Innovations in Interventional Pain Management
2:15pm – 3:45pm

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Encinitas, CA

Minimally Invasive Spine Surgery

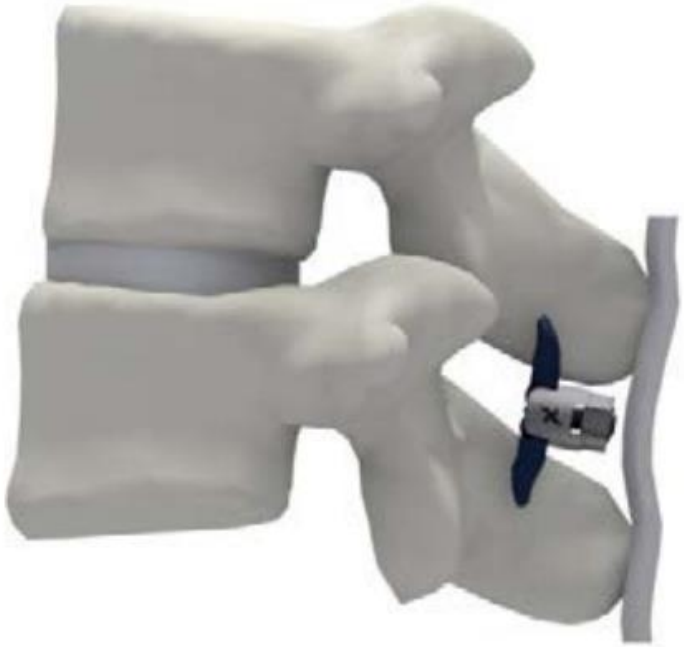
- Superion Indirect Decompression System (5/2015)
- Minimally Invasive Lumbar Decompression (*mild*)
  - X-Sten *mild* toolkit FDA Clearance 2006
  - 2017 CMS approved coverage
- Minuteman Lateral Fusion G3R (2017)

Zurich Claudication Questionnaire

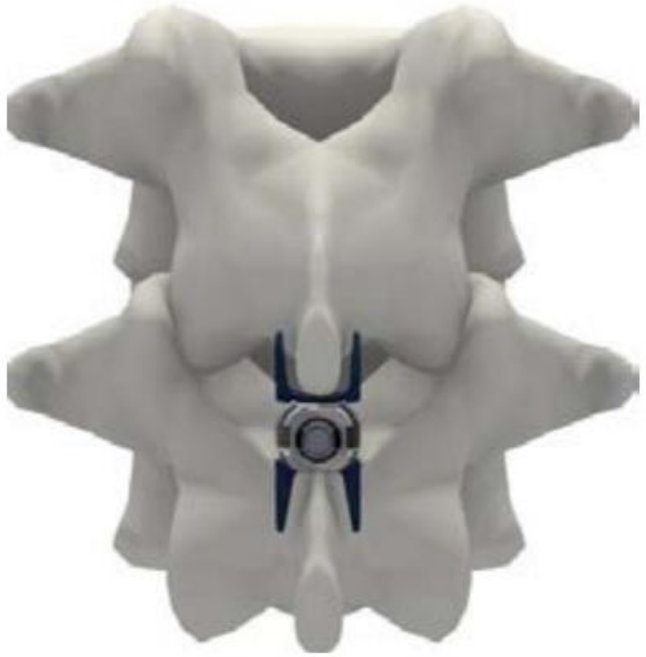
Three subscales:

- Symptom severity scale (questions I-VII)
  - Possible range of the score is 1 to 5.
- Physical function scale (questions VIII-XII)
  - Possible range of scores is 1 to 4.
- Patient's satisfaction with treatment scale (questions XIII-XVIII)
  - Range of the scale is 1 to 4.
- Higher scores are worse

Superion Indirect Decompression System



Superion® Spacer in situ – Lateral View



Superion® Spacer in situ – A/P View

https://www.accessdata.fda.gov/cdrh_docs/pdf14/p140004d.pdf

Superion Indirect Decompression System

Indicated to treat skeletally mature patients suffering from pain, numbness, and/or cramping in the legs (neurogenic intermittent claudication) secondary to a diagnosis of moderate lumbar spinal stenosis, with or without Grade 1 spondylolisthesis, confirmed by X-ray, MRI and/or CT evidence of thickened ligamentum flavum, narrowed lateral recess, and/or central canal or foraminal narrowing.

Indicated for those patients with impaired physical function who experience relief in flexion from symptoms of leg/buttock/groin pain, with or without back pain, who have undergone at least 6 months of non-operative treatment.

https://www.accessdata.fda.gov/cdrh_docs/pdf14/p140004d.pdf

Contraindications

Allergy, Cauda Equina Syndrome, infection, prior fusion at index level, severe Osteoporosis (T-score > -2.5), BMI >40, abnormal anatomy:

- >Grade 1 spondylolisthesis
- Ankylosed segment
- Fracture, including pars interartucularis
- Scoliosis >10 degree Cobb angle

Consider for Fracture Risk: Kissing spine, Thin spinous process

https://www.accessdata.fda.gov/cdrh_docs/pdf14/p140004d.pdf

Clinical Trial (Non-inferiority X-STOP)

- 470 subjects at 31 sites
- Age >45
- Leg/Buttock/Groin +/- Back Pain – Relieved with forward bend
- <3mm translation and <5 degree scoliosis
- T-score ≤ -2.5
- No prior lumbar surgery
- BMI <40

Results (24 months)

- Primary Effectiveness Outcome:
  - Demonstrated improvement in two of the three domains of the ZCQ (physical function, symptom severity, and patient satisfaction)
  - Experienced no re-operations or revisions
  - Experienced no device- or procedure-related complications; and
  - Required no spinal cord stimulators, rhizotomies, or epidural injections.
- 52.7% achieved outcome in Superion
- 11.1% spinous fracture

Safety

- Surgical Risks (Injury, Infection, Bleeding)
- Pain at operative site
- Spinous process Fracture (Osteoporosis)
- Migration of implant (scoliosis >10 degree Cobb)
- Device breakage

Long-term Results

- Study Participants evaluated at 3 & 5 years
- Primary composite endpoint
  - Improvement in two of three domains of the Zurich Claudication Questionnaire
  - No reoperations at the index level
  - No major implant/procedure-related complications
  - No clinically significant confounding treatments
- 52.5% achieved primary composite endpoint
- At 5 years, sustained clinical benefit
- 75% no reoperation, revision, supplemental fixation

Patel et al. "Superion® interSpinous spacer for treatment of moderate degenerative lumbar spinal stenosis: durable three-year results of a randomized controlled trial." *Journal of Pain Research* 8 (2015): 657.

