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Dorsal Root Ganglion Stimulation Therapy for Treatment of Persistent Nociceptive and Neuropathic Knee Pain Secondary to Bilateral Patellectomy

Daniel J. Lopez, MD[1], Joshua Winegar, MD[2], and Juan Mora, MD[2]

Background: Chronic refractory knee pain in the form of complex regional pain syndrome (CRPS) continues to become more prevalent as surgical interventions for knee pain increase. Neuromodulation with a dorsal root ganglion stimulator (DRGS) has been proven to benefit focal knee pain.

Case Report: A 59-year-old woman with a past medical history of rheumatoid arthritis and Sjogren's syndrome presented with chronic bilateral knee pain despite multiple surgeries and bilateral patellectomy. She underwent a DRGS trial that improved her pain, ability to stand and walk for longer times, and ability to perform activities of daily living. She underwent permanent implantation of a bilateral L3 DRGS, resulting in an 18-point reduction in her Oswestry Disability Index (ODI) score and 80% to 100% improvement of pain at 9 months post operation.

Conclusions: We successfully implanted a bilateral L3 DRGS in a patient with chronic bilateral nociceptive and neuropathic knee pain secondary to bilateral patellectomy.

Key words: Case report, dorsal root ganglion stimulator, knee pain, patellectomy

BACKGROUND

Chronic knee pain negatively affects quality of life and increases disability in approximately one-fourth of the population (1). Common etiologies of chronic knee pain include osteoarthritis, rheumatoid arthritis, peripheral neuropathy, unrepaired ligamentous or meniscal injuries, fractures of the involved joint, and complex regional pain syndrome (CRPS) (2-4). In addition, postsurgical knee pain continues to rise as more patients undergo surgical interventions for chronic knee pain. A rare yet unavoidable procedure for select cases of refractory patella dislocations and comminuted patella fractures is patellectomy (4). Novel advances in neuromodulation have established effective treatment options for chronic, refractory, painful postsurgical conditions using devices such as a spinal cord stimulator (SCS) and dorsal root ganglion stimulator (DRGS). Growing evidence supports the use of DRGS as a treatment modality for CRPS type I and type II (causalgia) (5-7). More specifically, the literature highlights DRGS as a novel and promising treatment option for chronic medically refractory postoperative knee pain (6,8). We present a case of DRGS in a patient with chronic bilateral postoperative knee pain. To our knowledge, this is the first case of a successful bilateral L3 DRGS implantation for the treatment of chronic, bilateral, nociceptive and neuropathic knee pain with CRPS type II features in

From: [1]Department of Emergency Medicine, HCA Florida Kendall Hospital, Miami, FL; [2]Division of Pain Medicine, Department of Anesthesiology, University of Florida College of Medicine, Gainesville, FL

Corresponding Author: Juan Mora, MD, E-mail: jmora@anest.ufl.edu
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a patient with bilateral patellectomies. The patient provided informed consent for the publication of this case report.

CASE

A 59-year-old woman with a past medical history significant for rheumatoid arthritis, multiple joint osteoarthritis, and Sjogren's syndrome presented to the pain clinic. She had experienced 40 years of bilateral knee pain initially caused by a high school sports-related injury. The patient underwent numerous knee surgeries (19 in total) in an attempt to obtain pain relief. The Maquet procedure, a surgical intervention elevating the anterior tibia tubercle, was performed for bilateral patellofemoral syndrome. Eventually, lateral release surgery of the bilateral knees was performed for patella realignment in addition to resections of painful neuromas. After multiple surgeries affecting the stability of the knee joint, the patient continued to have refractory knee pain. In an attempt to alleviate pain and repetitive refractory patella dislocations, she ultimately underwent bilateral patellectomy (Fig. 1).

