CLINICAL REPORT

Lumbar Transgrade Dorsal Root Ganglion Stimulation Lead Placement in Patients with Post-Surgical Anatomical Changes: A Technical Note

Kenneth B. Chapman, MD*,†,‡; Ryan R. Ramsook, MD*; Pauline S. Groenen, BS*,§; Kris C. Vissers, MD, PhD¶; Noud van Helmond, MD*,¶,**

*The Spine & Pain Institute of New York, New York, New York; †Department of Anesthesiology, New York University Langone Medical Center, New York, New York; ‡Northwell Health, New York, New York, U.S.A.; §College of Medicine, Radboud University, Nijmegen; ¶Department of Anesthesiology, Pain and Palliative Medicine, Radboud University Medical Center, Nijmegen, The Netherlands; **Department of Anesthesiology, Cooper Medical School of Rowan University, Cooper University Hospital, Camden, New Jersey, U.S.A.

■ **Abstract**

Background: Stimulation of the dorsal root ganglion (DRG-S) has been shown to be an efficacious treatment option for refractory neuropathic pain syndromes. However, placement of the percutaneous leads for trial implantation can be challenging in patients with prior spinal surgical interventions resulting in anatomical changes and adhesions.

Methods: This technical report describes the transgrade placement of DRG-S leads in 4 patients with back pain surgery histories in whom secondary to specific anatomical pathologies the traditional anterograde placement of DRG-S leads was not feasible.

Results: We used a transgrade placement approach, entering superior and contralateral to the target level of placement, resulting in uncomplicated and effective placement of DRG-S leads.

Conclusions: Transgrade lead placement for DRG-S may be an efficacious alternative to traditional anterograde DRG lead placement in cases where interlaminar access below the level of the DRG is not available, or desirable. Further studies are needed to clarify the safety and applicability of this approach. ■

Key Words: dorsal root ganglion, dorsal root ganglion stimulation, neuromodulation, failed back surgery syndrome

INTRODUCTION

Chronic pain affects over 100 million Americans, and a relevant component of this disease burden can be attributed to neuropathic pain.[1–3] Dorsal root ganglion stimulation (DRG-S) has recently emerged as an efficacious treatment modality to treat certain chronic refractory neuropathic pain conditions.[4–7] It is thought that by stimulating the DRG, pain perception is reduced via reduction of action potential conduction at the sensory neuron's T-junction within the DRG, as well as

Address correspondence and reprint requests to: Kenneth B. Chapman, MD, 1360 Hylan Boulevard, Staten Island, New York, NY 10305, U.S.A. E-mail: chapmanken@spinepainny.com.

Submitted: September 3, 2019; Revised November 8, 2019; Revision accepted: November 10, 2019

DOI. 10.1111/papr.12859

through reduction of ectopic firing within the somata of sensory neurons in the DRG.[8,9]

The interlaminar approach for the insertion of percutaneous DRG-S leads has been well documented in an anterograde manner.[4–7,10–12] However, in patients with a history of spinal surgery at a level just below the target level for stimulation, anterograde placement of the leads can be difficult secondary to adhesions or epidural scaring. Importantly, a significant proportion of the patients with chronic pain syndromes have undergone back surgery.[13] Contralateral retrograde DRG lead placement approaches have anecdotally been used by different groups, most notably by Adnan Al-Kaisy et al.[14,15] who named it a "transgrade" approach, but these approaches have never been described in the literature in detail. The aim of this report is to detail our approach to transgrade interlaminar insertion of DRG-S leads in patients with specific anatomical conditions prohibiting traditional anterograde DRG-S lead placement.

We will first briefly describe the rationale for using the transgrade approach in 4 patients in whom we used it, before describing the transgrade approach in detail.

Written informed consent to publish this technical note was obtained from the patients described in this report. Consistent with local institutional review board standards, we did not submit this project for review, since case series consisting of <5 patients are not considered research.

Indication Considerations

In 4 cases we encountered separate indications for DRG-S lead placement using a transgrade approach; however, the principles used with this technique to access the foramen remain similar (as described below). The transgrade approach can be considered in anticipation of challenges accessing the epidural space, or when facing lead placement obstacles with a traditional anterograde approach.

