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Research Article

Gasserian Ganglion Radiofrequency Ablation for Trigeminal Neuralgia: A Resident's Experience of 23 Consecutive Cases and the Procedural Learning Curve

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ABSTRACT
Background: Trigeminal neuralgia is a severe neuropathic pain disorder characterized by recurrent paroxysmal facial pain in the distribution of one or more divisions of the trigeminal nerve. Although pharmacological therapy remains the initial treatment, patients with refractory symptoms or medication intolerance may require interventional treatment. Percutaneous procedures targeting the Gasserian ganglion, particularly radiofrequency (RF) thermocoagulation, provide an effective minimally invasive option. [1,2]
Percutaneous access to the Gasserian ganglion through the foramen ovale is technically demanding and requires familiarity with skull-base fluoroscopic anatomy and three-dimensional needle trajectory. This is particularly relevant during residency training in interventional pain medicine. [2,11]
Objective: To describe our experience with 23 consecutive percutaneous procedures for trigeminal neuralgia, predominantly Gasserian ganglion Radiofrequency ablation, with particular emphasis on clinical outcome, duration of pain relief, technical successand the progressive acquisition of fluoroscopic and needleplacement skills by residents.
Methods: A retrospective descriptive review was performed of 23 consecutive patients undergoing percutaneous treatment for trigeminal neuralgia at our institution. Twenty-two patients underwent Gasserian ganglion RF ablation, and one patient underwent balloon compression. The affected trigeminal division, duration of pain relief, technical success, clinical success, and resident participation in identification of the foramen ovale and needle placement were documented. [1,2]
Of the 23 patients, 4 had V1 involvement, 2 had V2 involvement, and 17 had V3 involvement. Technical success was defined as successful completion of the intended percutaneous procedure, while clinical success was defined according to meaningful post-procedural pain relief as documented during follow-up. [1]
Results: All 23 procedures were technically successful and all 23 patients achieved clinical success. The mean duration of pain relief was approximately 18 months, with a median duration of 18 months, ranging from 2 weeks to 3 years. [3,5]
Residents were able to independently identify the foramen ovale in 14 of 23 cases (60.9%). Independent needle placement into the foramen ovale was achieved in 10 of 23 cases (43.5%). The data demonstrated a progressive improvement in resident procedural capability over the case series, with independent needle placement occurring in the later cases. [12,13]
Conclusion: Our experience demonstrates that Gasserian ganglion RF ablation can provide substantial and prolonged pain relief in appropriately selected patients with trigeminal neuralgia. Importantly, the series also demonstrates a progressive resident learning curve in fluoroscopic identification of the foramen ovale and percutaneous needle placement. Structured supervision, repeated exposure to skull-base fluoroscopic anatomyand correlation of radiological landmarks with three-dimensional needle trajectory appear to be important components of training in this technically demanding procedure. [3,4,5]

Keywords: Trigeminal Neuralgia, Gasserian Ganglion, Radiofrequency Ablation, Foramen Ovale, Fluoroscopy, Resident Training, Learning Curve, Interventional Pain Medicine.

INTRODUCTION

Trigeminal neuralgia is one of the most disabling facial pain syndromes encountered in clinical practice. It is characterized by recurrent episodes of unilateral, brief, severe, electric shock-like or stabbing pain involving one or more divisions of the trigeminal nerve. The pain may be triggered by innocuous activities such as chewing, speaking, brushing the teeth, touching the face, or exposure to cold air. [1]

Pharmacological treatment with anticonvulsant medications remains the mainstay of initial management. However, a proportion of patients experience inadequate pain control, medication intolerance, adverse effects, or recurrent symptoms despite appropriate medical therapy. In such patients, interventional procedures can provide significant pain relief and reduce dependence on medication. [1]

Several surgical and minimally invasive approaches are available for refractory trigeminal neuralgia. These include microvascular decompression, stereotactic radiosurgery, balloon compression, glycerol rhizolysisand radiofrequency thermocoagulation of the trigeminal ganglion. [1,7,8]

Percutaneous RF treatment of the Gasserian ganglion is particularly relevant to interventional pain practice. The technique involves percutaneous access to the trigeminal ganglion through the foramen ovale under fluoroscopic guidance, followed by sensory and motor stimulation and controlled RF lesioning. [2,4,11]

