

Clinical Efficacy of Pulsed Radiofrequency Treatment Targeting the Mid-cervical Medial Branches for Intractable Cervicogenic Headache

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Objective: Cervicogenic headache has been known to originate from the convergence of the upper 3 cervical and trigeminal afferents. The administration of conservative treatments, interventional procedures, and more recently, pulsed radiofrequency, has been used to relieve cervicogenic headache. In this study, the authors evaluated the clinical efficacy and safety of pulsed radiofrequency targeting the mid-cervical medial branches.

Materials and Methods: From September 2012 until December 2017, 395 patients were diagnosed with cervicogenic headache based on the third edition of the International Classification of Headache Disorders. The authors treated them conservatively at first, and those patients with nonresolution of pain were treated with mid-cervical medial branches block applied from C3 to C5 twice. Subsequently, if any patient continued to experience persistent pain, the authors classified them as having intractable cervicogenic headache and performed pulsed radiofrequency treatment targeting the mid-cervical medial branches from C3 to C5 bilaterally. The authors analyzed their demographics and used a Visual Analogue Scale to assess their pain for 12 months.

Results: Fifty-seven patients were enrolled in this study. The mean age was 49.8 years, and the mean duration of symptoms was 47.7 months. The mean Visual Analogue Scale score was 6.21 before pulsed radiofrequency treatment, and it improved to 1.54 immediately after the procedure without the symptoms recurring for a minimum of 12 months. There were no severe complications, such as vascular or nerve injuries.

Conclusions: In patients with intractable cervicogenic headache, pulsed radiofrequency treatment targeting the mid-cervical medial branches resulted in a satisfactory, long-lasting outcome without serious complications.

Key Words: cervicogenic headache, pulsed radiofrequency, neuro-modulation, chronic neck pain, medial branch block

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The authors declare no conflict of interest.

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Cervicogenic headache (CHA) is one of the secondary headache disorders. The prevalence of CHA was estimated to be ~4.1%, and most of the patients affected by CHA report unresolved, recurrent throbbing pain.¹ Since CHA was studied by Sjaastad et al in 1983,² it has been treated with many treatment modalities, such as the administration of medicines, physiotherapy, transcutaneous electrical nerve stimulation, and interventional procedures. However, these treatments do not result in long-term relief for many patients and need to be repeated. Pulsed radiofrequency treatment (PRF) is one of the modalities used to treat CHA.^{3,4} CHA has been known to originate from the convergence of the 3 upper cervical and trigeminal afferents, and therefore, many physicians have performed PRF targeting the upper cervical structures (occipital nerve, C2 dorsal root ganglion).^{5–8} However, this results in only short-term pain relief in the posterior head, and it can lead to some complications, such as vascular and nerve injuries.^{9–11} Because of these limitations, we have attempted PRF targeting the mid-cervical medial branches, and we evaluated the clinical efficacy and safety of this modality as an alternative treatment option for CHA.

MATERIALS AND METHODS

Our study was approved by the institutional review board (IRB number 2018-07-009-001). From September 2012 until December 2017, 395 patients were diagnosed with CHA in our institute based on the third edition of the International Classification of Headache Disorders¹² (Table 1). All patients received conventional treatment that included medication (nonsteroidal anti-inflammatory drugs, analgesics, muscle relaxants), physiotherapy, and advice regarding lifestyle modifications. We performed a diagnostic block twice with an interval of 2 weeks in between, for those patients in whom the conservative treatment failed. We used a total of 12 mL of mixed solutions; 5 mL of 2% lidocaine (K. M. Lidocaine HCl injection 400 mg/V; HUONS. Co., Ltd), 1 mL of 5 mg dexamethasone (Dexa-S injection 5 mg/1 mL/A; Ilsung Pharmaceuticals Co., Ltd.), and 6 mL of normal saline. Two milliliters of this mixed solution was injected around every single medial branch (from C3 to C5 bilaterally). If the dual diagnostic block provided adequate pain relief for >2 weeks, conservative treatment was continued. If not, the patients were diagnosed with intractable CHA and enrolled in our study. PRF targeting the mid-cervical medial branches (from C3 to C5 bilaterally) was performed for these patients (Fig. 1).

The data associated with the patients' demographic characteristics and the clinical outcomes that were obtained from their medical records were analyzed retrospectively.