Nunley et al. "Five-year durability of stand-alone interspinous process decompression for lumbar spinal

Post-op Instructions

- General wound care
- No lifting > 10 lbs
- 6 weeks limited bending, twisting
- Avoid strenuous activity: swimming, golfing, tennis, racquetball, running, jogging, or sexual activity

Minimally Invasive Lumbar Decompression (*mild*)

- When ligamentum flavum hypertrophy (LFH) is primary source of stenosis (Approximately 85% of time)
- Debulks LFH
- 5.1mm incision, unilaterally or bilaterally
- Resume normal active within 24h, no restrictions

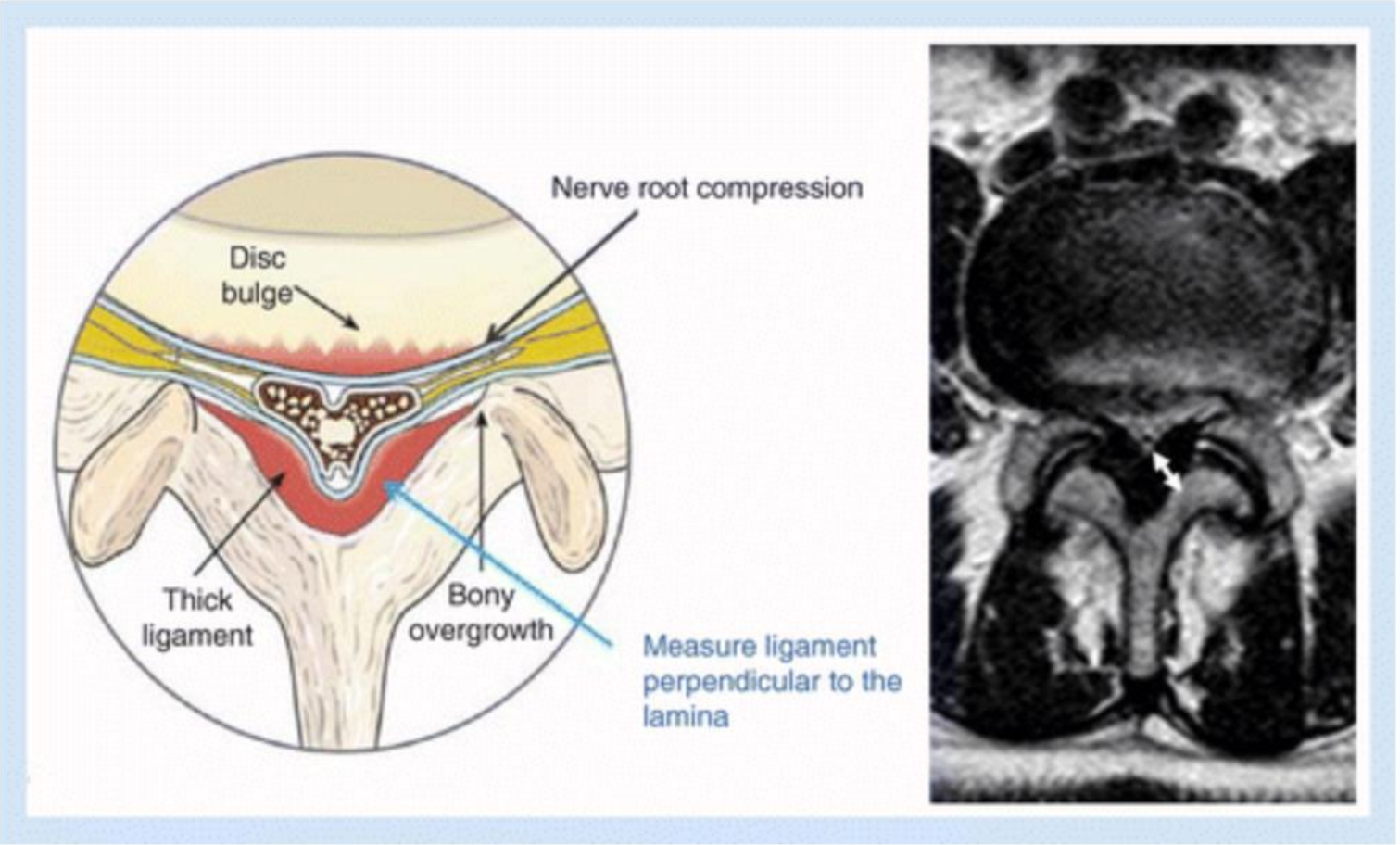
Jain et al. "Minimally invasive lumbar decompression: a review of indications, techniques, efficacy and safety." *Pain Management* 10.5 (2020): 331-348.

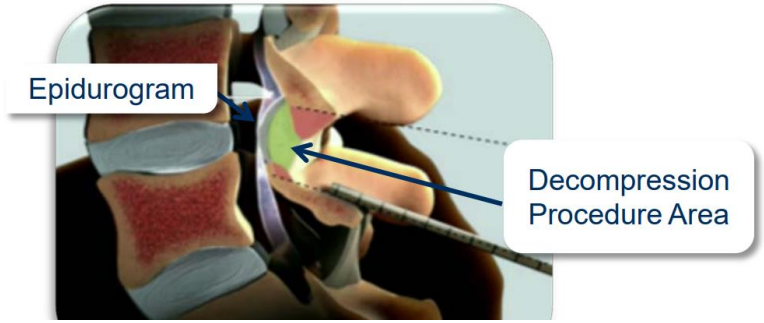
Mild

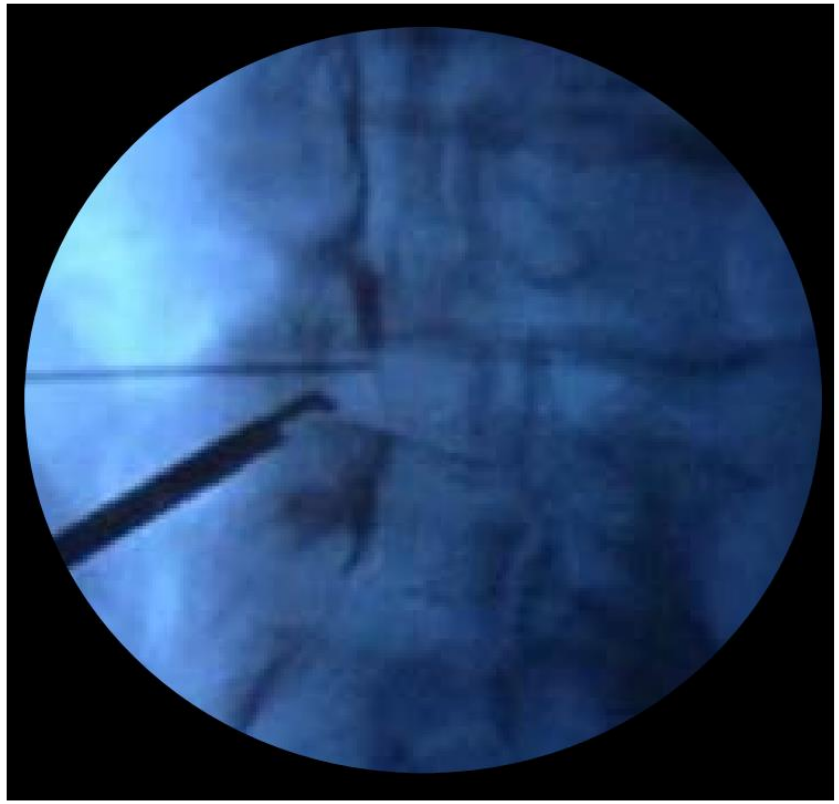
- Indications:
  - Symptoms consistent with stenosis
    - Little or no pain at rest, sitting and laying down
    - Pain with standing and walking
  - Stenosis with AP diameter of spinal canal < 10mm
  - LFH ≥ 2.5 mm
- Contraindications:
  - Prior spine surgery at level or localized infection
- Relative contraindications:
  - > Grade II Spondylolisthesis
  - Systemic infection or bleeding disorder

Jain et al. "Minimally invasive lumbar decompression: a review of indications, techniques, efficacy and safety." *Pain Management* 10.5 (2020): 331-348.

