Observational Study

Comparison of the Efficacy of Percutaneous Balloon Compression and Extracranial Non-gasserian Ganglion Radiofrequency Thermocoagulation for Primary Multibranch Trigeminal Neuralgia

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Background: Both computed tomography-guided extracranial nongasserian ganglion radiofrequency thermocoagulation (RFT) and percutaneous balloon compression (PBC) have significant clinical efficacy in the treatment of trigeminal neuralgia, but a comparison of the efficacy of the 2 methods for pain in primary multibranch trigeminal neuralgia (TN) has not been studied clinically.

Objective: To compare the efficacy and safety of PBC with extracranial nongasserian ganglion RFT in the treatment of primary multibranch TN.

Study Design: This is a single-center, retrospective, observational study.

Setting: This study was conducted at the Pain Department of the Affiliated Hospital of Jiaxing College in Jiaxing, People's Republic of China.

Methods: A total of 202 patients, including 112 patients in the RFT group and 90 patients in the PBC group, with multi-branch TN who visited the pain department of Jiaxing First Hospital for percutaneous minimally invasive surgery from April 2016 through June 2021 were retrospectively analyzed. Patients in both groups were followed-up regularly after surgery, and the Numeric Rating Scale, recurrence-free survival rate, Barrow Neurological Institute facial numbness score, and other postoperative complications were recorded before surgery (T0), immediately after surgery (T1) and at 3 months (T2), 6 months (T3), 12 months (T4), and 15 months (T5) postoperatively.

Results: All patients completed the operation successfully. No significant difference was found between the two groups in terms of gender, age, pain duration, preoperative Numeric Rating Scale (NRS-11), lateralization of pain and affected branches, and preoperative underlying disease ($P > 0.05$). There was a significant difference in preoperative and immediate postoperative NRS-11 scores between the 2 groups ($P < 0.01$). NRS-11 scores decreased at each time point (T1-T5) and were significantly different from preoperative scores ($P < 0.001$). Meanwhile, no significant difference was found in NRS-11 scores at T0, T1, and T2 between the RFT and PBC groups ($P > 0.05$). However, the differences were statistically significant at T3 ($P < 0.05$), T4 ($P < 0.001$), and T5 ($P < 0.001$). BNI-N scores decreased in both groups at T2, T3, T4, and T5 after surgery and were significantly different from preoperative scores ($P < 0.05$). BNI-N scores were significantly lower in the PBC group than in the RFT group at all time points ($P < 0.05$). In the long-term treatment of multibranch trigeminal neuralgia, the PBC group exhibited a lower recurrence rate than the RFT group. No severe complications or deaths were observed in either of the 2 groups.

Limitations: A small sample size and being conducted at a single center are limitations of our study.

Conclusion: Both RFT and PBC were effective in relieving primary multibranch TN, but patients in the PBC group had a lower recurrence-free survival rate, fewer complications, and a better safety profile. Follow-up studies with a larger patient sample held at multiple locations should be conducted.

Key words: Radiofrequency thermocoagulation, percutaneous balloon compression, trigeminal neuralgia, extracranial nongasserian ganglion, multibranch pain

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Trigeminal neuralgia (TN) is a recurrent, paroxysmal, electric shock-like pain distributed in one or more branches of the trigeminal nerve (1). The vast majority of patients have distinct trigger points, with severe paroxysmal pain during speech, washing, brushing, and even walking, causing great inconvenience to their lives (2). The disease is prevalent in middle-aged and elderly people, with a prevalence of 4 per 100,000 population (3). One study found that it is not uncommon for patients to have multiple branches involved at the same time, with a rate of 10% for ophthalmic and maxillary branches and 20% - 32% for maxillary and mandibular branches (4).

Clinical studies have shown that multiple branches of TN are painful, difficult to treat, and prone to recurrence; there are no uniform treatment standards. The etiology and pathogenesis of TN remain unclear, but studies have concluded that neurovascular contact is a common cause and 98% of severe neurovascular contacts are arterial in origin and are caused by arteries located in the root entry zone (5). Currently, the main treatments for TN are medication, radiofrequency thermocoagulation (RFT), percutaneous balloon compression (PBC), and microvascular decompression (MVD). Of these, medication is the first-line treatment (6). However, about half of the patients with TN have difficulty with pain control, and some of them cannot tolerate the side effects of drugs and cannot control their pain by taking the drugs for a long time.

Several studies have compared the effectiveness and safety of different procedures. Berger, et al (7) found that MVD provided better outcomes in terms of pain reduction. However, MVD requires a craniotomy, has a high incidence of intracranial complications, and is difficult for elderly patients to tolerate surgical stimulation (8). As a result, MVD is increasingly being replaced by minimally invasive percutaneous surgery. Although RFT was found to have a treatment efficiency of more than 90% (9), a high recurrence rate of painful disorders one year postsurgery has been reported (2). PBC is simple to perform, has a short operative time, and a low recurrence rate of postoperative pain; and side effects such as postoperative facial numbness are reversible and do not affect the patient's daily life (10).

PBC and RFT are less invasive and repeatable and are widely used in clinical practice. Several previous studies have also compared the safety and efficacy of RFT and PBC (11). However, the application of both methods in multiple painful branches has not been reported. The present study aimed to compare the effectiveness and safety of RFT and PBC in the treatment of multibranch trigeminal pain and provide better options for the treatment of multibranch TN.

Methods

Patients

This study was approved by the Ethics Committee of the Affiliated Hospital of Jiaxing College (2022-KY-550). A total of 202 patients, including 112 patients in the RFT group and 90 patients in the PBC group, with multi-branch TN who visited the pain department of Jiaxing First Hospital for percutaneous minimally invasive surgery from April 2016 through June 2021 were retrospectively analyzed (Fig. 1).