TABLE 1. Diagnostic Criteria of Cervicogenic Headache in the International Classification of Headache Disorders, Third Edition

Diagnostic criteria

- A. Any headache fulfilling criterion C
- B. Clinical and/or imaging evidence of a disorder or lesion within the cervical spine or soft tissues of the neck, known to be able to cause headache
- C. Evidence of causation demonstrated by at least 2 of the following:
 1. Headache has developed in temporal relation to the onset of the cervical disorder or appearance of the lesion
 2. Headache has significantly improved or resolved in parallel with the improvement in or resolution of the cervical disorder or lesion
 3. Cervical range of motion is reduced and headache is made significantly worse by provocative maneuver
 4. Headache is abolished after a diagnostic blockade of a cervical structure or its nerve supply
- D. Not better accounted for by another ICHD-3 diagnosis

ICHD-3 indicates Third Edition of International Classification of Headache Disorders.

For all the patients, the pain experienced was assessed using a Visual Analogue Scale (VAS) before PRF, immediately after the procedure, and during follow-up at 1, 3, 6, and 12 months. The patients were monitored at the outpatient clinic or by telephone interview. If any patient had $\leq 50\%$ improvement in their pre-PRF VAS scores, we provided additional treatments (other medication, an occipital nerve blockade, a medial branch block, or repeated PRF), and the VAS score at that time was recognized as the last VAS score.

Data were analyzed using version 23 of the Statistical Package for the Social Sciences (SPSS) software (SPSS Inc.) and a paired *t* test was used to analyze the changes in the VAS scores.

PRF Technique

The PRF procedure was performed using a Cosman G4 (Cosman Inc., Burlington, MA) radiofrequency generator under biplane fluoroscopy in the neurointervention room. Each patient was made to lie down in the prone position, and the target site was prepared aseptically. After confirming the correct anatomic site with radiologic assistance, 22-G insulated needles

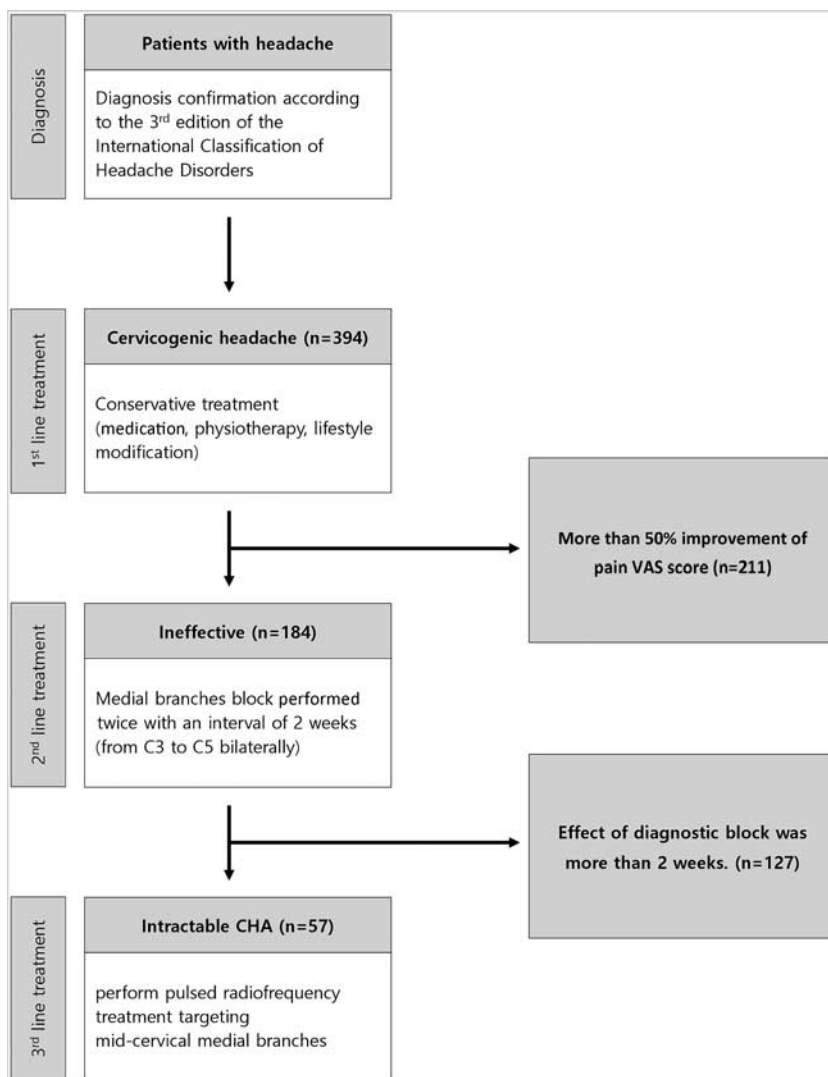


FIGURE 1. Treatment paradigm of CHA and patient inclusion process. CHA indicates cervicogenic headache; VAS, Visual Analogue Scale.