In Case 1, a 66-year-old woman with chronic sacroiliac joint pain, the technique was chosen to place bilateral L1 leads due to a history of spinal decompression and fusion from the L2 to S1 levels, and laminotomies performed at the L2 level. In Case 2, a 72-year-old man with chronic knee pain after a knee replacement, there was a history of an L4–S1 fusion, with decompression of L5 lamina and thus loss of the L4–5 interlaminar space, necessitating a transgrade approach to access the right L3 foramen. Case 3, a 49-year-old woman with chronic abdominal pain after a bypass procedure, was a revision procedure of a T11 DRG-S lead secondary to migration at 3 months postimplantation. Removing the lead required additional tension, leading us to believe that there was scar tissue formation in the area. This was confirmed when, after accessing the epidural space, the lead and introducer could not be passed to the foramen. The anterograde approach was then aborted and the transgrade placement technique was used. Case 4, a 76-year male with chronic back pain, had a history of L1–2 and L2–3 laminectomy and L4–5 and L5–S1 laminectomy and fusion surgery. The L1–2 laminectomy made the traditional anterograde approach not feasible in this case to reach the bilateral T12 target DRGs.

Transgrade Placement Technique

The patient should be monitored by an anesthesiologist and the procedure should be performed under minimal sedation with a responsive patient. After sterile prepping and draping, 1.0% lidocaine is administered for local anesthesia. The entry point for the Tuohy needle should be at the vertebral level above the target foramen, requiring optimization of the view of the interlaminar space of the target foraminal level and the lamina of the level above (Figure 1A). Once the interlaminar space is visualized clearly, one must evaluate the inferior border of the lamina forming the rostral border of the space. This inferior laminar line will allow the interventionalist to contact the lamina with the Tuohy needle and to walk the needle off caudally into the ligamentum flavum (Figure 1B). Now a trajectory needs to be made to enter in a lateral and caudad angulation by having the Tuohy needle contact the inferior laminar border and arriving at the epidural space in the midline position. Midline access of the epidural space is vital for ease of introducer and lead placement. For this to occur, the Tuohy needle entry point at the skin should be rostral to the target foramen, and typically will be at the level of the pedicle/lateral border of the vertebral body at or above the endplate of the vertebral body above the target foramen. This entry point may vary depending on the kyphosis/lordosis of the vertebral level or other anatomical variations.

Given the rigid nature of the introducer sheath, attention should always be paid to the direction of the curve of the sheath. At levels at which the spinal cord is ventral to the epidural space (ie, above L1–L2), caution must be exercised to not rotate the curve toward the

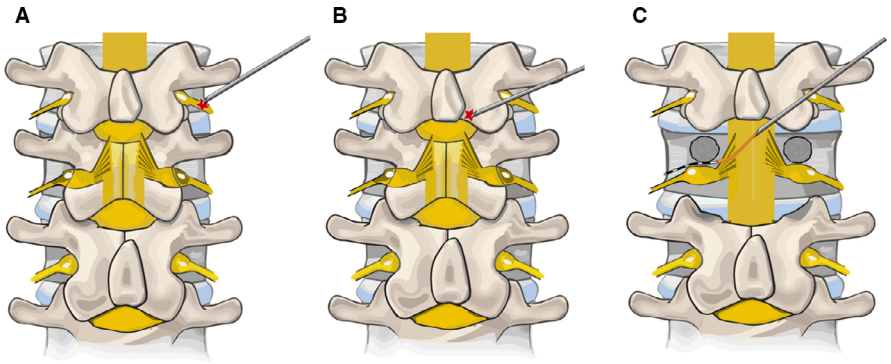

Figure 1. Schematic representation of transgrade dorsal root ganglion (DRG) lead placement. A, Initial position of entry at the skin. B, The needle is directed to the inferior laminar border, where contact is made with the Tuohy needle. C, After walking the needle inferomedially and accessing the epidural space in the midline using loss of resistance to air, the lead is positioned over the contralateral inferior DRG.

spinal cord. This statement holds true for the traditional anterograde approach as well as with the transgrade approach, since the curved tip of the introducer sheath can potentially induce a blunt insult to the dorsal aspect of the cord, potentially inducing transient postprocedural neuropathic pain.

Given the planned trajectory, with the skin entry point at or above the lower vertebral endplate of the level above, contacting the lower laminar border with the Tuohy needle, and then walking the needle off into the center of the epidural space in the midline, the Tuohy needle should have a caudad angulation which will allow the introducer and lead to have a relatively direct path to the target foramen (Figure 1C).

