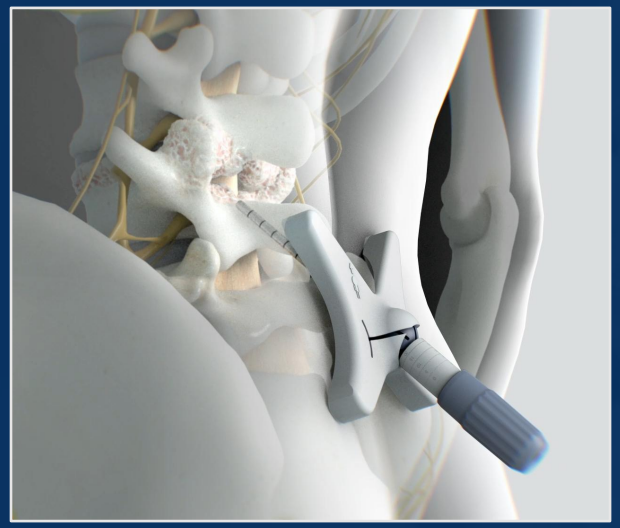
No Implants

No Stitches

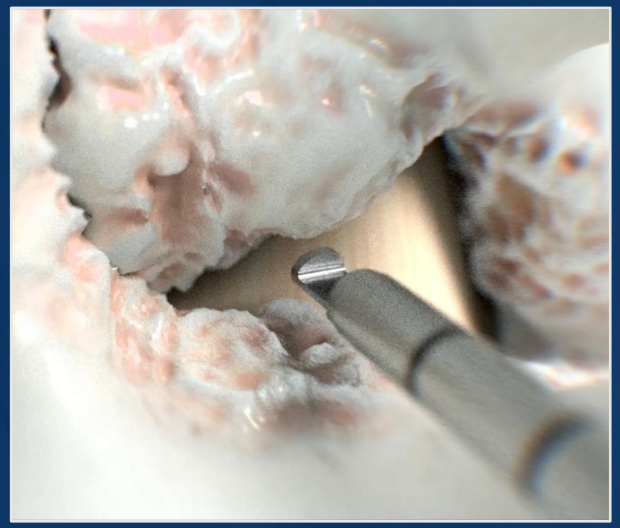
No Steroids or Opioids

PILD Procedural Steps

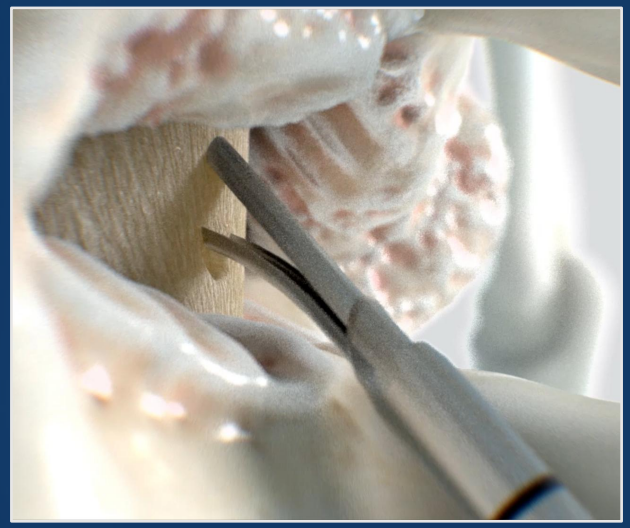
Outpatient decompression achieved through a tiny incision, smaller than the size of a baby aspirin



Insert portal (5.1mm)



Remove bone to achieve access



Debulk hypertrophic ligament

Remove instruments and close w/ Steri-strip

Broad Foundation of Scientific Evidence

13 clinical studies and >25 published articles

Level 1 Data

Two Level 1 RCT studies

Significant Functional Improvement[1]

Clinically meaningful & statistically significant mobility & pain improvement

5-Year Durability[2]

88% of patients avoided surgical decompression while experiencing significant symptom relief

Safety Profile Equivalent to an ESI[3]

Clinically proven safety equivalence to epidural steroid injections (ESIs)

> 45k patients treated to date[4]

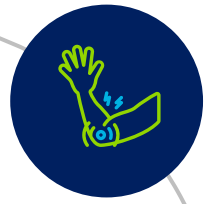
Thank You

SI Joint Fusion

Patrick Buchanan, MD

PROBLEM

Sacroiliac Joint Dysfunction



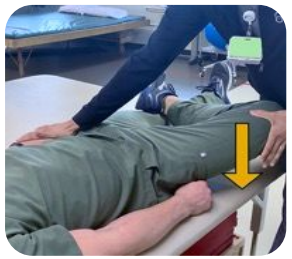
Mechanical pain stemming from too much or too little movement where the sacrum meets the ilium.

