Retrospective Study

Comparison of Clinical Outcomes Trigeminal Nerve Block With and Without Radiofrequency Thermocoagulation for Trigeminal Neuralgia

Ji H. Hong, MD, PhD, Seung W. Lee, MD, and Ji H. Park MD, PhD

From: Department of Anesthesiology and Pain Medicine, Keimyung University Dong San Hospital Daegu, Republic of Korea

Address Correspondence:
Ji H. Hong, MD, PhD
Department of Anesthesiology and Pain Medicine, Keimyung University Dong San Hospital
1035 Dalgubeol-daero
Dalseo-gu, Daegu, 42601,
Republic of Korea.
E-mail: swon13@daum.net

Disclaimer: There was no external funding in the preparation of this article.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Article received: 03-15-2024
Revised article received: 05-23-2024
Accepted for publication: 07-09-2024

Free full article: www.painphysicianjournal.com

Background: Trigeminal neuralgia (TN) is known to be an excruciating disease. It leads to a reduced quality of life and psychological distress, often even to suicide. Patients who are intractable to pharmacotherapy should receive a percutaneous treatment, such as a trigeminal nerve block (TB) or radiofrequency thermocoagulation (RFT) of the trigeminal ganglion.

Objectives: The primary endpoint of this study was to compare the clinical outcome of TB alone with TB and RFT of the trigeminal ganglion.

Study Design: Retrospective study.

Setting: The pain clinic of a tertiary university hospital.

Methods: Patients with TN received an ultrasound-guided supraorbital, infraorbital, or mental nerve block twice depending on the affected division. They were divided into TB only group (n = 42) and TBRF group (n = 60) depending on the result of the nerve block. The TBRF group, which had an unresponsive result to the initial nerve block, then received radiofrequency thermocoagulation (RFT) at the trigeminal ganglion.

Results: The Numeric Rating Scale (NRS-11), measured at 2 and 4 weeks post the initial nerve block, was significantly lower in the TB group than the TBRF group ($P < 0.001$). However, when RFT was performed in the TBRF group, the NRS-11 score became similar between the 2 groups (2.4 vs 2.05). Patients with a Barrow Neurological Institute (BNI) Pain Intensity Scale score of I or II, had a successful outcome: 45 patients in the TBRF group (45/60, 75%). Whereas, patients with a BNI score of IV or V, had an unsuccessful outcome: 6 patients (6/60, 10%) in the TBRF group. The time to recurrence in the TB and TBRF groups was 11.2 ± 1.6 and 19.4 ± 2.8 months, respectively ($P = 0.01$). The total recurrence rate at the 3-year follow-up in the TB and TBRF groups was 57% (24/42) and 23% (14/60), respectively ($P = 0.001$).

Limitation: Facial hypoesthesia is an important sign of successful destruction of the trigeminal ganglion. However, we did not analyze the BNI score according to the degree of facial hypoesthesia.

Conclusion: When patients with TN were unsuccessful with trigeminal nerve block alone, combining RFT at the trigeminal ganglion demonstrated a successful NRS-11 score reduction with a lower recurrence rate and a longer time to recurrence than trigeminal nerve block alone.

Key words: Barrow Neurological Institute Pain Intensity scale, radiofrequency thermocoagulation, recurrence rate, trigeminal nerve block, trigeminal neuralgia

Pain Physician 2025: 28:241-248

Trigeminal neuralgia (TN), recurrent severe lancinating facial pain, involves one or more branches of the trigeminal nerve and affects mostly a unilateral side of the face. The severe and paroxysmal pain disables the mental and physical function of patients (1-4). Among cranial neuralgia, TN is known to be the most excruciating disease, which may lead to a reduced quality of life and psychological distress, often even to suicide (3,5,6).

A leading cause of TN is vascular compression near the dorsal root entry zone of the trigeminal ganglion. However, idiopathic TN or intracranial lesions, such as tumors, cysts, and multiple sclerosis, can also cause symptoms similar to TN due to vascular compression (3). The incidence of secondary TN, intracranial tumor compression of the trigeminal nerve, is known to be less than 10% (7). Therefore, magnetic resonance imaging of the brain is necessary to exclude specific lesions in the posterior cranial fossa.

