Combination Therapy of Radiofrequency Lumbar Facet Joint Denervation and Epidural Spinal Cord Stimulation for Failed Back Surgery Syndrome

—Case Report—

Tohru TERAOKA,¹ Takuya ISHII,¹ Satoshi TANI,² and Toshiaki ABE²

¹Department of Neurosurgery, Atsugi City Hospital, Atsugi, Kanagawa;

²Department of Neurosurgery, Jikei University School of Medicine, Tokyo

Abstract

An 81-year-old woman with failed back surgery syndrome (FBSS) was treated using a combination of percutaneous radiofrequency (RF) lumbar zygapophysial joint denervation and epidural spinal cord stimulation (SCS). She had undergone a staged laminectomy for narrowing of the spinal canal from L1 to S1 and degenerative spondylolisthesis at the L3-4 level. Postoperatively, in addition to low back pain (LBP) induced by dynamic motion, she began to experience intractable leg pain with a burning sensation, presumably caused by damage to the cauda equina. She initially underwent RF lumbar zygapophysial joint denervation for the LBP and subsequently underwent SCS via dual electrode leads for the leg pain. This combination therapy of RF denervation and SCS relieved the LBP almost entirely and relieved the leg pain by approximately 50%. The combination of these two minimally invasive interventions is particularly effective for severe leg pain and LBP in elderly patients or medically compromised cases with contraindications against general anesthesia, as well as in patients with FBSS.

Key words: failed back surgery syndrome, lumbar zygapophysial joint, medial branch of the posterior ramus, radiofrequency lumbar facet joint denervation, spinal cord stimulation

Introduction

Optimal care for patients with failed back surgery syndrome (FBSS) is often difficult to provide, because clinical evaluation of FBSS mainly depends on the subjective symptoms of the patient.³⁰⁾ The patient must describe the intensity of the pain and disability that may be intermittent or newly occurring following surgery.^{9,10)} Patients with FBSS often do not attain lasting relief even after various therapies, such as repeat surgery, oral medication, physical therapy, chiropractic care, and dorsal root ganglionectomy.^{1,15,16)} Encouragingly, epidural spinal cord stimulation (SCS) shows promise as a minimally invasive method for alleviating FBSS-associated pain, with both effective results and fewer permanent complications.^{11,14,18,26)} SCS procedures are completely reversible, and patients can be screened for responsiveness with temporally percutaneous electrodes before implantation of a permanent stimulation system.⁸⁾ The stimulation parameters are adjustable after the implantation, ensuring the pain-ameliorating effects of the SCS system.^{18,25)} Lumbar zygapophysial joint denervation is a minimally invasive radiofrequency (RF) therapy applied for low back pain (LBP), and is safe and effective for reducing LBP induced by skeletal instability

associated with lumbar spondylolisthesis and/or scoliosis.^{4,19,21,27,28)} However, patients who undergo the procedure, especially those with neuromuscular disorders, face a relatively high risk of surgical complications and a high rate of repeated surgery.²⁾ RF lumbar zygapophysial joint denervation is an especially flexible treatment for alleviating LBP in patients with serious neuromuscular disorders²³⁾ or patients with poor bone stock who require surgery for spinal deformities.

We performed combination SCS with RF lumbar zygapophysial joint denervation in a patient with FBSS associated with intractable leg pain and LBP, and describe the efficacy of this minimally invasive combination therapy for the relief of leg pain and LBP.

Case Report

An 81-year-old woman presented with lumbar spinal stenosis from L1 to S1 associated with spondylolisthesis at the L3-4 level. She began to experience LBP together with dysesthesia and pain in the left leg in March 2003. Her symptoms gradually progressed over the ensuing months, leading to full-fledged pain in the right leg one year later. She underwent laminectomy from L3 to L5 at another institution to alleviate the severe LBP and pain in her left leg in March 2005. No remarkable complications were reported.

ed, but her symptoms were not completely relieved. Eventually her leg pain re-emerged and intensified, and a burning pain (causalgia) developed on the sole of her left foot. Second laminectomy at L2 was performed in the same facility in November 2007, but had no effect on the LBP or leg pain. Symptoms continued to deteriorate and the pain medication dosage was increased over a 17-month course of conservative follow up. The patient was admitted to our hospital to undergo staged combination surgeries of SCS with RF lumbar zygapophysial joint denervation.

