Retrospective Study

Effectiveness Analysis of Awake Computed Tomography-Guided Double-Needle Percutaneous Radiofrequency Thermocoagulation for the Treatment of Glossopharyngeal Neuralgia

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Background: Percutaneous radiofrequency thermocoagulation (PRT) is an established treatment for glossopharyngeal neuralgia (GPN). However, the effectiveness of conventional single-needle PRT is limited due to the glossopharyngeal nerve's unique anatomical location.

Objectives: A major objective of our study was to evaluate the effectiveness and long-term outcomes of computed-tomography (CT)-guided double-needle PRT for patients with GPN.

Study Design: Retrospective study.

Setting: Department of Pain Medicine, the First Affiliated Hospital of Zhengzhou University.

Methods: Clinical data from 38 postoperative GPN patients who underwent CT-guided double-needle PRT between October 2019 and September 2022 were retrospectively reviewed and analyzed. Pain severity was assessed using the Barrow Neurological Institute Pain Intensity Scale (BNI-P) score, and anxiety and depression were evaluated using the Hospital Anxiety and Depression Scale (HADS).

Results: Thirty-eight GPN patients were treated with CT-guided double-needle PRT, and 28 patients could be contacted for follow-up. Pain was relieved in 23 patients (82.14%) immediately after the PRT procedure. The percentage of patients who experienced persistent pain relief was 85.71% at T2, 85.71% at T3, 89.28% at T4 and 89.28% at T5. Post-procedure complications included dysesthesia in the throat, dysphagia, choking on drinking water, and hoarseness. No mortality was observed during or after PRT procedures. Twelve patients (42.9%) suffered from anxiety, and 16 patients (57.1%) had depression. Postoperative HADS scores showed notable improvements over the preoperative scores.

Limitations: Because this study was observational and retrospective, there was no detailed evaluation of the patients. Additionally, the study's small sample size and single-center nature may have further contributed to the bias of the results. A multicenter, prospective study with a large sample size should be performed to further investigate the effectiveness of CT-guided double-needle PRT as a GPN treatment.

Conclusion: This study's findings suggest that CT-guided double-needle PRT is a safe and effective alternative treatment for GPN.

Key words: glossopharyngeal neuralgia, double-needle, percutaneous radiofrequency thermocoagulation

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Glossopharyngeal neuralgia (GPN) is a rare condition characterized by pain in the sensory distribution of the ninth cranial nerve (CN IX). According to the International Headache Society (IHS), GPN is defined as "severe, transient, stabbing, and unilateral pain felt in the ear, base of the tongue, tonsillar fossa, or beneath the angle of the jaw" (1). Common triggers for the pain include swallowing, talking, or coughing. GPN may also be accompanied by symptoms such as hypotension, syncope, and even cardiac arrest. Patients diagnosed with chronic pain are at higher risk for experiencing comorbid psychiatric disorders, including anxiety and depression, resulting in a significant negative impact on patients' overall quality of life (2,3). This situation places a substantial burden on patients' families as well. Despite these findings, there is still a lack of focus on GPN's psychological effects. The progression of the condition and the characteristics of the associated pain resemble those observed in trigeminal neuralgia, including remitting and relapsing phases. Due to the rarity of GPN, data on it are sparse; specifically, GPN's overall incidence appears to be much lower than that of trigeminal neuralgia, with rates of 0.2–0.7 cases per 100,000 persons annually and 0.2%–1.3% of orofacial pain syndromes (4-6). The idiopathic form of GPN shares similar pathophysiology with trigeminal neuralgia and is frequently linked to neurovascular compression (4,7,8). Moreover, GPN could potentially be caused by tumors located in either the cerebellopontine angle or the extracranial regions, such as the oropharynx (9,10).

