Clinical Case Report

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Effect of bipolar pulsed radiofrequency on refractory chronic cervical radicular pain

A report of two cases

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Abstract

Rationale: Despite undergoing transforaminal epidural steroid injection (TFESI), many patients complain of persisting cervical radicular pain. For the management of chronic cervical radicular pain, clinicians are widely applying pulsed radiofrequency (PRF) stimulation to dorsal root ganglions (DRGs). To enhance the effect of PRF stimulation, we conducted bipolar PRF stimulation in 2 patients with chronic cervical radicular pain that was refractory to monopolar PRF and repeated TFESIs.

Patient concerns: Patients 1 and 2 presented with a numeric rating scale (NRS) score of 7 and 6 for chronic cervical radicular pain, respectively, despite undergoing monopolar PRF and 2 TFESIs.

Diagnoses: On cervical magnetic resonance imaging, foraminal stenosis at the right C6–7 and right central to right foraminal disc protrusion on C6–7 were observed in patients 1 and 2, respectively. Two patients showed a positive response on diagnostic right C7 selective nerve root block with 0.5 mL of 1% lidocaine.

Interventions: Bipolar PRF stimulation was performed under C-arm fluoroscopy. Two parallel RF cannulas (less than 1 cm apart) were used for DRG stimulation. The PRF treatment was administered at 5 Hz and a 5-ms pulsed width for 360 seconds at 45 V with the constraint that the electrode tip temperature did not exceed 42°C.

Outcomes: At the 2-week and 1-month follow-up, after undergoing bipolar PRF, the pain of patient 1 was completely relieved, and at 2, 3, and 6 months, the pain was scored as NRS 2. In patient 2, at the 2-week follow-up after undergoing bipolar PRF, pain severity was reduced from NRS 6 to 2. The effect of bipolar PRF on patient 2 lasted for at least 6 months. No adverse effects were observed in either patient.

Lessons: Application of bipolar PRF to DRGs seems to be an effective and safe technique for treating refractory chronic cervical radicular pain.

Abbreviations: CRF = continuous radiofrequency, DRG = dorsal root ganglion, IL = interleukin, MRI = magnetic resonance imaging, NRS = numeric rating scale, PRF = pulsed radiofrequency, TFESI = transforaminal epidural steroid injection, TNF = tumor necrosis factor.

Keywords: bipolar, cervical radicular pain, chronic pain, pulsed radiofrequency, refractory pain

1. Introduction

Cervical radicular pain is defined as pain perceived as arising in the upper limb caused by ectopic activation of the spinal nerve roots or other neuropathic mechanisms.[1,2] Cervical radicular pain affects approximately 83 persons in 100,000.[3] Chemical inflammation and mechanical compression of the cervical nerve root are known to be responsible for cervical radicular pain.[4,5] For the suppression of inflammation-related processes or molecules such as various cytokines and chemokines, transforaminal epidural steroid injection (TFESI) is being widely performed.[6–8] Its effect for reducing the cervical radicular pain has been well-demonstrated in several previous studies.[6–8] However, several patients are unresponsive to TFESI. Therefore, various techniques have been applied for the management of uncontrolled cervical radicular pain.[9–11]

Pulsed radiofrequency (PRF), a technique introduced by Sluijter et al[12] in 1998, is known to be safe and effective in alleviating pain. PRF functions by delivering an electrical field and heat bursts to targeted nerves or tissues without significant damage of these structures.[13–15] Continuous radiofrequency (CRF) exposes target nerves or tissues to a continuous electrical stimulation and ablates the structures by increasing the temperature around the RF needle tip.[16] In contrast to CRF, PRF applies a brief electrical stimulation followed by a long resting phase.[17] Thus, PRF does not produce sufficient heat to cause significant structural damage.[17] The proposed mechanism of PRF is that the electrical field produced by PRF can alter pain signals.[18–20] To date, several studies have reported that PRF