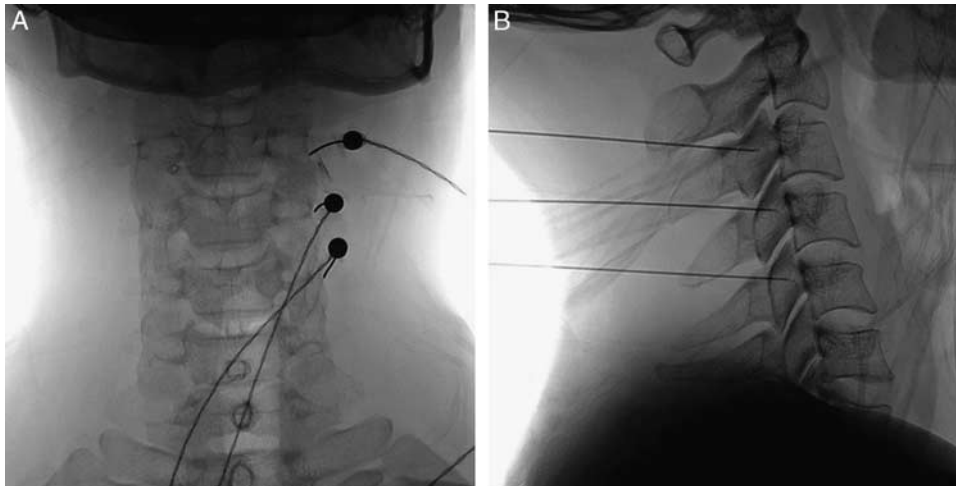


FIGURE 2. Radiograph showing the radiofrequency needles targeting the right C3, C4, and C5 medial branches. A, An anterior-posterior radiograph showing the needle tips on the concave lateral surface of the articular pillar of each cervical vertebra. B, A lateral radiograph showing the needle tips in the center of the articular pillars.

were inserted into both the medial branches of C3, C4, and C5 by means of the posterior approach under the guidance of biplane fluoroscopy. Subsequently, the introducer was removed, and an electrode (Diros OWL RF cannula; Diros Technology, Inc., Canada) was inserted. Selective sensory nerve stimulation (50 Hz) was conducted and showed concordant pain below 0.5 V. This response was recognized as a positive response, and it confirmed the correct localization of the electrode. Motor nerve stimulation was then tested at 2 Hz to avoid damage to the nerve. Following this, PRF was performed below 42°C for 2 minutes (50 V, 240 pulses) at each site (Fig. 2).

RESULTS

A total of 57 patients were included in our study who were experiencing intractable CHA. Their mean age was 49.8 years (18 to 78 y). Among them, 42 were women (mean age was 50.6 y) and 15 were men (mean age was 47.5 y). Seventeen patients had underlying diseases that were not known to influence CHA such as hypertension, diabetes mellitus, dyslipidemia, arterial fibrillation, old myocardial infarction, and old cerebrovascular disease. The mean duration for which the symptoms were present was 47.7 months, and the mean follow-up period was 15.3 months. The patients’ demographics are summarized in Table 2.

All the patients reported experiencing marked pain relief immediately after PRF (VAS 6.21→1.54, $P=0.017$) and significant pain relief when the last VAS score was assessed (VAS 6.21→1.77, $P<0.001$). Although there were patients who

reported recurrent pain, the overall VAS score tended to improve. The mean duration of pain relief was 12.4 months (4 to 27 mo). Twenty-five patients reported marked improvement in their symptoms and were able to stop analgesic medications. The mean VAS scores that were evaluated during the follow-up period are presented in Figure 3.

During follow-up, 15 of the 57 patients experienced $\leq 50\%$ improvement in their pre-PRF VAS scores. Their mean duration of pain relief was 10.1 months. Their mean VAS score was 6.86 before PRF, and 2.13 immediately after PRF, and the last VAS score was 4.4. The demographic characteristics and clinical outcomes of the patients with recurrent pain are presented in Table 2. The other 42 patients (73%) experienced marked pain relief, noted as a $\geq 50\%$ improvement of their VAS scores at the 12-month follow-up after PRF (Table 3).