Pharmacotherapy should be considered as the first-line therapy since TN presents a good response to oral medication. Well known first choice antiepileptics are carbamazepine and oxcarbazepine. Other commonly applied antiepileptics are gabapentin, pregabalin, phenytoin sodium, and lamotrigine (5). If patients are still intractable with these pharmacotherapy treatments or if they experience severe side effects from oral medication, percutaneous treatments should be considered (8-11).

Percutaneous treatment includes a destructive measure which involves penetrating the foramen ovale to reach and destroy the trigeminal ganglion or root using radiofrequency thermocoagulation (RFT), percutaneous balloon compression, or a glycerol injection. Among percutaneous treatments, trigeminal ganglion RFT is a successful treatment for patients who have a Barrow Neurological Institute (BNI) Pain Intensity Scale score of I or II with 83% getting relief (12). However, RFT is a destructive treatment, resulting in facial numbness and dysesthesia (13). Also, penetrating the foramen ovale during trigeminal ganglion RFT results in hemodynamic fluctuation, which can be an additional burden to older patients (14).

Administering local anesthetics alone to the trigeminal nerve or its terminal branches—supraorbital (SO), infraorbital (IO), and mental nerves—has been demonstrated to have good treatment results (15-19). In contrast to RFT of the trigeminal ganglion, an SO, IO, or mental nerve block is very simple to perform with a low risk of severe complications. Moreover, facial foramens, where each terminal branch of the trigeminal nerves come out, are easily identified using ultrasound (17).

The primary endpoint of our study was to compare the clinical outcome of trigeminal nerve block alone with trigeminal nerve block with and RFT at the trigeminal ganglion.

Methods

This retrospective study was approved by our institutional review board (approval number 2024-02-052), which waived the need for informed patient consent. Patients who were diagnosed with idiopathic or classic TN according to the beta-version of the Third Edition of the International Classification of Headache Disorders and who were seen from August 2017 through March 2022 were included (20). Before a final TN diagnosis, magnetic resonance imaging was performed in all patients to verify if any vascular lesion or intracranial tumor was around the trigeminal ganglion. Included patients received an ultrasound-guided SO, IO, or mental nerve block alone or trigeminal ganglion RFT subsequent to nerve block under C-arm guidance due to intractable facial pain.

Patients who had insufficient medical records were excluded. Also, patients who received different types of nerve block other than SO, IO, or mental nerve block were also excluded.

We used Clinical Data Warehouse v 2.5 (CDW, Planit Healthcare) to identify patients diagnosed with TN who received a trigeminal nerve block using the key words "trigeminal neuralgia and nerve block."

Patient Assignment

All included patients received an ultrasound-guided SO, IO, or mental nerve block, depending on the affected division of the trigeminal nerve twice every 2 weeks. After 2 consecutive SO, IO, or mental nerve blocks, these patients were divided into a trigeminal nerve block (TB) group or a trigeminal nerve block with radiofrequency thermocoagulation (TBRF) group according to the initial treatment outcome. If patients responded to the 2 consecutive SO, IO, or mental nerve blocks, then they were assigned to the TB group; they received a third SO, IO, or mental nerve block. If patients were nonresponsive to the 2 consecutive SO, IO, or mental nerve blocks, then they were assigned to the TBRF group and received RFT of the trigeminal ganglion. Responsiveness or nonresponsiveness was determined by a patient's Numeric Rating Scale (NRS-11) score reduction after the initial treatment: a reduction

≥ 50% was considered responsive and a reduction of < 50% was considered non-responsive (Fig. 1).

Outcome Evaluation

To measure pain improvement, an NRS-11 score was obtained before the initial nerve blocks, and at 2 weeks, 4 weeks, and 8 weeks subsequent to nerve block or RFT. In addition, patients in the TBRF group were also measured with the (BNI) pain scale (Table 1).

Clinical characteristics, including demographic data, pain duration, medications, and trigeminal nerve distribution were obtained by careful reviewing of the electrotonic medical records. Time to recurrence was defined by calculating the total months required for a second visit due to the reappearance of facial pain since the initial visit to the pain clinic.