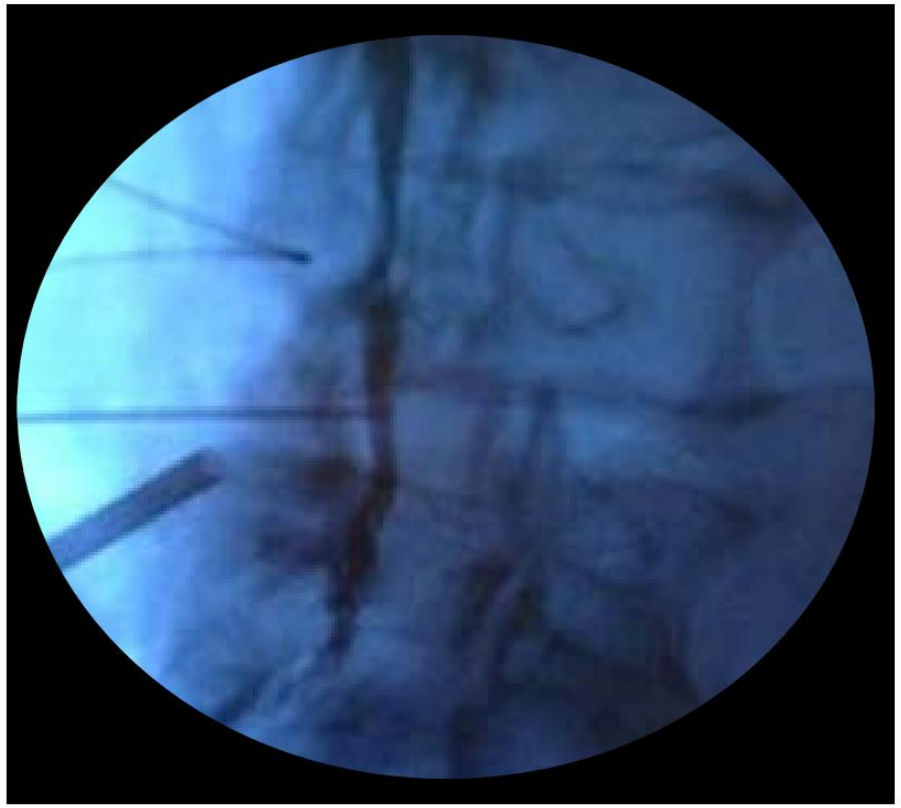
Ligamentum Flavum Measurement







Pre-procedure



Post-procedure

https://www.cms.gov/Medicare/Coverage/DeterminationProcess/Downloads/Kloth_comment_05012013.pdf

Clinical Trial Primary Outcome

- Improvement in 2 of 3 ZCQ
  - Physical functioning
  - Symptoms severity
  - Patient satisfaction
- No re-operations or revisions
- No epidural steroid or selective nerve root block

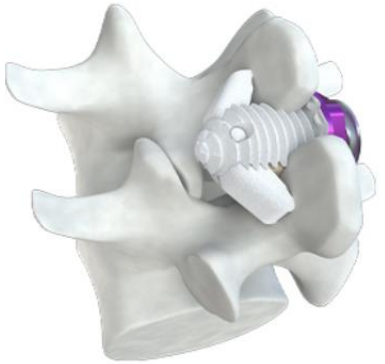
MiDAS ENCORE (*mild* vs. Epidural Steroids) 2 year data

- RCT (274 participants)
- Average Age ~ 75 y.o. (95%had >5 spinal comorbidities)
- Mean VAS 7.8
- ODI improved 22.7 points
- NPRS improved 3.6 points
- ZCQ improved symptom severity (1) and physical functioning (0.8)
- No serious AE
- Lower reoperation and spinous fracture than Intraspinous Spacer, surgical decompression and fusion

Staats et al. "Long-term safety and efficacy of minimally invasive lumbar decompression procedure for the treatment of lumbar spinal stenosis with neurogenic claudication: 2-year results of MiDAS ENCORE." *Regional Anesthesia & Pain Medicine* 43.7 (2018): 789-794.

Minuteman Intraspinous Fusion

- Single level in the non-cervical spine (T1-S1) that is intended for plate fixation/attachment to spinous processes for the purposes of achieving fusion in the following conditions:
  - Lumbar spinal stenosis
  - Degenerative disc disease
  - Spondylolithesis
- Provides immobilization & stabilization



https://spinalsimplicity.com/minuteman/

Clinical Trails

- No published clinical trials
- Multicenter RCT in UK comparing lumbar decompression
  - "**Minuteman Spinal Fusion Implant Versus Surgical Decompression for Lumbar Spinal Stenosis**" ***NCT01455805***
- Unpublished preliminary data apparently demonstrates equal effectiveness in lumbar stenosis symptoms, with superiority in leg pain
- Biomechanical studies demonstrate stability

Kaye et al. "A Comprehensive Review of Novel Interventional Techniques for Chronic Pain: Spinal Stenosis and Degenerative Disc Disease—MILD Percutaneous Image Guided Lumbar Decompression,

Minuteman Intraspinous Fusion

- Features:
  - Percutaneously Placed
  - < 2.5cm incision
  - Ligament preservation
  - Under local or general
- Complications
  - Bleeding
  - Pain
  - Infection

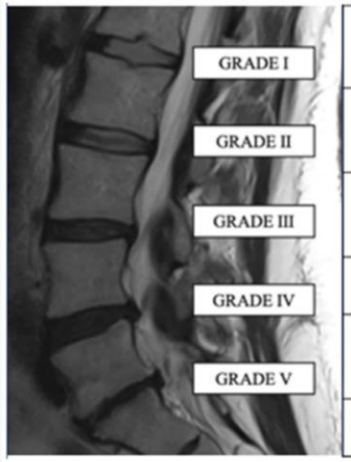
Summary & Conclusion

- Spinal stenosis is common and results in pain and disability
- Innovation and engineering are expanding therapeutic options
- Enhanced understanding of the safety and efficacy are necessary to modernize treatment algorithms

ViaDisc – Lumbar Discogenic Pain

- Allograft intended to supplement degenerated intervertebral discs
- Processed human nucleus pulposus injected into disc
- In vitro testing suggests similar water absorption and may support biomechanical function
- Contraindicated if allergy to gentamicin, vancomycin, or bacitracin
- Studies in progress

Pfirmann grading system to assess disc degeneration.