Inclusion Criteria

Inclusion criteria were: 1) patients with a clinical diagnosis of primary multibranch TN according to the third edition of the International Classification of Headache Disorders (ICHD-3) diagnostic criteria for classic TN; 2) those who poorly responded to regular medication or could not tolerate adverse drug reactions; and 3) a preoperative Numeric Rating Scale (NRS-11) score of ≥ 5 points.

Exclusion Criteria

Exclusion criteria were: 1) a history of minimally invasive surgery, such as RFT or PBC; 2) those with psychiatric and psychological disorders that made it impossible or difficult to continue the clinical assessment; 3) those with a combination of other types of acute or chronic pain; and 4) those with incomplete medical records.

Surgical Methods

Instruments used include Somatom Huan Yue computed tomography (CT) (Siemens), Radical-7 monitor (Masimo Corporation), 21G × 150 mm RF puncture needle (Inomed Health, Ltd), RF therapy device (REF PMG-230, Baylis), and balloon catheter kit and stabbing needle (Shenzhen Prime Source Medical Devices Co., Ltd.).

Patients fasted solid food for 8 hours and abstained from drinking for 4 hours before surgery. Immediately after entering the CT operating room, intravenous fluid access was established, oxygen was administered by nasal cannula, and electrocardiogram, noninvasive blood pressure, and pulse oximetry were applied and monitored.

Radiofrequency Thermocoagulation Procedure

The patient was placed supine with a thin pillow under the shoulder to keep the head tilted back 20°. The patient's jaw was secured with a wide adhesive tape to minimize head position movement. The eye and the neck were protected with lead-based shields. A positioning grid was placed on the affected side of the face (Fig. 2). Then, the CT scan was used for localization of the craniotomy.

The first supraorbital foramen RF or the second infraorbital foramen RF was swept in the vertical axis with a layer thickness of 2 mm. The second round hole and the third oval hole were in a semicoronal position with a layer thickness of 3 mm. The puncture level was selected and the puncture path was designated.

After measuring the angle and depth of needle insertion using CT, and under local anesthesia, the RF needle was punctured into the corresponding supraorbital foramen, infraorbital foramen, or round or oval foramen (Fig. 3). The RF needle core was removed, a matched electrode was inserted, and high-frequency (50 Hz, 0.1 milliseconds) and low-frequency (2 Hz, 1 millisecond) currents were applied for sensory and motor stimulation tests.

For the V1 branch, if 0.5 mA or less current was enough to induce pain symptoms in the original lesion area in sensory tests (high frequency, 50 Hz, 0.1 V) and muscle twitch in the ipsilateral supraorbital area in the movement test (low frequency, 2 Hz, 1.0 V), the RFT target was accurate. For the V2 branch, if the sensory test (high frequency 50 Hz, 0.1 V, 0.5 mA) replicated the pain symptoms in the original pain area and the motor test (low frequency 2 Hz, 1.0 V, 0.5 mA) induced muscle twitching in the upper lip and maxillary region of the affected side, the RF target was accurate. And for the V3 branch, asynchronous and rhythmic twitches were tested at 0.1-0.5 mA. If the 0.5 mA current did not cause a tingling sensation and rhythmic jerking in the mandibular region, the needle tip position was adjusted appropriately and the test was then performed until the results were satisfactory.

Next, isoproterenol (1-2 mg/kg) was administered intravenously; after the patient fell asleep, continuous RFT was performed at 90°C for 120 seconds.. When the patient woke up, the pain was tested by pricking the skin with a needle. If the area was numb, the treatment was terminated, the RF needle was withdrawn, the puncture site was compressed locally, covered with a sterile dressing, and the patient was returned to the ward.

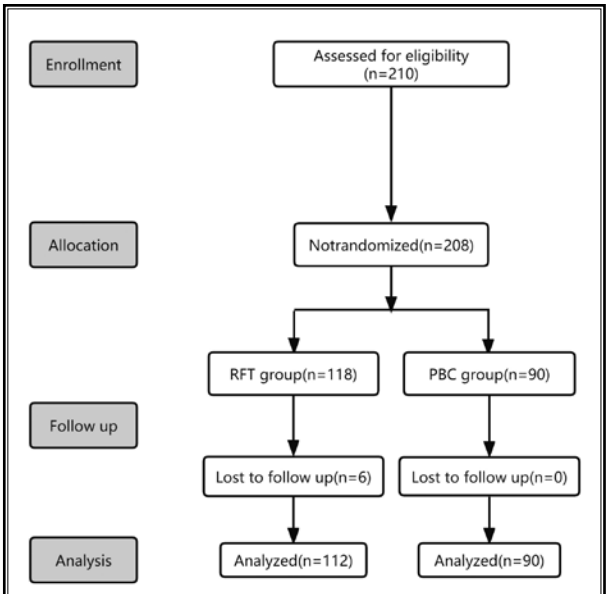

Fig. 1. *Study flowchart of the 202 initial patients. RFT, radiofrequency thermocoagulation; PBC, percutaneous balloon compression.*

