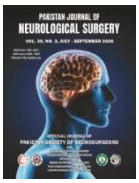

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Original Research

From Cannulation to Relief: Efficacy of H-figure Fluoroscopic Landmark-Guided Radiofrequency in Trigeminal Neuralgia

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ABSTRACT

Objective: A retrospective case series to evaluate the clinical efficacy, safety profile, and technical feasibility of percutaneous radiofrequency rhizotomy (RFR) using the H-figure fluoroscopic landmark for foramen ovale access in trigeminal neuralgia (TN).

Materials & Methods: This retrospective case series included 37 patients diagnosed with trigeminal neuralgia (TN) who underwent RFR at Sir Ganga Ram Hospital and Jinnah Hospital, Lahore. The foramen ovale was accessed using H-figure fluoroscopic guidance. Sensory and motor stimulation confirmed electrode placement. Pain intensity was recorded using the Barrow Neurological Institute (BNI) pain scale at baseline, postoperative day 1, and 1-month follow-up. Cannulation success, complications, and recurrence were also evaluated.

Results: Of 37 patients, 9 (24.3%) were male and 28 (75.7%) were female, with a mean age of 54.84 ± 12.2 years. Left-sided pain was present in about fifty percent of patients (51.4%). The most affected branch was V2 (48.6%), followed by V3 (24.3%), V2+V3 (18.9%), and V1+V2+V3 (8.1%). Foramen ovale cannulation was successful in **91.9%** of cases. Median BNI score improved from 4.0 (IQR 4.0–5.0) preoperatively to 2.0 (IQR 1.0–2.0) on day 1, and 1.0 (IQR 1.0–1.0) at 1 month ($p < 0.001$). Complications occurred in 6 patients (16.2%), most commonly transient V1 numbness. Four patients (10.8%) experienced recurrence within 18 months.

Conclusion: RFR using the H-figure Fluoroscopic Landmark is an effective technique for trigeminal neuralgia management, providing high rates of pain relief with minimal recurrence and reduced pain intensity in recurrent cases.

Keywords: Trigeminal Neuralgia, Radiofrequency Rhizotomy, H-figure Landmark, Foramen Ovale, Percutaneous Technique, Neuroablative Surgery, Minimally Invasive Neurosurgery.

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INTRODUCTION

Trigeminal neuralgia (TN) is a chronic condition characterized by sudden, severe, recurrent facial pain. The pain is typically unilateral and electric shock-like, affecting one or more divisions of the trigeminal nerve. The reported incidence of TN is approximately 4.3 per 100,000 individuals annually, with a prevalence of 0.3%. However, some literature suggests a higher incidence, up to 12 per 100,000.[1,2]

TN predominantly affects females and typically presents in the fifth or sixth decade of life.[2,3] It may be idiopathic or secondary to structural pathology. In idiopathic cases, the superior cerebellar artery is often implicated as the offending vessel, compressing the nerve at its root entry zone.[4]

Refractory cases are referred for surgical intervention. Among surgical options, microvascular decompression (MVD) is considered the gold standard in patients with vascular conflict. However, it demands high surgical skill, has a steep learning curve, and carries a risk of complications such as cranial nerve injury.[4]

Among these, radiofrequency rhizotomy (RFR) stands out as a safe and straightforward method. Both glycerol rhizotomy and balloon compression are non-selective. RFR offers selective lesioning of specific nerve branches**.** The procedure can be done under short-term sedation with fluoroscopic guidance.[5]

Rationale of the Study

Trigeminal neuralgia (TN) remains one of the most debilitating facial pain syndromes encountered in neurosurgical practice. Successful RFR depends largely upon accurate cannulation of the foramen ovale and selective targeting of trigeminal divisions.

Conventional Hartel's technique relies heavily on anatomical estimation and repeated fluoroscopic adjustments, which may prolong operative time, increase radiation exposure, and increase the risk of failed cannulation or neurovascular complications. However, identification of the foramen ovale may be technically demanding for junior surgeons and may prolong operative time, increase radiation exposure, and increase the likelihood of multiple puncture attempts. In resource-limited settings where advanced neuronavigation or CT-guided techniques may not be readily available, there is a need for simpler and reproducible fluoroscopic methods.

