Prospective Evaluation

Computed Tomography–Guided Percutaneous Coblation of the Thoracic Nerve Root for Treatment of Postherpetic Neuralgia

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Background: Postherpetic neuralgia (PHN) is one of the most intractable pain disorders and often does not respond to medication, physical, and interventional procedures. Coblation technology has been demonstrated to have potential for neuralgia, but there are rare reports of the efficacy and security of coblation for PHN. The thoracic segment is the most common predilection part of PHN, so we conducted this long-term study to investigate the results of coblation for the treatment of thoracic PHN.

Objectives: The aim of this study was to determine the efficacy and security of computed tomography (CT)-guided coblation of the thoracic nerve root for treatment of PHN.

Study Design: Self before-after controlled clinical assessment.

Setting: Department of Pain Management, Xuanwu Hospital, Capital Medical University.

Methods: Seventy-seven patients with thoracic PHN sustained for at least 6 months and refractory to conservative therapy were identified. Patients underwent CT-guided percutaneous coblation to ablate the thoracic nerve root for thoracic PHN. The therapeutic effects were evaluated using a Visual Analog Scale (VAS), medication doses, and pain-related quality of life (QoL) scale before coblation, and at 1 week, and at 1, 3, and 6 months after the procedure. Patients who achieved more than 50% pain relief were defined as responders. In addition, adverse effects were also recorded to investigate the security of this procedure.

Results: The VAS score significantly decreased from 7.22 ± 1.15 before the coblation to 3.51 ± 1.12 ($P = 0.01$), 3.02 ± 1.21 ($P = 0.006$), 3.11 ± 2.15 ($P = 0.014$), and 2.98 ± 2.35 ($P = 0.008$) at 1 week, and at 1, 3, and 6 months after the procedure, respectively. The number of responders were 56 (77.78%), 54 (75%), 55 (76.39%), and 54 (75%) at 1 week, and at 1, 3, and 6 months after the procedure, respectively. The doses of anticonvulsants and analgesics were decreased significantly at all time points after the procedure compared with before treatment ($P < 0.05$). Patient responses on the Brief Pain Inventory Short Form indicated mean scores that were significantly lower than baseline across all domains of pain interference with QoL at all evaluations ($P = 0.001$). Most of the patients had mild numbness and it did not affect the daily activities after the procedure. No other severe adverse events occurred during or after the procedure.

Limitations: A single-center study, relatively small number of patients, short duration of review of medical record, and the retrospective study.

Conclusions: CT-guided percutaneous thoracic nerve root coblation is an effective and safe method for the treatment of thoracic PHN, and the procedure can also significantly improve the QoL in patients with PHN.

Key words: Neuropathic pain, quality of life, radiofrequency ablation, plasma-mediated technology, numbness

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Postherpetic neuralgia (PHN) is the most common complication of herpes zoster (HZ). Some 10% to 20% of patients with HZ will develop PHN, and the risk of developing PHN would increase significantly if no effective pain treatments were performed in the acute phase of HZ (1-3). The most commonly affected site of PHN is the thoracic area, and the pain may be described as burning, stabbing, shooting, or pinching (4). Fatigue, anorexia, weight loss, insomnia, reduced physical activity, depression, anxiety, and a decrease in social contacts are commonly associated with PHN. Therefore PHN generate a significant impairment of quality of life (QoL) in the general population and more specifically in older persons who are particularly affected by these pathologies (5).

Numerous therapies are available, including medications, nerve blocks, neuromodulation, and minimally invasive surgery, all of which have varying success rates (6-11). Currently, plasma-mediated technology (commonly known as the plasma knife or the controlled ablation [coblation] technique) is being used in several medical fields, such as otolaryngology, urology, and gynecology (12-14). Coblation utilizes bipolar radiofrequency current to generate a thin plasma field at a relatively low temperature (40℃–70℃), the kinetic energy ion layer interrupts the molecular bond, cuts or ablates the tissue, and the tiny pieces are then removed through the tunnel of an introducer needle (15). Coblation has been used for the treatment of discogenic pain, cervicogenic headache, phantom limb pain, stump pain, painful bone diseases, and Achilles tendinosis (16-20). Recently, a pilot study at our center demonstrated that plasma-mediated technology was successful in alleviating thoracic neuralgia, but only 5 patients with PHN were included (21).