Latest evidence shows sacroiliac joint (SIJ) dysfunction is responsible for up to 30% of chronic low back pain (cLBP) and has been misdiagnosed for years.

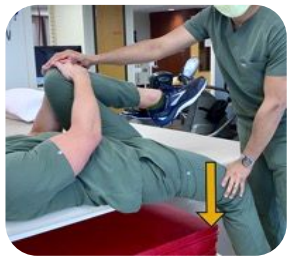
Other interventions often perceived to fail due to mechanical pain from the SIJ has been overlooked or left untreated. (Intervertebral spacers, lumbar fusion, spinal cord stimulation, etc.)

Diagnosis

SI Joint Provocative Tests



FABER Test
(Patrick's Test)



Gaenslen Test

Compression Test

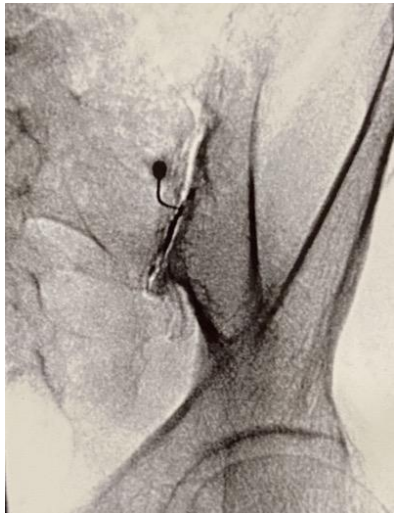
Thigh Thrust Test
(Posterior Shear Test)

Gaenslen Test
(modified technique)

Distraction Test

- ☑ 3/5 positive provocative signs: 85% pretest probability that image guided intraarticular injection is successful (Szadek et al)
- ☑ 1 out of 3 positive results must be thigh thrust or compression