The H-figure fluoroscopic landmark provides a direct and practical radiological orientation for identifying the foramen ovale. Despite its growing use in clinical practice, limited local data are available. Therefore, this study was conducted to evaluate the clinical outcomes, procedural feasibility, complication profile, and recurrence rates associated with H-figure fluoroscopic landmark-guided RFR in patients with trigeminal neuralgia.

MATERIALS AND METHODS

Study Design and Setting

This was a retrospective case series conducted at Sir Ganga Ram Hospital and Jinnah Hospital, Lahore, from January 2023 to December 2024. Patients were selected using purposive sampling.

Inclusion Criteria

Adults (≥18 years) with confirmed TN diagnosis with availability of complete clinical records, including BNI pain scores and follow-up data, were included in the inclusion criteria.

Exclusion Criteria

Patients unable to follow commands during the procedure, having Uncontrolled hypertension, and Patients on anticoagulants or antiplatelets due to cardiac conditions were excluded.

Operational Definitions

Trigeminal Neuralgia (TN)

Trigeminal neuralgia was defined as recurrent unilateral facial pain characterized by sudden, severe, electric shock-like episodes distributed along one or more branches of the trigeminal nerve, consistent with the International Classification of Headache Disorders-3 (ICHD-3) diagnostic criteria.

Refractory Trigeminal Neuralgia

Patients were labeled as having refractory trigeminal neuralgia if adequate pain control was not achieved despite optimal medical therapy using carbamazepine, oxcarbazepine, or other standard neuropathic pain medications.

Radiofrequency Rhizotomy (RFR)

RFR was defined as a minimally invasive percutaneous neuroablative procedure in which thermal lesions are created within selected trigeminal nerve fibers using controlled radiofrequency energy.

H-Figure Fluoroscopic Landmark

The H-figure fluoroscopic landmark refers to the characteristic radiographic appearance obtained on fluoroscopy by appropriate C-arm angulation, enabling easier localization of the foramen ovale during percutaneous cannulation.

Successful Cannulation

Successful cannulation was defined as accurate placement of the cannula tip within the foramen ovale confirmed by fluoroscopic visualization along with concordant sensory and motor stimulation responses.

Pain Relief

Pain relief was assessed using the Barrow Neurological Institute (BNI) Pain Intensity Scale.

- BNI I: No pain, no medication.
- BNI II: Occasional pain, no medication required.
- BNI III: Some pain, adequately controlled with medication.
- BNI IV: Some pain, not adequately controlled with medication.
- BNI V: Severe pain or no pain relief.

Significant clinical improvement was defined as reduction of BNI score to grade I or II during follow-up.

Recurrence

Recurrence was defined as reappearance of significant facial pain after an initial satisfactory response following RFR, requiring medical treatment escalation or repeat intervention.

Procedure-Related Complications

Any new neurological deficit, sensory disturbance, cranial nerve dysfunction, severe headache, infection, or mastication weakness occurring after the procedure was considered a procedure-related complication.

Data Collection and Analysis

Clinical data were retrospectively extracted from patient medical records, operative notes, and outpatient follow-ups. Collected demographic variables included age and sex. Clinical parameters documented were the side of facial pain (right or left), distribution across trigeminal nerve branches (V1, V2, V3), and baseline pain severity assessed using the Barrow Neurological Institute (BNI) pain intensity scale. Procedural notes were reviewed for any technical difficulties encountered during cannulation. Clinical outcomes included the degree of pain relief, measured by changes in BNI scores on postoperative day 1 and at 1-month follow-up. Secondary outcomes included procedure-related