The purpose of this study was to present our first-hand experience using computed tomography (CT)-guided percutaneous coblation to ablate the thoracic nerve root in patients with PHN, and to evaluate the efficacy and security of this procedure.

Methods

Patients

From June 2014 to April 2018, patients who had intractable PHN and who were treated with coblation to ablate the thoracic nerve root were enrolled. This study was approved by the institution's ethics examination committee of human research (Xuanwu Hospital, Capital Medical University, Beijing, China), and informed patient consent was obtained from all patients before the procedure.

The inclusion criteria were as follows: age 30 to 80 years, a history of PHN greater than 6 months, and pain Visual Analog Scale (VAS) score of greater than 4. Patients were also refractory to medication, physical, and interventional procedures. Also, having pain in the dermatome belt between T2 and T11. Additionally, patients were treated with coblation to ablate the thoracic nerve root.

The exclusion criteria were refusal to participate, uncooperative behavior, and intellectual inability to complete the self-evaluation questionnaires.

Description of Interventions

The patients' main physiological parameters, blood pressure, heart rate, electrocardiography, and saturation of pulse oxygen were monitored, and the baseline data were recorded while in a supine position. All patients received continuing low-flow nonhumidified nasal cannula oxygen (2 L/min) and continued intravenous infusion of 0.9% normal saline solution while respiratory signs were closely monitored throughout the procedure. The procedure was performed in an operating room equipped with CT-guided machine. Patients in the lateral position were placed on the procedure table, and a suitable cushion was placed under the flank to keep the thoracic vertebrae straight.

After the position was satisfactory, the initial image was acquired to design the treatment plan, including the puncture point, route, and distance. First, the image showed the outer aspect of the intervertebral foramen, and the point where the thoracic nerve root exited was the target. Second, the puncture routine was locally anesthetized using 1% lidocaine. After local anesthesia onset, an 18G introducer needle was carefully inserted via CT-guidance until the needle tip reached the upper edge of the intervertebral foramen (in close proximity to the target) (Figs. 1, 2). Third, the introducer needle was retracted 2 to 3 mm after reaching its target, the coblation wand (UNITEC, China America United Technology [Beijing] Co. Ltd., Beijing, China) was inserted through the introducer needle, and extended approximately 5 mm beyond the introducer needle. Fourth, coagulation mode was used to confirm if the wand tip reached the target. The coblation procedure was performed as our center previous reported (21). The coagulation mode was set with a radiofrequency controller at 1' (33 Watts) for 0.5 seconds to induce the presence of paresthesia and movement

in the distribution of the target nerve and ensure that the active portion of the wand had reached the target. Finally, the target nerve was ablated using a previously used ablated program: 100 kHz, 2' (52 Watts), 10 sec/cycle, 6 ablations. The total duration of coblation was approximately 1 minute. Following the procedure, patients were mandated to stay in bed for 24 hours. All procedures were performed by 1 experienced physician.

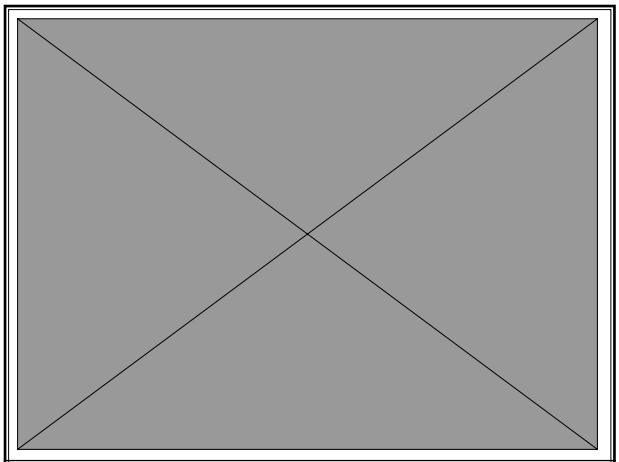

Fig.1. *CT image of coblation cannulas that reached the ideal thoracic nerve root.*