The main pharmacologic treatment for GPN is primarily based on carbamazepine. Additional antiepileptic drugs, such as phenytoin, oxcarbazepine, gabapentin, and amitriptyline, may be employed as well (11-13). In cases of refractory neuralgia or treatment intolerance, surgical intervention may be necessary. The surgical treatment options for GPN primarily include microvascular decompression (MVD), glossopharyngeal nerve rhizotomy, and percutaneous radiofrequency thermocoagulation (PRT) (4,14). MVD and rhizotomy of the glossopharyngeal nerve provide high rates of pain relief (up to 80%-90%) and sustained results (4,15). However, surgical intervention is not without risks, particularly as far as potential nerve damage is concerned. On average, approximately 5.5% of patients undergoing microvascular decompression (MVD) and up to 19.1% of those undergoing rhizotomy may experience permanent cranial nerve damage (4,15). In contrast, PRT is widely recognized as an effective method for relieving neuropathic pain (16-18). However, when used to treat GPN, the effectiveness of conventional single-needle PRT is reduced due to the unique anatomical position of the laryngopharyngeal nerve and its significant mobility at the posterior margin of the styloid process (19). Previous studies have documented immediate effectiveness rates ranging from 50% to 78% for single-needle PRT (19,20). Furthermore, the utilization of double-needle PRT to treat GPN has the potential to enhance the coverage of radiofrequency (RF) and improve overall treatment effectiveness. The innovative aspect of this study was to investigate the effectiveness and safety of double-needle PRT in the treatment of GPN.

Methods

Patient Population

The proposal for this study was approved by the Medical Ethics Committee at the First Affiliated Hospital of Zhengzhou University. The Institutional Review Board number is 2022-KY-1512-002. A waiver of written informed consent was granted by the Institutional Review Board because this study was retrospective. The trial was registered on Clinicaltrials.gov before patients were enrolled (ChiCTR2300076876, Principal Investigator: Xiaochong Fan, registration date: October 23, 2023). The collection of primary data was conducted according to epidemiology guidelines that strengthened the reporting of observational studies. Patient information was anonymized and deidentified prior to analysis.

This retrospective study involved the clinical data of patients who were clinically diagnosed with primary GPN. These patients received CT-guided double-needle PRT treatment in the Pain Department of the First Affiliated Hospital of Zhengzhou University between October 2019 and September 2022. The following is a detailed list of inclusion and exclusion criteria.

For inclusion, the following criteria were used : 1) meeting the ICHD-3 diagnostic criteria for primary GPN (1); 2) age ≥ 18 years; 3) having unilateral symptoms and Barrow Neurological Institute pain intensity (BNI-P) scores ≥ grade IV; 4) being intolerant of or refractory to medical treatment; and 5) having no other comorbid chronic head and facial pain disorder, such as trigeminal neuralgia or migraine. The following exclusion criteria were applied: 1) having bilateral symptoms or a diagnosis of secondary GPN resulting from conditions such as intracranial space-occupying lesions or infections; 2) having complications such as puncture site

infections, severe cardiopulmonary insufficiency, or blood coagulation dysfunction; 3) lacking the ability to comprehend and respond to the questionnaires; and 4) having undergone other surgical interventions, such as microvascular decompression (MVD) or radiofrequency treatment.

There were 38 patients who met the inclusion and exclusion criteria. However, 3 patients were excluded because of incomplete clinical data, and 7 patients were lost to follow-up, leaving 28 patients to be included. Fig. 1 shows the flow chart used to select patients. The duration of disease ranged from one month to 30 years. The demographic and clinical characteristics of the 28 patients are summarized in Table 1. Preoperative magnetic resonance imaging (MRI) and laryngoscopy were routinely performed.

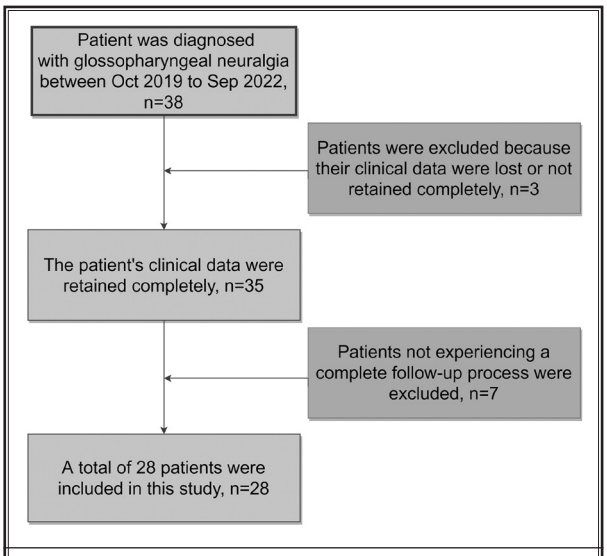

Fig. 1. *The flow chart of patient selection.*

Table 1. *General demographic information and clinical profile of the patients*

General information	
Age (mean±standard deviation, years)	58±12
Sex (female/male)	15 (53.57)/13 (46.43)
Side (left/right)	18 (64.29)/10 (35.71)
Duration of symptoms, months	15 (2.25,57)
Preoperative pain severity(BNI-P grade IV-V)	28 (100)