SI Joint Diagnostic Injection

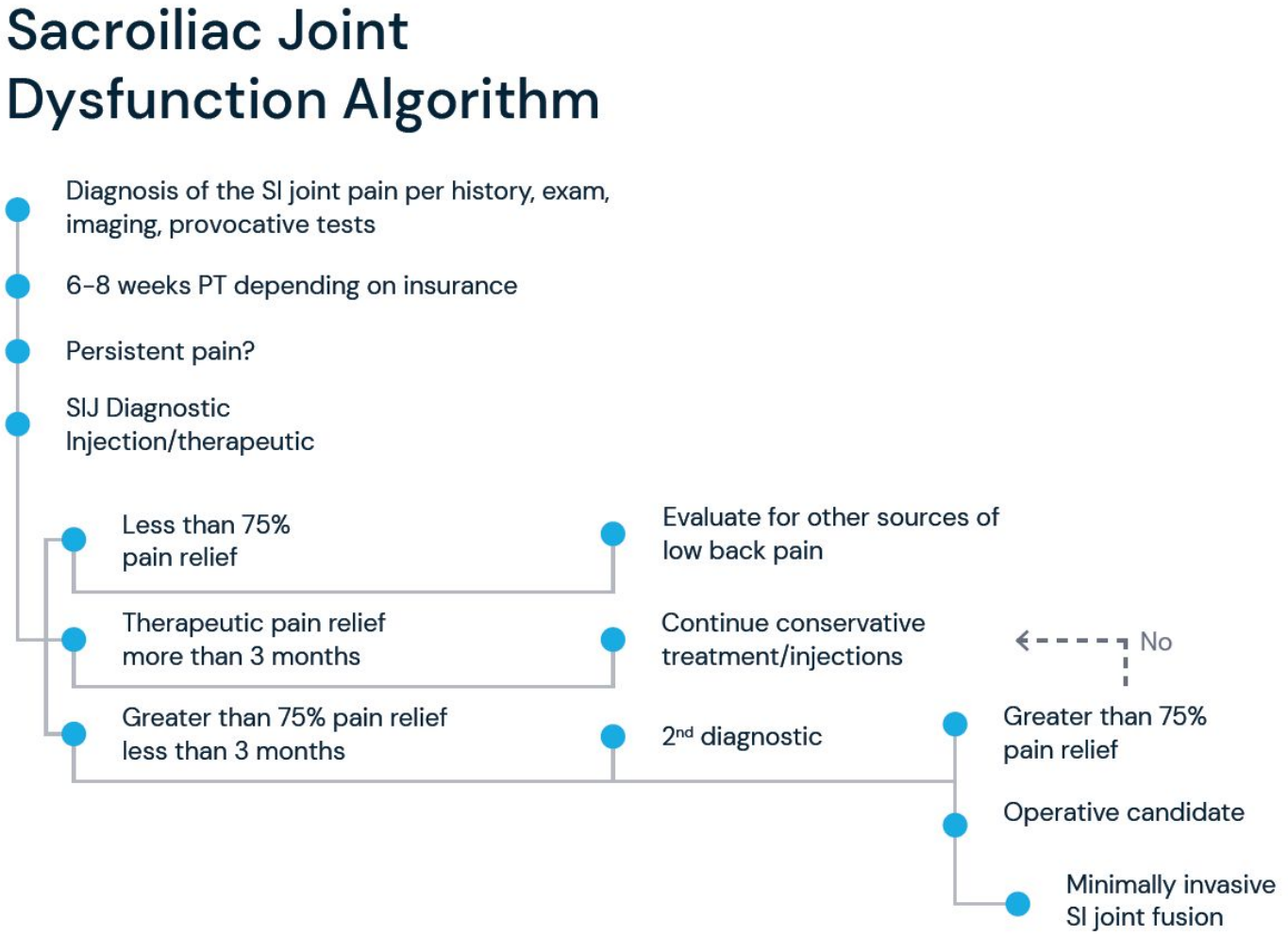


- Two SIJ injections performed on two separate occasions that are contrast enhanced per Medicare Guidelines
  - one should be diagnostic and one should be therapeutic
- The recommended volume of injectate ranges from 1 to 2 mL (Simopoulos et al)
- Significant Positive Clinical Response: >75% VAS reduction indicates positive diagnosis of SIJ as the pain generator

Algorithm in the Diagnosis and Treatment of SIJ Pain

Medicare Guidelines for Medical Necessity[1]

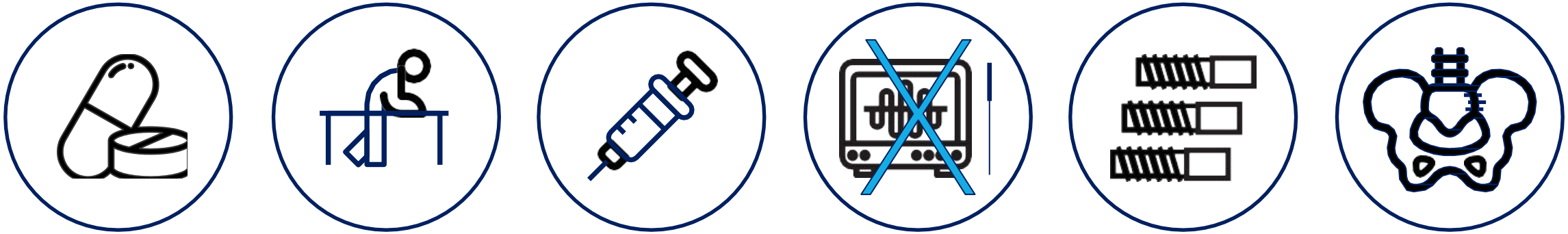
- 6 months failed conservative treatment
- Negative CT or MRI of SI Joint, Lumbar Spine, Negative xray of pelvis
- 3 out of 5 positive provocative tests
  - Compression or Thigh Thrust Test
  - Two of the following: Gaenslens, Distraction, Patrick's Sign (Faber)
- 2 diagnostic SIJ injections > 75% pain relief
  - At least one of the injections needs a therapeutic agent



1. LCD - Minimally-Invasive Surgical (MIS) Fusion of the Sacroiliac (SI) Joint (L36494)

From least to most invasive

Less is more. It is an established principle in medicine to follow a continuum from least invasive to most invasive, exhausting safe, simple and effective treatments first prior to advancing to more complex, invasive options. The SI joint is no different, and new therapies are emerging that give patients options when consenting to a care path.