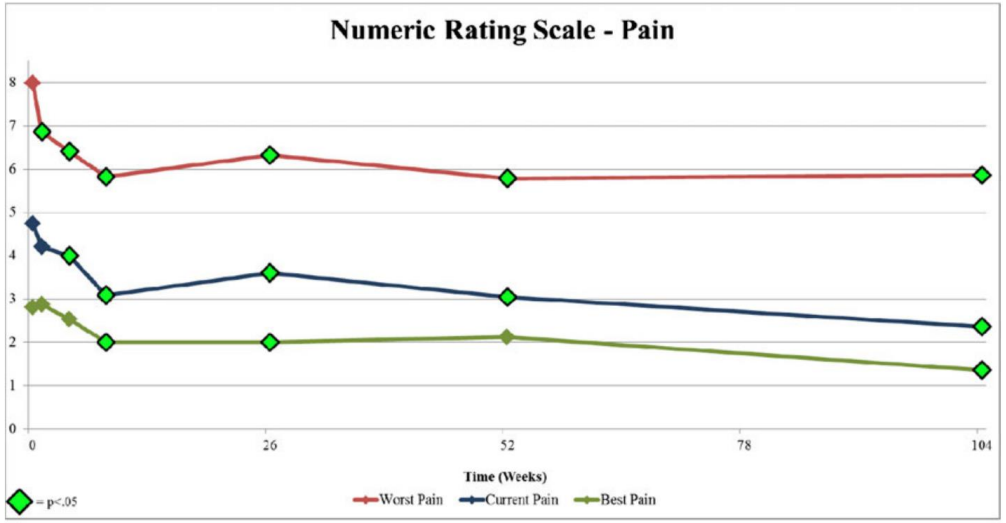


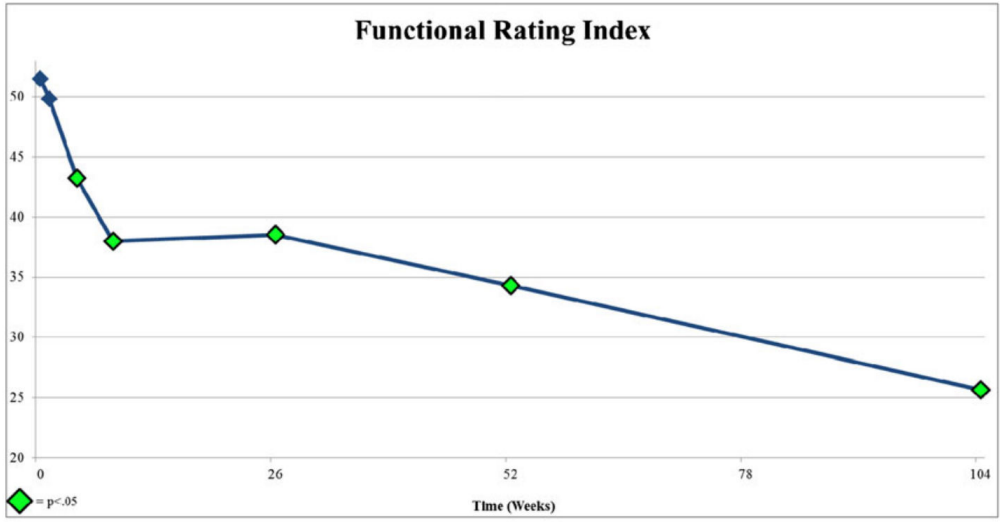
GRADE	STRUCTURE	DISTINCTION OF NUCLEUS AND ANNULUS	SIGNAL INTENSITY (T2)	HEIGHT OF IVD
I	Homogenous	Clear	Hyperintense (bright white), isointense to cerebrospinal fluid	Normal
II	Inhomogeneous, with or without horizontal bands	Clear	Hyperintense, isointense to cerebrospinal fluid	Normal
III	Inhomogeneous	Unclear	Intermediate (grey)	Normal to slightly decreased
IV	Inhomogeneous	Lost	Intermediate hypointense (grey to black)	Normal to moderately decreased
V	Inhomogeneous	Lost	Hypointense (black)	Collapsed disc space

https://gotviadisc.com/

PRP for Discogenic Pain

- In vitro Evidence
  - Nucleus cell proliferation increased 7-11 times vs. control with upregulated proteoglycan content
  - Downregulation of IL-q and TNF-α
- Clinical Trial of 29 subjects had statistically and clinically significant improvements in pain and function through 2 years





Monfett, Michael, et al. "Intradiscal platelet-rich plasma (PRP) injections for discogenic low back pain: an update." *International orthopaedics* 40 (2016): 1321-1328.

Basivertebral Nerve Ablation

- Vertebrogenic Pain = pain associated with Basivertebral Nerve
- Basiverterbal nerve
  - High level substance P
  - Markers for high level nociceptors
- Chronic low back pain associated with Modic Changes (Type I and II) – especially L4-5 and L5-S1