The lead and sheath are then introduced into the epidural space and steered towards the foramen on the contralateral side. The lead is then advanced through the foramen in the usual fashion, with the first electrode extraforaminal, the second and third under the pedicle, and the fourth contact medial to the pedicle. A superior tension loop is created by retracting the introducer into the Tuohy needle while keeping the lead in place, then rotating the curved tip introducer cephalad, retracting the stylet of the lead ~10 cm, and advancing the lead itself to make the superior loop. The introducer is then rotated to orientate the curve in the caudad direction. This requires clockwise rotation when approaching from the left side and counterclockwise rotation when approaching from the right side. The lead is then advanced, and the inferior portion of the strain relief loop is created. Again, while manipulating the introducer, close attention must be paid to avoid rotating the curve of the introducer ventrally. After lead placements are confirmed on anteroposterior and lateral views (Figures 2 and 3), the leads may be connected to the adapter and tested, if deemed necessary, for concordant paresthesia coverage. The Tuohy needle and introducer are then removed in the usual fashion and the lead is secured.

DISCUSSION

Research supporting the efficacy and safety of DRG-S for treatment of chronic pain syndromes continues to grow.[4–7,10,12,13,16,17] Many patients with chronic pain conditions have had prior surgical interventions on the spine, and a substantial subset of patients may present with postsurgical changes in anatomy. These changes may complicate placement of DRG-S leads via the traditional anterograde approach if the surgical level was just below the target level for DRG-S. Compromise of the epidural space by a laminectomy or laminotomy at the level below the target foramen can make the epidural space inaccessible. The transgrade insertion approach described in this report may be a valuable alternative approach if anterograde placement difficulties are encountered or anticipated.

Upon review of the literature, we found several reports on retrograde lead placement of conventional spinal cord stimulation leads. Van Helmond et al.[16] presented a case in which a retrograde approach from C7–T1 was used for the placement of conventional spinal cord stimulator leads on the T8 level. A detailed description of the retrograde approach for the placement of cervical spinal cord stimulation leads has been provided by Oosterbos et al.,[18] and retrograde lead placement for conventional spinal cord stimulation in

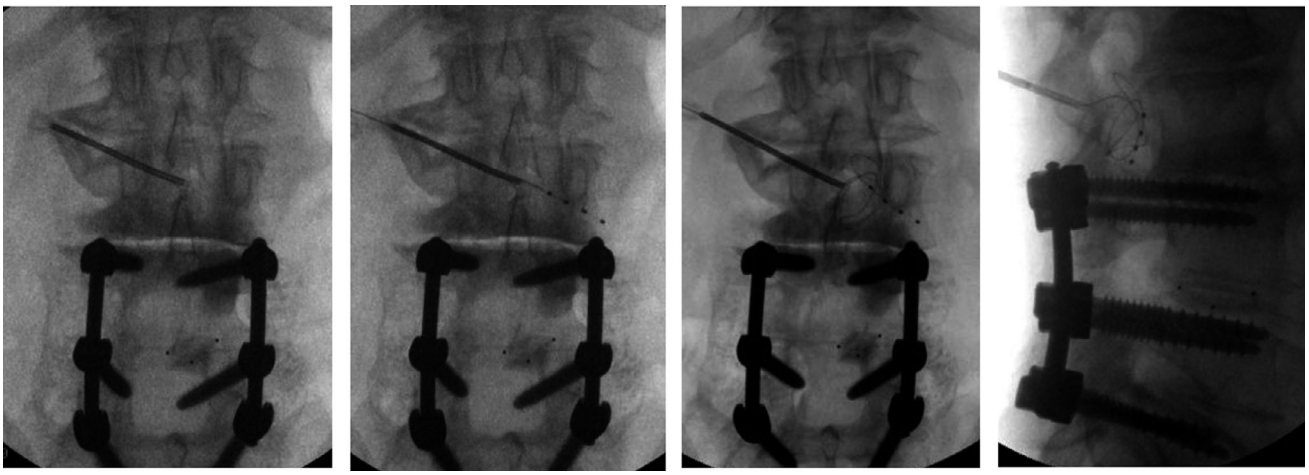

Figure 2. Anterior posterior and lateral fluoroscopic views of dorsal root ganglion stimulation lead placement using the transgrade approach at the L3 level.

