Percutaneous Continuous Radiofrequency Application to Dorsal Root Ganglia in Spinal Cord Lesion Patients: Pilot Case Series

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Purpose: This pilot case series study aimed to evaluate the efficacy of continuous radiofrequency (CRF) application on dorsal root ganglia (DRG) to reduce spasticity of spinal cord lesion (SCL) patients.

Methods: We performed CRF procedures on DRG in 8 subjects (7 males; mean age 39 years, range 31-53 years) with intractable spasticity that impeded activities of daily living and caregiving, although they had maximal tolerable doses of anti-spastic medications and active rehabilitative treatment. All subjects underwent CRF (90 seconds at 90°C) at multiple lumbosacral and/or cervical DRG. Muscle tone of the extremities was measured by the modified Ashworth scale (MAS) before and one month after procedures. Functional goals were established at baseline, and subjects' satisfaction levels were categorized one month after procedures.

Results: A total of 54 CRF treatments were performed in 8 patients. In all patients, we found some improvement in muscle tone measured by the MAS. Six patients reported themselves satisfied with their current status at one month's post-treatment, and 2 patients were fairly satisfied with their gait pattern. In 3 patients, neuropathic pain was present after CRF on DRG. In 1 lumbar case, the pain subsided after several days, and the other 2 cervical cases suffered from tolerable neuropathic pain treated with anti-convulsant medication.

Conclusion: CRF on DRG might be a promising alternative treatment to reduce spasticity in SCL patients. Further well-designed clinical trials on the efficacy and safety of CRF application on DRG are needed.

Keywords: Continuous radiofrequency, Spinal Cord Lesion, Spasticity, Dorsal Root Ganglia

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I. Introduction

A spinal cord lesion (SCL) results in neurological functional loss that can cause significant long-term complications, including spasticity, pain, pressure sores, and fatigue.[1] Among these complications, spasticity may create major problems in chronic rehabilitation management. It occasionally impedes activities of daily living (ADL) and nursing care by interfering with positioning and functional movement of normally innervated muscles. Furthermore, severe spasticity also produces painful disability, decubitus ulcer, and sleep disturbance. Thus, control of spasticity in SCL patients is required to improve quality of life.

A daily routine of prolonged muscle stretching is the foundation for management of spasticity and, in some cases, may be sufficient to suppress spasms and maintain range of motion.[2-5] However, in general, reduction of hypertonia by prolonged stretching cannot last for a long time. The therapeutic approach to reduce spasticity has included a broad range of medical and surgical modalities. If physical therapy and anti-spastic medications are ineffective, chemical block or electrical ablation of peripheral nerves has been utilized as a means of treating spasticity.[6-8] Radiofrequency current is applied by a radiofrequency lesion generator through an electrode. This electric field places an electric force on the ions within tissue electrolytes, causing them to oscillate at a high rate (i.e., 300,000

times per second). Tissue heating is created by frictional dissipation of the ionic current within the fluid medium, which heats the electrode. As a result, by tissue heating, radiofrequency current produces ablation of the nerve. In the 1980's, several authors reported that radiofrequency rhizotomy might be used to treat spasticity in SCL patients.[9,10] Continuous radiofrequency (CRF) on dorsal root ganglia (DRG) has been suggested as a potential therapeutic option for chronic radicular pain.[11,12]

However, there have been reports about the efficacy of CRF on DRG to relieve spasticity. Herein, we report our preliminary short-term treatment experience of CRF application on DRG to relieve spasticity in SCL patients.

II. Methods

This was a case series study conducted on SCL patients who visited our spine center to control spasticity. Patients with spasticity were evaluated by a multi-disciplinary spasticity management team (physical therapist, physician). The procedures of CRF on DRG were conducted in 8 patients who had sustained spasticity, which caused difficulties in ADL and caregiving, despite the maximal tolerable dose of anti-spastic medications and active physical and occupational treatments. Subjects' spasticity and the amount of anti-spastic medications were not changed for latest one month before procedures. Target DRG for CRF application was chosen according to predominant spastic muscles of the extremities.

Eight patients were evaluated at baseline and 1 month after treatment. The modified Ashworth scale (MAS) was used for assessment of changes in muscle tone before and one month after procedures.[13,14] In the MAS, the muscles have a score of 0, 1, 1^{+}, 2, 3, and 4. The functional goals of the CRF procedure were determined at baseline assessment. Patients` levels of satisfaction regarding CRF procedures were categorized into three categories (good, fair, poor). The “good” categories were reflective of patients' satisfaction after the CRF procedure. The amount of physical therapy, occupational therapy, and anti-spastic drugs used were not changed before or after procedures.