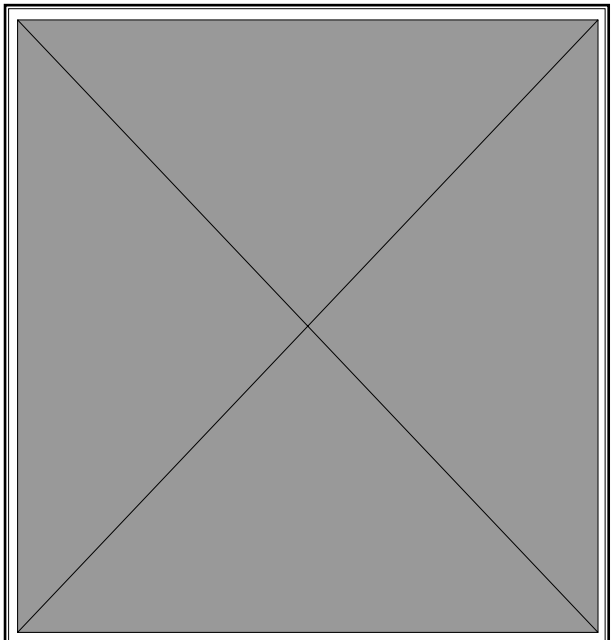

Fig. 2. *CT three-dimensional vertebral reconstruction image showing the extraforaminal areal and introducer needle, which reached their target.*

Evaluation of Therapeutic Effect

Data Collection

The clinical status of the patients was evaluated 1 day before coblation (baseline) and at 1 week after coblation, and the patients were followed up by outpatient review or telephone at 1, 3, and 6 months. A physician blinded to patient status was responsible for data collection.

VAS

Pain intensity was evaluated via VAS scores (a 10-cm unmarked line with anchors: 0 = no pain and 10 cm = worst pain imaginable). Patients whose pain VAS score decreased by more than 50% were defined as responders, and the percentage of responders was calculated at 1 week and at 1, 3, and 6 months after the procedure. Patients with a VAS score of greater than 3 were advised to continue oral medications to alleviate pain until the score was 3 or less.

Medication Use

Doses of anticonvulsants and analgesics are expressed as pregabalin-equivalent doses and oral morphine-equivalent doses, respectively. The doses of anticonvulsants and analgesics of the PHN patients at the following time points were recorded: before coblation, at 1 week, and at 1, 3, and 6 months after the procedure. The numbers of patients who discontinued medication due to sufficient pain reduction were also recorded.

QoL Measurement

The pain-related QoL was measured with the Items 9A-G of the Brief Pain Inventory (BPI) Short Form. Patients were asked to circle the number on an 11-point Likert scale of 0 (does not interfere) to 10 (completely interferes) that described the extent to which pain had interfered with their activities of daily living during the prior 24 hours. The 7 domains of pain interference with QoL were: general activity, mood, walking ability, normal work, relations with other people, sleep, and enjoyment of life. Mean scores for pain interference with QoL was examined at each time point and was summed across all items to provide composite indices of pain interference with QoL at each time point (22).

Adverse Events

All adverse events, such as numbness, hemorrhage,

infection, pneumothorax, and spinal injury, were also recorded. To measure the numbness degree, a numbness rating scale was used (0 = no numbness, I = no obvious numbness, has no influence on daily lives, II = mild numbness, occasionally affect daily lives, III = moderate numbness, frequently affect daily lives, and IV = painful numbness, severely affect daily lives).

Statistical Analysis

Because this was a self before-after controlled clinical trial, no calculations were made regarding sample size or statistical power. SPSS 22.0 (IBM Corporation, Armonk, NY) was used for statistical analysis of the demographic and clinical data. The data were expressed as mean ± standard deviation, median (interquartile range), and the percentage. Repeated measurement analysis of variance (parameter test) was used to analyze the changes in pain intensity, medication dosage, and QoL scores over time. The Pearson χ^2 test was used to evaluate the significant difference of categorical variables. A P value < 0.05 was considered statistically significant.

Results

Patient Demographics

A total of 77 patients underwent coblation due to thoracic PHN. One patient died at 7 weeks post-treatment because of cerebral hemorrhage, 2 patients dropped out at 3 months, and 2 patients refused to participate in the study after coblation. Seventy-two patients met inclusion criteria and were included in the present study. The demographic characteristics are shown in Table 1.