Although the procedure is minimally invasive, the technical approach is challenging. The foramen ovale is a relatively small skull-base targetand successful cannulation requires an understanding of its three-dimensional orientation. The procedure therefore represents an important technical learning experience for residents training in pain medicine. [11,14]

The present case series describes 23 consecutive percutaneous procedures for trigeminal neuralgia performed at our institution. In addition to clinical outcomes, we specifically documented the residents' ability to identify the foramen ovale and subsequently advance the needle into the target. This provides an opportunity to describe the procedural learning curve associated with this intervention.

MATERIALS AND METHODS

Study Design

This was a retrospective descriptive case series of 23 consecutive patients undergoing percutaneous intervention for trigeminal neuralgia at our institution.The cases were performed in the Department of Anaesthesiology and Pain Medicine under appropriate supervision of a Senior Interventional pain physician of more than 20 years' experience in Pain management. The primary intervention was Gasserian ganglion RF ablation. One patient underwent balloon compression for V1 division neuralgia rather than RF ablation. [15,16]

Patient Distribution

A total of 23 patients were included.The affected trigeminal divisions were

Table 1. Table Showing the Number and Percentage of Patients Presenting With Pain across the Three Divisions of Trigeminal Nerve

Division	Number	Percentage
V1	4	17.4%
V2	2	8.7%
V3	17	73.9%

V3 was therefore the predominant division involved, accounting for 17 of the 23 patients.Among the 4 cases of V1 neuralgia, three underwent RF ablation at 60 degrees Celsius and one underwent balloon compression for fear of exposure keratitis following ophthalmic nerve involvement. Both V2 cases and all 17 V3 cases underwent RF ablation.Thus, the RF cohort consisted ofV1: 3 patients, V2: 2 patients, V3: 17 patients.Total RF: 22 patients

Procedural Technique

After getting procedural consent and a pre anaesthetic evaluation a day before the intervention, Patients who were kept fasting for 6 hours were positioned supine and standard ASA monitoring was instituted. The procedure was performed under fluoroscopic guidance using a percutaneous approach to the foramen ovale.The skull base was visualized fluoroscopically and the foramen ovale was identified as the target for needle placement (Figure 1). The foramen ovale was identified in the submental ipsilateral oblique view. [11,15]

After local anaesthesia, the RF cannula was advanced toward the foramen ovale under fluoroscopic guidance in tunnel vision (Figure 2). Appropriate radiological views were obtained to confirm the trajectory and target. [11,14,15]

For balloon compression of the ganglion, under general anaesthesia, a 13G needle was advanced through the foramen ovale into Meckel's cave under fluoroscopic guidance with serial dilatations. A 4Fr Fogarty catheter was then introduced and inflated with radiocontrast to compress the Gasserian ganglion for 90 seconds, producing selective injury to pain-conducting fibres while preserving most sensory function. The appearance of a characteristic pear-shaped balloon confirmed correct positioning.

Figure 1. Fluoroscopic Image Showing Visualisation of Foramen Ovale in Ipsilateral Oblique and Lateral Views

Figure 2. Patient Image Showing Radiofrequency Needle 2 Cms Lateral To the Angle of Mouth

Figure 3. Patient Image Showing 4 Fr Fogarty Catheter Inserted Through 13 G Needle for Balloon Compression of the Gasserian Ganglion

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Following satisfactory positioning and confirmation with lateral fluoroscopy, sensory stimulation was performed. The patient was asked to report the location of the induced sensation or paraesthesia. The purpose of stimulation was to correlate the electrode position with the clinically affected trigeminal division.Motor stimulation was used as an additional safety and localization step, particularly when treating V3 disease. [10,11]
Once satisfactory localization had been achieved, RF lesioning was performed according to the institutional protocol.The patient was subsequently observed and assessed for pain relief, sensory changes, neurological deficitsand other procedure-related complications. [2,4]

Resident Training and Procedural Learning Curve

An important component of this series was documentation of the resident's technical participation.
Two separate procedural milestones were recorded:

1. **Identification of the foramen ovale**

The resident was considered successful when they were able to independently identify the foramen ovale on fluoroscopy.