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stimulation of the dorsal root ganglion (DRG) can successfully manage cervical radicular pain.[6,9,21] However, in the clinical practice, despite undergoing PRF, some patients continue to complain of persisted cervical radicular pain. In all previous PRF studies, a single cannula was used to produce a therapeutic electrical field. This method is called monopolar PRF stimulation. To overcome the limitations of monopolar PRF stimulation, we used bipolar PRF stimulation, a technique that applies 2 electrode tips to the DRG. We considered that bipolar PRF can be more effective than monopolar PRF because 2 parallel PRF cannulas would produce denser and larger electrical fields compared to a single PRF cannula.[22–24]

In this study, we report a positive response to bipolar PRF stimulation on cervical DRG in 2 patients with chronic cervical radicular pain who were refractory to monopolar PRF and repeated TFESIs.

2. Case report

Two patients with refractory chronic cervical radicular pain were recruited for this study. Both the patients provided informed consent for participation. The study was approved by the Institutional Review Board of Yeungnam university hospital.

Patient 1 was a 74-year-old woman who visited the department of physical medicine and rehabilitation at our university hospital due because of right cervical radicular pain during a period of 8 months. She had tingling sensation and piercing pain on posterior arm and forearm. The numeric rating scale (NRS) score was 7 out of 10. On physical examination, she showed a positive Spurling sign on the right side and hypoalgesia on the right C7 dermatome. Motor weakness was not checked. On cervical magnetic resonance imaging (MRI), foraminal stenosis at the right C6–7 was observed (Fig. 1A). The patient showed a positive response on diagnostic right C7 selective nerve root block with 0.5 mL of 1% lidocaine. At first, we performed TFESIs on the right C7 nerve root with 20 mg (0.5 mL) of dexamethasone mixed with 0.25 mL of 0.125% bupivacaine twice, within a 2-week interval. Its effect was spontaneous. The NRS score was reduced from 7 to 2, but it lasted only for 1 day. After 9 months of symptom onset, monopolar PRF on the right C7 DRG was performed with a 22-gauge curved-tip cannula (SMK Pole needle, 100 mm with a 10 mm active tip, Cotop International BV). For the procedure, the patient was laid in a supine position for C-arm fluoroscopy (Siemens). The sensory stimulation test and PRF treatment were conducted using an RF generator (Cosman G4, Burlington, MA). The catheter needle was placed around the DRG. The inserted catheter needle was placed close to the DRG when the patient reported a tingling sensation and/or dysesthesia at less than 0.3 V. The PRF treatment was administered at 5 Hz and a 5-ms pulsed width for 360 seconds at 45 V with the constraint that the electrode tip temperature did not exceed 42°C. One month after monopolar PRF, the patient reported that the radicular pain was not reduced at all. After 10 months of symptom onset, we applied bipolar PRF on the right C7 DRG to the patient. Two catheter needles (active tip electrodes) were inserted under C-arm fluoroscopy (Fig. 1A). The distance between the 2 catheter