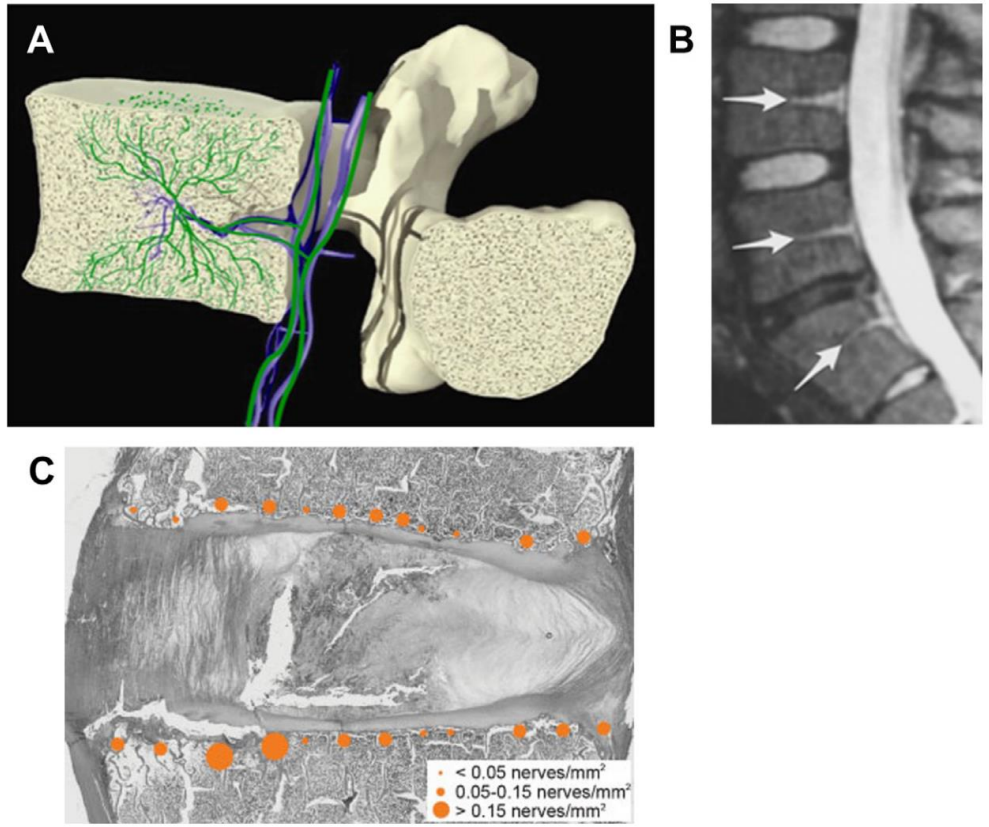
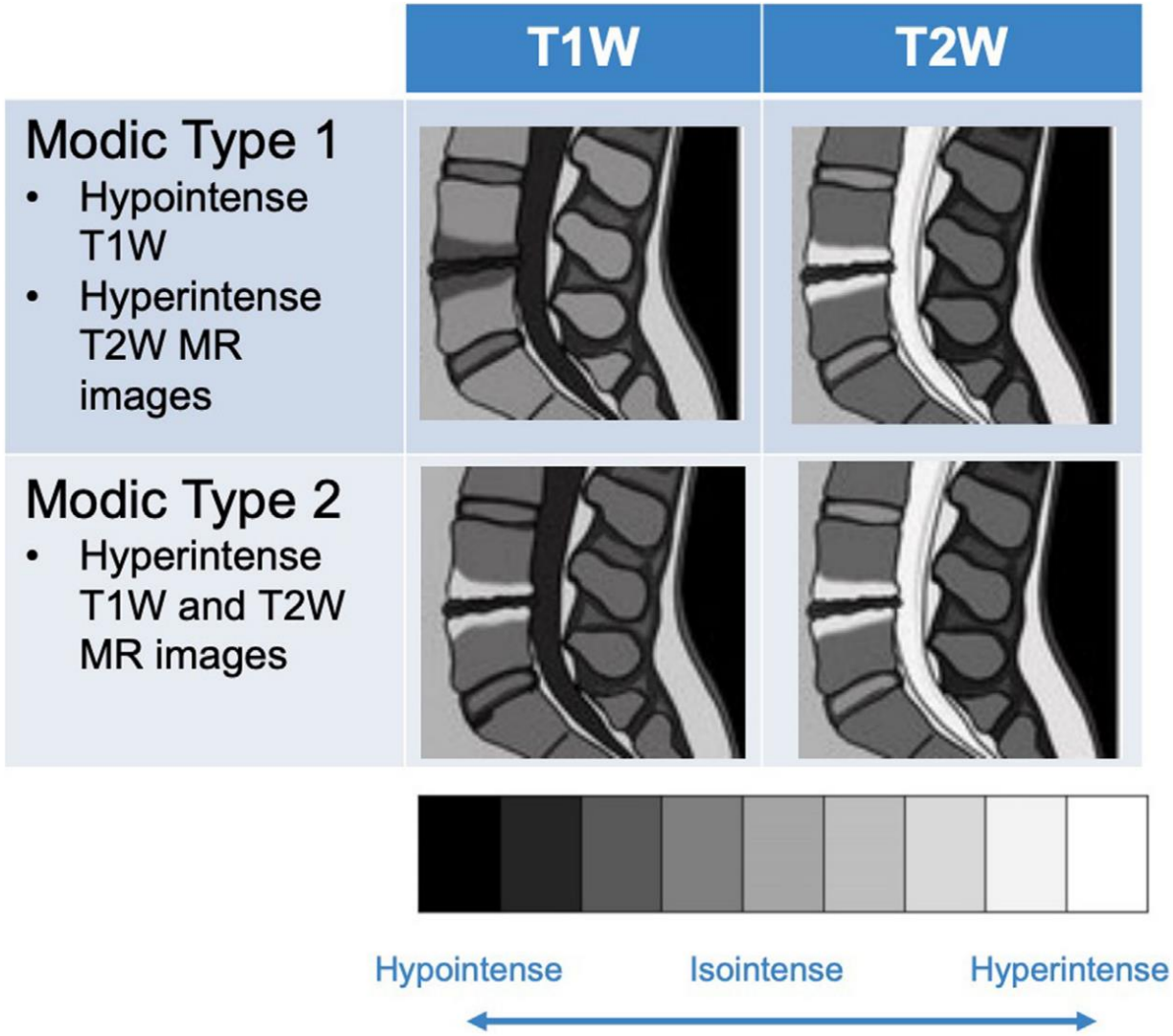


Fig. 10. (*A*): Distribution of basivertebral nerve. (*B*): Basivertebral nerve. (*C*): Distribution of PGP + nerve fibers across endplate. (Images provided courtesy of Relievant Medsystems. ©2021 All rights reserved.)

Eshraghi, Yashar, Jay D. Shah, and Maged Guirguis. "Novel Technologies in Interventional Pain Management." *Physical Medicine and Rehabilitation Clinics* 33.2 (2022): 533-552.