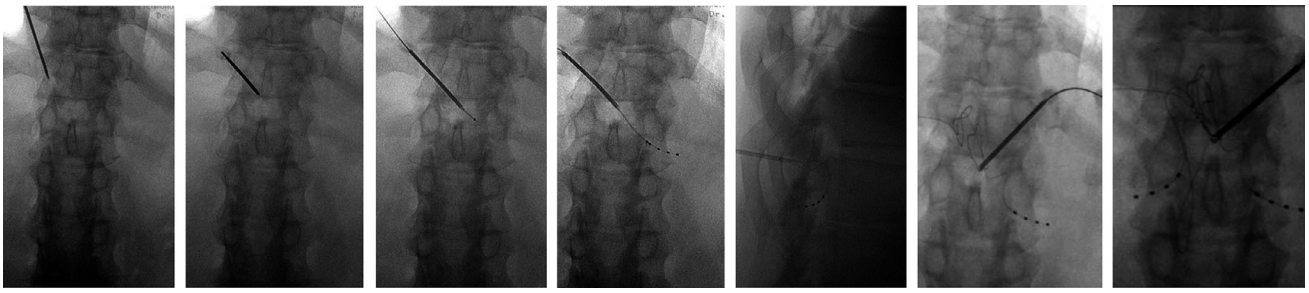

Figure 3. Anterior posterior and lateral fluoroscopic views of dorsal root ganglion stimulation lead placement using the transgrade approach at the T12 level.

the lumbar[19] and sacral areas[20] have also been performed previously.

Since the anatomy of the thoracic spine and the lumbar spine differs, the technique of lead placement is different as well. In comparison, in the lumbar spine the distance between the ligamentum flavum and the dura mater can be up to 5 to 6 mm, whereas the distance between the ligamentum flavum and dura mater in the area of T12–L1 can be only 3 to 4 mm.[21] The reduction of this space requires a shallow angle in which the needle is brought into the epidural space. Given that the spinal cord typically ends at L1–2, additional attention needs to be made to avoid contact with the dorsal aspect of the spinal cord with the introducer sheath, as it is more rigid than the lead itself. Contact with the spinal cord with the introducer may lead to transient postprocedural neuropathic pain. Since we used this technique to place leads on the DRG, it is further necessary to steer leads out of the contralateral foramen. Overall, the described retrograde approach may be more challenging to perform than the conventional anterograde approach.[21]

As with every neuromodulation procedure, it is important to monitor the patient closely for adverse events, such as lead migration, lead fracture, infection, inflammation, or cerebrospinal fluid leak.[4,7,22] When the lead is placed in an anterograde position, the lead is likely to migrate in a caudad direction if migration occurs. In comparison, when the lead is placed in a retrograde position, the lead might migrate in a cephalad direction. When permanently implanting upper lumbar/lower thoracic leads, we anchor leads to the fascia to avoid migration.[17] Furthermore, all patients should have a psychological clearance completed prior to their trials, which was done in each of the cases described in this report.

The ability to have another approach for DRG-S lead insertion may expand the realm in which we can apply DRG-S technology. Technically, proper positioning of the leads using the transgrade approach may be

challenging without considerable training and experience. We suggest that variations in traditional anterograde lead placements should be performed only by experienced practitioners to ensure safety. Proper strain loop formation and anchoring is necessary to prevent lead migration, in particular when the distance to the generator pocket is more significant.

CONCLUSION

DRG-S has been shown to be effective in relieving pain from a variety of neuropathic pain syndromes. Typical lead placement via an anterograde approach can be difficult in patients who previously underwent surgical procedures of the spine. We demonstrated DRG-S lead placement at the T11, T12, L1, and L3 spinal levels in a transgrade manner in 4 cases for abdominal pain, low back pain, sacroiliac joint pain, and post–total knee replacement pain. In cases where interlaminar access below the level of the DRG is not available, or desirable, alternate access may be attained from above using the presented transgrade approach. Further studies using this technique are needed to investigate long-term success, efficacy, and complication rates.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

FUNDING

The authors received no specific funding for this work.

REFERENCES

1. Institute of Medicine Committee on Advancing Pain Research Care and Education. The National Academies Collection: Reports funded by National Institutes of Health. *Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research*. Washington, DC: National Academies Press, (U.S.) National Academy of Sciences; 2011.