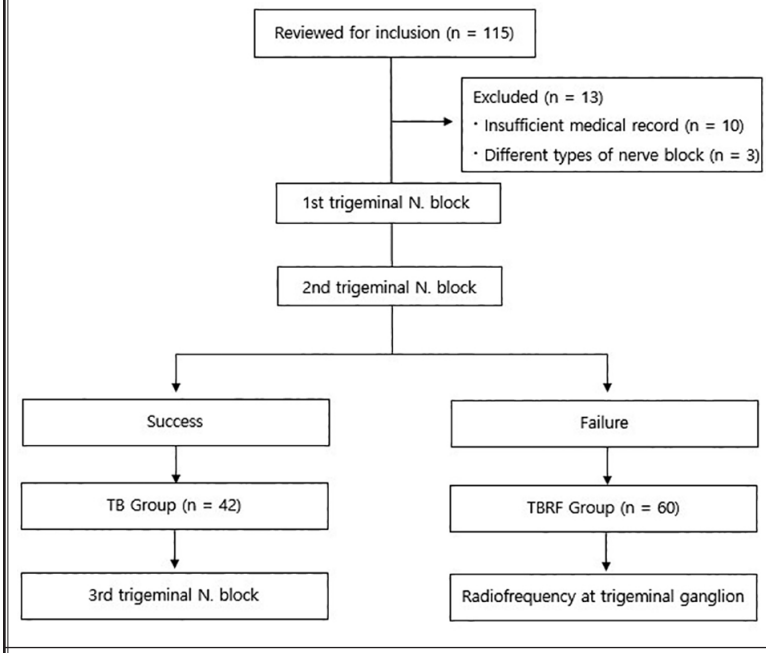

Fig. 1. *Flow chart of this study.*

Ultrasound-guided SO, IO, or Mental Nerve Block

The patient was placed supine with sterile draping on the affected side of the face. A hockey stick probe (Logiq S8, GE Healthcare), enveloped in a sterile polyvinyl cover containing an ultrasound gel was used. The SO, IO, and mental foramens were easily identified using the hockey stick probe near the eyebrow, cheek, and lower mandible, respectively. Once an intended facial foramen was identified, 2 mL of 0.2% ropivacaine was injected using an in-plane technique (Fig. 2). If a patient reported facial pain at both sides of the cheek (maxillary division, V2) and mandible (mandibular division, V3), both IO and mental nerve blocks were performed sequentially.

Radiofrequency Thermocoagulation of the Trigeminal Ganglion

The patient was supine position with neck extension of 30°-40°. A 10 cm height pillow was put under the upper back for neck extension. The fluoroscopic view was adjusted using 10°-15° lateral rotation from the midline and a 30°-35° caudal tilt. The foramen ovale (FO) was easily identified between the mandibular ramus laterally and the maxilla medially using fluoroscopic view. If the FO was superimposed by the mandibular ramus or maxilla, ipsilateral lateral rotation of the C-arm was done to locate the FO at the midpoint between the mandibular ramus and the maxilla.

Table 1. *Barrow Neurological Institute (BNI) pain intensity scale.*

	Definition
I	No trigeminal pain, no medication required
II	Occasional pain not requiring medication
III	Some pain adequately controlled with medication
IV	Some pain not adequately controlled with medication
V	Severe pain, no pain relief

Subsequent to clear visualization of the FO, local skin infiltration using 1% lidocaine was administered 3 cm lateral to the lips. For the RFT of the trigeminal ganglion, a 10 cm 22G curved RF cannula with a 2 mm active tip was used. Targeting the center of the FO, the cannula was advanced using a coaxial view. To attenuate a sudden increase in heart rate and blood pressure, nicardipine (1 mg) or sufentanil (5 μg) was injected in advance to the final puncture of the FO.

If the cannula entered the FO successfully, the C-arm was rotated to a lateral view to identify the clival line. For V1 TN, the cannula was advanced beyond the clival line (Fig. 3A). However, it was avoided to advance the cannula 10 mm further beyond the clival line (21). The cannula was advanced to the clival line if the pa-

tient had TN of the V2 region (Fig. 3B). If the patient had TN of the V3 region, the cannula was advanced 3-4 mm farther after entering the FO, however, it was not advanced to the clival line (Fig. 3C).

After confirming the suitable position of the cannula using a lateral fluoroscopic view, an electrical stimulation ranging between 0.1–0.3 V at 50 Hz from an RF generator (Baylis Medical Technologies) was applied. The patient was then asked if he could feel electrical sensation in the original pain area of the face. If electrical sensation ws weak or absent, the cannula was advanced or withdrawn under the guidance of C-arm to find a position with maximal stimulation. If the patient reported a proper electrical sensation within 0.1–0.3 V in the affected facial region, final thermal heating was performed once at 70°C for 60 seconds.