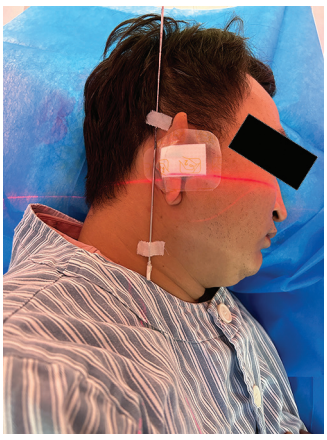

Fig. 2. *The patient was placed in the lateral position with the surgical site exposed, and a Kirschner needle was placed behind the ear. The red line shows the plane of puncture.*

Surgical Technique

The double-needle PRT procedures were conducted in a disinfected computed tomography (CT) examination room. The standard pre-anesthesia guidelines set by the American Society of Anesthesiologists (ASA) were followed for all patients.

Following the placement of a standard ASA monitor and completion of the preoperative time-out, the patient was positioned in the lateral position with their head secured to the pillow. The surgical site was identified and then aseptically prepared. A Kirschner needle was placed behind the ear for accurate localization (Fig. 2). Cranial localization images were captured using the cervical spine mode, with a layer thickness of one mm for axial scanning in the styloid process area. The resulting images were reviewed. The puncture site was determined based on the level that included both the C1 transverse process and the styloid process. At this level, 2 lines were drawn upward from the anterior and posterior sides of the styloid process, using the CT's built-in measurement tool software. The avoidance of obstructions, such as the internal jugular vein and bones, was ensured. The puncture point was identified at the intersection of these 2 lines with the external surface of the neck. Subsequently, measurements were conducted to determine the puncture depth (representing the distance between the puncture point and the target point) and the paracentesis distance (representing the distance between the puncture point and the Kirschner needle), followed by marking the skin accordingly (Fig. 3).

After routine disinfection and toweling, local anesthesia was administered using 0.5% lidocaine at the puncture site. Next, 2 22-gauge, 10-cm RF needles with 5-mm movable tips (model 240102; Innomed Medical Technology Co., Ltd.) were inserted into the target site under the guidance of CT via the preestablished channel, and their accurate placement was confirmed

through CT scanning with 3-dimensional reconstruction (Fig. 4).

RF electrodes (Radio Frequency instrument model R-2000B A1; Neo Science Co., Ltd.) were connected after drawing back showed no blood or cerebrospinal fluid. Sensory electrical stimulation was conducted with a frequency of 0.3 V-2.0 V at 50 Hz, in which a positive response was characterized as the elicitation of a tingling sensation in the original painful area of the ipsilateral pharynx without inducing nausea, coughing, or sudden fluctuations in heart rate. Motor electrical stimulation, applied at a frequency of 2 Hz and a voltage of one V, resulted in rhythmic shaking in the neck and shoulder muscles, indicating a positive response. The needle tip's position for electrical stimulation testing was diligently adjusted multiple times until only a positive sensory electrical stimulation response was observed and no positive motor electrical stimulation response appeared. These conditions were met prior to proceeding with RF treatment. The glossopharynx