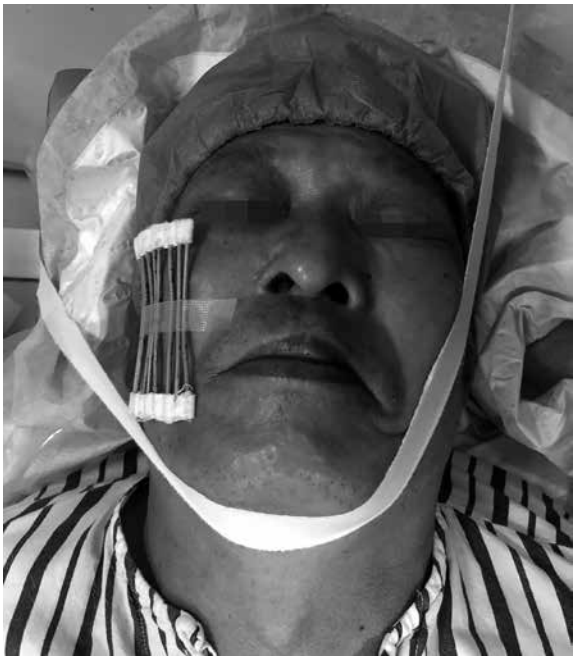

Fig. 2. *Positioning grid placed on the patient's side.*

Balloon Compression Procedure

The patient was placed supine on the CT operating table with a thin pillow under the shoulder to keep

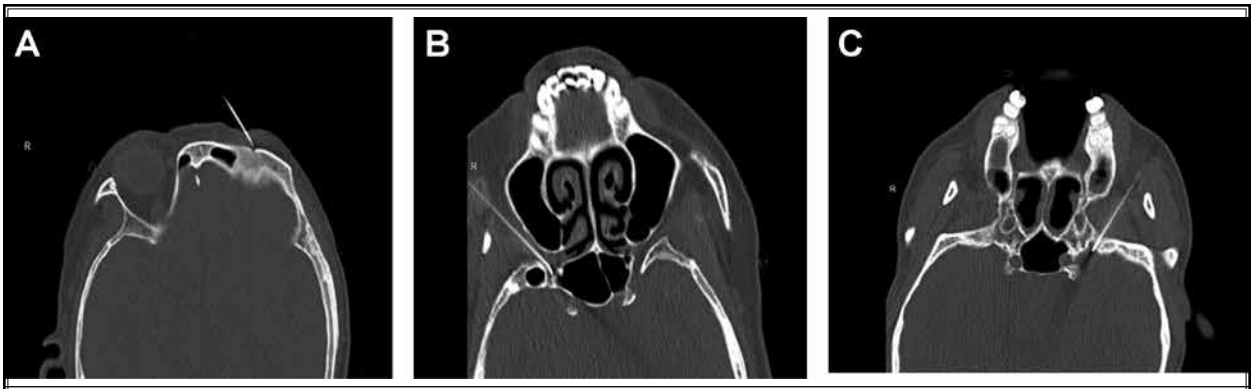

Fig. 3. *(A) CT scan showing the path and position of the needle located in the left supraorbital foramen. (B) CT scan showing the path and position of the needle located in the right foramen ovale. (C) CT scan showing the path and location of the needle located in the left foramen ovale. CT, computed tomography.*

the head tilted back at 20°. CT images of the affected mastoid region were obtained using a 3-mm layer maxillofacial scan method, targeting the foramen ovale of the temporal bone. A straight line (approximately 2 cm) from the corner of the mouth to the foramen ovale was used as the puncture path and the puncture point was designated.

After disinfection and spreading of the towel, the puncture site was injected locally with 1 mL of 2% lidocaine, and fentanyl 0.05 mg (50 μg) was given as an intravenous push, along with 0.5 mg of atropine intravenously to prevent potential bradycardia and hypotension caused by the trigeminal-vagal reflex. Under CT guidance, a 10-cm long trocar needle (CTZ-15L, Shenzhen Qingyuan Medical Equipment Co., Ltd.) was used to reach the oval hole along a predesignated path. The depth and sagittal angle of the trocar needle were also recorded. After confirming the position, another 1 mL of 2% lidocaine was locally injected.

After reaching the foramen ovale, the needle was withdrawn and the balloon catheter (No. QKS-0050005, Shenzhen Qingyuan Medical Equipment Co., Ltd.) was inserted into the cannula. Under intermittent CT guidance, the tip of the balloon catheter was advanced until it reached the valgus portion of the temporal bone, allowing the balloon portion of the catheter tip to completely cross the tip of the puncture needle into the Meckel cavity. After confirming the position using the CT scan, the guidewire was removed and about 0.3-0.5 mL of 30% iohexol contrast medium was slowly injected into the balloon to fill the balloon. The injection port was sealed with a tee tube to prevent backflow of the contrast medium.

The balloon position was then confirmed using 3D reconstructed CT images (Fig. 4). The balloon was well positioned and the "inverted pear-shaped" balloon shape was achieved. After 3-5 minutes of compression of the semilunar ganglion, the balloon was emptied and the balloon and puncture needle were withdrawn simultaneously. The patient's vital signs were closely monitored during the entire treatment. Urapidil (this drug is not approved for use in the United States) was used to control the sudden rise in blood pressure, and atropine was used to elevate the heart rate in case of severe bradycardia to prevent cardiovascular and cerebrovascular accidents. Finally, the puncture site was compressed for a few minutes and covered with a sterile dressing, and the patient was returned to the ward.

Efficacy Evaluation and Follow-up

Preoperative data were recorded, including gender, age, duration of pain, preoperative NRS-11, lateralization of pain and affected branches, and preoperative underlying disease. Follow-up assessments were performed immediately after surgery (T1) and at 3 months (T2), 6 months (T3), 12 months (T4), and 15 months (T5) postoperatively.