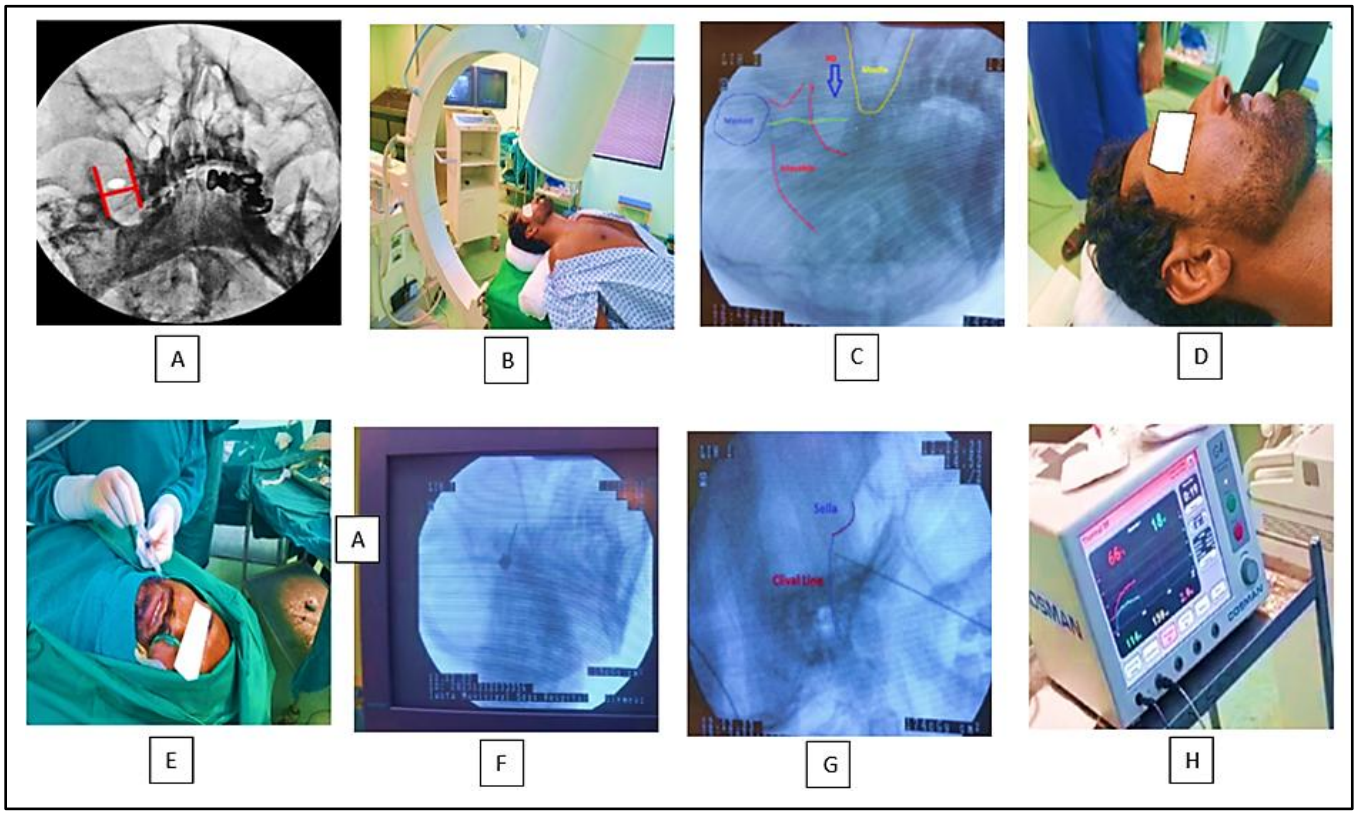

Figure 1A-H: *Figure view as seen on fluoroscopic image.* **Figure 1B:** *Position of face with respect to C-arm position.* **Figure 1C:** ***Foramen Ovale*** *identification.* **Figure 1D:** *Hartel's marking.* **Figure 1E:** *Cannula insertion perpendicular to fluoroscopic beam.* **Figure 1F:** ***Foramen Ovale*** *Cannulation on anteroposterior.* **Figure 1G:** ***Foramen ovale can****nulation confirmation on lateral view.* **Figure 1H:** *Lesion generation by G4 Cosman lesion generator.*

complications include facial numbness, neurological deficits, and recurrence of pain.