Table 1. *Baseline characteristics of the study patients.*

Number of patients (n)	72
Gender, n, male/female	39/33
Mean age (yrs), mean ± SD	61.12 ±14.46
Weight (kg), mean ± SD	68.43 ± 11.54
Left/right	38/34
Pain duration (mos), mean ± SD	20.51 ±12.51
Pain VAS score, mean ± SD	7.22 ± 1.15
No. of nerves treated (n), M (IQR)	3 (2–4)
Medication, n	68
Anticonvulsants with analgesics, n	38
Anticonvulsants only, n	20
Analgesics only, n	10

Abbreviations: M (IQR), median (interquartile range); SD, standard deviation.

VAS

The mean VAS scores before coblation were 7.22 ± 1.15. Coblation treatment induced significant pain relief at 1 week (3.51 ± 1.12; P = 0.01), and the effects were maintained during the subsequent 6 months of follow-up evaluations: 3.02 ± 1.21 (P = 0.006), 3.11 ± 2.15 (P = 0.014), and 2.98 ± 2.35 (P = 0.008) at 1, 3, and 6 months, respectively (Fig. 3). Additionally, 56 (77.78%), 54 (75%), 55 (76.39%), and 54 (75%) patients achieved more than 50% pain relief at 1 week, and at 1, 3, and 6 months after the procedure, respectively (Fig. 4). All responders had a positive response to treatment during the follow-up period, whereas 8 patients were unresponsive.

QoL

Patient responses on the BPI Short Form indicated mean scores that were significantly lower than baseline across all domains of pain interference with QoL at all evaluations (P = 0.001) (Fig. 5).

Medication Use

The doses of anticonvulsants and analgesics were decreased significantly at all time points after the procedure than before treatment ($P < 0.05$). Five, 8, and 12 patients discontinued their anticonvulsants at 1, 3, and 6 months after the procedure, respectively, and 10, 8, 10, and 15 patients discontinued their analgesics at 1 week and at 1, 3, and 6 months after the procedure, respectively (Table 2; Fig. 6).

Adverse Events

No major complications occurred in all 72 patients. The main adverse events include pain, numbness, tachycardia, and hypertension; no patients withdrew from the treatment because of adverse events. Although 94.44% of the patients still had numbness at 6 months after the procedure, all responders reported slight numbness (grade I–II). There were no cases of infection, spinal injury, pain exacerbation, pneumothorax, or other serious adverse effects following the procedure (Table 3).

Discussion

PHN is a refractory chronic pain. The characteristics of the pain vary considerably and can be either constant or aggravated by certain conditions, and the