NSAIDS or bracing

Physical therapy

Therapeutic injections

Radiofrequency ablation

Lateral or metal SI joint fusion

Open or revision surgery

SI Joint Fusion

SI Joint Fusion as a salvage option

Contraindications

Contraindications for the posterior SI joint fusion are similar to those of other systems of similar design. The choice of any device or procedure must be carefully weighed against the patient's overall evaluation. The circumstances listed below may reduce the chance of a successful outcome:

1. Patients with acute or chronic infection of any etiology and localization, inflammation, fever, tumors, elevated white blood count, morbid obesity, pregnancy, mental illness and other medical or surgical condition which would preclude the potential benefit of LinQ SI-Fusion surgery.

2. Patients resistant to following post-operative restrictions on movement, especially in athletic and occupational activities.

3. Grossly distorted anatomy caused by congenital abnormalities that would prevent or interfere with LinQ placement.

4. Rapid joint disease, bone absorption, osteopenia. Osteoporosis is a relative contraindication since this condition may limit the degree of obtainable correction, stabilization, and/or the amount of mechanical fixation, and/or the quality of the bone graft.

5. Unsuitable or insufficient bone support, bone immaturity.

6. Any patient having inadequate tissue coverage over the operative site or inadequate bone stock or quality and/or lack of anatomical definition.

7. Any patient in which implant utilization would interfere with anatomical structures or expected physiological performance.

8. The patient should be advised not to smoke or consume alcohol during the bone graft healing process.

All surgical operations and procedures carry risks from both known and unforeseen causes. Potential benefits, risks or side effects of the operation or procedure, including potential problems that might occur with the anesthesia to be used in surgery and during recuperation should be evaluated.

Medication Usage

NSAIDs

- Spinal fusion models have confirmed NSAIDS have an inhibitory effect on healing of a fusion most significant in early postop phase (Riew et al).
- Patients who continued to take NSAIDs for more than 3 months postoperatively showed significantly lower fusion success rates (Sivaganesan et al).
- **Best avoided when possible**.

Antibiotics

- In the presence of intraoperative and preincisional antibiotic prophylaxis, postoperative antibiotics for surgical site infection reduction did not show evidence of reduced infection rates in lumbar spinal surgery patients (Horlocker et al).

Anticoagulation

- Anticoagulation may be resumed 24 hours after completion of the procedure as per NACC and ASRA guidelines

Tobacco Use

- Relative risk reduction of 41% for prevention of postoperative complications (Mills et al).

Phase 1: 0-5 weeks

- Educate patient on restrictions (no bending, lifting >10 lbs, wearing pelvic belt correctly, and twisting at the waist for 12 weeks)
- Performing ADLs with correct body mechanics

Phase 2: 6-11 weeks

- Continue patient education with added focus on limiting activity to properly performing ADLs and walking
- Tissue mobilization around surgical site to promote appropriate collagen alignment
- Evaluate and treat muscle tightness throughout the hip's range of motion with stretching of muscles surrounding SIJ without engaging past end range of motion.
- Start deep abdominal muscle and pelvic floor muscle retraining
- Start gait training to decrease step length through home exercise program (HEP)

Phase 3: 12-19 weeks

- Continue to advance HEP with addition of resistance exercises and progress patients stabilization exercises
- Evaluating ergonomics at patient's work as patient's are able to return to work with modifications (such as standing breaks every 20 minutes)
- Initiate single leg exercises but no high impact exercises

Phase 4: >20weeks

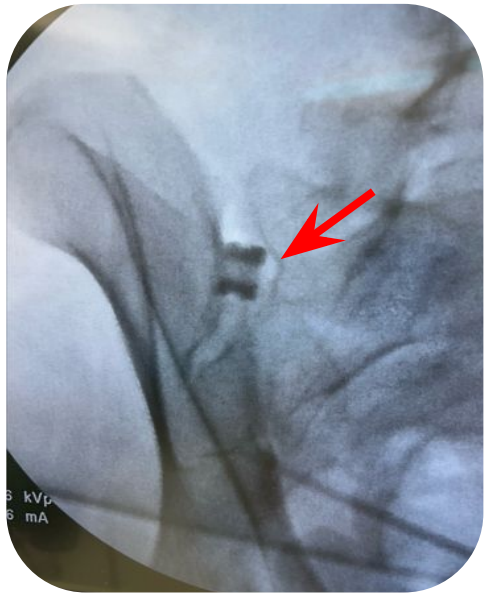
- All restrictions with day-to-day activity are lifted
- Can incorporate high impact exercises into HEP but cannot return to playing contact sports