If the patient had TN of both the V2 and V3 regions, thermal heating at V2 was done first and the second thermal heating at V3 region was performed after withdrawal of the cannula.

During RFT, light sedation using midazolam (0.02 mg/kg) and sufentanil 5 μg was given to minimize procedure pain. In order to facilitate the patient's cooperation during the procedure, light sedation was maintained. Blood pressure, pulse oximetry, and electrocardiography were measured during the entire RFT procedure and until 30 minutes postprocedure. Oxygen (3 L/min) was supplied using a face mask.

Statistical Analysis

Statistical calculations were made using IBM SPSS Statistics 20.0 (IBM Corporation). The Kolmogorov-Smirnov test was used to examine normal distribution. If it showed normal distribution, an independent Student's t test was used to compare the continuous variables between the TB and TBRF groups. Categorical variables were reported as the number of patients (%) and compared using Pearson's χ^2 test or Fisher's exact test. A P value of < 0.05 was considered statistically significant.

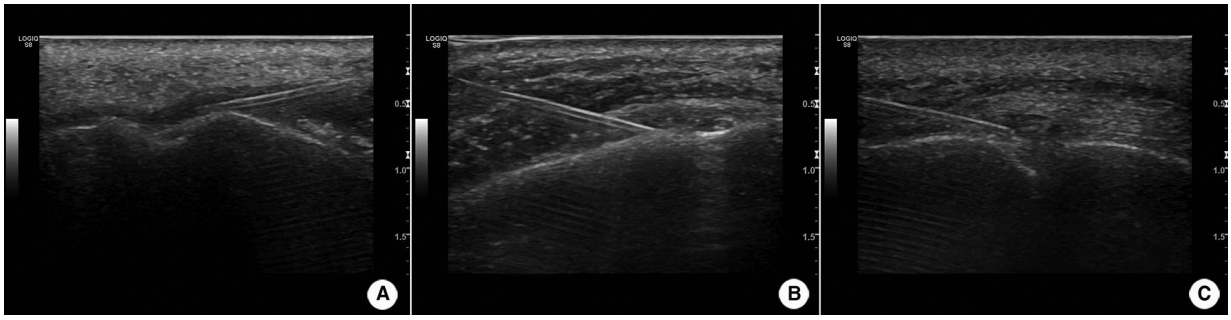

Fig. 2. *Ultrasound images showing supraorbital (A), infraorbital (B), and mental nerve (C) blocks.*

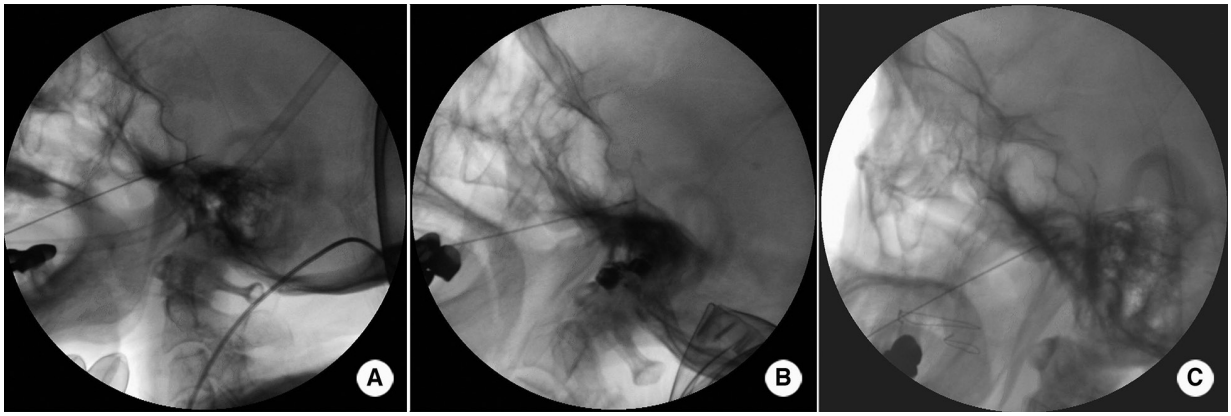

Fig. 3. *Lateral fluoroscopic images showing the position of the cannula tip in patients with V1 (A), V2 (B), or V3 (C) division of trigeminal neuralgia.*

Results

After excluding 13 patients, the electronic medical records of 115 patients were carefully reviewed.. Excluded patients had insufficient medical records, or received different types of nerve block (Fig. 1). When patients with TN received an SO, IO, or mental nerve block twice according to the affected division of the trigeminal nerve, 42 (TB group) and 60 patients (TBRF group) demonstrated responsive and nonresponsive results, respectively (Fig. 1). The TBRF group patients, who were nonresponsive to the initial nerve blocks, received RFT at the trigeminal ganglion without any further nerve block (Fig. 1).

