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Outcome of Radiofrequency Ablation of Gasserian Ganglion for the Management of Trigeminal Neuralgia: Prospective Interventional Study

Ahmed A. Elnoury[a] , Mohamed M. Adawy[a], Maher M. Elabagy[a], Mostafa S. Elmaghraby[b]

[a] Neurosurgery Department, Faculty of Medicine Benha University, Egypt.

[b] Neurosurgery Department, Faculty of Medicine Alazhar University, Egypt.

Corresponding to:
Dr. Maher M. Elabagy.
Neurosurgery Department, Faculty of Medicine Benha University, Egypt.
Email: maherabagy@gmail.com

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Abstract:

Background: Trigeminal neuralgia (TN) is characterized by sudden, severe, lancinating pain confined to one or more divisions of the trigeminal nerve. This study aimed to evaluate the efficacy and safety of radiofrequency ablation (RFA) targeting the Gasserian ganglion and identify factors influencing post-procedural outcomes. **Methods:** A prospective interventional study was conducted on patients diagnosed with TN and admitted to the Neurosurgery Department at Benha University Hospitals between February 2024 and October 2024. All patients underwent clinical evaluation preoperatively and postoperatively, along with brain MRI to exclude secondary causes. Pain severity was assessed using the Visual Analog Scale (VAS). **Results:** Twelve patients (6 males, 6 females) with a mean age of 57 years were included. The mean preoperative VAS score was 9.75, indicating severe pain. Following RFA, pain scores significantly decreased to a mean of 0.33, demonstrating marked improvement. Recurrence occurred in a small subset of patients, with moderate pain levels (mean VAS ≈ 5), but overall pain relief was highly significant. Minor complications were reported in 5 patients: three cases of facial ecchymosis at the needle insertion site and two cases of postoperative facial paresthesia. No major adverse events were observed. **Conclusions:** RFA of the Gasserian ganglion is a highly effective and safe intervention for TN, providing substantial pain relief, rapid recovery, and minimal complications. These findings support RFA as a preferred minimally invasive technique for managing medically refractory TN, with low recurrence and favorable safety profiles.

Keywords: Trigeminal Neuralgia, Radiofrequency Ablation, Gasserian Ganglion.

Introduction

Trigeminal neuralgia (TN) is a chronic pain disorder characterized by sudden, severe, and recurrent episodes of facial pain, often described as electric shock-like sensations. The condition is caused by irritation or damage to the trigeminal nerve, which is responsible for sensory functions in the face. TN significantly impacts patients' quality of life, leading to difficulties in daily activities and psychological distress. Various treatment modalities have been explored to manage TN, ranging from pharmacological interventions to surgical procedures. Among these, radiofrequency ablation (RFA) of the trigeminal ganglion has emerged as a promising minimally invasive technique for pain relief [(1)]

Radiofrequency ablation is a minimally invasive technique that delivers controlled thermal energy to the Gasserian ganglion, effectively disrupting pain transmission while preserving motor function [(2)]. The procedure involves the percutaneous insertion of an electrode near the ganglion under fluoroscopic or computed tomography (CT) guidance. Once positioned, thermal energy is applied at a carefully controlled temperature to induce partial coagulation of trigeminal sensory fibres [(3)].

RFA can be performed as pulsed or continuous, with each approach tailored to patient needs:

Continuous RFA (CRFA) generates sustained thermal energy, leading to lesion formation and prolonged neural disruption., Pulsed RFA (PRFA) in contrast, delivers intermittent energy pulses, aiming to modulate nerve conduction while minimizing tissue damage [(4)].

Several studies have demonstrated that RFA provides significant pain relief in patients with TN, reducing pain intensity and frequency while improving overall quality of life [(5,6)] While the procedure does not offer permanent relief, its effectiveness is comparable to microvascular decompression (MVD) in selected patients, with repeatable applications enabling continued pain management [(7)]

Through an extensive review of existing literature, discussion of case studies, and evaluation of emerging advancements, this research seeks to contribute to the current understanding of RFA as a viable therapeutic option for TN. By examining the interplay between anatomical considerations, procedural methodologies, and clinical outcomes, the thesis aims to offer insights into optimizing treatment protocols and improving patient-centric approaches in pain management.

Patients and Methods

This study is a prospective interventional study. All Cases were admitted to Neurosurgery department and/or diagnosed with Trigeminal Neuralgia in outpatient clinic fulfilling inclusion criteria during the period between February 2024 and October 2024 at Benha University Hospitals.