All patients were treated in our inpatient clinic. For the lumbosacral procedure, the patient was placed prone on the fluoroscopic table. The procedures were performed in tunnel vision, a technique for entering the electrode in the direct vision of the x-ray. Therefore, the C-arm was adjusted in such a way that the x-ray ran parallel to the end plates of the relevant level. Thereafter, the C-arm was rotated until the spinous process projected over the contralateral facet column, approximately 25～30°. A 10 cm long, 18 G needle SMK-10 mm tip (Cotop International BV, Amsterdam, the Netherlands) was inserted locally in the direction of the x-ray. Thereafter, a needle was inserted and slowly advanced using a tunnel vision technique. The depth of the needle was checked following each advancement using a lateral view. If the needle tip was located in the proper position within the intervertebral foramen, the catheter needle was then inserted and positioned as near as possible to the DRG with the aid of a radio frequency generator (RFG-1A, Cosman Medical Inc. USA), and 50 Hz stimulation test was performed (Figure 1A). When abnormal sensation or motor response was observed with a stimulation of less than 0.3 V, the catheter needle was considered to be placed near the DRG. Following that, a CRG was applied at 90°C for 90 seconds. This procedure was repeated at each level.

For the cervical procedure, the subject was laid in a supine position under fluoroscopic control using a C-arm (Arcadis Orbic, Siemens, Germany). A 22-gauge cannula (SMK Pole needle 54 mm with 4 mm active tip, Cotop International BV, Amsterdam, the Netherlands) was placed around the dorsal root ganglion that lay within the intervertebral foramen. The cannula was inserted over the caudal and posterior parts of the intervertebral foramen, and its tip was placed at the border between the center and one third of the caudal part from the posterior neural foramen (Figure 1B). The catheter needle was then inserted and positioned as near as possible to the DRG with the aid of a radio frequency generator (RFG-1A, Cosman Medical Inc. USA), and a sensory stimulation test was performed. When abnormal sensation or pain was observed with a stimulation of less than 0.3 V, the catheter needle was considered to be placed near the DRG. When a sensory stimulation was not made, the catheter needle was inserted more deeply into the intervertebral foramen until the subject complained of a dull pain; however, the needle was not inserted beyond the lateral half of the articular mass seen on an anteroposterior view. The radiofrequency generator was set so that the temperature of the catheter needle tip would not exceed 90°C, and a radiofrequency was applied for 90 seconds at 90°C.

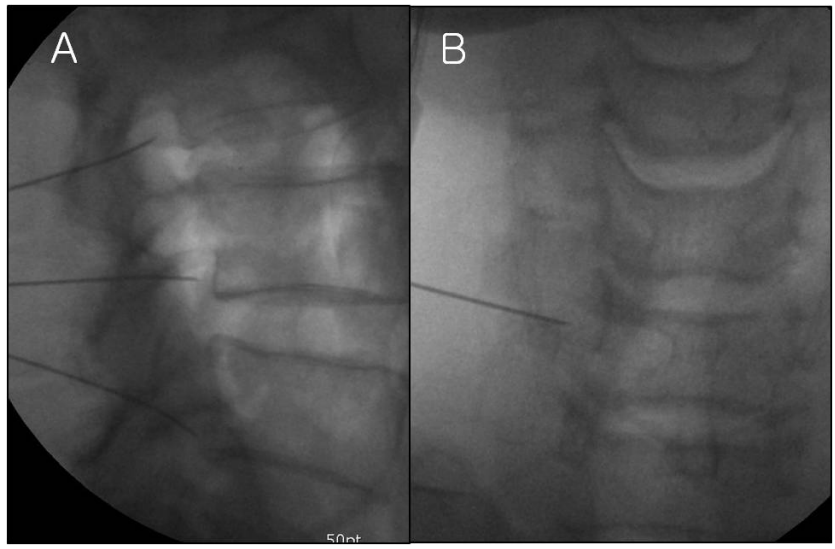

Figure 1A is lateral view of lumbar area on C-arm fluoroscopy. Needle tips of continuous radiofrequency (CRF) were placed adjacent to lumbar dorsal root ganglia (DRG). 1B is anteroposterior view. Needle tip of CRF was placed adjacent to right 7th cervical DRG.