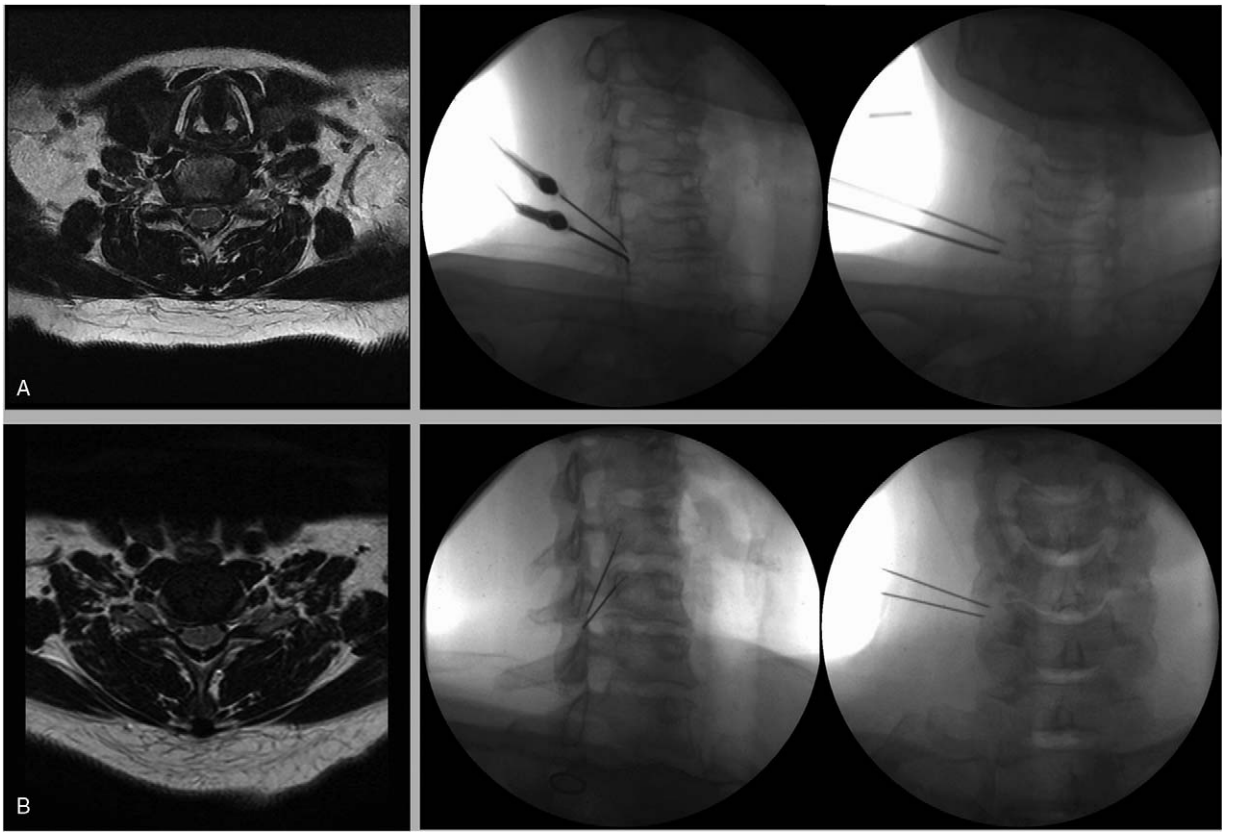

Figure 1. (A) Patient 1: axial T2-weighted cervical spine MRI at 8 months after symptom onset showed foraminal stenosis at the right C6–7 (right). Bipolar pulsed radiofrequency on the right C7 dorsal root ganglion was performed under the C-arm fluoroscopy (oblique and anteroposterior views) (left). (B) Patient 2: axial T2-weighted cervical spine MRI at 6 months after symptom onset presented with right central to right foraminal disc protrusion on C6–7 (right). Fluoroscopy-guided bipolar pulsed radiofrequency on the right C7 dorsal root ganglion was performed (oblique and anteroposterior views) (left).

needle tips was less than 1 cm, but they were not in contact with each other. When the patient reported a tingling sensation and/or dysesthesia at less than 0.3 V, the PRF treatment was administered with the same protocol as the bipolar PRF treatment. At the 2-week and 1-month follow-up, the patient reported that her cervical radicular pain was completely relieved (NRS 0). At 2, 3, and 6 months after bipolar PRF, the pain was scored as NRS 2.

Patient 2 was a 52-year-old woman who visited the department of physical medicine and rehabilitation at our university hospital due to right cervical radicular pain during a period of 6 months. She complained of tingling sensation and piercing pain on the right posterior arm and forearm. The NRS score was 6. On physical examination, she showed a positive Spurling sign on the right side, hypoalgesia on the right C7 dermatome, and motor weakness of the right elbow extensor (Medical Research Council[25]: 4). On cervical MRI, we observed right central to right foraminal disc protrusion on C6–7 (Fig. 1B). On the diagnostic right C7 selective nerve root block with 0.5 mL of 1% lidocaine, a positive response was shown. However, 2 TFESIs on the right C7 nerve root with 20 mg (0.5 mL) of dexamethasone mixed with 0.25 mL of 0.125% bupivacaine were not effective (NRS was not changed). After 7 months of symptom onset, we performed monopolar PRF on the right C7 DRG, but 1 month after the monopolar PRF procedure, the patient reported that the procedure was not effective, and the severity of pain was not changed. At 8 months after symptom onset, we conducted bipolar PRF on the right C7 DRG (Fig. 1B). In the monopolar and bipolar procedures, the catheter needle and RF generator used in patient 2 were the same as those in patient 1. Two weeks after the bipolar PRF, the pain was reduced from NRS 6 to 2. The pain score remained as NRS 2 at 1, 2, 3, and 6 months after the procedure. No adverse effects of bipolar PRF stimulation on DRG were noted.