On admission, she reported dysesthesia throughout the bilateral lower extremities, with strong intensity in the area of the left lateral femoral cutaneous nerve. This dysesthesia was thought to be induced by compression of the cauda equina nerve in the dural sac, and/or the stenosis of the nerve root at the lateral zone of the intervertebral foramen. Furthermore, she complained of severe burning pain in the soles of her feet, predominantly on the left, which was also thought to be a result of injury to the cauda equina. LBP with predominance on the left was induced when she changed her posture from the decubitus or sitting position to the standing position. No motor weakness of the lower extremity was apparent. The ratio of the development of spinal instability at L3-4, defined as the percentage slip in a patient with degenerative spondylolisthesis estimated on lateral roentgenography in standing dynamic motion, was 14.0% in both extension and flexion. The slip angle was 5.0° in extension and 18.0° in flexion (difference between extension and flexion 13.0°) (Fig. 1). Preoperative magnetic resonance imaging revealed narrowing of the spinal canal from L1 to S1 (Fig. 2). The cause of the leg pain may have been peripheral neuropathy.

Her LBP was much more severe than her leg pain, so we decided to perform RF lumbar zygapophysial joint denervation before the SCS. One week before the RF denervation, the patient underwent a diagnostic facet block. The target levels of the block, L2-3, L3-4, and L4-5, were injected with a local anesthetic solution (1 ml of 1% mepivacaine hydrochloride at each target). The patient's evaluation of her LBP using a visual analogue scale (VAS) was reduced from 10 to 5, so the back pain was assumed to

derive from excitation of the medial branch of the dorsal ramus of the lumbar posterior root induced by spinal instability. The patient underwent RF denervation under local anesthesia on March 3, 2009. The procedure was performed with a RF generator (Neuro Therm JK3; Toyo Medic Instruments, Tokyo) under the following conditions: maximum temperature 90°C , coagulation time 120 seconds, and coagulation size 4-mm diameter (Fig. 3). Two or three coagulation points for each facet joint at L2-3, L3-4, and L4-5 were established to coagulate the medial branch of the posterior ramus (Fig. 4). RF denervation was effective in relieving the facet joint pain induced by skeletal instability, and the patient's evaluation of her LBP using the VAS was reduced from 10 to 2.

Three days after the RF denervation, SCS treatment began with percutaneous placement under local anesthesia using fluoroscopy to guide the lead to an appropriate position. Dual quarter lead electrodes (3487A Pisces-Quad; Medtronic, Inc., Minneapolis, Minnesota, USA) were implanted to enable perioperative stimulation with verbal responses from the patient to identify areas where stimulation evoked paresthesia. This procedure was made more comfortable for the patient by covering the painful area of the foot before the electrode was anchored subcutaneous-

Fig. 2 Preoperative magnetic resonance images revealing narrowing of the spinal canal from L2 to L5 with degenerative spondylolisthesis at L3-4.

Fig. 1 Lumbar roentgenograms, anteroposterior view (left), lateral view in extension (center), and lateral view in flexion (right), showing the ratio of the development of spinal instability at L3-4, defined as the percentage slip in a patient with degenerative spondylolisthesis on lateral roentgenography in standing dynamic motion, was 14.0% in both extension and flexion. The slip angle was 5.0° in extension and 18.0° in flexion (difference between extension and flexion 13.0°).

Fig. 3 Photographs showing the radiofrequency generator (left) used to coagulate the nerve, with a 22-gauge needle 100 mm in length (upper right) and a 250-mm-long joint connector cable (lower right) for lumbar zygapophysial joint denervation.

Fig. 4 Left column: Surgical target point for radiofrequency lumbar zygapophysial joint denervation of the median branch of the posterior ramus of the lumbar posterior root (upper, asterisk), and the locations of the procedure (lower) performed under the following conditions: maximum temperature 90°C, coagulation time 120 seconds, and coagulation size 4 mm diameter. Right column: Surgical locations for radiofrequency lumbar zygapophysial joint denervation at L2-3 (upper), L3-4 (middle), and L4-5 (lower), using 2 or 3 denervation points for each facet joint.