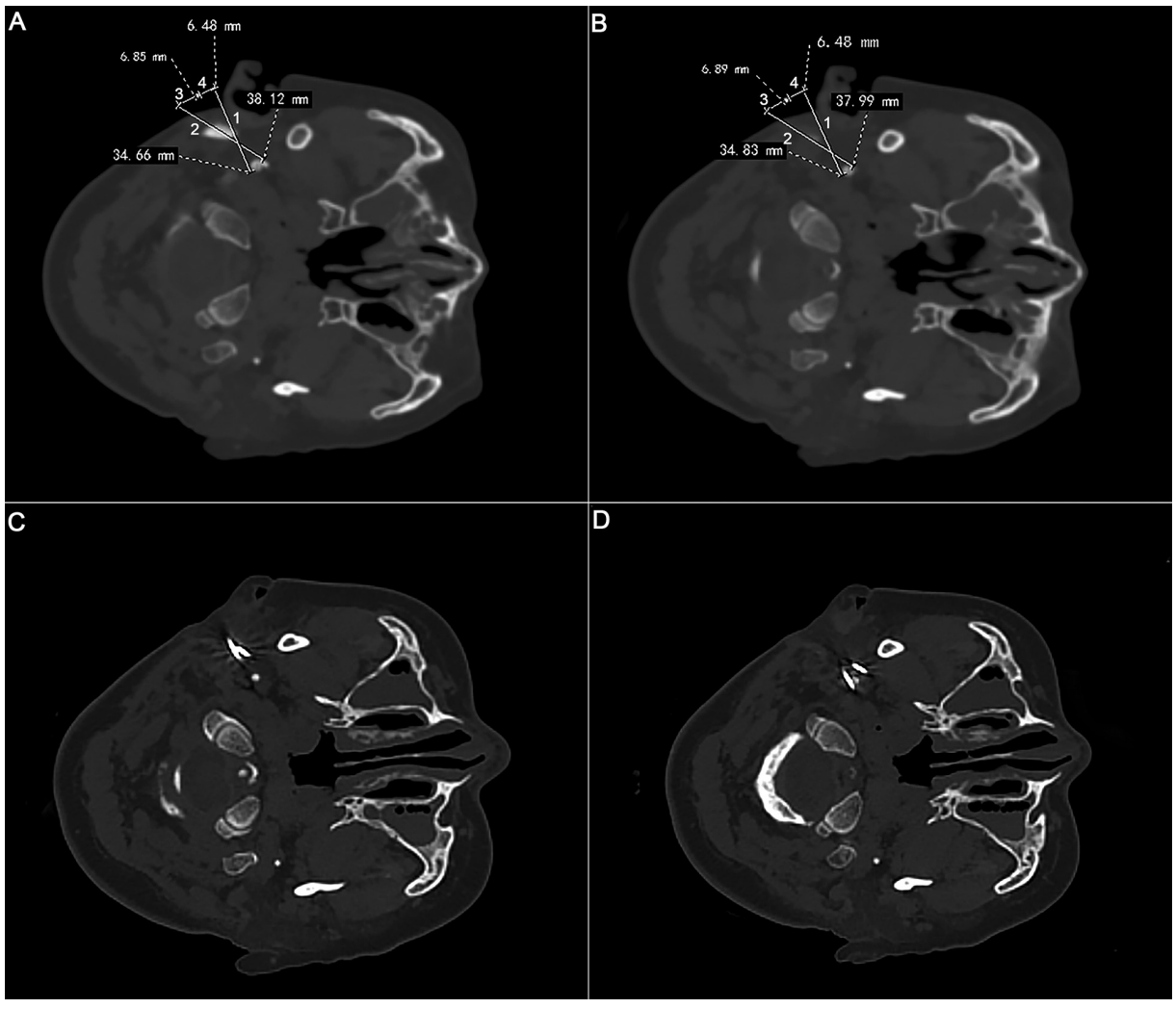

Fig. 3. *Intraoperative steps for using awake CT-guided double-needle PRT to treat GPN.*
A: Puncture paths targeting the styloid process root via the anterior or posterior approach (this level is occluded by bone). B: Puncture paths through an anterior or posterior approach after avoiding osseous occlusion, targeting the styloid process root. The depth of penetration is indicated by 1 and 2, and the paracentesis distance is indicated by 3 and 4. C: CT imaging performed during the double-needle puncture procedure. D: CT image depicting the double needle puncture at the target point with needle overlap.

nerve was subjected to thermocoagulation using RF energy at temperatures ranging from 70°C to 85°C for a duration of 120 to 180 s, depending on the stimulus response and the experience of the physician.

While the PRT procedures were conducted, patients were instructed to suck saline intermittently through a straw. If the patients experienced dysphagia or a coughing reaction, the procedures were discontinued promptly. Subsequently, patients were returned to the ward for appropriate symptomatic treatment, with PRT or other interventions pursued once vagal nerve injury had resolved.

Follow-Up and Effect Evaluation

An adaptation of the widely used BNI system for scoring pain intensity (21) was used to assess pain relief in patients with GPN (Table 2): I, no glossopharyngeal pain with no medication; II, occasional pain that does not require medication; IIIa, no pain with continued medication; IIIb, persistent pain controlled by medication; IV, some pain not adequately controlled by medication; and V, severe pain with no relief. Postoperative BNI-P ≤ IIIa was defined as pain relief (22,23). Recurrence was defined as a change from class I to a worse outcome class. Minor recurrence was defined as a lower frequency and intensity of pain that was well tolerated by the patient and did not require a new surgical procedure. Major recurrences were defined as those requiring an additional open, percutaneous, or radiosurgical procedure (23).