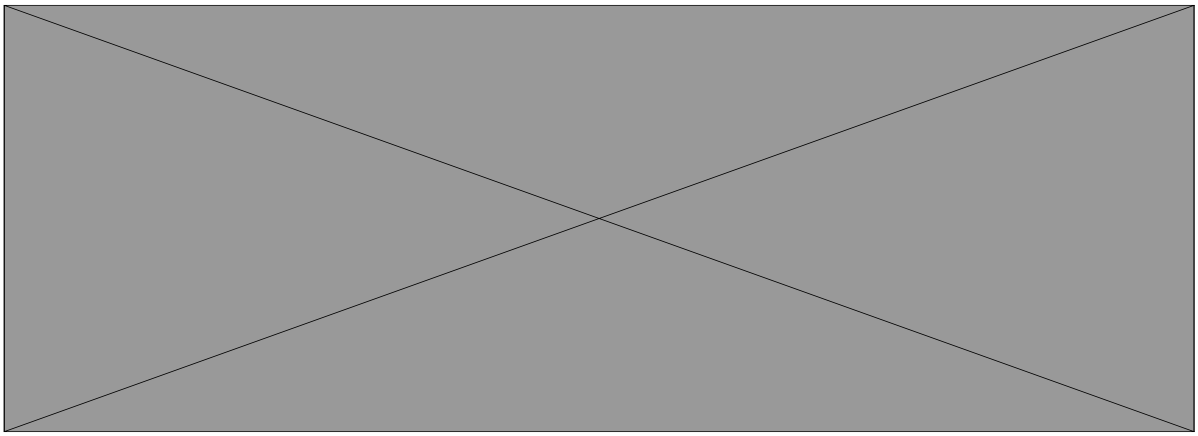

Fig.3. *The pain visual analog scale (VAS) score.*

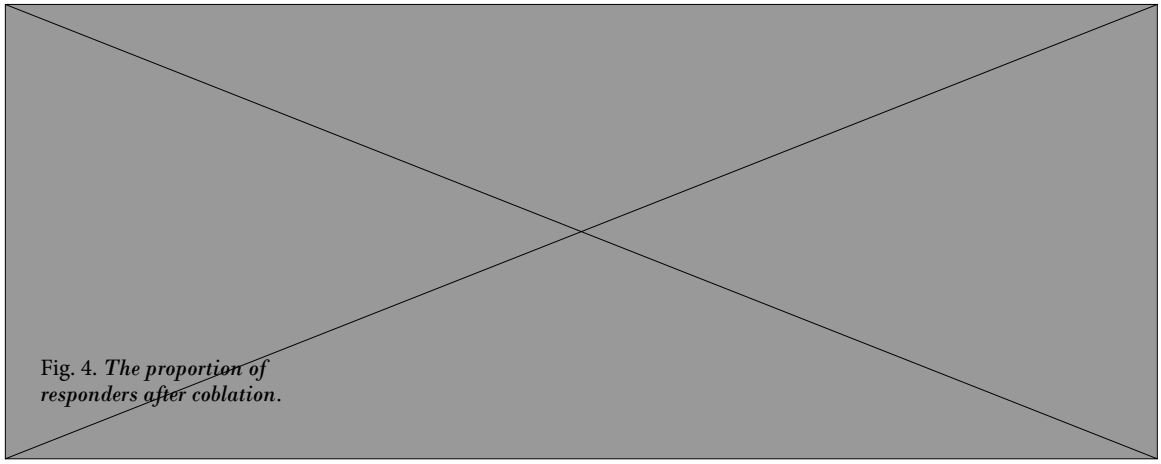

Fig. 4. *The proportion of responders after coblation.*

pain may be described as burning, stabbing, shooting, or pinching (7). PHN is typically defined as chronic pain that persists for more than 3 months after rash onset (7,23-25). In the stage of PHN, this neuropathology brings a considerable amount of pain and limits a patient's ability to perform daily self-care and seriously affects QoL (26,27). The duration of pain in this study was more than 6 months and did not respond to medication and interventional procedures, suggesting that the recovery of normal nerve function was extremely unlikely. Therefore in this study the selection criteria used to enroll the patients was quite strict. To our knowledge, this is the first report evaluating the results of coblation of the thoracic nerve root due to PHN. We found that most patients experienced a dramatic pain relief. In this study, 54 (75%) patients had a consistently positive response to the treatment at 6 months following the procedure. The clinical status of the responders was also significantly improved. Therefore this study demonstrates that coblation is an effective treatment for PHN.

Table 2. *Number of patients who were able to discontinue the prescribed medication.*

	Anticonvulsants	Analgesics
Baseline	2 (2.78)	10 (13.89)
1 wk, n (%)	0 (0)	10 (13.89)
1 mo, n (%)	5 (6.94)	8 (11.11)
3 mos, n (%)	8 (11.11)	10 (13.89)
6 mos, n (%)	12 (16.67)	15 (20.83)