*Notes: *While introducing patients to the new physical therapy goals during each phase, it is equally important to engrain and build upon teachings from prior phases as well rather than focus solely on the newly introduced goals.*

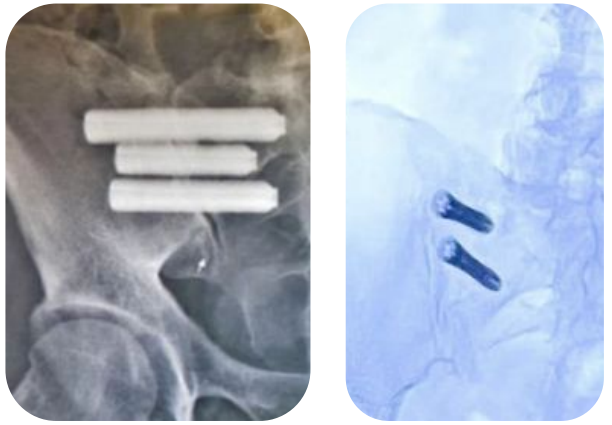
Summary

- ✔ Single point
- ✔ Allograft with large graft window
- ✔ Drill-less system
- ✔ Uniquely safe
- ✔ Proven
- ✔ Efficacious

SI Joint Fusion with Posterior Intra-articular Allograft Implant



Lateral & Lateral Oblique approaches



Basivertebral Nerve Ablation

Ramo Naidu, MD, Pratik Gandhi, DO

Basivertebral Nerve Ablation Patient Indications

- Chronic Low Back Pain of at least 6 months duration
- Failure to respond to at least 6 months of conservative care
- MRI Changes consistent with Modic Type 1 and Type 2 at one one or more levels from L3 to S1

Patient Characteristics of Vertebrogenic Pain

- Vertebrogenic pain patients often describe their pain as:
  - In the middle of the low back “on the spine”
  - Pain that is worse during physical activity, prolonged sitting, and by bending forward or bending and lifting
  - Pain with tying shoes, pain with leaning forward at a low sink
  - Functional debility




Basivertebral Nerve Ablation Procedure Contraindications

- Severe cardiac or pulmonary compromise
- Where the targeted ablation zone is <10mm away from a sensitive structure not intended to be ablated
- With active systemic infection or local infection in the treatment area
- Pregnancy
- Skeletally immature (≤18)
- With active Implantable Pulse Generators (e.g. pacemakers, defibrillators)
- Where untended tissue damage may result
- With instruments not tested / specified for use with RFG

VERTEBRAL AUGMENTATION OVERVIEW

JD Williams, MD

INDICATIONS, CONTRAINDICATIONS & PATIENT SELECTION

Indications

Painful compression fractures recalcitrant to non-surgical management

- Osteoporotic primarily (also malignant and traumatic)
- Advanced imaging confirming diagnosis

Contraindications

Relative

- Cardiorespiratory issues (sedation)
- Retropulsion vs Breach posterior cortex (tumor extension into spinal canal)

Strong

- Myelopathy from fracture
- Neurologic deficit/impingement
- Spinal instability
- Pregnancy
- Allergy to bone cement

Absolute

- Active infection (surgical site, blood-borne osteomyelitis)
- Non-symptomatic fracture

COMPLICATIONS & MANAGEMENT

Complications

- Fortunately very rare (<<1%)
- Bleeding
- Cement leakage/embolus
- Neurologic damage
- Structural damage
- Persistent pain
- Sedation/anesthesia complications
- Allergic reaction
- Non-surgical care