III. Results

A total of 54 CRF applications on DRG were conducted in 8 patients who had been managed for a long period of time with the maximal tolerable dose of oral baclofen as well as tizanidine. A summary of the clinical data, including treated levels and subjects' satisfaction levels, are given in Table 1. Cases 1, 2, and 3 were complete SCL patients, and there were difficulties in transfer or caregiving due to spasticity of the lower extremities with generalized phasic pattern. Thus, the target DRG by CRF application were from L2 to S1 in these patients. After procedures, transfer and nursing by the caregiver became easier than pre-treatment. All three patients reported themselves satisfied with their current status at one month's post-treatment. MAS scores of target motor segments were markedly decreased 1 month after treatment compared to pre-treatment (Table 2).

Cases 4, 5, 6, 7, and 8 were incomplete SCL patients with focal pattern spasticity of the extremities. Cases 4, 5, and 6 patients had difficulty in gait due to spasticity of the lower extremities. The spasticity in the lower extremities had reached the point where it was difficult to ambulate safely. They were dependent upon a cane for short distance mobility due to scissoring and hypertonic knee extensors or ankle plantar flexors. After CRF on target DRG according to their respective spastic muscles, the MAS of target motor segments was moderately reduced (Table 3). Cases 7 and 8 patients had difficulty in daily living activities due to spasticity of the upper extremities. Case 7 patient had clumsy hand function due to spasticity of the finger flexors. After CRF on left C8 DRG, manipulation in the hand markedly improved. In case 8 patient, spasticity of the elbow extensor disturbed use of the upper extremities. After CRF on left C7 DRG, function of the left upper extremity, eating or typing with equipment, improved. Cases 4, 7, and 8 patients were satisfied with their current functional status due to reduced spasticity. On the other hand, spasticity of the lower extremities of cases 5 and 6 patients was not adequately reduced, and they were fairly satisfied with their gait ability.

In 3 patients, neuropathic pain was present after CRF on DRG. Cases 7 and 8 patients suffered from neuropathic pain over the dermatomal distribution of the 8^{th} and 7^{th} cervical DRG, respectively. However, their neuropathic pain was maintained at a tolerable level with pregabalin medication. Case 6 patient also experienced neuropathic pain over the dermatomal area of the 1^{st} sacral DRG, but it subsided after several days.

Table 1. Subjects' characteristics, treatment levels, and satisfaction levels regarding procedures

Case	Age/Sex	Interval(injury to CRF)(mo)	Diagnosis	Treatment levels	Problems	Functional goals	Subjects' satisfaction
1	38/M	5	Spinal trauma (C3 complete tetraplegia)	Both L2~S1	Difficulty in transfer and caregiving due to leg spasticity	Nursing care	Good
2	60/M	24	Spinal trauma (C5 complete tetraplegia)	Both L2~S1	Difficulty in transfer and caregiving due to leg spasticity	Nursing care	Good
3	45/M	20	Spinal trauma (C6 complete tetraplegia),	Both L2~S1	Difficulty in transfer and caregiving due to leg spasticity	Nursing care	Good
4	40/M	240	Hereditary spastic paraplegia	Both L2,3,S1	Spastic gait due to both hip adductor and ankle plantar flexor spasticity	Improving gait pattern	Good
5	53/M	9	Spinal cord tumor (T5 incomplete tetraplegia)	Both L3	Gait disturbance due to bilateral knee extensor spasticity	Improving gait pattern	Fair
6	49/F	8	Spinal cord tumor (T7 incomplete paraplegia)	Both S1	Spastic gait due to bilateral ankle plantar flexor spasticity	Improving gait pattern	Fair
7	33/M	26	Spinal trauma (C3 incomplete tetraplegia)	Left C8	Left clumsy hand due to finger flexors spasticity	In hand manipulation	Good
8	38/M	5	Spinal trauma(C3 incomplete tetraplegia)	Right C7	Difficulty in self feeding due to elbow extensor spasticity	Self feeding with equipment	Good

IV. Discussion

There have been no studies on the efficacy of CRF on DRG to relieve spasticity after SCL. In the present study, we reported on the short-term treatment experience of CRF on DRG to reduce spasticity in 8 cases. Generalized phasic spasticity in the lower extremities of complete tetraplegia and paraplegia was well controlled, and satisfaction of patients was achieved. Nursing care was managed more easily post-treatment than pre-CRF procedures. Focal spasticity in incomplete tetraplegia and paraplegia was moderately decreased, resulting in improved gait patterns and upper extremity functions. Three patients presented with neuropathic pain after the procedure, but these adverse events were not long lasting and were tolerable with neuropathic pain medication.