Data were entered and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables such as age were presented as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Since BNI scores represented ordinal data and did not follow a normal distribution, non-parametric analysis was performed using the Wilcoxon Signed-Rank Test to compare preoperative and postoperative pain scores. Effect size (r) was also calculated to estimate the magnitude of clinical improvement. A p-value of <0.05 was considered statistically significant.

Ethical Consideration

The study protocol was reviewed and approved by the ethical review board of Allama Iqbal Medical College, Jinnah Hospital, Lahore, as well as by Fatima Jinnah Medical University, Lahore. Written informed consent was obtained from all patients or their legal guardians before enrollment. Confidentiality and privacy were strictly maintained in accordance with ethical standards and principles outlined in the Helsinki Declaration. Ethical approval reference number: ERB198OBS/20/16-12-2025/AIMC/JHL and CERB no.111/C1ERB Fatima Jinnah Medical University, Lahore, Combined Institutional Ethics Review Board. (Original forms attached in pics).

Procedure

Patients were positioned supine on a radiolucent table with the head extended and rotated contralaterally. The C-arm was tilted ~15° and

rotated ~30° to obtain an H-figure view aligning the foramen ovale (Figure 1 – A, B, C). After local anesthesia and sedation (midazolam and nalbuphine), a 115 mm cannula was inserted perpendicular to the fluoroscopic beam (Figure 1– D, E).

Functional confirmation of cannula placement was done via sensory (50 Hz) and motor (2 Hz) stimulation. V2 was targeted near the clival line, and V3 slightly posterior (Figure 1 – F, G). If V1 distribution was inadvertently stimulated, the cannula was repositioned. Lesioning was performed under deep sedation (propofol) at 65°C for 60 seconds. Multiple lesions were applied as needed (Figure 1, A – H).

Table 1: *Summary of Demographics, Clinical Characteristics, and Outcomes (n = 37).*

Variable	Value
Demographics	
Mean Age (years)	54.84 ± 12.20 (Range: 36–83)
Gender – Male, n (%)	9 (24.3%)
Gender – Female, n (%)	28 (75.7%)
Clinical Characteristics	
Side of Pain – Right, n (%)	18 (48.6%)
Side of Pain – Left, n (%)	19 (51.4%)
Nerve Distribution – V2 only, n (%)	18 (48.6%)
Nerve Distribution – V3 only, n (%)	9 (24.3%)
Nerve Distribution – V2 + V3, n (%)	7 (18.9%)
Nerve Distribution – V1 + V2 + V3, n (%)	3 (8.1%)
Procedure Success & Cannulation	
Successful Foramen Ovale Cannulation, n (%)	34 (91.9%)
BNI Pain Score (Median, IQR)	
Pre-operative	4.0 (4.0–5.0)
Post-op Day 1	2.0 (1.0–2.0)
1-Month Follow-up	1.0 (1.0–1.0)
Statistical Comparisons (Wilcoxon Test)	
Pre-op vs Post-op Day 1	W = 0.0, p < 0.001, r = 0.83 (Large)
Pre-op vs 1-Month Follow-up	W = 0.0, p < 0.001, r = 0.86 (Large)
Post-op Day 1 vs 1-Month Follow-up	W = 21.0, p = 0.002, r = 0.52 (Medium)
Complications	
Total Complications, n (%)	6 (16.2%)
V1 Sensory Numbness, n (%)	3 (8.1%)
CN VI Palsy, Headache, Mastication Weakness	1 each (2.7%)
Recurrence	4 (10.8%), range: 2 weeks – 18 months

RESULTS

Age & Gender Distribution

A total of 37 patients were included in the study. Of these, 9 were male (24.3%), and 28 were female (75.7%). The mean age was 54.84 ± 12.19 years.