The NRS-11 is used to evaluate the degree of pain using a 0-10 ranking scale: 0 = no pain; 1-3 = mild pain, but no sleep disturbance; 4-6 = moderate pain, no or mild sleep disturbance; 7-9 = severe pain and inability to sleep, or waking up with pain after sleep; 10 = severe unbearable pain.

The Barrow Neurological Institute facial numbness (BNI-N) score is used to evaluate the degree of facial numbness: grade I = no facial numbness; grade II = mild facial numbness, not irritating; grade III = facial numbness, sometimes irritating; grade IV = facial numbness, very irritating.

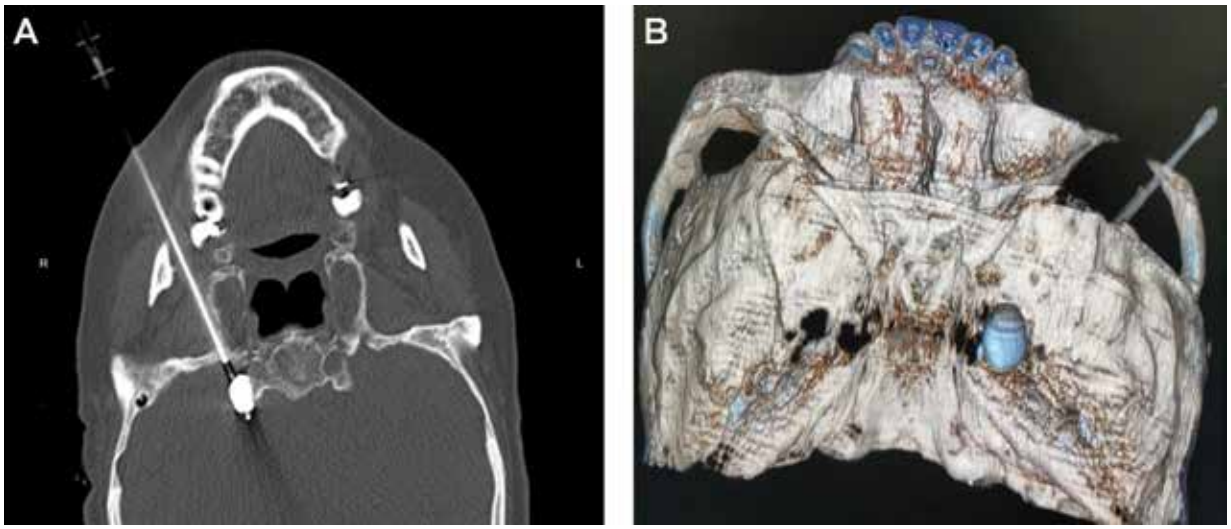

Fig. 4. *Confirmation of the balloon position in the Meckel cavity. CT images of (A) balloon after it was filled with iohexol contrast agent and (B) with 3-dimensional reconstruction. CT, computed tomography.*

A postoperative NRS-11 score of ≤ 3, which indicates mild pain or pain-free, was defined as effective; postoperative pain relief and subsequent recurrence of pain at any of the primary sites with an NRS-11 greater than or equal to the preoperative value were defined as recurrence (12). The recurrence rate was the number of recurrences/total number of patients followed-up.

Statistical Analysis

The data were analyzed using IBM SPSS Statistics 25.0 (IBM Corporation). The measurement data were first tested for normality, and the one-sample Kolmogorov-Smirnov test was used in nonparametric tests. Quantitative data with normal distribution were expressed as mean ± standard deviation (mean ± SD), and quantitative data with nonnormal distribution were expressed as median (M) (Q1, Q3) using nonparametric tests. Paired t tests were used for pre-and posttreatment comparisons, and repeated data were analyzed using repeated measures analysis of variance (ANOVA). Categorical data were analyzed using χ^2 and data were expressed as the number of cases (%). The recurrence-free survival rate (RFSR) was assessed using Kaplan-Meir survival analysis. The log-rank test was used to compare the risk of recurrence between the 2 groups. GraphPad Prism software version 8.0.0 (GraphPad Software) was used to draw violin plots. A $P < 0.05$ was considered statistically significant.

Results

Patient Characteristics

The preoperative patient characteristics of RFT and PBC groups were compared. No significant difference was found between the 2 groups in terms of gender, age, pain duration, preoperative NRS-11, lateralization of pain and affected branches, and preoperative underlying disease ($P > 0.05$) (Table 1).

Preoperative and Postoperative NRS-11 Pain Scores

There was a significant difference in preoperative and immediate postoperative NRS-11 scores between the 2 groups ($P < 0.01$) (Fig. 5). NRS-11 scores decreased at each time point (T1-T5) and were significantly different from preoperative scores ($P < 0.001$) (Fig. 5). Meanwhile, no significant difference was found in NRS-11 scores at T0, T1, and T2 between the RFT and PBC groups ($P > 0.05$) (Table 2, Fig. 6). However, the differences were statistically significant at T3 ($P < 0.05$), T4 ($P < 0.001$), and T5 ($P < 0.001$).