The NRS-11, measured at 2 and 4 weeks post the initial nerve blocks, was significantly lower in the TB group than the TBRF group ($P < 0.001$, Fig. 4). However, when RFT was performed in TBRF group, the NRS-11 became similar between the TB and TBRF groups at 8 weeks (2.4 vs 2.05, Fig. 4).

Age, gender, duration (month), and facial pain side were similar between the TB and TBRF groups. Carbamazepine alone was the most common drug used prescribed to both groups. The V2 or V3 division of the trigeminal nerve was the most common affected nerve (Table 2).

In the TBRF group patients with a BNI I or BNI II, 45 patients (75%) had a successful outcome (Table 3). However, the patients with a BNI IV or BNI V, 6 (10%) had an unsuccessful outcome (Table 3).

The time to pain recurrence in the TB and TBRF groups was 11.2 ± 1.6 and 19.4 ± 2.8 months, respectively ($P = 0.01$, Table 4). The total recurrence rate at 3 years follow-up in the TB and TBRF groups was 57% (24/42) and 23% (14/60), respectively ($P = 0.001$, Table 4).

No patients in the TB group had a complication. However, 53 patients in the TBRF group demonstrated

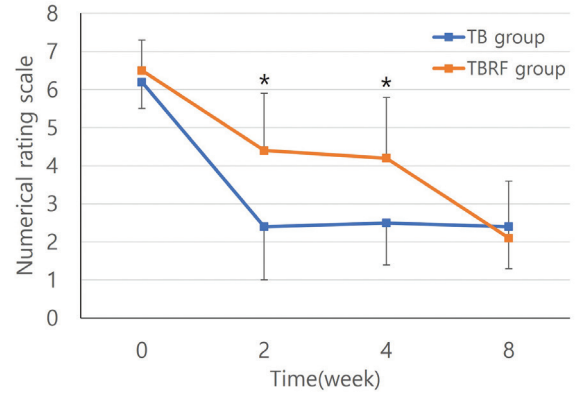

Fig. 4. *Changes in Numeric Rating Scale score after terminal branch of trigeminal nerve block. The result at 8 weeks in the TBRF group is the score after radiofrequency thermocoagulation, not after trigeminal nerve block. * $P < 0.001$.*

Table 2. *Clinical characteristics of trigeminal nerve block (TB) group and trigeminal nerve block with radiofrequency (TBRF).*

	TB Group (n = 42)	TBRF Group (n = 60)	Total (n = 102)	*P* Value
Age (years)	64 ± 14.8	68.2 ± 13.7	66.5 ± 14.3	0.15
Gender (men)	16 (38.1)	31 (51.7)	47 (46.1)	0.23
Pain duration (mos)	26.9 ± 45.7	29.1 ± 43.9	28.2 ± 44.4	0.81
Affected Side	26 (63.4) Right	34 (56.7) Left	102 (100)	0.54
Medications				0.99
Carbamazepine	26 (61.9)	38 (63.3)	64 (62.7)	
Oxcarbazepine	4 (9.5)	6 (10)	10 (9.8)	
Pregabalin or Gabapentin	6 (14.3)	7 (11.7)	13 (12.7)	
Unknown or no medication	6 (14.3)	9 (15)	15 (14.7)	
Distribution of trigeminal nerve				0.32
V1	5 (11.9)	1 (1.7)	6 (5.9)	
V2	15 (35.7)	25 (41.7)	40 (39.2)	
V3	13 (31)	18 (30)	31 (30.4)	
V1+V2	2 (4.8)	3 (5)	5 (4.9)	
V2+V3	7 (16.7)	13 (21.7)	20 (19.6)	

Table 3. *Outcome of trigeminal ganglion radiofrequency thermocoagulation in trigeminal nerve block and radiofrequency thermocoagulation group patients.*