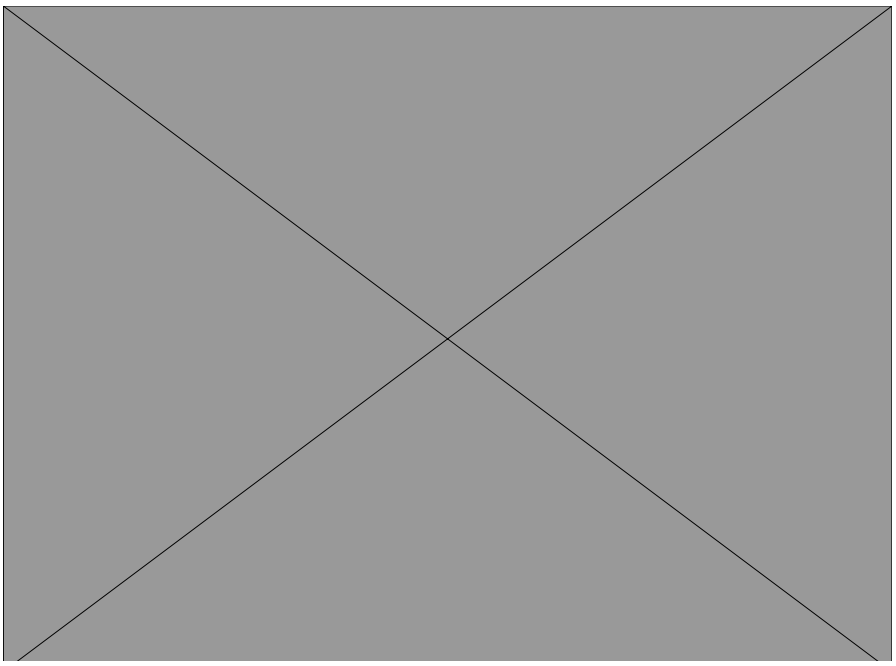

Fig.5. *Mean pain interference with quality of life scores (BPI).*

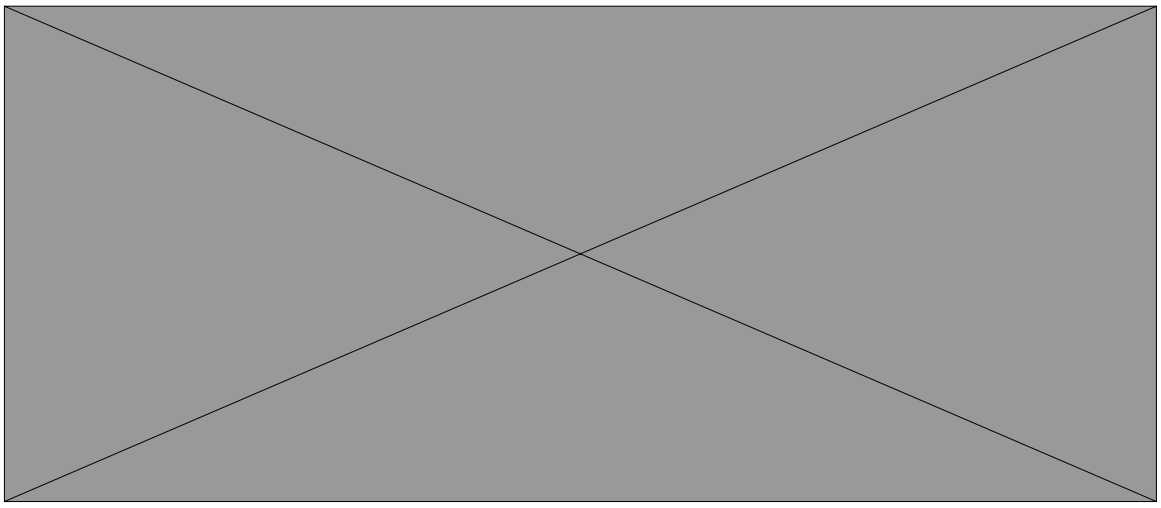

Fig.6. *Changes in doses of prescribed medications after treatment.*

Table 3. *Changes in numbness after coblation.*

Numbness Degree	Baseline	1 Week	1 Month	3 Months	6 Months
Grade 0	65	3	3	3	4
Grade I	5	38	42	50	54
Grade II	2	22	25	19	14
Grade III	0	9	2	0	0
Grade IV	0	0	0	0	0

At present, traditional methods of interventional procedures is to block the nerve and modulate the conduction of abnormal electrical signals using pulsed radiofrequency, radiofrequency thermocoagulation, and spinal cord stimulation (28-30). However, the efficacy of each options is different, and there is a lack of sufficient clinical evidence. Furthermore, the selection of treat-

ment options should balance the benefits of pain relief with possible adverse effects, therefore we sought to maximize the patients' gain. In 2016, Zeng et al (19) reported satisfactory results using coblation to treat one case of phantom limb pain. In this case study, coblation of the femoral and sciatic nerves lead to complete immediate resolution of the stump pain, and analgesic medications were not needed. Moreover, a pilot study of thoracic neuropathic pain at our center (24) reported that coblation of the thoracic paravertebral nerve leading to 12 of the 15 patients (80%) had greater than 50% pain relief, and all responders reported mild pain (VAS score ≤ 3) at 6 months after the procedure. Recently, a study of cervicogenic headache at our center reported that C2 nerve root coblation has also achieved significant and long-lasting pain relief (17).