Postoperative Barrow Neurological Institute Numbness Scores

BNI-N scores decreased in both groups at T2, T3, T4, and T5 after surgery and were significantly different from preoperative scores ($P < 0.05$). BNI-N scores

Table 1. *Presurgery general conditions in patients.*

Parameters	RFT Group (n = 112)	PBC Group (n = 90)	χ^2/t	*P*
Gender (men/ women, %)	49(43.8) / 63(56.2)	31(34.4) / 59(65.6)	1.807	0.179
Age (years)	66.52 ± 11.36	65.24 ± 12.05	0.771	0.442
Disease course (months)	4.71 ± 4.10	5.66 ± 5.81	-1.359	0.176
Pain location - side of the face (n, %)			0.081	0.776
Left	42 (37.5)	32 (35.6)		
Right	70 (62.5)	58 (64.4)		
BMI(kg/m^2)	22.80 ± 3.27	23.47 ± 3.52	-1.398	0.164
NRS-11	6.18 ± 0.43	6.34 ± 0.48	-1.027	0.306
Divisions affected (n, %)			3.382	0.184
V1 + V2	30 (26.8)	22 (24.4)		
V2 + V3	68 (60.7)	48 (53.3)		
V1 + V2 + V3	14 (12.5)	20 (22.2)		
Basic diseases (No/ Hypertension/ Diabetes/ Hypertension+ Diabetes)	53/50/2/7	55/29/1/5	3.937	0.268

BMI: Body Mass Index; NRS-11: Numeric Rating Scale.

were significantly lower in the PBC group than in the RFT group at all time points ($P < 0.05$) (Fig. 7).

Postoperative Recurrence-free Survival Rate

The RFSR of patients in the RFT group was 84.54%, 81.44%, 74.23%, 68.04%, 51.55%, and 40.21% at one, 3, 6, 9, 12, and 15 months postoperatively, respectively. The RFSR of patients in the PBC group was 93.41%, 90.11%, 87.91%, 83.52%, 82.40%, and 81.26% at one, 3, 6, 9, 12, and 15 months postoperatively, respectively. The Kaplan-Meier curve for RFSR is shown in Fig. 8. Patients treated with RFT had a higher risk of recurrence than those treated with PBC ($P < 0.0001$, log-rank test). In the long-term treatment of multibranch trigeminal neuralgia, the PBC group exhibited a lower recurrence rate than the RFT group.

Postoperative Complications

In the RFT group, 110 patients (98%) reported masticatory weakness on the treated side immediately postoperatively, and 21 (18.8%) who completed the 15-month follow-up reported mild masticatory weakness. In the immediate postoperative period, 66% (74/112) had mild to moderate facial hypesthesia. At 15

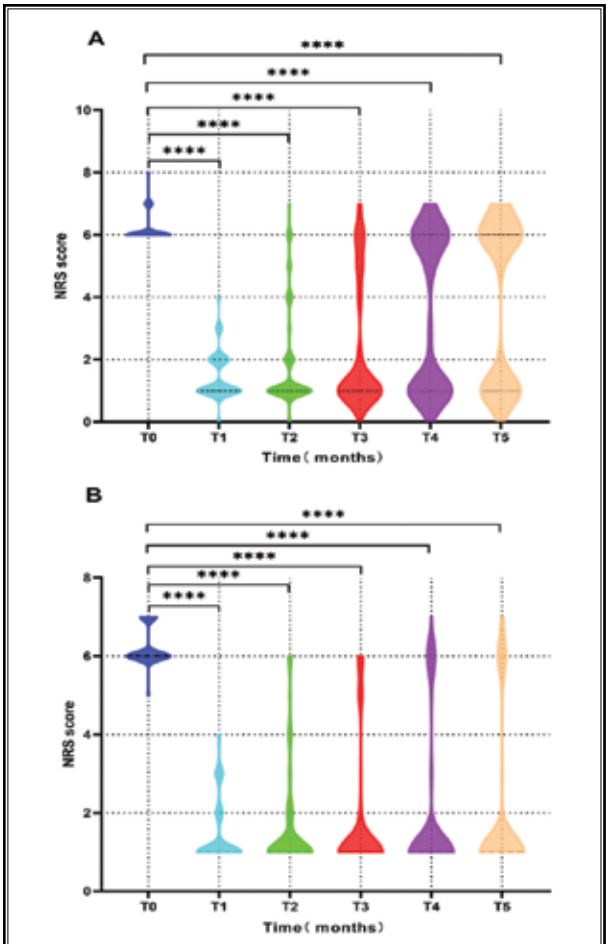

Fig. 5. *Comparison of NRS-11 scores in RFT (A) and PBC (B) groups at various time points before and after treatment. $P < 0.0001$. NRS-11, Numeric Rating Scale; RFT, radiofrequency thermocoagulation; PBC, percutaneous balloon compression.*

Table 2. *Assessment of Numeric Rating Scale (NRS-11).*

Time Points	RFT	PBC	t	*P* Value
T0 (Presurgery, mean ± SD)	6.18 ± 0.43	6.24 ± 0.48	-1.014	0.312
T1 (Postsurgery, mean ± SD)	1.49 ± 0.79	1.42 ± 0.79	0.613	0.541
T2 (3 months, mean ± SD)	1.86 ± 1.57	1.54 ± 1.27	1.568	0.119
T3 (6 months, mean ± SD)	2.32 ± 2.07	1.77 ± 1.68	2.106	0.036
T4 (12 months, mean ± SD)	3.55 ± 2.49	1.94 ± 1.91	5.193	< 0.001
T5 (15 months, mean ± SD)	3.96 ± 2.59	2.01 ± 2.03	6.012	< 0.001