BNI Pain Intensity Scale	Number of patients (%)
I	27 (45)
II	18 (30)
III	9 (15)
IV	4 (6.6)
V	2 (3.3)
Total	60 (100)

BNI; Barrow neurological institute; I; no trigeminal pain, no medication required, II; occasional pain not requiring medication, III; some pain adequately controlled with medication, IV; some pain not adequately controlled with medication, V; severe pain, no pain relief

Table 4. *The time to recurrence and recurrence rate in the trigeminal nerve block (TB) group and trigeminal nerve block with radiofrequency (TBRF) group.*

	TB Group (n = 42)	TBRF Group (n = 60)	Total (n = 102)	*P* Value
Time to recurrence (mos)	11.2 ± 1.6	19.4 ± 2.8	14.2 ± 9.7	0.01
Recurrence (%)	24 (57)	14 (23)	38 (37)	0.001

a mild to moderate degree of facial sensory loss or hypoesthesia.

Discussion

Among 102 patients included in this study, 42 patients (TB group) demonstrated a successful NRS-11 reduction without needing RFT of the trigeminal ganglion. However, the TB group had a shorter time to recurrence and a higher total recurrence rate than the TBRF group.

Blocking the SO, IO, mental nerves, and the terminal branch of the trigeminal nerve can be performed in an outpatient setting due to the procedure's ease. In addition, this block has few side effects and can be easily used in elderly patients. In one study, when a block of the trigeminal nerve's terminal branch with superior and inferior alveolar nerves was performed, all included patients demonstrated pain relief, which decreased up to 78% at 2 weeks postprocedure (18). The best therapeutic effect was observed at 2 weeks postprocedure; NRS-11 scores started increasing following 2 weeks postprocedure. However, long-term pain relief in this study was uncertain (18).

Similarly, 9 patients with TN who had intractable pain who received SO, IO, and mental nerve blocks demonstrated immediate pain relief of > 50% with more than half patients becoming completely pain free (19). Among these 9 patients, 6 of them showed long-lasting pain relief, varying 1–8 months (19).

Deeper injection into the maxillary nerve in the pterygopalatine fossa or mandibular nerve posterior to the lateral pterygoid plate, can also be performed for TN. When 35 patients with TN received maxillary or mandibular nerve block with 10% lidocaine, 34.3% of them showed a successful response; their pain relief lasted 3–172 weeks (22). The 34.3% successful response rate was slightly lower than the result of this study (41.1%) (22). Considering the deep location of the maxillary and mandibular nerves and the higher level of difficulty of this block, superficial injection could be technically easier to perform yet still provide a favorable outcome (17).

In our study, SO, IO, and mental nerve blocks were all performed using ultrasound guidance. The advantage of high-resolution ultrasound is the real-time visualization of peripheral nerves with neighboring structures, including muscle, tendon, vessel, and ligaments. Moreover, this procedure allows precise targeting of the affected nerve without the risk of accidental nerve injury, vascular thrombosis, and postinjection hematoma (17).

Microvascular decompression is known to be the first interventional choice of treatment for classic TN. However, elderly patients with various medical illnesses might not tolerate it. A previous study (23) suggested that TN with cardiovascular system disease and hypertension were the most common comorbidities. Moreover, microvascular decompression is only indicated in patients who present any vascular contact or compression with the trigeminal ganglion or rootlet (5). If patients cannot tolerate microvascular decompression or are not a candidate, RFT is an alternative treatment option.

A recent systematic review (24) demonstrated that the mean initial pain relief following RFT of the trigeminal ganglion was 95.3% (SD, 77.8%-100%). The recurrence rate at one year follow-up was 4.9%-59.5%. Mean time to pain recurrence was 9–36 months (24). However, direct comparison with a previous systematic review (24) has some limitations since above meta-analysis included pulsed RFT, which was not performed in our study. Our study also demonstrated a good therapeutic result of RFT of trigeminal ganglion, as 75% of patients showed initial pain relief (BNI I or II) with 23% of recurrence rate during 3 years follow up and 19.4 months mean time to recur. Mild to moderated degree of post-RFT facial sensory loss was observed in almost all cases except 7 patients. Facial hypoesthesia following RFT of trigeminal ganglion indicates a successful sensory system destruction which is essential for good therapeutic result (24). In 13 patients (6.2%) whose sensory changes in the face were uncertain, they showed early BNI grade IV (3.8%) and V (2.3%) (23). Due to an association of therapeutic result and facial hypoesthesia, controversy still presents whether facial hypoesthesia should be considered as a complication of RFT or not (13,23).