3. Discussion

In the current study, we reported 2 cases of successful response to bipolar DRG stimulation on cervical DRG in patients who were refractory to monopolar PRF and repeated TFESIs.

The PRF is a minimally neurodestructive method to treat many types of chronic pain.[26] However, despite of its increasing use, the exact mechanism of PRF stimulation is not clearly elucidated. However, Erdine et al[27] reported structural alteration of sensory nociceptive nerve fibers after PRF stimulation using electron microscopy. They described that PRF selectively caused changes in smaller principal sensory neural fibers such as C and Aδ fibers, compared with larger nonpain-related sensory fibers such as Aβ fibers.[27] Cho et al[18] reported that PRF of the DRG decreased microglia activity in the spinal dorsal horn of a rat model of lumbar disc herniation. Because microglia are strongly responsible for the development of chronic neuropathic pain through releasing various cytokines and chemokines, which are related with pain signaling, they proposed that down-regulation of microglia can possibly prevent progression to chronic neuropathic pain. Further, Vallejo et al[28] proved that levels of proinflammatory cytokines, such as tumor necrosis factor (TNF)-α and interleukin (IL)-6, were normalized after PRF stimulation. Hagiwara et al[19] found that PRF activates the noradrenergic and serotonergic descending pain inhibitory pathways and inhibits excitatory nociceptive C fibers. Thus far, for the management of the various types of pain, most of clinicians have been applying monopolar PRF.[6,9,12,29]

Recently, it has been suggested that treatment using 2 parallel RF cannulas is more effective in reducing pain than monopolar PRF. Cosman et al[30] showed that parallel-tip bipolar RF induced larger-sized lesions compared with monopolar RF. Similarly, Kapural et al[31] suggested that bipolar intradiscal RF can target a broader area compared with monopolar RF. In addition, Shen et al[32] investigated normal human lumbar DRG in an imaging study and showed that in the case of L5 DRG, average mean length was 11.58 mm and mean width was 6.40 mm. When CRF was conducted using a cannula with a 20-gauge, 10-mm exposed tip, mean lesion size of monopolar RF was $7.8 \times 12.8\,mm^2$, whereas that of bipolar RF using parallel cannulas spaced by 10 mm was $15.5 \times 11.8\,mm^2$.[30] Considering the size of the human L5 DRG, a bipolar RF can sufficiently cover whole DRG area, but the monopolar RF cannot. Whereas it is unfitting to apply the results of CRF stimulation to PRF, we believe that similar results could be observed with the PRF procedure. In 2017, Chang et al[21] recruited 50 patients with chronic lumbosacral radicular pain, and assigned to monopolar or bipolar group. They reported that bipolar PRF on DRG controlled chronic lumbosacral radicular pain more effectively compared with monopolar PRF. However, no study has been conducted to evaluate the therapeutic efficacy of bipolar PRF in cervical radiculopathy.

In conclusion, we report 2 patients with refractory chronic cervical radicular pain who showed a good response to bipolar PRF on DRG to reduce radicular pain. The results of this study showed that bipolar PRF on DRG could be useful for controlling the cervical radicular pain, especially in patients who are unresponsive to monopolar PRF and TFESI. This is the first report to show the effective use of bipolar PRF for managing refractory cervical radiculopathy. However, this is limited because it is a case study. Further studies that involve larger case numbers are warranted for the clear elucidation of the effect of bipolar PRF.

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