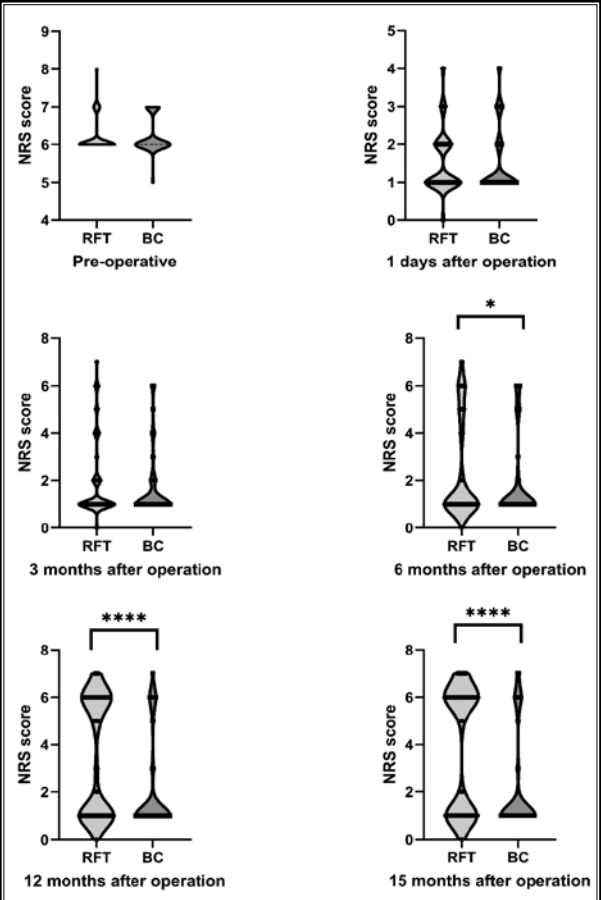

Fig. 6. *Comparison of NRS-11 at various time points before and after treatment.*

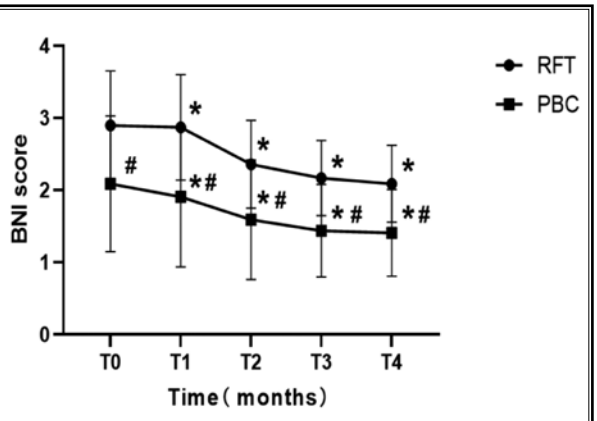

Fig. 7. *Comparison of postoperative BNI-N scores between RFT and PBC groups. Data are expressed as mean ± SD. • Compared to preoperative, P < 0.05; # compared with RFT group, P < 0.05. BNI-N, Barrow Neurological Institute facial numbness; RFT, radiofrequency thermocoagulation; PBC, percutaneous balloon compression.*

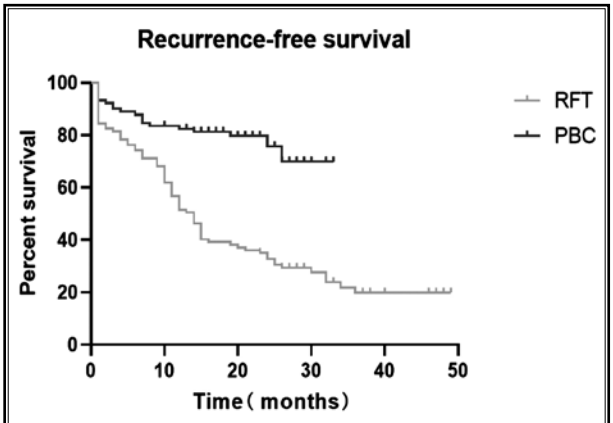

Fig. 8. *Kaplan-Meir analysis of recurrence-free survival.*

Table 3. *Postsurgery complications.*

	RFT (n = 112)	PBC (n = 90)
Masseter muscle weakness (n)	• 98% (immediately after operation) • 18.8% (at 15-months follow-up)	• 90% (immediately after operation) • 5.6% (at 15-months follow-up)
Facial hypoesthesia (n)	• 66% (immediately after operation) • 18.8% (at 15-months follow-up)	• 31% (immediately after operation) • 4.4% (at 15-months follow-up)
Impairment of corneal reflex (n)	3 (2.7%)	1 (1.1%)
Hemifacial spasm (n)	None	1 (1.1%)
Temporary hearing loss (n)	None	1 (1.1%)

months postoperatively, 18.8% of patients still experienced mild ipsilateral lateral hypesthesia.

Three patients (2.7%) developed impaired corneal reflexes, which fortunately resolved gradually after one day. No keratitis, hearing loss, meningitis, diplopia, or oculomotor disorders were detected during the follow-up period.

Masticatory weakness on the treated side was reported in 81 patients (90%) in the PBC group in the immediate postoperative period. At the most recent follow-up, 5 patients (5.6%) reported mild masticatory weakness.

One patient developed ipsilateral lateral muscle spasms, which gradually resolved after 3 months. One patient had an impaired corneal reflex, which gradually resolved after one week. One patient developed temporary hearing loss, which gradually resolved after 2 weeks (Table 3).

Discussion

The trigeminal nerve is a mixed nerve, the 5th pair of nerves in the brain, and the thickest nerve in the face. The trigeminal nerve is formed by the confluence of the ophthalmic (branch I), maxillary (branch II) and mandibular (branch III) branches, which innervate sensory and masticatory muscle contractions above the eye fissure, between the eye and mouth fissures, and below the mouth fissure, respectively.

It has been found that primary TN predominantly involves branches II and III, mainly presenting as spontaneous pain and touch-evoked pain (2). Most patients can have distinct trigger points with sharp lightning-like, knife-like pain in the corresponding area or adjacent areas when talking, washing their faces, brushing their teeth, or even walking (13). The fear of triggering pain deters patients from speaking, eating, and maintaining facial hygiene, severely affecting their quality of life (14).