Severe spasticity in tetraplegia and paraplegia may create functional problems in chronic rehabilitation, and daily prolonged stretching or anti-spastic medications are routinely

Table 2. Modified Ashworth scale scores of cases 1, 2, and 3, patients with complete spinal cord lesion: pre-treatment and post-treatment after 1 month

Case	Time	Hip flexor		Hip adductor		Knee extensor		Ankle Plantar flexor	
		Right	Left	Right	Left	Right	Left	Right	Left
1	Pre	2	2	2	2	2	2	2	2
	Post	0	0	0	0	1	1	1	1
2	Pre	3	3	3	3	3	3	3	3
	Post	1	1	1+	1+	1+	1	1+	1+
3	Pre	3	3	3	3	3	3	3	3
	Post	1+	1+	1+	2	1+	1+	1+	2

Pre: pre-treatment, Post: post-treatment

Table 3. Modified Ashworth scale scores of cases 4, 5, 6, 7, and 8, patients with incomplete cord lesion: pre-treatment, post-treatment after 1 month

Case	Spastic muscles		Pre	Post
4	Hip adductor	Right	2	2
		Left	3	2
	Ankle plantar flexor	Right	3	1+
		Left	3	1+
5	Knee extensor	Right	2	1+
		Left	2	1+
6	Ankle plantar flexor	Right	3	2
		Left	3	2
7	Finger flexor	Left	1+	1
8	Elbow extensor	Right	3	1+

Pre: pre-treatment, Post: post-treatment

applied to suppress spasticity. If anti-spastic medications and physical therapy fail or are incapable of reducing spasticity, there is a second option of interventional or surgical procedures. The afferent limb of the classic stretch reflex includes the skeletal muscle spindle and its afferent fibers, which travel proximally in the peripheral nerve and posterior spinal root to the spinal cord, where they synapse directly or indirectly with the anterior horn motor neurons. Surgical posterior rhizotomy and percutaneous posterior rhizotomy interrupts the afferent limb of the stretch reflex at the posterior sensory root level, which is proximal to DRG. Sherrington reported a reduction of hypertonus after resection of posterior sensory roots in decerebrate cats.[15] After this study, interest in modifying posterior rhizotomy procedures for the relief of spasticity arose.[16,17]

CRF that was previously utilized to treat chronic radicular pain demonstrated effectiveness in pain control through the application of heat and the subsequent destruction of afferent nociceptive fibers. Pulsed radiofrequency on DRG has also been utilized to control radicular pain, because DRG is believed to be special sensory neurons' collection to transmit sensory input to the dorsal horn of the spinal cord. Interruption of the afferent limb of the stretch reflex at DRG by percutaneous CRF could more effectively suppress hyperexcitable sensory neurons implicated in spasticity by percutaneous or surgical posterior rhizotomy. Furthermore, some advantages of the CRF procedure are safety and simplicity of the method, percutaneous application, and possibility of localizing the nerve with the help of electrical stimulation.

In the present study, no incomplete SCL patients receiving CRF on DRG experienced loss of motor function. One patient, case 8, reported reduction of elbow extensor spasticity and improvement in hand voluntary motor function after the procedure. We cannot exactly explain the mechanism of improvement of hand function. Partial interruption of the afferent limb of the myotactic stretch reflex by non-selective coagulation of sensory neurons in the 7th cervical DRG might be responsible for improved hand function. It could be explained by motor facilitation of finger flexor muscles, which had been inhibited by spastic metacarpophalangeal extensor muscles innervated by the 7th cervical segment.

This pilot study also demonstrated that neuropathic pain developed after CRF on DRG in incomplete SCL patients. In particular, CRF application on cervical DRG provoked sustained neuropathic pain during the observational period, which required neuropathic pain medication. There is a possibility that neuropathic pain induced by CRF procedures on DRG might limit widespread use of this procedure in incomplete SCL patients.

In conclusion, we found that CRF on DRG might be a promising alternative treatment to reduce spasticity in chronic SCL patients. To the best of our knowledge, this is the first case series study about the efficacy of CRF application on DRG in SCL patients. The major limitation of this study is that it is a short-term follow up case study, and quantitative functional evaluation parameters were not utilized to measure the efficacy of the procedure. Therefore, we believe that a well-designed

long-term follow-up clinical trial with a larger group of subjects is necessary in future studies. Long-term efficacy and adverse events following CRF on DRG should then be elucidated in detail.

Author Contributions

Research design: Lee DG, Ahn SH
Acquisition of data: Lee DG
Analysis and interpretation of data: Lee DG, Ahn SH
Drafting of the manuscript: Lee DG, Ahn SH
Research supervision: Ahn SH

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