Fig. 5 Roentgenograms after implantation of the leads for dual-lead spinal cord stimulation. Stimulation of the spinal cord at the T12 level was effective for alleviating the leg pain, especially in distal regions of the leg. The stimulator settings were as follows: Right: contact 0-, 1+, 2+, 3 off; amplitude 2.0 V; frequency 50 Hz; and pulse width 200 μ sec. Left: contact 4-, 5+, 6+, 7 off; amplitude 2.0 V; frequency 50 Hz; and pulse width 200 μ sec.

ly.¹¹⁾ Stimulation of the spinal cord at the T12 level alleviated the leg pain, especially in distal regions of the leg (Fig. 5). After 7 days of therapeutic test stimulation trials, a permanent pulse generator (Synergy V [7424] Pulse Generator; Medtronic, Inc.) was implanted.

At 21 months after the combination surgeries, the stimulator settings were as follows: Right: contact 0-, 1+, 2+, 3 off; amplitude 2.0 V; frequency 50 Hz; and pulse width 200 μ sec. Left: contact 4-, 5+, 6+, 7 off; amplitude 2.0 V; frequency 50 Hz; and pulse width, 200 μ sec. Dual bipolar stimulation has suppressed the leg pain and LBP without adverse paresthesia or abnormal muscle contraction. The patient's evaluation of her leg pain using the VAS was reduced from 10 to 5. Physical activity commensurate with neurological status was achieved and LBP was relieved by at least 80% (VAS 2).

Discussion

A meta-analytical review of SCS for the treatment of FBSS found that the primary outcome of successful pain control (> 50% leg pain relief) was attained in 59% of cases.²⁶⁾ On the other hand, the success rate of reoperation involving laminectomy, foraminotomy, and/or discectomy in patients with or without spinal fusion ranged widely from 12% to 100%.^{4,16,24,29,30)} A prospective, randomized, controlled trial of 50 patients with FBSS from a single institution (24 patients with SCS and 26 patients with reoperation) followed by a mean postoperative follow up of 3 years found that 47% of patients randomized to SCS achieved at least 50% pain relief, compared to 12% of patients randomized to reoperation.¹⁶⁾ Patients randomized to SCS were significantly less likely to cross over than those randomized to reoperation (20.8% versus 53.8%). Patients randomized to reoperation required increased doses of opiate analgesics significantly more often than those randomized to SCS.¹⁶⁾ Thus, SCS after lumbosacral spine surgery is more likely than reoperation to result in a successful outcome for pain relief.^{13,14)} In addition, SCS may have several advantages over reoperation for successful pain relief, including reduced blood loss, shorter operation time, and improved cost effectiveness.^{13,14,17)} However, SCS is probably much less effective in alleviating LBP or axial pain than in relieving predominantly neuropathic pain of the extremities.⁵⁾ The effects of SCS for LBP were improved using dual electrode arrays and dual stimulation with alternating programs of stimulation.⁷⁾ For treatment of LBP with a predominantly axial component, dual Pisces electrodes or Specify-Lead implantation (Medtronic, Inc.) provided significant long-term pain relief, with 60% improvement in leg pain and 58% improvement in LBP.⁷⁾

The analgesic efficacy of RF lumbar zygapophysial joint denervation has been assessed in many patients as another option for the minimally invasive treatment of LBP induced by skeletal instability of the spine.^{19,21)} RF denervation of the medial branch is efficacious against chronic lumbar zygapophysial joint pain under electromyographic monitoring of the multifidus, a muscle innervated by the medial branches, based on preoperative diagnostic block-

ade of the lumbar zygapophysial joints to evaluate the optimal level of RF denervation, and 60% of the patients obtained at least 90% pain relief, and 87% obtained at least 60% pain relief at 12 months after denervation.³⁾ A prospective study of 174 patients with intractable low back pain showed that treatment with RF lumbar zygapophysial joint denervation resulted in good to excellent pain relief after 6 months in 68.4% of the patients, and median time to pain relief was 9 months.⁶⁾ Our technique of RF denervation followed by diagnostic medial branch blockade was highly effective for LBP relief, in combination with SCS using dual Pisce electrodes. The LBP relief has been maintained for 21 months in our patient, a period significantly longer than the period of relief conferred by only RF denervation.⁶⁾