RFT is a reliable tool in the treatment of TN, as it destroys the nerve by thermal denaturation and blocks the upstream transmission of pain signals to produce more reliable pain relief (15). Although percutaneous oval-hole puncture of the gasserian ganglion with RFT is the classic approach (16), it is not very selective for trigeminal nerve branches, and because the trigeminal gasserian ganglion is in the middle cranial fossa, the procedure needs to be performed so that the RF needle is punctured into the skull, thus increasing the risk of intracranial infection or intracranial vascular injury.

Our research group designed a CT-guided extracranial nonhemispheric RF treatment technique that can achieve highly selective treatment of trigeminal branches without entering the skull (17). The supraorbital foramen (18), circular foramen (19), and oval foramen (20) can be punctured for branches I, II, and III, respectively. For patients with multiple painful branches, a combined multiport RF puncture with RF can be performed, thus preventing spillover to untargeted branches. This study cohort was directly treated with standard RFT at 90°C for 120 seconds (21), which was more effective and safer in clinical observations (19). This treatment approach uses a CT-guided design of the optimal puncture path and performs puncture according to the measured depth and angle, which can reduce the number of punctures and improve the success rate of puncture.

In 1983, Mullan and Lichtor (22) reported the use of PBC for the treatment of primary TN, which has now been clinically proven to be less invasive, easy to perform, safe, and effective, and therefore more suitable for patients who cannot tolerate MVD (23).

It was found that the rationale for PBC treatment may be related to the selective injury of myelinated thick fibers by PBC, thereby blocking the transmission of nociceptive signals and relieving local microvascular compression and adhesions around the nerve (24). All patients in our study were treated by local anesthesia with conscious analgesia under CT. The local anesthesia-conscious analgesia CT-guided PBC treatment technique is more innovative than the traditional general anesthesia C-arm x-ray-guided PBC treatment.

C-arm x-ray is a 2-dimensional imaging tool. The image lacks a 3-dimensional display function and has poor accuracy and clarity. The CT-guided puncture can enhance the puncture operation accuracy and convenience by designating the puncture path and measuring the puncture depth and angle, thus reducing the number of puncture needle adjustments, effectively reducing the risk of bleeding, infection, and damage to the adjacent structures.

The operation of PBC treatment under local anesthesia with conscious analgesia supervision can be improved by asking the patient if numbness and pain disappears in the original painful area as the end of treatment criteria. Huang, et al (25) showed that the awake CT-guided PBC technique was effective in treating all distributions of TN pain and had a one-year recurrence rate of 13%, slightly higher than the historical performance of classic PBC.

In our study, patients with multi-branch TN were followed-up at different periods postoperatively to assess the efficacy, the occurrence of complications, and the degree of recurrent pain. Overall, satisfactory results were achieved in both the RFT and PBC groups. Postoperative NRS-11 scores were significantly lower than the pretreatment scores in both groups. By comparing NRS-11 scores before and after treatment, it was found that short-term results (up to 3 months postoperatively) were similar for both minimally invasive procedures for the treatment of multibranch trigeminal nerve pain ($P > 0.05$). However, the PBC group had better long-term results than the RFT group; the NRS-11 score in the PBC group was lower than that in the RFT group ($P < 0.05$).

Kaplan-Meir survival curves showed that for patients with multiple painful branches, the postoperative recurrence rate was lower in the PBC group than in the RFT group. Patients in the PBC and RFT groups had recurrence rates of 18.74% and 59.79% after 15

months of treatment, respectively. The difference was statistically significant ($P < 0.05$).

For postoperative complications, the data on the incidence of ipsilateral masticatory weakness in the immediate postoperative period were comparable between the 2 groups (Table 3). Some patients in both groups also reported mild masticatory weakness after completing 15 months of follow-up, with a smaller number in the PBC group. Compared with the PBC group, most patients in the RFT group had facial hypesthesia, which was confined to the painful area only, preventing damage to the nonresponsible branch;, it did not affect the overall quality of life of all patients at follow-up.

Although most scholars believe that the standard RF thermal coagulation temperature should be started at 65°C and then stepped up by 5°C, for 60 second cycles (26), our cohort directly used a steady RF thermal coagulation temperature of 90°C for 120 seconds without other serious complications. In addition, only 3 patients in the RFT group had impaired corneal reflexes that gradually resolved after one month. One patient in the PBC group had ipsilateral lateral muscle spasms, one patient had an impaired corneal reflex, and one patient had temporary hearing loss; all of them had gradually resolved by a later follow-up.

BNI-N scores decreased in both groups at each postoperative time point and were significantly different from preoperative values. BNI-N scores were significantly lower in the PBC group than in the RFT group at all time points. This could be due to the disruption of the structural integrity of the trigeminal nerve by thermal coagulation destruction. In all follow-ups, only a small proportion of patients in the PBC group had diverse complications. No serious complications occurred in either group, with relatively high patient satisfaction.

Limitations

This was a single center, retrospective observational study. The reliability of this finding may need to be confirmed in a multicenter, randomized controlled trial. In addition, the sample size of this study was relatively small. A larger sample size may need to be collected for validation.