2. **Needle placement**

The second milestone was achieved when the resident was able to independently advance the needle into the foramen ovale.These two stages were intentionally considered separately because recognition of the radiological target does not necessarily imply the ability to reproduce the correct three-dimensional needle trajectory. [16,17]

RESULTS

All 23 procedures were technically successful. Hence technical success = 23/23 (100%)
All 23 patients also achieved clinical success according to the outcome definition used in this series.
Clinical success = 23/23 (100%). Thus, there was no documented technical failure in the 23 procedures.

Duration of Pain Relief

Across all 23 procedures done over three years, only one patient reported for a repeat RF ablation for V1 neuralgia related pain after good pain relief for 30 months. These findings suggest that most patients experienced substantial and relatively prolonged pain relief following percutaneous trigeminal intervention. [3,5]

Resident Performance

The resident learning curve was an important observation from this case series. [16,17]

Identification of the Foramen Ovale

Residents were able to independently identify the foramen ovale in14 of 23 cases (60.9%). In the remaining 9 cases, the attending physician was required to assist with identification.

Needle Placement

Residents were able to independently advance the needle into the foramen ovale in10 of 23 cases (43.5%). Thus, independent needle placement was more challenging than radiological identification of the foramen ovale.This distinction is important educationally. Recognition of the anatomical target represents the first step, whereas successful needle placement requires integration of fluoroscopic anatomy, trajectory, depth perceptionand real-time adjustment of the needle. [16,17]

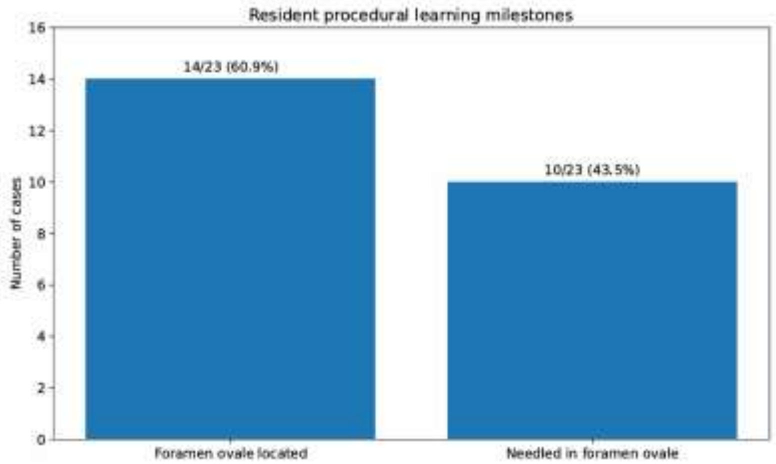
Case-wise Procedural Learning

The initial cases demonstrated that residents were unable to independently identify or cannulate the foramen ovale.Cases 1–6 required attending assistance for both target identification and needle placement. [16,17]
In Case 7, the resident was able to identify the foramen ovale independently, although needle placement still required supervision.Cases 11 and 12 similarly demonstrated progression in target identification.From Case 14 onwards, the resident demonstrated the ability to both identify the foramen ovale and independently place the needle into the target.This represents an important transition in the learning curve. [16,17]

The data therefore suggest three stages of skill acquisition:

- **Stage 1 – Recognition and orientation**
  The resident requires assistance to identify the foramen ovale and understand the appropriate fluoroscopic orientation.
- **Stage 2 – Target identification**
  The resident can independently recognize the foramen ovale but still requires supervision or assistance with needle trajectory.
- **Stage 3 – Independent needle targeting**
  The resident can independently identify the foramen ovale and advance the needle into the target under fluoroscopic

guidance.This progression is clearly demonstrated in our 23-case experience. [16,17].