Patients' anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS) (24). Anxiety or depression levels were considered negative if the HADS score was < 9; otherwise, they were deemed positive.

Preoperative and postoperative data were collected through a comprehensive review of the patients' medical charts and postoperative questionnaires. To improve quality of life and patient satisfaction, all patients with GPN were routinely followed up on. The follow-up was conducted by an independent supervising nurse, who ensured that all patients were followed up on either in the outpatient department or through telephone communication. Postoperatively, all patients were followed for 12 months regardless of recurrence.

The BNI-P and HADS scores were assessed at multiple time points: preoperatively (T0), one day (T1), one month (T2), 3 months (T3), 6 months (T4), and 12 months (T5) postoperatively. Furthermore, any operation-related side effects were recorded immediately after the surgery and during follow-up.

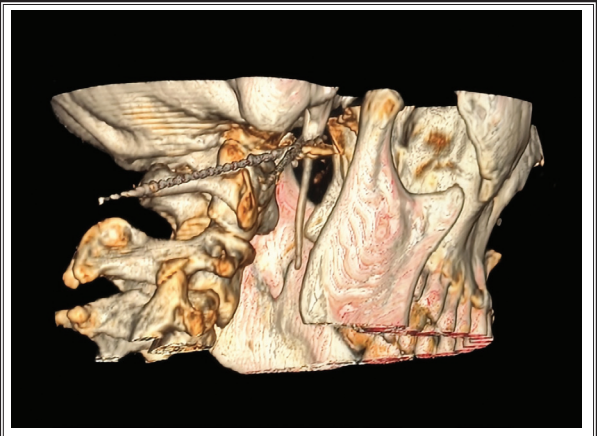

Fig. 4. *3D reconstruction for site confirmation after 2-needle placement.*

Table 2. *Barrow Neurological Institute pain severity (BNI-P) scoring system*

Pain intensity grade	Definition
I	No pain, no medication
II	Occasional pain, no medication required
IIIa	No pain with continued medication
IIIb	Persistent pain controlled by medication
IV	Some pain, not adequately controlled with medication
V	Severe pain/no pain relief

Statistical Analyses

Data analysis was performed using IBM® SPSS® version 24.0. The overall data distribution was assessed using the Shapiro-Wilk test. Enumeration data are presented as percentages, while measurement data are reported as mean ± SD. Changes in BNI-P and HADS scores at different time points were evaluated using generalized estimating equations. Statistical significance was defined as $P < 0.05$.

Results

Characterization of the Study Population

This study analyzed the clinical data of 38 patients diagnosed with GPN. Ten patients were excluded from the study due to not meeting the inclusion and exclusion criteria, resulting in a final sample size of 28 patients for our retrospective analysis. The mean age of the patients was 58 ± 12 years, and most were women. The demographic and clinical characteristics of the patients are presented in Table 1.

Clinical Outcomes

The efficacies at the different time points were 82.14%, 85.71%, 85.71%, 89.28%, and 89.28% (BNI-P score ≤ IIIa). There were 23 patients who were pain free after surgery (pain intensity scores of I–IIIa), including 10 who were pain free without medication (score of I) on the first day. One patient experienced partial improvement, with a score of IV. In 2 patients, the intensity of pain remained unchanged, with a score of V. At the last follow-up, 12 patients were pain free without medication (score of I), and 7 patients had occasional pain that did not require medication (score of II). Six patients were pain free with medication (IIIa), one patient's pain showed partial improvement (score of IV), and 2 patients' pain intensity remained unchanged (score of V).. Moreover, the patients' prognosis improved with longer follow-up, with a significant step of patients having increasingly lower pain scores. The outcomes of the 28 patients are shown in Table 3, Table 4, and Fig. 5. At T1~T5, the BNI-P and HADS scores showed significant decreases from the scores at T0 ($P < 0.001$).

The postoperative side effects are listed in Table 5. Twenty-three patients experienced dysesthesia in the throat that waned progressively over the course of a year and was well tolerated by nearly all those affected by it. Additional post-procedure complications included dysphagia (n = 2), choking on drinking water (n = 1), and hoarseness (n = 1); symptoms improved within 2 weeks from the procedure's initiation. No facial palsy or shrugging disorder was observed in any of the patients, and no cases of cerebral infarction or death were observed during or after the double-needle PRT procedure.