Although RFT of the trigeminal ganglion is a more

invasive and destructive method than SO, IO, and mental nerve blocks, it demonstrated a lower recurrence rate and longer time to recurrence. For patients with recurrent facial pain due to TN after RFT, repeated RFT has demonstrated a similar therapeutic outcome compared to the first RFT. In addition, repeated RFT did not show any increased side effects or severity compared to the initial RFT (25). Good prognostic factors of RFT of the trigeminal ganglion in terms of long-term pain relief and complication rate were typical facial pain, normal facial sensation, and good initial response to medication (26). When patients received RFT with a temperature higher than 80°C, they demonstrated troublesome dysesthesia, keratitis, and masseter weakness (26).

Complications related to RFT of the trigeminal ganglion include hemosialorhea (by piercing the parotid duct), pterygo-maxillary hematoma (injury to the maxillary artery), obstruction of the Eustachian tube and carotid puncture. Severe sequelae (anesthesia dolorosa, corneal hypoesthesia with keratitis) or lighter sequelae (facial numbness or masticatory weakness) can be avoided using proper electrical testing or stimulation and communication with the patient (27).

Limitations

Our study includes several limitations. First, when SO, IO, and mental nerve blocks were performed, a superior or inferior alveolar nerve block was not performed. Superior and inferior alveolar nerves are important branches of the maxillary and mandibular nerves, respectively. Therefore, an additional block of those alveolar nerves with superficial terminal branch might result in a better therapeutic outcome. Second, we included patients who visited our pain clinic from August 2017 through March 2022. The recurrence rate of 57% (TB group) and 23% (TBRF group) were observed at the 3-year follow-up. However, some patients included in 2022 could not satisfy the 3-year follow-up period. Finally, facial hypoesthesia is an important sign of successful trigeminal ganglion destruction. However, we did not analyze the BNI score according to the degree of facial hypoesthesia.

Conclusion

In conclusion, when patients with TN were unresponsive to trigeminal nerve block alone, combining RFT at the trigeminal ganglion successfully reduced NRS-11 scores with a lower recurrence rate and longer time to recur than trigeminal nerve block alone.

References

1. Jones MR, Urits I, Ehrhardt KP, et al. A comprehensive review of trigeminal neuralgia. *Curr Pain Headache Rep* 2019; 23:74.
2. Ibrahim S. Trigeminal neuralgia: Diagnostic criteria, clinical aspects and treatment outcomes. A retrospective study. *Gerodontology* 2014; 31:89-94.
3. Maarbjerg S, Di Stefano G, Bendtsen L, Cruccu G. Trigeminal neuralgia - diagnosis and treatment. *Cephalalgia* 2017; 37:648-657.
4. Lee CH, Jang HY, Won HS, Kim JS, Kim YD. Epidemiology of trigeminal neuralgia: An electronic population health data study in Korea. *Korean J Pain* 2021; 34:332-338.
5. Kim, JY, Abdi S, Huh Billy, Kim KH. Mirogabaline: Could it be the next generation gabapentin or pregabalin? *Korean J Pain* 2021; 34: 4-18.
6. Koh W, Lim H, Chen X. Atypical triggers in trigeminal neuralgia: The role of A-delta sensory afferents in food and weather triggers. *Korean J Pain* 2021; 34:66-71.
7. Hong JH, Lee JY, Kim SJ, Seo KH. Retrospective analysis of clinical feature in trigeminal neuralgia. *Pain Physician* 2023; 26:39-44.
8. Li LM, Liu XD, Liu Y, Liu TT, Zhang ZL. Efficacy of high-voltage, long duration pulsed radiofrequency for the treatment of acute herpes zoster related trigeminal neuralgia in a patient with permanent pacemaker. *Korean J Pain* 2024; 37: 178-181
9. Zhu PB, Kim YD, Jeong HY, Yang MY, Won HS. New insight into the mandibular nerve at the foramen ovale level for percutaneous radiofrequency thermocoagulation. *Korean J Pain* 2023; 36: 465-72.
10. Albayrak O, Toprak CS, Gunduz OH, Sencan S. Is conventional radiofrequency ablation of the superolateral branch, one of the three genicular nerves targeted as standard, necessary or not? A non-inferiority randomiazed controlled trial. *Korean J Pain* 2024; 37: 264-74.
11. Karm MH, Kwon HJ, Kim CS, Kim DW, Shin JW, Choi SS. Cooled radiofrequency ablation of genicular nerve for knee osteoarthritis. *Korean J Pain* 2024; 37: 13-25.
12. Hong J, Park JH, Je HJ. Fluoroscopic analysis of cannula tip location during radiofrequency thermocoagulation of the trigeminal ganglion. *Pain Physician* 2023; 26:283-288.
13. Wang JY, Bender MT, Bettegowda C. Percutaneous procedures for the treatment of trigeminal neuralgia. *Neurosurg Clin N Am* 2016; 27:277-295.
14. Lee JY, Park JH, Hong JH. Analysis of the hemodynamic response during radiofrequency thermocoagulation in trigeminal neuralgia. *Pain Physician* 2022; 25:E1057-E1062.
15. Jacques N, Karoutsos S, Marais L, Nathan-Denizot N. Quality of life after trigeminal nerve block in refractory trigeminal neuralgia: A retrospective cohort study and literature review. *J Int*