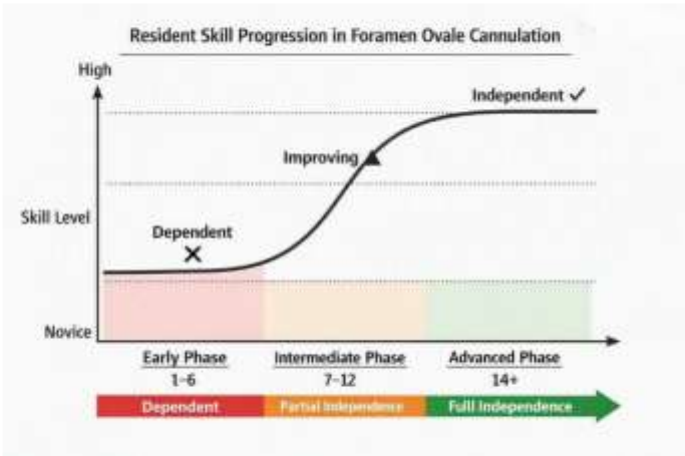
Graph 1. Bar Chart Depicting Resident Procedural Learning Milestones

DISCUSSION

The present series provides two important observations.

First, percutaneous treatment of trigeminal neuralgia resulted in clinical success in all 23 patients in this series, with a substantial duration of pain relief. [3,4,5]

Secondand perhaps more importantly from an educational perspective, the series demonstrates a progressive learning curve for residents performing a technically demanding skull-base procedure. [16,17]



Graph 2. Sigmoid Shaped Skill Progression Curveshowing Slow Initial Progress, Rapid Improvement In the Middle Phaseand Then a Plateau as Mastery Is Reached.

The Technical Challenge of the Foramen Ovale

The foramen ovale represents a relatively small and obliquely oriented target at the skull base. Although the target can be readily identified once the appropriate fluoroscopic anatomy is understood, translating the two-dimensional fluoroscopic image into a three-dimensional needle trajectory is more difficult.This explains the difference observed in our series between the ability to identify the foramen ovale and the ability to successfully place the needle into it. [11,14]

While 60.9% of procedures demonstrated independent target identification by residents,independent needle placement was achieved in 43.5%.This difference illustrates that radiological recognition precedes procedural mastery.

Importance of Repeated Exposure

The transition to independent needle placement in the later cases suggests that repeated exposure to the procedure may facilitate acquisition of the necessary visuospatial and psychomotor skills.With repeated procedures, these components become integrated into a reproducible procedural sequence.Residents gradually learn to recognizeskull-base orientation, shape and position of the foramen ovale, appropriate fluoroscopic angulation, needle entry point, needle trajectory, depth of advancement, relationship between needle position and the bony target. [16,17]

Sensory Stimulation as a Learning Tool

Sensory stimulation at 50 Hz provides an objective confirmation of the target. From an educational standpoint, it allows the resident to correlateradiological anatomy, needle position, trigeminal division, patient reported sensation on stimulation. For example, stimulation corresponding to V1 should produce sensation in the ophthalmic distribution, whereas V2 and V3 stimulation should correlate with their respective facial territories.This creates a direct feedback loop that reinforces anatomical learning.Therefore, sensory and motor stimulation can be considered both a safety mechanism and an educational tool during resident training. [10,12]

Division-specific Observations

The marked predominance of V3 disease was notable.Seventeen of 23 patients had V3 involvement, accounting for 73.9% of the cohort.V1 accounted for four cases and V2 for two cases.The predominance of V3 in this institutional series should be interpreted cautiously because the sample size is small and referral and patient-selection factors may have influenced the observed distribution.The series was not designed to determine whether V3 trigeminal neuralgia is epidemiologically more common or whether V3 responds better to RF treatment. [6]

Nevertheless, the finding provides an interesting basis for future prospective studies comparingV1 versus V2 versus V3 response, duration of analgesia, sensory complications, recurrence, medication reduction, repeat intervention rates. [6,7,8]

RF Ablation versus Balloon Compression

Out of the 4 patients with V1 division neuralgia, only one patient consented for balloon compression procedure under general anaesthesia. Other patients preferred a RF ablation in view of the more invasive nature of ballon compression procedure. Patient who consented for a balloon compression for V1 division trigeminal neuralgiaunderwent an uneventful procedure under general anaesthesia. All the RF ablations were performed under local anaesthesia. [7,8]

Clinical Success

All 23 patients in the present series were classified as clinically successful.Although this represents a 100% clinical success rate in this dataset, this result should be presented carefully.Carefully selected objective parameters like pain scores before and after the intervention, medication requirement at weeks, duration of pain relief, recurrence if any and sensory complications arising out of the intervention were documented to add value to the study (Table 2). [3,4,5]