Clinical Background

Pain was left-sided in 19 (51.4%) of **37** patients and right-sided in 18 (48.6%) patients. The most common trigeminal distribution involved was isolated V2, seen in 18 (48.6%) patients. V3 involvement was observed in 9 (24.3%), while combined V2 and V3 was present in 7 (18.9%) patients. Involvement of all three branches (V1, V2, V3) was noted in 3 (8.1%) cases.

Cannulation Outcomes

Successful cannulation of the foramen ovale using the anterior fluoroscopic approach was achieved in 34 (91.9%) cases. Cannulation was unsuccessful in three patients (8.1%) because the foramen ovale could not be clearly visualized on the anteroposterior fluoroscopic view. This was mainly observed in elderly patients where age-related skull base sclerosis and calcification obscured the bony landmarks. As a result, the foramen ovale could not be identified with sufficient confidence, and safe needle advancement was not attempted.

Evaluation of the Pain Intensity

Pain intensity was measured using the Barrow Neurological Institute (BNI) pain scale. The median preoperative BNI score was 4.0 (IQR 4.0–5.0). This decreased to 2.0 (IQR 1.0–2.0) on postoperative day 1, and further to 1.0 (IQR 1.0–1.0) at 1-month follow-up.

Statistical Findings

The Wilcoxon Signed-Rank Test showed a statistically significant reduction in BNI scores from preoperative levels to postoperative day 1 ($W = 0.0$, $p < 0.001$, $r = 0.83$). A significant reduction was also observed from preoperative levels to the 1-month follow-up ($W = 0.0$, $p < 0.001$, $r = 0.86$). Additionally, BNI scores further decreased between day 1 and the 1-month follow-up ($W = 21.0$, $p = 0.002$, $r = 0.52$), indicating continued improvement over time.

Postoperative Complications

Postoperative complications were noted in 6 patients (16.2%). These included V1 sensory numbness in 3 patients (8.1%), severe headache in 1 patient, abducens nerve palsy in 1 patient, and weakness of mastication muscles in 1 patient. Recurrence of pain occurred in 4 patients (10.8%) within a period ranging from 2 weeks to 18 months post-procedure.

DISCUSSION

The present study demonstrates that radiofrequency rhizotomy using the H-figure fluoroscopic landmark is an effective and technically reliable treatment modality for medically refractory trigeminal neuralgia.

The demographic profile of our cohort is consistent with previously published literature describing trigeminal neuralgia as a disease predominantly affecting middle-aged and elderly females. In our study, females constituted seventy-five percent (75.7%) of the cohort, while the mean age was 54.84 years. Similar female predominance has been reported by Araya et al,[1] and Koopman et al,[3,] supporting the known epidemiological pattern of TN.

The maxillary division (V2) was the most commonly involved branch in our patients; this observation differs slightly from some international studies where V2 and V3 combined involvement is more frequently described, as wang et al,[2] potentially due to ethnic variation.[6]

One of the most important observations in this study was the high cannulation success rate of approximately ninety-one percent. (91.9%) using the H-figure landmark technique. Accurate localization of the foramen ovale remains the most technically demanding step of percutaneous trigeminal procedures. Traditional Hartel approaches often require repeated adjustments, especially for surgeons early in their learning curve. The H-figure approach simplifies fluoroscopic orientation by providing a clearer and more reproducible radiographic target. This may reduce procedural difficulty, shorten operative time, and potentially minimize radiation exposure. Functional testing using sensory and motor stimulation enhances targeting accuracy and safety.

The marked improvement in BNI pain scores observed immediately after surgery and during follow-up highlights the clinical efficacy of RFR. Median BNI scores improved from severe preoperative pain levels to near-complete pain control at one month. The large effect sizes further strengthen the clinical relevance of these findings. Our results are comparable to those reported by Kanpolat et al , who demonstrated durable pain control in a large series of patients undergoing radiofrequency rhizotomy.