Discussion

This study focused on investigating the effectiveness and safety of double-needle PRT in the treatment of GPN. Our findings provide compelling evidence that double-needle PRT is a safe and effective approach that effectively reduces patient pain, improves mood, and enhances patients' overall quality of life. To our knowledge, our study pioneers the use of double-needle PRT as an innovative treatment for GPN, effectively enhancing and complementing existing treatment strategies.

The use of PRT has gained popularity since 1974 (25). It is reported that the heat generated by the RF needle selectively destroys the pain fibers (Aδ and C fibers) through thermocoagulation at temperatures exceeding 65° C (26). Since the first reports of the use of PRT for GPN in 1979 (27), numerous related studies have reported high rates of pain relief and low rates of morbidity (28-30). The glossopharyngeal nerve is the ninth pair of cranial nerves, originating in the medulla oblongata and exiting the cranium through the jugular foramen within the pontine pool along with the vagus and accessory nerves (31,32). Within the jugular venous foramen, the glossopharyngeal, vagus, and accessory nerves are near the internal jugular vein, which poses a challenge in selecting targets for glossopharyngeal nerve PRT therapy. Therefore, to maximize the prevention of potential injury to the internal jugular vein, vagus, and accessory nerves, the target of glossopharyngeal nerve PRF treatment is mostly selected at the proximal segment of the glossopharyngeal nerve after it exits the jugular venous foramen. CT imaging provides clear visualization of the configuration of bones and soft tissue. Therefore, CT-guided puncture allows for more precise puncture and closer proximity to the glossopharyngeal nerve. This may also be the reason for our high surgical ef-

Table 3. *The postoperative outcomes of the 28 patients (n)*

Pain score	T1	T2	T3	T4	T5
I	10	10	10	10	12
II	5	5	6	8	7
IIIa	8	9	8	7	6
IIIb	2	1	1	0	0
IV	1	1	2	1	1
V	2	2	1	2	2

Table 4. *Outcomes of the observation indexes before and after double-needle PRT treatment (n, %)*

Time	BNI-P (mean ± SD)	HADS			
		HADS (A) < 9	HADS (A) ≥ 9	HADS (D) < 9	HADS (D) ≥ 9
T0	4.43±0.50	16 (57.1)	12 (42.9)	12 (42.9)	16 (57.1)
T1	2.29±1.21	24 (85.7)	4 (14.3)	23 (82.1)	5 (17.9)
T2	2.29±1.21	25 (89.3)	3 (10.7)	26 (92.9)	2 (7.1)
T3	2.21±1.13	27 (96.4)	1 (3.6)	25 (89.3)	3 (10.7)
T4	2.18±1.19	26 (92.9)	2 (7.1)	27 (96.4)	1 (3.6)
T5	2.07±1.22	25 (89.3)	3 (10.7)	26 (92.9)	2 (7.1)
Statistics	135.347	111.075		61.935	
P	< 0.001	< 0.001		< 0.001	

Abbreviations: PRT = percutaneous radiofrequency thermocoagulation, BNI-P = Barrow Neurological Institute pain intensity score, HADS (A) = Hospital Anxiety and Depression Scale (Anxiety), HADS (D) = Hospital Anxiety and Depression Scale (Depression)

ficiency. In our study, all punctures were successfully guided by CT, which further confirms its reliability. In addition, damage or stimulation to the vagus nerve can result in significant hemodynamic complications, including syncope, asystole, or bradycardia (33,34); for this reason, we emphasize the significance of hemodynamic monitoring during interventional procedures of this nature.

Several reports on surgical treatment options for GPN exist. For instance, researchers have suggested the use of ultrasound-guided glossopharyngeal nerve blocks as a safe and minimally invasive option for GPN treatment. However, the study on which this suggestion was based included only 12 patients, which might have introduced a large bias, and the one-year effective rate was only 58.3% (35). Reports on MVD's use as a GPN treatment have found that immediate pain relief can be achieved in approximately 85% of patients, while long-term pain relief rates range from 65% to 90%. In spite of these results, transient hoarseness and dysphagia are common complications of this type of procedure (36). Open surgery carries a risk of permanent cerebral neurological deficits, including hearing loss and other complications. Rhizotomy of the glossopharyngeal nerve yields lower long-term pain relief rates than MVD does, with approximately 44.2% to 87.5% of patients experiencing relief (36). The primary adverse effects include dysphagia and sensory dullness in the distribution along the glossopharyngeal nerve (37,38). The largest series of studies conducted by Kano et al found that 50% of patients experienced significant pain relief after Gamma Knife radiosurgery (GKRS) treatment during a mean follow-up period of 45 months (39). Additionally, when the same pain control criteria are utilized, a favorable pain response has been reported in 78.6% of cases (BNI grades I-III), and among these patients, recurrence has been reported in 41.6% of cases. Furthermore, doses below 80 Gy may be linked to a poor prognosis in patients undergoing GKRS (40). However, due to the rare occurrence of GPN and the limitations in the study protocol design, it remains challenging at present to propose management strategies that are both safe and effective.