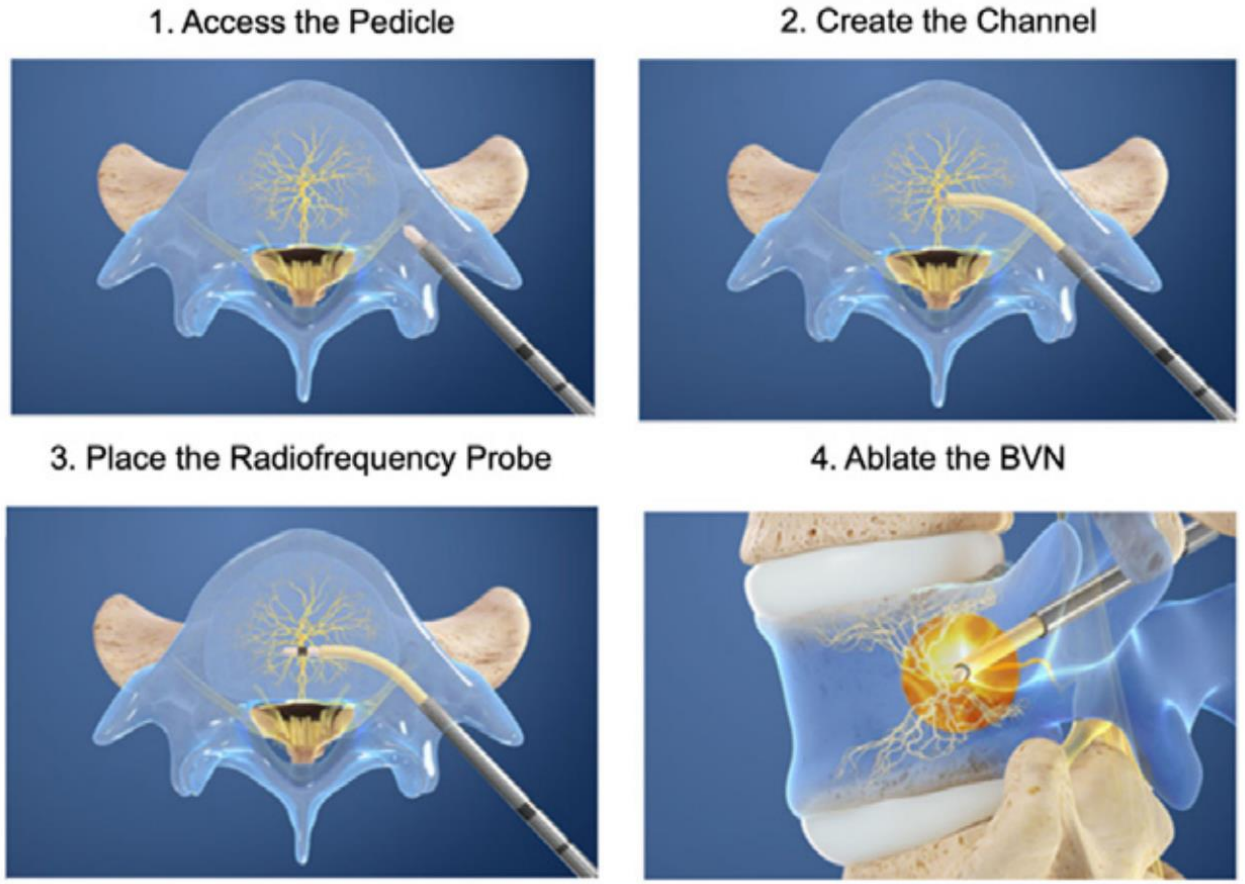
Modic Changes

- Type I
  - Edema and inflammation
- Type II
  - Conversion of hematopoietic marrow into yellow, fatty marrow
- Type III
  - Endplates hypointense (T1 and T2) – bony sclerotic changes



Intracept Procedure

- RCT – 140 subjects
- Modic I and II (L3-5)
- Improvement
  - ODI
  - VAS
- Double Blind Sham Controlled RCT
- 225 subjects
- ODI
  - 3 months – 48% decrease
  - 24 months – 53.7% decrease



Eshraghi, Yashar, Jay D. Shah, and Maged Guirguis. "Novel Technologies in Interventional Pain Management." *Physical Medicine and Rehabilitation Clinics* 33.2 (2022): 533-552.

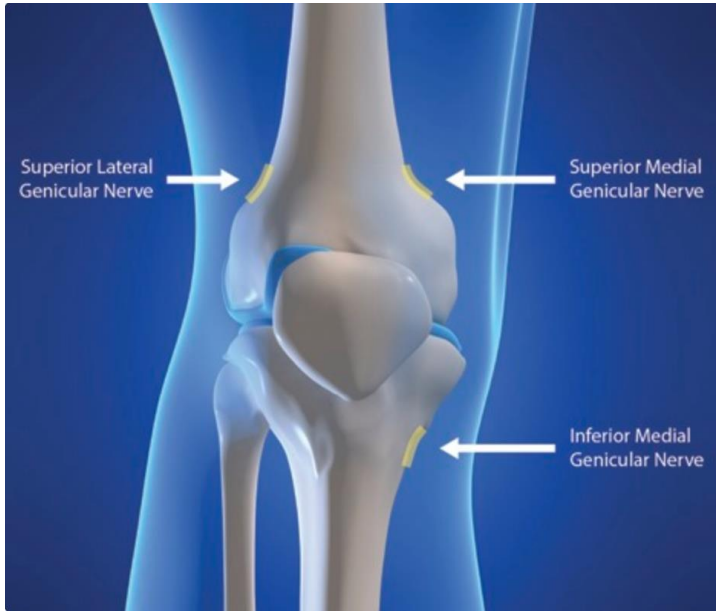
Radiofrequency Suprascapular Nerve for Shoulder Pain

- Rotator cuff, arthritis, adhesive capsulitis, post-surgical
- Suprascapular nerve innervates 70% of the glenohumeral joint
- Pulsed RF – non-destructive – doesn’t paralyze supraspinatus or infraspinatus
- Case series:
  - RF if 50% relief with anesthetic block
  - NRS 7.2 (± 1.2) decreased to 3 (± 0.9) at 5-7 weeks
  - ROM improved: 60° ± 28° (flexion) and 58° ± 28° (abduction) to 99° ± 46° (flexion) and 107° ± 39° (abduction)
  - Duration 3-18 months

Simopoulos, Thomas T., Jyotsna Nagda, and Musa M. Aner. "Percutaneous radiofrequency lesioning of the suprascapular nerve for the management of chronic shoulder pain: a case series." *Journal of Pain Research* (2012): 91-97.

Radiofrequency Genicular Branches for Knee Pain

- Knee pain when failure of conservative treatments or surgery, or are not candidates for surgery
- ≥ 50% relief with anesthetic block (U/S or Fluoro)
- Genicular nerves collectively sensory nerves
- Reduced innervation, not complete denervation
- Charcot-type joint unlikely
- Generally duration is 6 months



Kidd, Vasco Deon, et al. "Genicular nerve radiofrequency ablation for painful knee arthritis: the why and the how." *JBJS essential surgical techniques* 9.1 (2019): e10.

Radiofrequency of Articular Branches for Hip Pain

- Innervation
  - Anteromedial – branches of obturator nerve
  - Anterior – articular branches of femoral nerve
  - Posterior – branches of sciatic nerve
- Study of Cooled RF:
  - 23 subjects with two >50% relief prognostic blocks
  - Change in pain scores: 7.61 ± 1.2 to 2.25 ± 1.4 after the RF ablation ($P < 0.01$)

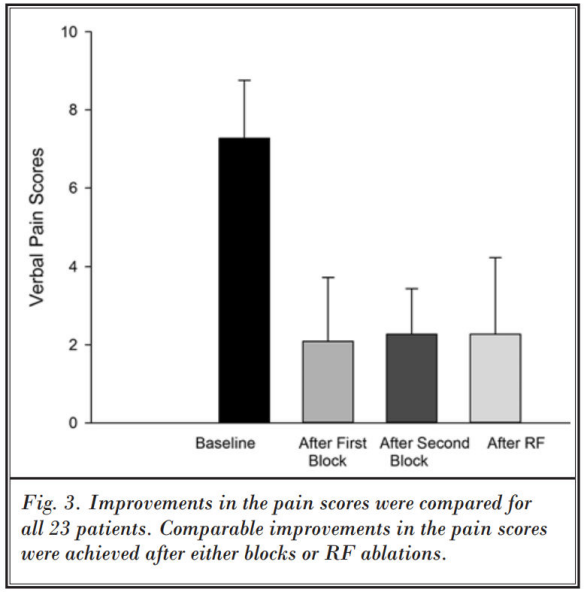


Fig. 3. Improvements in the pain scores were compared for all 23 patients. Comparable improvements in the pain scores were achieved after either blocks or RF ablations.