Med Res 2022; 50:3000605221132027.

16. Takechi K, Konishi A, Kikuchi K, et al. Real-time ultrasound-guided infraorbital nerve block to treat trigeminal neuralgia using a high concentration of tetracaine dissolved in bupivacaine. *Scand J Pain* 2015; 6:51-54.
17. Allam AE, Khalil AAF, Eltawab BA, Wu WT, Chang KV. Ultrasound-guided intervention for treatment of trigeminal neuralgia: An updated review of anatomy and techniques. *Pain Res Manag* 2018; 2018:5480728.
18. Seo HJ, Park CK, Choi MK, Ryu J, Park BJ. Clinical outcome of percutaneous trigeminal nerve block in elderly patients in outpatient clinics. *J Korean Neurosurg Soc* 2020; 63:814-820.
19. Perloff MD, Chung JS. Urgent care peripheral nerve blocks for refractory trigeminal neuralgia. *Am J Emerg Med* 2018; 36:2058-2060.
20. Maarbjerg S, Sørensen MT, Gozalov A, Bendtsen L, Olesen J. Field-testing of the ICHD-3 beta diagnostic criteria for classical trigeminal neuralgia. *Cephalalgia* 2015; 35:291-300.
21. Sandwell S, Montoya S, Towner JE, Markman JD, Schell MC, Bhalla T. Anatomical study of percutaneous trigeminal compressive balloon positioning on merged 3-D rotational x-ray and preprocedural magnetic resonance imaging. *Stereotact Funct Neurosurg* 2018; 96:182-189.
22. Han KR, Kim C, Chae YJ, Kim DW. Efficacy and safety of high concentration lidocaine for trigeminal nerve block in patients with trigeminal neuralgia. *Int J Clin Pract* 2008; 62:248-254.
23. Gunduz HB, Cevik OM, Asilturk M, et al. Percutaneous radiofrequency thermocoagulation in trigeminal neuralgia : Analysis of early and late outcomes of 156 cases and 209 interventions. *J Korean Neurosurg Soc* 2021; 64:827-836.
24. Wang Z, Wang Z, Li K, Su X, Du C, Tian Y. Radiofrequency thermocoagulation for the treatment of trigeminal neuralgia. *Exp Ther Med* 2022; 23:17.
25. Liu G, Du Y, Wang X, Ren Y. Efficacy and safety of repeated percutaneous radiofrequency thermocoagulation for recurrent trigeminal neuralgia. *Front Neurol* 2018; 9:1189.
26. Zhao W, Yang L, Deng A, Chen Z, He L. Long-term outcomes and predictors of percutaneous radiofrequency thermocoagulation of Gasserian ganglion for maxillary trigeminal neuralgia: A retrospective analysis of 1070 patients with minimum 2-year follow-up. *Ann Med* 2022; 54:2420-2430.
27. Singh S, Verma R, Kumar M, Rastogi V, Bogra J. Experience with conventional radiofrequency thermorhizotomy in patients with failed medical management for trigeminal neuralgia. *Koran J Pain* 2014; 27: 260-265.