None of the patients experienced vertebral artery injuries, nerve root injuries, infections, or hematoma. Five patients (9%) reported several minor side effects. Three of these 5 patients developed transient hypoesthesia on the posterior part of their necks; however, the symptoms spontaneously subsided within a week. One patient each experienced nausea and dizziness immediately after the procedure, both of which improved within a few hours.

TABLE 2. Demographics of the Patients With Intractable Cervicogenic Headache

Factors	All Patients (57)	No Recurrent (42)	Recurrent (15)
Male/female	15/42	11/31	4/11
Mean age (y)	49.8 (18-78)	51.8 (20-78)	44.4 (18-76)
Underlying disease (yes/no)	17/40	12/30	5/10
Mean duration of symptom (mo)	47.7 (1-480)	38.3 (1-240)	74.1 (1-480)
Mean follow-up period (mo)	15.3 (6-39)	13.9 (6-39)	19 (8-39)

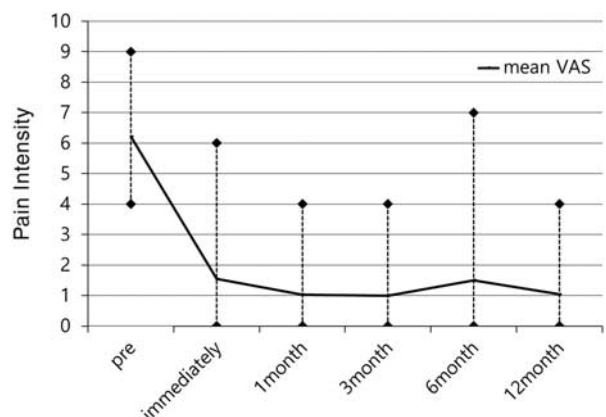


FIGURE 3. Mean VAS score of patients during the follow-up period. VAS indicates Visual Analogue Scale.

TABLE 3. Clinical Outcomes of the Patients With Intractable Cervicogenic Headache

Factors	All Patients (57)	No Recurrent (42)	Recurrent (15)
Mean VAS (pre)	6.21	5.97	6.86
Mean VAS (immediately after)	1.54	1.33	2.13
Mean VAS (last)	1.77	0.85	4.4
Mean pain relief period (mo)	12.4 (5-29)	13.2 (6-27)	10.1 (5-29)
Medication after 1 y (yes/no)	32/25	17/25	15/0
Complications	5	3	2

VAS indicates pain Visual Analogue Scale.

DISCUSSION

Although there are many treatment modalities for CHA such as medications, physiotherapy, transcutaneous electrical nerve stimulation, botulinum toxin injection, occipital nerve blockade, and surgical decompression,¹³⁻¹⁸ none have proven to be singularly effective.⁵ Among the aforementioned modalities, PRF has been shown to have long-term effects on variable pain disorders.^{3,19} The convergence of the 3 upper cervical and trigeminal afferents is known to cause CHA^{5,20}; therefore, many physicians who have performed PRF have focused on the upper cervical structures (C2 dorsal root ganglion, atlantoaxial joint, greater or lesser occipital nerve). The patients in our study were treated with PRF targeting the mid-cervical medial branches (from C3 to C5 bilaterally). The medial branch of the dorsal ramus of the C3 spinal nerve, which is also known as the third occipital nerve, innervates the semispinalis capitis muscles that are located in the middle of the occipital area.²⁰ An earlier study performed successful anesthetic blockades of the mid-cervical spinal nerves to treat CHA and demonstrated that CHA was also related to the mid-cervical spinal nerve and that mid-cervical spinal anesthetic blockades could be effective in treating CHA.²¹ Another study by Park et al²² reported that the muscle tone and stiffness of the upper trapezius muscle were increased in patients with CHA. As the C3 and C4 spinal nerves innervate the dermatomes on the posterior surface of the neck near the trapezius muscle,²³ CHA could be relieved with a targeted a mid-cervical radiofrequency that reduced the muscle tone and relaxed the trapezius. In addition, the entrapment of the occipital nerve within the trapezius has also been implicated in the pathogenesis of CHA²⁴; therefore, PRF targeting the mid-cervical medial branches could relieve the pain by relaxing the muscle.