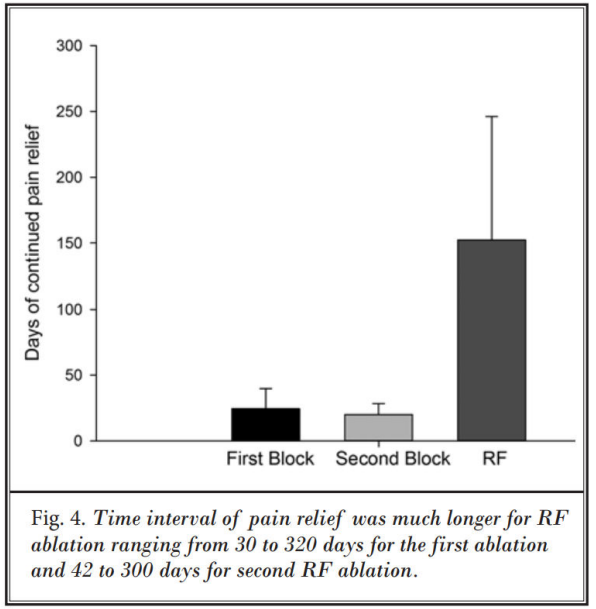


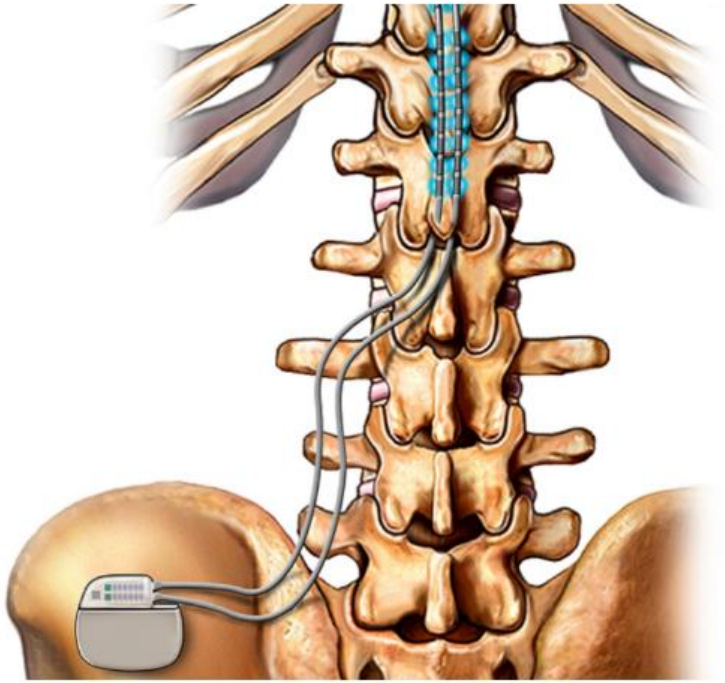
Fig. 4. *Time interval of pain relief was much longer for RF ablation ranging from 30 to 320 days for the first ablation and 42 to 300 days for second RF ablation.*

Spinal Cord Stimulation

Spinal Cord Stimulation

- Spinal cord stimulation is indicated in the management of chronic, intractable pain of the trunk and/or limbs-including unilateral or bilateral pain associated with the following conditions:
- Failed Back Syndrome (Multiple back surgeries)
- Radiculopathies
- Degenerative Disk Disease (DDD)/herniated disk pain refractory to conservative and surgical interventions
- Peripheral causalgia
- Epidural fibrosis
- Arachnoiditis
- Complex Regional Pain Syndrome (CRPS), Reflex Sympathetic Dystrophy (RSD), or causalgia
- Diabetic Peripheral Neuropathy

Spinal Cord Stimulation



- Implantation of leads in the epidural space
- Gate-control Theory
- Neuropathic Pain
  - May alter local neurochemistry
  - Suppress hyperexcitability of wide dynamic range neurons by increasing GABA and serotonin release
  - Suppress excitatory cytokines glutamate and aspartate
- Ischemic Pain
  - May alter sympathetic tone, restoring oxygen supply to tissue

Garcia, Karolain, Joseph K. Wray, and Sanjeev Kumar. "Spinal cord stimulation." (2020).

Spinal Cord Stimulation

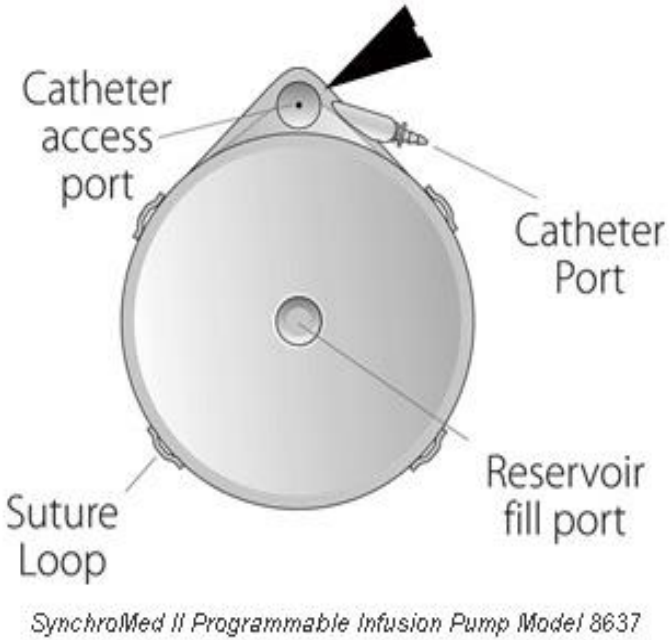
- Battery
  - Primary Cell
  - Rechargeable
- MRI Compatibility
- Waveforms
- Trial Stimulation
  - Generally 50% decreased pain and 50% improvement in function
- Percutaneous Leads
- Surgical Leads