The mechanism resulting in the synergy of SCS and RF denervation in relieving intractable pain remains unclear. SCS is believed to modulate the pathways for pain perception including suppression of the hyperexcitability of the wide dynamic range neurons and the gamma-aminobutyric acid increase in the dorsal horn.²²⁾ Increase in c-Fos immunoreactive cells was demonstrated in the dorsal horn after SCS, suggesting late cellular activation in the dorsal horn after SCS.²²⁾ SCS may also induce a similar effect on the glutamate transporters that regulate spatiotemporal and intensity coding for sensory input and prevent excessive activation of glutamate receptors in the spinal dorsal horn.¹²⁾ On the other hand, spinal instability at facet joints may induce excitation of the nociceptive or proprioceptive acceptors, thus promoting the secretion of neurotransmitters such as carrageenan, substance P, and phospholipase A2 which increase pain sensitivity.²⁰⁾ RF denervation may decrease nociceptive or proprioceptive pain by inhibiting the secretion of these neurotransmitters. Therefore, we speculate that combination therapy of SCS and RF denervation may provide additional therapeutic effects than use either individual treatment. Presently, one of our surgical strategies for treatment of intractable leg pain or LBP caused by FBSS is to assign patients to RF denervation or to SCS treatment, if less invasive treatments, such as analgesic medication, have not succeeded. SCS is the first choice if pain predominates in the lower limbs, whereas RF denervation is the usual treatment for severe LBP that derives from lumbar zygapophysial joint instability. If RF denervation does not achieve adequate reduction in LBP, additional dual lead SCS is recommended.

The combination of RF denervation and SCS using dual Pisce electrodes is particularly effective as a therapy for severe leg pain and LBP in elderly patients or medically compromised patients with contraindications against general anesthesia, as well as for FBSS.

References

- 1) Aronoff GM, McAlary PW, Witkower A, Berdell MS: Pain treatment programs: do they return workers to the workplace? *Occup Med* 3: 123-136, 1988
- 2) Babat LB, McLain RF, Bingaman W, Kalfas I, Young P, Rufo-Smith C: Spinal surgery in patients with Parkinson's disease: construct failure and progressive deformity. *Spine (Phila Pa 1976)* 29: 2006-2012, 2004

- 3) Dreyfuss P, Halbrook B, Pauza K, Joshi A, McLarty J, Bogduk N: Efficacy and validity of radiofrequency neurotomy for chronic lumbar zygapophysial joint pain. *Spine (Phila Pa 1976)* 25: 1270-1277, 2000
- 4) Finnegan WJ, Fenlin JM, Marvel JP, Nardini RJ, Rothman RH: Results of surgical intervention in the symptomatic multiply-operated back patient. Analysis of sixty-seven cases followed for three to seven years. *J Bone Joint Surg Am* 61: 1077-1082, 1979
- 5) Fogel GR, Esses SI, Calvillo O: Management of chronic limb pain with spinal cord stimulation. *Pain Pract* 3: 144-151, 2003
- 6) Gofeld M, Jitendra J, Faclier G: Radiofrequency denervation of the lumbar zygapophysial joints: 10-year prospective clinical audit. *Pain Physician* 10: 291-300, 2007
- 7) Kumar K, Hunter G, Demeria D: Spinal cord stimulation in treatment of chronic benign pain: challenges in treatment planning and present status, a 22-year experience. *Neurosurgery* 58: 481-496, 2006
- 8) Kumar K, Taylor RS, Jacques L, Eldabe S, Meglio M, Molet J, Thomson S, O'Callaghan J, Eisenberg E, Milbouw G, Buchser E, Fortini G, Richardson J, North RB: The effects of spinal cord stimulation in neuropathic pain are sustained: a 24-month follow-up of the prospective randomized controlled multicenter trial of the effectiveness of spinal cord stimulation. *Neurosurgery* 63: 762-770, 2008
- 9) Law JD, Lehman RA, Kirsch WM: Reoperation after lumbar intervertebral disc surgery. *J Neurosurg* 48: 259-263, 1978
- 10) Lehmann TR, LaRocca HS: Repeat lumbar surgery. A review of patients with failure from previous lumbar surgery treated by spinal canal exploration and lumbar spinal fusion. *Spine (Phila Pa 1976)* 6: 615-619, 1981
- 11) Linderer B, Meyerson BA: Spinal cord stimulation. Mechanisms of action, in Burchiel K (ed): *Pain Surgery*. New York, Thieme, 2000, pp 505-526
- 12) Nie H, Weng HR: Glutamate transporters prevent excessive activation of NMDA receptors and extrasynaptic glutamate spillover in the spinal dorsal horn. *J Neurophysiol* 101: 2041-2051, 2009
- 13) North RB, Campbell JN, James CS, Conover-Walker MK, Wang H, Piantadosi S, Rybock JD, Long DM: Failed back surgery syndrome: 5-year follow-up in 102 patients undergoing repeated operation. *Neurosurgery* 28: 685-691, 1991
- 14) North RB, Ewend MG, Lawton MT, Kidd DH, Piantadosi S: Failed back surgery syndrome: 5-year follow-up after spinal cord stimulator implantation. *Neurosurgery* 28: 692-699, 1991
- 15) North RB, Kidd DH, Campbell JN, Long DM: Dorsal root ganglionectomy for failed back surgery syndrome: a 5-year follow-up study. *J Neurosurg* 74: 236-242, 1991
- 16) North RB, Kidd DH, Farrokhi F, Piantadosi SA: Spinal cord stimulation versus repeated lumbosacral spine surgery for chronic pain: a randomized, controlled trial. *Neurosurgery* 56: 98-107, 2005
- 17) North RB, Kidd D, Shipley J, Taylor RS: Spinal cord stimulation versus reoperation for failed back surgery syndrome: a cost effectiveness and cost utility analysis based on a randomized, controlled trial. *Neurosurgery* 61: 361-369, 2007
- 18) North RB, Kidd DH, Zahurak M, James CS, Long DM: Spinal cord stimulation for chronic, intractable pain: experience over two decades. *Neurosurgery* 32: 384-395, 1993
- 19) Ogsbury JS 3rd, Simon RH, Lehman RA: Facet "denervation" in the treatment of low back syndrome. *Pain* 3: 257-263, 1977
- 20) Saal JS: The role of inflammation in lumbar pain. *Spine (Phila Pa 1976)* 20: 1821-1827, 1995
- 21) Shealy CN: Percutaneous radiofrequency denervation of spinal facets. *J Neurosurg* 43: 448-451, 1975
- 22) Smits H, Kleef MV, Honig W, Gerver J, Gobrecht P, Joosten EA: Spinal cord stimulation induces c-Fos expression in the dorsal horn in rats with neuropathic pain after partial sciatic nerve injury. *Neurosci Lett* 450: 70-73, 2009
- 23) Terao T, Yokochi F, Ishii T, Taniguchi M, Takahashi H, Okiyama R, Tani S, Abe T: Radiofrequency thermocoagulation for the median branch of posterior ramus of lumbar spine for the treatment of lumbar facet joint pain in patients with Parkinson's disease and associated scoliosis. *Funct*