We have accumulated a lot of experience in the treatment of thoracic neuropathic pain by coblation. In this study, we observed that most patients experienced dramatic pain relief. From 1 week to 6 months after the procedure, up to 75% of the patients received more than 50% pain relief. All responders reported slight numbness immediately following coblation, indicating that the target nerves had been ablated. Importantly, this perception of numbness had no negative impact on their regular activities, including sleep. In addition, mean scores for each QoL item at each time point were decreased most markedly in the first week of treatment. All evidence indicated that coblation resulted in pain relief in responders via ablation of the thoracic nerve root for treatment of PHN.

Coblation utilizes bipolar radiofrequency current to create a thin plasma field (0.2 mm) that breaks the target tissue into tiny pieces with relatively low temperatures (40℃–70℃), and although the thermal penetration distance is only approximately 1.1 mm (15), this might maximally retain neural function. Therefore the principle of treatment of PHN may be as follows: (1) the temperature of the active portion of the wand is relatively low temperature, and the thermal damage to adjacent tissues is very light, thus increasing the accuracy of treatment; and (2) the tissue of the target nerve is vaporized and deactivated completely. This unique mechanism well explained the effective rate of pain treatment and mild numbness after coblation in this study. Nevertheless, in this study 3 patients did not experience numbness, and it was found that these patients' treatment of pain was ineffective. All the patients had induced sensation and motion of the target nerve distribution area in the electrocoagulation mode, it was confirmed that the active portion of the wand reached the target nerve, but there may still be some problems affecting the therapeutic effect, such as wrong selection or anatomic variants of the nerve (21).

Medication is often used as an auxiliary treatment for PHN, however, the adverse reactions of high dosage and long-term use of anticonvulsant, antidepressant, and analgesic medication can cause severe damage to the body of patients. A systematic review of the treatment of PHN found that the average daily dose of gabapentin was 1,800 to 2,400 mg (31), and the dose was even as high as 3,600 mg in some trails (32). In addition, studies have shown that the daily dose of pregabalin in the treatment of PHN was 50 to 600 mg (33). Although in this study there was no significant changes in the dose of anticonvulsants over time, the number of medication users decreased significantly at 6 months after the procedure compared with the baseline. Analgesics are another important auxiliary medication for the treatment of PHN; however, adverse reactions include nausea, itching, dizziness, sedation, constipation, respiratory suppression, addiction, and others. In this study, the oral morphine-equivalent doses and analgesics users were generally lower after coblation. Moreover, many patients discontinued their anticonvulsants and analgesics after coblation. The dosage, duration, and number of drugs use were decreased, resulting in a decrease in the incidence of drug-related adverse reactions, which may also be one of the important factors for the improvement of QoL in the study.

In this study, 8 patients had no pain relief after coblation, and the overall effective rate was only 75% at 6 months after the procedure. A review of the medical history showed that these patients were long-term (> 3 years) PHN patients and had ineffective treatments before coblation. In addition, of the patients with PHN who were included in this study it was found that 37.1% of these patients had a course of more than 12 months, 29.03% had a course of more than 2 years, and 7 patients with a medical history of up to 72 months. In clinical work, it is also found that the longer the course of PHN, the worse the therapeutic effect. This may be related to the mechanism of PHN. It is certain that HZ affects the central and peripheral nervous systems (34). We speculated that the HZ virus may have invaded the superior portion of the nerve in the dorsal root ganglion or spinal dorsal horn. Consequently, coblation of the thoracic nerve root would not block the conduction of abnormal discharge. When central nervous system remodeling occurs, coblation of the peripheral nerve

is ineffective. Even spinal cord electrical stimulation, surgery, and others are powerless to the abnormal pain of PHN (35).

Nevertheless, there were several limitations in our current study design, which should be addressed in future trials. First, this study comprised a retrospective clinical trial that lacked a control group. Second, the study was a single-center study, the included patients may also not be generalizable to different patient populations. Third, the long time span of some patient's condition, which may affect the overall therapeutic effect. Fourth, because the sample size was relatively small, the subgroup analysis of therapeutic effect was not carried out according to the course of disease. Future studies should include a large, prospective study across multiple sites with the inclusion of a nonintervention control group, and a longer length of follow-up should be performed to further evaluate its benefits and risks.

Conclusions

CT-guided percutaneous thoracic nerve root coblation is a potential therapy for PHN. Ablation can significantly produce pain relief, improve pain-related QoL and numbness slightly, and when combined with image guidance, reduces the risk of complications associated with the puncture and treatment.

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