2. Hoy D, Brooks P, Blyth F, Buchbinder R. The epidemiology of low back pain. *Best Pract Res Clin Rheumatol*. 2010;24:769–781.

3. Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Ann Intern Med*. 2007;147:478–491.

4. Deer TR, Grigsby E, Weiner RL, Wilcosky B, Kramer JM. A prospective study of dorsal root ganglion stimulation for the relief of chronic pain. *Neuromodulation*. 2013;16:67–71; discussion 71–62.

5. Huygen F, Liem L, Cusack W, Kramer J. Stimulation of the L2–L3 dorsal root ganglia induces effective pain relief in the low back. *Pain Pract*. 2018;18:205–213.

6. Weiner RL, Yeung A, Montes Garcia C, Tyler Perryman L, Speck B. Treatment of FBSS low back pain with a novel percutaneous DRG wireless stimulator: pilot and feasibility study. *Pain Med*. 2016;17:1911–1916.

7. Liem L, Russo M, Huygen FJ, et al. A multicenter, prospective trial to assess the safety and performance of the spinal modulation dorsal root ganglion neurostimulator system in the treatment of chronic pain. *Neuromodulation*. 2013;16:471–482; discussion 482.

8. Sundt D, Gamper N, Jaffe DB. Spike propagation through the dorsal root ganglia in an unmyelinated sensory neuron: a modeling study. *J Neurophysiol*. 2015;114:3140–3153.

9. Kent AR, Min X, Hogan QH, Kramer JM. Mechanisms of dorsal root ganglion stimulation in pain suppression: a computational modeling analysis. *Neuromodulation*. 2018;21:234–246.

10. Pope JE, Deer TR, Kramer J. A systematic review: current and future directions of dorsal root ganglion therapeutics to treat chronic pain. *Pain Med*. 2013;14:1477–1496.

11. Liem L. Stimulation of the dorsal root ganglion. *Prog Neurol Surg*. 2015;29:213–224.

12. Liem L, van Dongen E, Huygen FJ, Staats P, Kramer J. The dorsal root ganglion as a therapeutic target for chronic pain. *Reg Anesth Pain Med*. 2016;41:511–519.

13. Chan CW, Peng P. Failed back surgery syndrome. *Pain Med*. 2011;12:577–606.

14. Al-Kaisy A. TransGrade multimodal neuromodulation of the dorsal root ganglion ensemble for refractory neuropathic pain. ClinicalTrials.gov; 2017. https://clinicaltrials.gov/ct2/show/NCT03318250 (accessed November 06, 2019).

15. Al-Kaisy A. Long term safety and efficacy in novel trans-grade DRG stimulation for chronic neuropathic pain. In: *The 22nd Annual Gabor Racz Advanced Interventional Budapest Pain Conference and Workshop*. Budapest, Hungary: World Institute of Pain; 2017.

16. van Helmond N, Kardaszewski CN, Chapman KB. Cervical retrograde spinal cord stimulation lead placement to treat failed back surgery syndrome: a case report. *A A Case Rep*. 2017;8:334–336.

17. Chapman KB, Groenen PS, Patel KV, Vissers KC, van Helmond N. T12 dorsal root ganglion stimulation to treat chronic low back pain: a case series. *Neuromodulation*. 2019. [Epub ahead of print]. https://doi.org/10.1111/ner.13047

18. Oosterbos C, Vanvolsem S, Duyvendak W, et al. Retrograde placement of high cervical electrodes: a technical refinement and case series. *Neuromodulation*. 2018;21:755–761.

19. Richter EO, Abramova MV, Alo KM. Percutaneous cephalocaudal implantation of epidural stimulation electrodes

over sacral nerve roots—a technical note on the importance of the lateral approach. *Neuromodulation*. 2011;14:62–67; discussion 67.

20. De Andres J, Perotti L, Villaneuva-Perez VL, Asensio-Samper JM, Fabregat-Cid G. Role of lumbosacral retrograde neuromodulation in the treatment of painful disorders. *Pain Physician*. 2013;16:145–153.

21. Barolat G. Experience with 509 plate electrodes implanted epidurally from C1 to L1. *Stereotact Funct Neurosurg*. 1993;61:60–79.

22. Vancamp T, Levy RM, Pena I, Pajuelo A. Relevant anatomy, morphology, and implantation techniques of the dorsal root ganglia at the lumbar levels. *Neuromodulation*. 2017;20:690–702.