- Neurosurg 48: 106–112, 2009
- 24) Turner JA, Ersek M, Herron L, Haselkorn J, Kent D, Ciol MA, Deyo R: Patient outcomes after lumbar spinal fusions. *JAMA* 268: 907–911, 1992
 - 25) Turner JA, Loeser JD, Bell KG: Spinal cord stimulation for chronic low back pain: a systematic literature synthesis. *Neurosurgery* 37: 1088–1096, 1995
 - 26) Turner JA, Loeser JD, Deyo RA, Sanders SB: Spinal cord stimulation for patients with failed back surgery syndrome or complex regional pain syndrome: a systematic review of effectiveness and complications. *Pain* 108: 137–147, 2004
 - 27) van Kleef M, Barendse GA, Kessels A, Voets HM, Weber WE, de Lange S: Randomized trial of radiofrequency lumbar facet denervation for chronic low back pain. *Spine (Phila Pa 1976)* 24: 1937–1942, 1999
 - 28) van Wijk RM, Geurts JW, Wynne HJ, Hammink E, Buskens E, Lousberg R, Knape JT, Groen, GJ: Radiofrequency denervation of lumbar facet joints in the treatment of chronic low back pain: a randomized, double-blind, sham lesion-controlled trial. *Clin J Pain* 21: 335–344, 2005
 - 29) Waddell G, Kummel EG, Lotto WN, Graham JD, Hall H, McCulloch JA: Failed lumbar disc surgery and repeat surgery following industrial injuries. *J Bone Joint Surg Am* 61: 201–207, 1979
 - 30) Wilkinson HA: *The Failed Back Syndrome: Etiology and Therapy*, ed 2. Philadelphia, Harper & Row, 1991

Address reprint requests to: Department of Neurosurgery, Atsugi City Hospital, 1–16–36 Mizuhiki, Atsugi, Kanagawa 243–8588, Japan.
 e-mail: tohru@jg7.so-net.ne.jp