The patient presented to our pain clinic with refractory bilateral anterior knee pain despite conservative treatments including medication management with nonsteroidal anti-inflammatories, duloxetine, and opioids, as well as interventions such as bilateral knee intraarticular corticosteroid injections and a lumbar sympathetic plexus block. Despite these interventions, the patient endorsed a Numerical Rating Scale (NRS) for Pain score of 9 out of 10, Oswestry Disability Index (ODI) of 46, and Patient-Reported Outcomes Measurement Information System (PROMIS) Pain Intensity, Physical Function T-Score, and Depression T-score of 6, 30.7, and 55.7, respectively. After consultation with the orthopedic surgeon, she was deemed to not be a candidate for total knee arthroplasties or other reconstructive surgery. Given the patient's persistent pain after multiple bilateral knee operations, hyperalgesia, skin color changes, and edema, a diagnosis of CRPS type II, or causalgia, was made. After a lengthy discussion of the risks and potential benefits of further treatment options for her pain, a DRGS trial was offered.

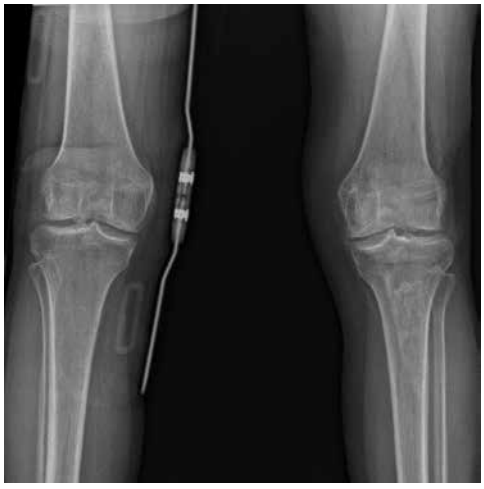

Fig. 1. Bilateral knee patellectomy.

A DRGS trial was performed in an ambulatory surgical center using monitored anesthesia care and fluoroscopic guidance. The patient was placed in the prone position throughout the procedure. Using a radiolucent table, we established a true anteroposterior view of the thoracolumbar spine with the C-arm directly over the patient. The L3/L4 interspace was identified under fluoroscopy at the intended epidural entrance site and 3 mL of 1% lidocaine was injected in the subcutaneous tissue 2 levels below the intended epidural entrance site at the lateral aspect of the contralateral pedicle with a midline trajectory. After superficial anesthesia, a Tuohy needle was guided into the epidural space using an interlaminar approach. We used anteroposterior and lateral/contralateral oblique fluoroscopic views for visualization and confirmed epidural space entry using the loss-of-resistance technique. The introducer was passed through the Tuohy needle to the target location, the left L3/L4 foramen, and the DRGS trial lead was then placed on the dorsal aspect of the left L3 dorsal root ganglion (DRG) under continuous fluoroscopy. Once the lead was in the desired position, a superior followed by an inferior strain relief loop were created. The above procedure was repeated in a step-by-step fashion on the contralateral side, targeting the right L3/L4 foramen and placing the DRGS trial lead on the dorsal aspect of the right L3 DRG. After the percutaneous DRGS trial leads were secured to the skin externally, an external impulse generator (IPG) device was secured with sterile dressings. The trial stimulation parameters were set at a frequency of 16 Hz, a pulse width of 200 μs, and an amplitude of 0.025 mA and 0.050 mA in the left and right DRG leads, respectively.

During the 7-day trial, the patient reported meaningful clinical improvement in her pain symptoms. She was able to walk and stand for longer periods of time, perform household chores, and complete advanced

activities of daily living. She reported that the DRGS trial offered 100% pain relief on the left and 80% on the right knee. The DRGS trial leads were removed after the 7-day trial, and the patient underwent implantation of a permanent bilateral L3 DRGS.

The procedure for the permanent placement of the DRGS was similar to the trial lead intervention discussed above; however, some additions for permanent implantation are discussed below. A 4-contact lead electrode was placed in the epidural space at the dorsal aspect of the bilateral L3 DRG (Fig. 2A, B). After the permanent DRGS leads were in place, a 5-cm transverse incision was made in the left lateral aspect of the flank, just above the iliac crest, where a 1.5-cm depth pocket was created for the IPG. The DRGS leads were carefully tunneled to the subcutaneous pocket and connected to the IPG. After thorough irrigation of the incisional wounds, a 2-layer closure followed by skin staples for the surgical wounds was performed. Standard sterile dressings were placed over both incisions. The final DRGS implantation with the IPG is shown in Fig. 3.