Since this is a small retrospective series without a comparator group and because the definition of clinical success should ideally be standardized using a validated pain scale. [1,7,8]

Table 2. Table Depicting the Parameters Measuring the Clinical Outcome

Mean pre-procedure NRS	**9.1 ± 0.8**	**Severe baseline pain**
Immediate post-procedure NRS	2.1 ± 0.8	Significant reduction
8-week follow-up NRS	0.4 ± 0.5	Sustained relief
Medication requirement at 8 weeks	1 / 23 (4.3%)	Minimal analgesic use
Duration of complete pain relief	Median = 24 months (range 2 weeks–3 years)	Long-term efficacy maintained
Recurrence	1 / 23 (4.3%)	Single recurrence after 30 months
Sensory complications	0 / 23 (0%)	No adverse sensory effects

Learning Points for Residents

Our experience suggests several important educational principles.

1. Understand the anatomy before performing the procedure

   The foramen ovale should not simply be treated as a fluoroscopic point. Its three-dimensional orientation must be understood. [11,14]

2. Learn target identification before needle placement
   Residents should first become proficient in identifying the foramen ovale before attempting independent cannulation. [16,17]
3. Use multiple fluoroscopic views
   A single fluoroscopic view may give a false impression of satisfactory needle placement. Appropriate confirmation in multiple views is essential. [11,14]
4. Use sensory and stimulation
   Sensory stimulation provides functional confirmation and helps identify the affected trigeminal division. [10,12]
5. Develop three-dimensional needle visualization
   The transition from target identification to needle placement represents the major procedural learning step. [16,17]
6. Maintain supervised progression
   Independent needle placement should occur only after the resident has demonstrated adequate understanding of the anatomy and supervised procedural competence. [16,17]
7. Patient feedback is valuable
   During sensory stimulation, the patient's description of the induced sensation provides real-time functional information. [10,12]

Limitations

The present study has several limitations.First, the sample size was small, with only 23 procedures.Second, this was a retrospective observational series.Third, the cohort was heterogeneous because one patient underwent balloon compression rather than RF.Fourth, the trigeminal division distribution was highly unequal, with V3 representing most cases.Fifth, clinical success was recorded as a binary outcome and was not accompanied by standardized pain scores in the available dataset.Sixth, medication reduction and validated quality-of-life outcomes were not included.Seventh, the resident learning curve was based on a relatively small number of procedures and cannot establish a definitive number of cases required for competency.Finally, longer and standardized follow-up would be necessary to determine recurrence-free survival and durability of pain relief. [16,17]

CONCLUSION

Our 23-case institutional experience demonstrates that percutaneous treatment of trigeminal neuralgia can provide substantial and prolonged pain relief when performed in appropriately selected patients.Twenty-two patients underwent Gasserian ganglion RF ablationand one underwent balloon compression. V3 was the predominant symptomatic division, accounting for 17 cases (73.9%), followed by V1 in 4 cases (17.4%) and V2 in 2 cases (8.7%). [3,4,5]

All 23 procedures were technically successful and were associated with clinical success in the present series. The duration of pain relief ranged from 2 weeks to 3 years, with a median of approximately 18 months. [3,4,5]

Importantly, this series also documents the procedural learning curve of residents. Independent identification of the foramen ovale was achieved in 14 of 23 cases (60.9%), while independent needle placement was achieved in 10 cases (43.5%). The progression from assisted target identification to independent fluoroscopic needle placement in the later cases demonstrates the importance of repeated supervised exposure. [16,17]

The experience highlights that Gasserian ganglion RF ablation is not merely a technical procedure but a complex integration of anatomical knowledge, fluoroscopic interpretation, three-dimensional needle control, neurophysiological stimulation, patient communication, and clinical decision-making. [2,10,11,16]

A prospective study using standardized pain scores, medication requirements, sensory outcomes, recurrence-free survivaland validated competency assessment for residents would be valuable to further define both the clinical efficacy of Gasserian ganglion RF ablation and the learning curve associated with this technically demanding procedure. [1,5,16,17]

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