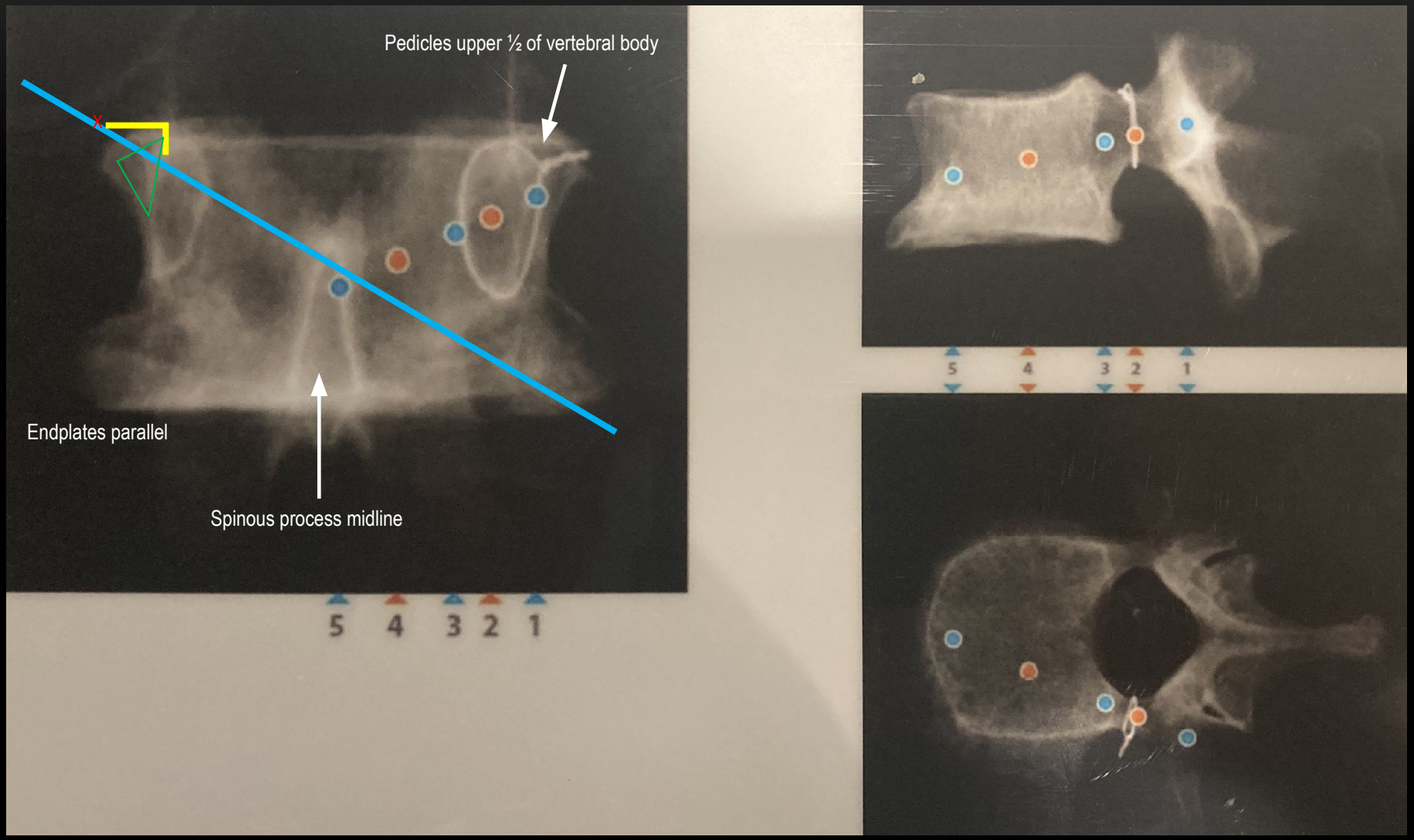
Management

- Good pre/post neuro exam
- Pre-sedation/anesthesia evaluation/labs
- Imaging
- Neurosurgical consultation

CLINICAL PEARLS

- #1 Rule: Never violate the medial border of the pedicle *before* safely into the posterior vertebral body
- Study pre-op advanced imaging
  - Fracture morphology, posterior wall intact, pedicle fracture, tools, trajectory
- Position patient appropriately (arms tucked vs up, lumbar extension)
- Imaging is key, take your time. Find the owl
- Size matters (cement volume and location)—top-bottom & pedicle-pedicle
- Last image hold: access and pre-cement fill
- Curette is underrated

TRAJECTORY


Pedicles upper ½ of vertebral body
Endplates parallel
Spinous process midline
5 4 3 2 1
5 4 3 2 1