A number of studies have demonstrated the efficacy of PRF in treating CHA. Grandhi et al²⁵ reviewed 10 articles to evaluate the efficacy of PRF in treating CHA. The studies that were included were analyzed using the Cochrane Risk of Bias to measure the methodological quality. Within the included studies, Halim and colleagues reported the long-term effect of PRF targeting the lateral atlantoaxial (C1-C2) joint through an anterolateral approach. In this study, 86 patients diagnosed with CHA were treated with C1-2 targeted PRF, of whom 44.2% (38/86) experienced ≥ 50% pain relief 1 year after the procedure.⁷ The authors, Hamer and Purath,⁸ performed PRF targeting the C2 dorsal root ganglion and the third occipital nerve of 40 patients. Based on the characteristics of the CHA symptoms, they either

TABLE 4. Comparison of this Study to Other Studies that Analyzed the Efficacy of PRF Treatment Targeting the Upper Cervical Structures

Article	Type of Study	Patients	Target of PRF	Assessment of Pain	Clinical Outcomes
Halim et al ⁷	Prospective	86 patients with CHA	Lateral atlantoaxial (C1-C2) joint	Pain was assessed by VAS score	44.2% (38/86) patients reported > 50% pain relief 1 y later the procedure
Hamer & Purath ⁸	Prospective	40 patients with intractable CHA and occipital neuralgia who have been received maximized conservative therapy	C2 dorsal root ganglion and/or third occipital nerve	Patients reported reduction of pain as 100%, 75%, 50%, 25%, 0%. And the duration of pain relief was evaluated	The mean duration of > 50% pain relief was 22.35 wk
Current study	Retrospective	57 patients who have been treated with medicine, medial branches block	C3-C5 medial branches	Clinical outcome was assessed by VAS score and pain relief period	73.6% (42/57) patients reported > 50% pain relief at 1 y later the procedure. The mean duration of > 50% pain relief was 12.4 mo

CHA indicates cervicogenic headache; PRF, pulsed radiofrequency; VAS, pain Visual Analogue Scale.

targeted the C2 dorsal root ganglion and the third occipital nerve individually or together at the same therapeutic session. Further, the study defined an improvement as a self-reported $\geq 50\%$ pain reduction after the treatment. They reported that the mean duration of the improvement was 22.35 weeks.⁸ Our results demonstrate that 42 of the 57 patients (73%) reported experiencing ≥ 50 pain relief at 1-year after the treatment, and the mean duration of this pain relief was 12.4 months (Table 4).

The previous technique to treat CHA that involved PRF targeting the upper level of the cervical spine rarely resulted in injury, although it carried an inherent risk of complications because of the proximity of anatomic structures such as the nerve roots and vertebral artery.^{9–11} And vertebral artery injury could be fatal for patients. In contrast, there are no such anatomic structures around the mid-cervical medial branches, and the cervical lamina prevents damage to important structures. Therefore, PRF targeting the mid-cervical medial branches could be a safer therapeutic approach.

Although 15 of the 57 patients in this study experienced pain relief immediately after PRF, their VAS scores increased to $> 50\%$ of the preprocedural scores within 1 year. There were no statistical differences in the demographic characteristics between the group of patients with recurrent pain and the one without recurrent symptoms (Table 2). Additional studies are required to uncover the factors that shorten the effects of PRF. Patients with recurrence of pain were advised additional treatment modalities. Two patients were treated with medial branch blocks (from C3 to C5, bilaterally), and we performed an additional session of PRF for 8 patients. As a result of these interventions (PRF, medial branches block), their symptoms were relieved immediately.

Our study has several limitations. We only assessed the clinical outcome using a pain VAS. Additional indices that assess the influence of CHA on the patients' quality of life are needed. Our study was a retrospective study and not a randomized controlled study. To the authors' knowledge, this study has the largest sample size among the published articles that analyzed PRF targeting the mid-cervical medial branches. However, the sample size is small (57 patients). Randomized, controlled studies with a larger study sample are required to investigate the clinical effects of PRF targeting the mid-cervical medial branches.

CONCLUSIONS

PRF targeting the mid-cervical medial branches can result in immediate and long-lasting pain relief for patients with intractable CHA whose symptoms were not relieved with other treatment modalities. Moreover, targeting the mid-cervical medial branches is safe because of the anatomy involved. Therefore, we suggest that PRF targeting the mid-cervical medial branches could be an alternative modality for patients with intractable CHA.

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