Intrathecal Drug Delivery

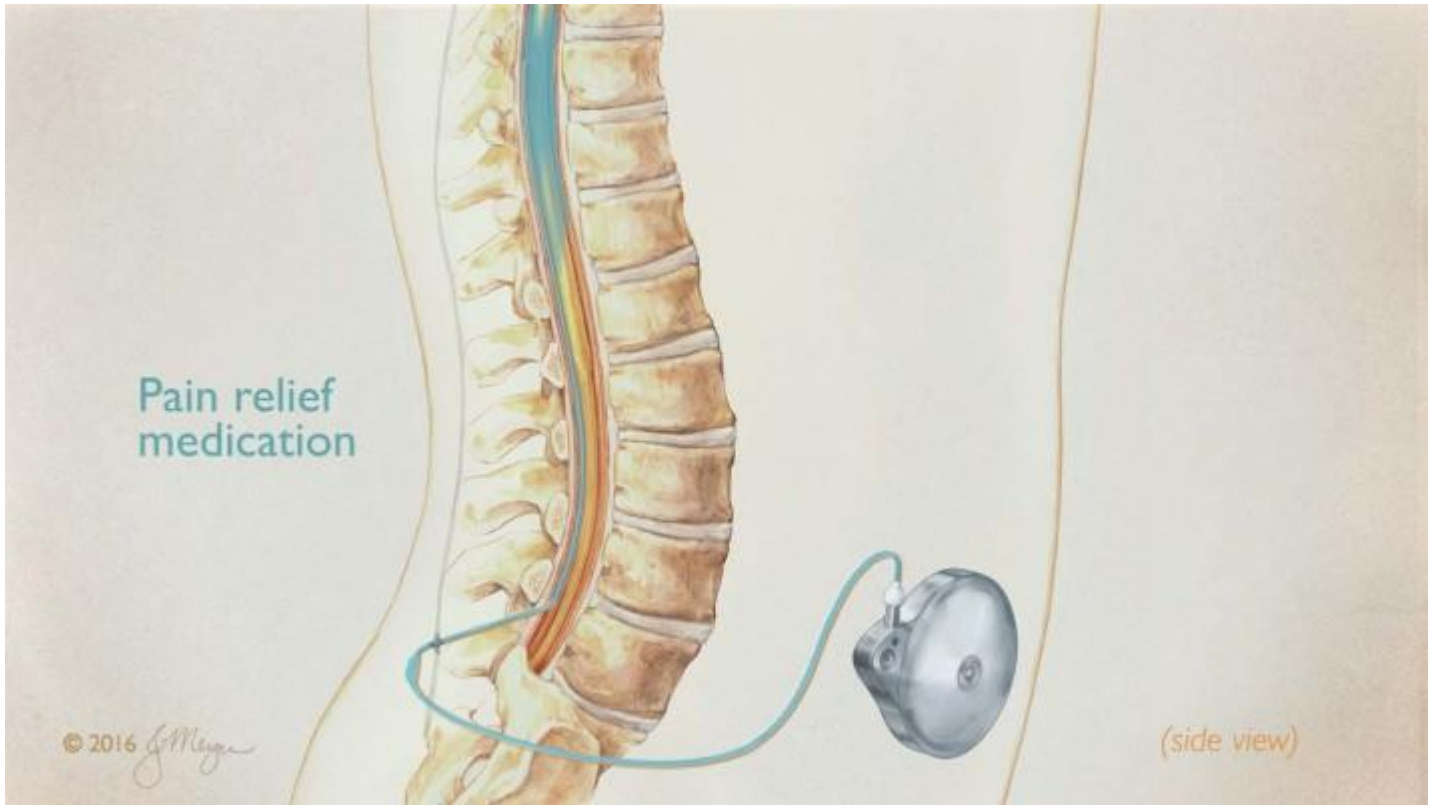
Rationale for use of Intrathecal delivery:

- To deliver drug to site of pain transmission
- To use smallest dose for maximal effect
- To minimize adverse effects

Intrathecal Pump Device and Placement



SynchroMed II Programmable Infusion Pump Model 8637



Successful Outcomes

Patient factors  Disease factors  Clinical team factors

IT therapy should not be used as a salvage therapy for failing systemic opioids

Patient selection for IT therapy

- Patients with severe refractory pain from cancer or noncancer etiologies
  - Localized, diffuse, global
- Patients with intolerable adverse events to systemic therapies
- Patients for whom the following have been considered:
  - Treatment history and inadequacy of alternate options
  - Psychological well being
  - Social support structure
  - Probability and capability of adherence to IT therapy requirements
  - Health care coverage and finances
- Implant following successful trial

Disease indications for IT therapy

- Axial neck or back pain; not a surgical candidate
  - Compression fractures
  - Discogenic pain
  - Spinal stenosis
  - Diffuse multiple-level spondylosis
- Failed back surgery syndrome
- Abdominal / pelvic pain
  - Visceral
  - Somatic

Disease indications for IT therapy

- Extremity pain
  - Radicular pain
  - Joint pain
- Complex regional pain syndrome (CRPS)
- Trunk pain
  - Postherpetic neuralgia
  - Post-thoracotomy syndromes
- Cancer pain; direct invasion or chemotherapy
- Analgesic efficacy with systemic opioid delivery complicated by intolerable side effects

Noncancer-Related Pain (Localize/Diffuse) Algorithm

Table 16. Noncancer-Related Pain With Localized Nociceptive or Neuropathic Pain.

Line 1A	Ziconotide		Morphine	
Line 1B	Fentanyl		Fentanyl + bupivacaine	
Line 2	Fentanyl + clonidine	Hydromorphone or morphine + bupivacaine	Fentanyl + bupivacaine + clonidine	Bupivacaine
Line 3	Fentanyl + ziconotide + bupivacaine	Morphine or hydromorphone + clonidine	Ziconotide + clonidine or bupivacaine or both	Bupivacaine + clonidine
Line 4	Sufentanil + bupivacaine or clonidine	Baclofen	Bupivacaine + clonidine + ziconotide	
Line 5	Sufentanil + bupivacaine + clonidine		Sufentanil + ziconotide	

Table 18. Noncancer-Related Pain With Diffuse Nociceptive or Neuropathic Pain.

Line 1A	Morphine		Ziconotide*	
Line 1B	Hydromorphone		Morphine or hydromorphone + bupivacaine	
Line 3	Hydromorphone or morphine + clonidine		Fentanyl + bupivacaine	Ziconotide + morphine or hydromorphone
Line 4	Hydromorphone or morphine + bupivacaine + clonidine	Fentanyl + ziconotide	Sufentanil + bupivacaine or clonidine	Ziconotide + clonidine or bupivacaine or both
Line 5	Fentanyl or sufentanil + bupivacaine + clonidine		Sufentanil + ziconotide	Baclofen
Line 6	Opioid + ziconotide + bupivacaine or clonidine			

*Ziconotide should be first choice in patients with >120 morphine equivalents or fast systemic dose escalation, in the absence of history of psychosis.

Deer, T. R., Pope, J. E., Hayek, S. M., Bux, A., Buchser, E., Eldabe, S., ... & Doleys, D. M. (2017). The Polyanalgesic Consensus Conference (PACC): recommendations on intrathecal drug infusion systems best practices and guidelines. *Neuromodulation: Technology at the Neural Interface*, *20*(2), 96-132.

Clinical Team

- Pump Managing Clinician
  - Both medical and surgical skills
  - Trial, implant, refill, complication assessment and management
  - Programming Hardware
- Psychological/Mental Health
  - Assessment and stabilization
- Clinical Staff Support
  - Pharmacy Relationship / Drug Ordering
  - Patient scheduling and transportation
- Device Technical Support
- Physical Therapy to rehabilitate to functional goals

Adler, J. A., & Lotz, N. M. (2017). Intrathecal pain management: a team-based approach. *Journal of Pain Research*, *10*, 2565.

Typical Patient Treatment Path

- Patient identified (patient/disease factors)
- Psychological Assessment (may be waived in terminal conditions)
- Trial (may be waived in terminal conditions)
- Surgical Implant
- Wound care and healing
- Titration and treatment stabilization
- Maintenance Refills (approximately every 1-6 months)
- Surgical Battery replacement approximately every 7 years