In our study, pain relief in all patients was 82.14% at one day, 85.71% at one month, 85.71% at 3 months, 89.28% at 6 months, and 89.28% at one year. Despite the presence of the styloid process as a bony landmark, the glossopharyngeal nerve, in addition to being slender, has a relatively free location and a high degree of positional variability during the surgical operation; therefore, traditional single-needle PRT usually fails to achieve a satisfactory therapeutic effect in the clinic. Previous studies have documented immediate effectiveness rates ranging from 50% to 78% for single-needle PRT (19,20). When double-needle PRT is used, the range of thermocoagulation between the double needle can better cover the pathway of the glossopharyngeal nerve at the posterior margin of the styloid process, so the excellent effectiveness of double-needle PRT for a single treatment can be significantly superior to that of single-needle PRT (19). Although PRT may be associated with a relatively lower probability of postoperative pain relief than MVD or rhizotomy of the glossopharyngeal nerve, PRT is a less invasive and more acceptable approach for patients.

Through postoperative follow-up, we found that the grades of some patients' pain scores decreased, and the remission rate rose steadily as the follow-up time increased. At the same time, patients' incidence of postoperative pharyngeal numbness was also higher. The above results may be because in this study, the double-needle thermocoagulation procedure was able to cover the area of the glossopharyngeal nerve more adequately, and the destruction of the nerve was closer to complete, which might also have been why there was no recurrence during the follow-up period.

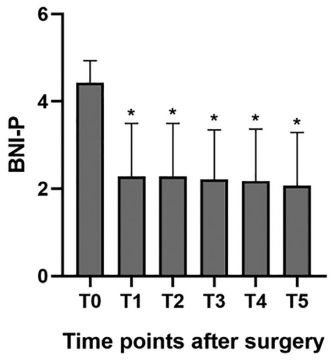

Fig. 5. *Changes in BNI-P scores after double-needle PRT compared to preoperative scores (T0), *P < 0.05.* Abbreviations: BNI-P, Barrow Neurological Institute pain intensity score.

Table 5. *Postoperative side effects*

Side effects	No. of patients (n)
Dysesthesias in the throat	23
Dysphagia	2
Choking on drinking water	1
Hoarseness	1

Both the BNI-P and HADS demonstrate high levels of reliability and validity, making them effective tools for assessing patients. GPN patients often experience prolonged durations of illness accompanied by severe pain, which can lead to the development of anxiety and depression, further exacerbating patients' discomfort. Previous research has consistently shown that individuals with chronic pain have a greater susceptibility to depression and anxiety than the general population (2,3,41,42). Nevertheless, double-needle PRT's impact on depression and anxiety in GPN patients has not been assessed through any research studies to date. In our investigation, we observed that HADS scores were significantly lower at T1-T5 than at T0. This finding suggests that double-needle PRT not only treats GPN effectively but also ameliorates negative emotions in patients.

The low occurrence of postoperative dysphagia, instances of choking on drinking water, and hoarseness observed in this study can be attributed to 2 factors. First, the use of CT guidance improved the accuracy of the puncture. Second, intraoperative testing repeatedly assessed each patient's swallowing function to prevent any damage to the vagus or accessory nerves.

The main limitation of our study is that it was an observational retrospective study that did not allow for a more detailed evaluation of the patients. Additionally, this was a single-center study with a small sample size and a short follow-up period. These factors may have contributed to bias in the results. A multicenter, prospective study with a large sample size should be performed to further investigate the effectiveness of CT-guided double-needle PRT as a treatment for GPN. Ultimately, in this study, CT-guided double-needle PRT was demonstrated to be a safe, less invasive procedure for GPN management.

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