The final stimulation parameters were set at a frequency of 16 Hz, a pulse width of 200 μs, and an amplitude of 0.275 μA and 0.450 μA in the left and right DRGS leads, respectively. At follow-up appointments after the permanent DRGS implantation, the patient reported an improved ability to perform household chores, walk up and down stairs, and participate in physical therapy and home exercises secondary to an overall decrease in her pain in both knees. Additionally, she no longer required mobility assistance with a cane or walker. She continued to wear her knee braces because of the laxity and anatomic instability of both knees. Opioid therapy was also permanently discontinued after the DRGS implant had given her sustained improvement in pain. The patient's improvement in functional status and quality of life in addition to her pain reduction were validated in her NRS, PROMIS, and ODI patient-reported outcome scores (Table 1). Specifically, 9 months after the procedure, her pain scores on the NRS improved from 9 out of 10 to 0 out of 10 in the left knee and 2 out of 10 in the right knee with and without activity. Additionally, her PROMIS Pain Intensity scores improved from 6 prior to the DRGS implant to 1 at 7 and 9 months after DRGS implantation. The patient's PROMIS Physical Function T-score improved from 30.7 prior to the DRGS implant to 41.8 and 40.4 at 7 and 9 months after implantation. Her PROMIS Depression T-score decreased from 55.7 before the procedure to 41 at 7 and 9 months. Her ODI score

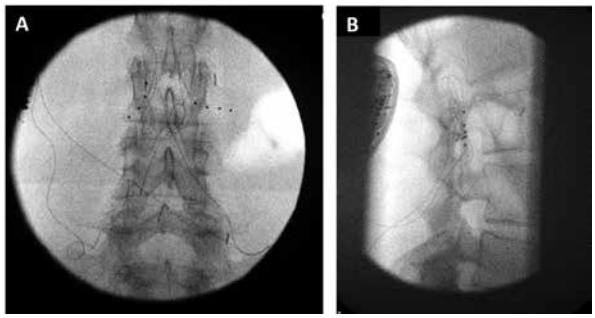

Fig. 2. (A) Anteroposterior view of bilateral L3 dorsal root ganglion leads. (B) Lateral view of bilateral L3 dorsal root ganglion leads.

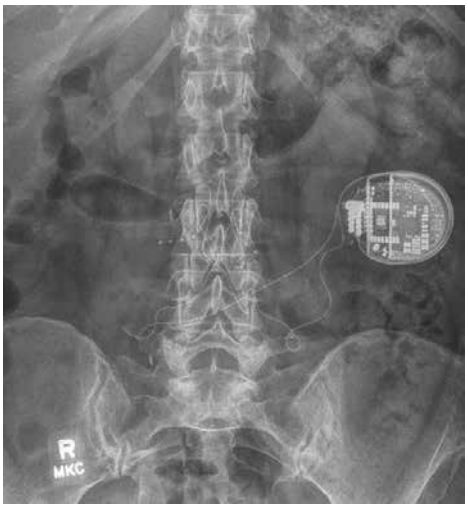

Fig. 3. Permanent dorsal root ganglion stimulator implant with leads and impulse generator.

Table 1. Patient-reported pain and function scores before dorsal root ganglion stimulation (DRGS) and at 7 and 9 months post-DRGS implantation.

Scale	Pain and function scores		
	Pre-DRGS	7 months post-DRGS	9 months post-DRGS
ODI	46	22	28
PROMIS Physical Function T-score	30.7	41.8	40.4
PROMIS Pain Intensity	6	1	1
PROMIS Depression T-score	57.7	41	41

Abbreviations: ODI, Oswestry Disability Index; PROMIS, Patient-Reported Outcomes Measurement Information System

prior to the DRGS was 46 and decreased to 22 and 28 at 7 and 9 months, respectively, after DRGS implantation.