Compared with other percutaneous procedures, RFR offers several practical advantages. Balloon compression and glycerol rhizotomy are effective alternatives but are relatively non-selective in targeting nerve fibers. Balloon compression usually requires general

anesthesia and may be associated with postoperative dysesthesia and masseter weakness.[8] Glycerol rhizotomy, although minimally invasive, carries the risk of aseptic meningitis due to glycerol spread into the cerebrospinal fluid.[7] In contrast, RFR allows selective lesioning of specific trigeminal divisions based on intraoperative stimulation testing, thereby preserving uninvolved sensory territories as much as possible.

An important technical aspect of our protocol was avoidance of intentional lesioning within the ophthalmic division (V1). Preservation of the corneal reflex is critical because corneal anesthesia may lead to keratitis and vision-threatening complications. Although transient V1 numbness occurred in a small proportion of patients. This suggests minor thermal spread rather than direct V1 targeting was responsible. Conservative management with corticosteroids and neuroprotective vitamins led to complete recovery within one month.

The overall complication rate in our study was acceptable and largely comparable with previously published reports. Most complications were transient and manageable conservatively. One patient developed temporary abducens nerve palsy, likely secondary to needle trajectory or thermal spread near the cavernous sinus region. Such complications are rare but have been documented in the literature. Similarly, transient weakness of mastication muscles may occur due to involvement of motor fibers traveling with the mandibular division.

Recurrence remains an important concern following all ablative procedures for trigeminal neuralgia. In our series, recurrence occurred in ten percent (10.8%) of patients within 18 months. This recurrence rate compares favorably with earlier reports describing recurrence rates between ten and thirty percent (10% and 30%) over longer follow-up periods. Precise lesion localization achieved through H-figure guidance may have contributed to improved durability of pain control.

Another practical advantage of the H-figure technique is its utility in low-resource settings. Many institutions in developing countries lack access to neuronavigation systems or CT-guided suites. Fluoroscopic-guided H-figure localization offers a cost-effective alternative that can be adopted widely without requiring sophisticated infrastructure. The technique may therefore improve accessibility of minimally invasive TN procedures in resource-constrained healthcare systems.

Technical difficulties were infrequent. However, elderly patients with low bone density or anatomical variations posed challenges in cannulation. One such case was excluded from analysis due to failure in accessing the foramen ovale.

Limitations

This study has several limitations. First, its retrospective design may have introduced selection and information bias. Second, the sample size was relatively small, which may limit the statistical strength of the findings. Third, the follow-up duration was short, making it difficult to assess long-term outcomes and complications. In addition, the study did not include a comparison with conventional Hartel or CT-guided techniques. Finally, as the study reflects experience from a single region, the results may not be fully generalizable to other populations or clinical settings.

Clinical Recommendation

The H-figure fluoroscopic landmark technique may serve as a practical alternative to conventional fluoroscopic methods for foramen ovale cannulation. It can be especially useful for early-career neurosurgeons, as it may help shorten the learning curve during RFR procedures. Routine use of functional sensory and motor stimulation is also recommended to

improve procedural safety and targeting accuracy. Unnecessary lesioning of the V1 division should be avoided to reduce the risk of corneal complications. Further prospective multicenter studies with larger series and longer follow-up are needed to assess long-term recurrence rates and to compare the efficacy of this technique with other established methods.

CONCLUSION

RFR using the H-figure fluoroscopic approach is an effective and technically accessible procedure for TN management. It offers high success rates, good patient tolerance, and acceptable complication rates. This technique shortens the learning curve.

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Additional Information

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Human Subjects: Consent was obtained from all patients/participants in this study.
Conflicts of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:
Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.
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AUTHORS CONTRIBUTION

Sr.#	Authors Full Name	Contribution
1.	Nabeel Choudhary	Conceptualization, Methodology, Writing Review & Editing, Quality Assurance.
2.	Talha Abbas	Methodology, Writing Original Draft, Software.
3.	Bilal Anwer	Data Curation, Investigation, Validation, Visualization.
4.	Tehreem Shahzadi	Data Curation, Investigation.
5.	Fauzia Sajjad	Supervision, Formal Analysis.
6.	Abdul Hameed	Supervision, Project Administration.