Conclusions

In summary, both RFT and PBC are effective in the treatment of primary multibranch trigeminal pain. Our PBC group had better long-term results than the RFT group plus a relatively lower recurrence rate postoperatively, while the RFT group had fewer complications because of the highly selective treatment of the trigeminal branches. Both groups had a comparable safety profile, with no serious complications. RFT of the trigeminal nerve may result in long-term or even permanent sensory loss, whereas balloon compression may cause short-term facial numbness. However, Patient quality of life was not affected by either method at follow-up. Facial numbness was considered a sign of successful surgery; most of the facial sensory loss resolved on its own after a few months. Both treatment options are available for elderly patients or those who are generally unable to tolerate surgery or have relapsed after surgery.

References

1. Scholz J, Finnerup NB, Attal N, et al. The IASP classification of chronic pain for ICD-11: Chronic neuropathic pain. *Pain* 2019; 160:53-59.
2. Wang Q, Du W-J. Analysis of short-term efficacy of radiofrequency thermocoagulation in the treatment of classic trigeminal neuralgia. *Agri* 2022; 34:1-6.
3. Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition. *Cephalalgia* 2018; 38:1-211.
4. Koopman JS, Dieleman JP, Huygen FJ, et al. Incidence of facial pain in the general population. *Pain* 2009; 147:122-127.
5. Maarbjerg S, Wolfram F, Gozalov A, et al. Significance of neurovascular contact in classical trigeminal neuralgia. *Brain* 2015; 138:311-319.
6. Liu G, Du Y, Wang X, et al. Efficacy and safety of repeated percutaneous radiofrequency thermocoagulation for recurrent trigeminal neuralgia. *Front Neurol* 2018; 9:1189.
7. Berger I, Nayak N, Schuster J, et al. Microvascular decompression versus stereotactic radiosurgery for trigeminal neuralgia: A decision analysis. *Cureus*, 2017; 9:e1000.
8. Mizobuchi Y, Nagahiro S, Kondo A, et al. Microvascular decompression for trigeminal neuralgia: A prospective, multicenter study. *Neurosurgery* 2021; 89:557-564.
9. Fraioli MF, Cristino B, Moschettoni L, et al. Validity of percutaneous controlled radiofrequency thermocoagulation in the treatment of isolated third division trigeminal neuralgia. *Surg Neurol* 2009; 71:180-183.
10. Xia Y, Yu G, Min F, et al. The focus and new progress of percutaneous balloon compression for the treatment of trigeminal neuralgia. J *Pain Res* 2022; 15:3059-3068.
11. Noorani I, Lodge A, Vajramani G,

Sparrow O. The effectiveness of percutaneous balloon compression, thermocoagulation, and glycerol rhizolysis for trigeminal neuralgia in multiple sclerosis. *Neurosurgery* 2019; 85:E684-E692.

12. Luo G, Zhang Z, Zhu J, et al. Association between the risk of relapse and the type of surgical procedure for herpes zoster-related pain. *Pain Physician* 2021; 24:E1227-E1236.
13. Cruccu G, Di Stefano G, Truini A. Trigeminal neuralgia. *N Engl J Med*, 2020; 383:754-762.
14. Barker FG 2nd, Jannetta PJ, Bissonette DJ, et al. The long-term outcome of microvascular decompression for trigeminal neuralgia. *N Engl J Med* 1996; 334:1077-1083.
15. Racz GB, Ruiz-Lopez R. Radiofrequency procedures. *Pain Pract* 2006; 6:46-50.
16. Emril DR, Ho KY. Treatment of trigeminal neuralgia: Role of radiofrequency ablation. *J Pain Res* 2010; 3:249-254.
17. Huang B, Luo Y, Chen Y, et al. Progress in Radiofrequency for Trigeminal Neuralgia: Extracranial Non-Gasserian Ganglion Radiofrequency Thermocoagulation. *Med Sci Monit;* 2019; 6:1-6.
18. Xie K, Liu S, Huang B, et al. Effects of supraorbital foramen variations on the treatment efficacy of radiofrequency therapy for V1 trigeminal neuralgia: A retrospective study. *Pain Res Manag* 2020; 2020:8142489.
19. Huang B, Yao M, Feng Z, et al. CT-guided percutaneous infrazygomatic radiofrequency neurolysis through foramen rotundum to treat V2 trigeminal neuralgia. *Pain Med* 2014; 15:1418-1428.
20. Huang B, Xie K, Chen Y, et al. Bipolar radiofrequency ablation of mandibular branch for refractory V3 trigeminal neuralgia. *J Pain Res* 2019; 12:1465-1474.
21. Chen Y, Zhu Q, Huang B, et al. The value and application of personalized needle modification in percutaneous infrazygomatic radiofrequency in isolated maxillary nerve pain through the foramen rotundum. *Pain Physician* 2019; 22:377-387.
22. Mullan S, Lichtor T. Percutaneous microcompression of the trigeminal ganglion for trigeminal neuralgia. *J Neurosurg* 1983; 59:1007-1012.
23. Texakalidis P, Xenos D, Tora MS, et al. Comparative safety and efficacy of percutaneous approaches for the treatment of trigeminal neuralgia: A systematic review and meta-analysis. *Clin Neurol Neurosurg* 2019; 182:112-122.
24. Green T H, Girgis F. Trigeminal neuralgia: Medical management and surgical options. *J Pain Palliat Care Pharmacother* 2019; 33:32-33.
25. Huang B, Yao M, Chen Q, et al. Efficacy and safety of awake computed tomography-guided percutaneous balloon compression of trigeminal ganglion for trigeminal neuralgia. *Pain Med* 2021; 22:2700-2707.
26. Deng M, Cai H, Fang W, et al. Three-dimensionally printed personalized guide plate for percutaneous radiofrequency thermal coagulation in idiopathic trigeminal neuralgia. *Int J Oral Maxillofac Surg* 2018; 47:392-394.