DISCUSSION

The standard of treatment for chronic postsurgical knee pain consists of physical therapy, braces and orthotics, analgesics, and therapeutic injections. Despite these interventions, chronic postsurgical pain refractory to analgesic alternatives may persist, leading to decreased quality of life and increased disability for this patient population. In our clinical case, the patient developed incapacitating mixed nociceptive and neuropathic pain consistent with causalgia after undergoing various surgical procedures in both knees.

Literature has supported the use of neuromodulation for patients with refractory postsurgical pain, including transcutaneous electrical nerve stimulation, pulse radiofrequency, SCS, and DRGS (7,9). Research also supports the successful use of SCS and DRGS in patients with CRPS (5,10,11). In patients suffering from localized knee pain secondary to CRPS type I or type II (causalgia) refractory to conservative and other minimally invasive treatment options, as in our patient's case, DRGS has been shown to improve pain management (6). The use of DRGS rather than SCS in CRPS has been at the forefront of continued debate in neuromodulation.

The DRG, located bilaterally on multiple spinal levels in the posterior epidural space, houses the primary sensory neurons. It receives sensory input from peripheral nerves and transmits these signals to the central nervous system (5). Given that the DRG is the warehouse for afferent and efferent sensory signaling, the proposed mechanism of DRG stimulation involves modulation of both alpha fibers (Aδ and Aβ) and C-fibers (12). In addition to this mechanism, GABA, an inhibitory neurotransmitter in neuronal transmission processes, is also thought to increase in the DRG upon neurostimulation. The unique physiologic properties of the DRG and its additive effects on neuronal signaling, as well as physicians' familiarity with interventional procedures in the epidural space, make it an ideal target for neuromodulation.

Research exploring potential advantages of DRGS for localized CRPS compared with SCS has highlighted its ability to offer precise targeting of painful areas and a potential for decreased lead migration (5,13). Additionally, given the proximity of the lead electrodes in the epidural space directly over a given DRG, the energy demand is markedly low (microamperes) compared with SCS (milliamperes). This decreased demand results in minimal battery consumption from the IPG, increasing the time of the implant (up to 10 years) without the need to recharge. Last, the efficiency and predictability of the DRGS is enhanced compared with other modes of neurostimulators given its proximity to the DRG in the epidural space, low volume of cerebrospinal fluid, and minimal movement of the neuroforaminal structures despite a patient's range of motion.

In this case report, DRGS of the bilateral L3 DRG successfully treated CRPS type II of the bilateral knees after multiple surgeries and bilateral patellectomy. The improvements in the patient's reported outcomes were both clinically significant and meaningful based on the minimal clinically important difference (MCID) of each reported score. Studies have validated an MCID of 10 for ODI, a gold standard patient-reported questionnaire for analyzing disability in patients with low back pain and other chronic pain conditions (14,15). Our patient's ODI improved 18 points at 9 months after DRGS implantation. The NRS, a widely used numerical scale analyzing patient pain intensity, has an MCID of 2.5 for chronic pain (14). At 9 months after DRGS implantation, our patient's NRS improved 9 and 7 points for her left and right knee pain, respectively. Last, evidence shows that the MCID for PROMIS scores is 5 (16). At 9 months after DRGS implantation, our patient's PROMIS Physical Function T-score, Depression T-score, and Pain Intensity score improved 9.4, 14.7, and 5 points, respectively.

CONCLUSIONS

This case report highlights the substantial pain and quality of life improvement that DRGS offered a patient who previously underwent multiple surgeries and other conservative therapies to control her pain. Although joint pain is typically mechanical and nociceptive in nature, chronic knee pain complicated by multiple surgeries may develop a mixed nociceptive, non-nociceptive, and neuropathic component, as in our patient's case. In these circumstances, DRGS may be a suitable long-term treatment option for chronic pain. Given our successful case, DRGS therapy should be considered in patients suffering from postsurgical and specifically postpatellectomy knee pain, CRPS type II of the knee, and focal neuropathic knee pain. The growing body of literature supporting the use of DRGS for postsurgical neuropathic knee pain continues to favor this neuromodulation device over traditional SCS for chronic focal postoperative pain syndromes (5-7).

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