We included patients with Trigeminal who are refractory to medical treatment ,patients who don`t tolerate medical treatment of trigeminal neuralgia and patients with poor general conditions that will not withstand craniotomy. We excluded patients with trigeminal neuralgia who respond well to medical treatment.

Patients were evaluated before the procedure and immediately after it with post-operative follow-up for 6 months.

Clinical evaluation including full history taking, complete general and neurological examination. We relayed on diagnostic criteria of trigeminal neuralgia that includes:

A. Paroxysmal attacks of pain lasting from a fraction of a second to two
minutes, affecting one or more divisions of the trigeminal nerve, and
fulfilling criteria B and C

B. Pain has at least one of the following characteristics:1. Intense, sharp, superficial, or stabbing
2. Precipitated from trigger zones or by trigger factors
C. Attacks are stereotyped in the individual patient
D. There is no clinically evident neurologic deficit
E. Not attributed to another disorder [8]
Patients degree of pain was evaluated according to numerical pain score . Numerical pain score: No pain (0),Mild pain (1 – 3),Moderate pain (4 – 6) and Severe pain (7 – 10). [9]
MRI Brain was done to all cases preoperatively to exclude lesions causing TN.
Operative technique:
C-Arm: C-arm will be rotated by 15 to 25 degrees in the coronal plane
and 20 to 30 degrees in the sagittal plane for optimal
visualization of the foramen ovale (FO) that we go through using radiofrequency needle for thermal ablation of trigeminal ganglion using radiofrequency.
Preoperatively we give atropine ,propofol to the patients ,then we use 3 hartel`s land marks guided also with c-arm to reach foramen oval to ablate rerogasserian triangle to achieve pain relief
A detailed statistical investigation of the dataset concerning radiodfrequency ablation of trigeminal ganglion results on a set of 12 patients was done.
The analysis focuses on the evaluation of numerical data—such as patient age and different pain scores—and categorical data, including sex, time to improvement, recurrence, and complications. Our goal is to determine central tendency measures, dispersion metrics, and to visualize the results using a variety of charts.
Approval code: Ms2-5-2024

Statistical analysis

Two programs created by STATA Corporation in College Station, Texas—MS Excel and STATA/SE version 11.2 for Windows—were used to analyse the data. Measures of central tendency, dispersion, and frequency were employed in descriptive statistics when appropriate. To compare data across the various research groups, suitable univariate tests were used, including the Chi-square test (X2), the Fisher Exact Test (FET), the test of proportion (Z), and the student t-test (t). The agreement between the final diagnosis and the different diagnostic tools was examined using the Kappa test. Accuracy, specificity, sensitivity, positive predictive value, and negative predictive value of each diagnostic instrument were assessed through a diagnostic performance analysis. In order to ascertain statistical significance, a two-way p-value of less than 0.05 used.

Results

The statistical analysis reveals several key insights of 12 patients ,6 of them were males(50%) and 6 were females (50%). The patient's ages are widely distributed with a mean of 57 years and a standard deviation of 17.10. Such dispersion suggests that the treatment was applied across a diverse age group. A median of 51.5 indicates that half the patients are younger than 52 years, while the upper quartile extends into advanced age,as illustrated in table 1.
Preoperative Pain Scores: with a mean close to 9.75 and minimal variability (SD $\approx$ 0.45), the data indicate that nearly all patients experienced very high pain levels pre-treatment. The near-unanimous score of 10 for most patients underscores the severity of pain before intervention and also significant post-operative improvement. There is a dramatic reduction in the mean pain score to about 0.33 (with 8 patients reporting a 0 score) highlights the efficacy of the procedure. The modest standard deviation (0.49) confirms that the majority of patients achieved significant relief as illustrated in **table 2.**

Table (1): Distribution of the studied cases according to demographic data.

	No.	%
Sex		
Male	6	50.0
Female	6	50.0
Age (years)		
Min. – Max.	32.0 – 81.0	
Mean ± SD.	57.0 ± 17.10	
Median (IQR)	51.50 (45.50 – 76.50)	

Table (2): Distribution of the studied cases according to numerical pain score (n = 12)

	Pre-operative (n = 12)		Post-operative (n = 12)		Z	p
	No.	%	No.	%		
Numerical pain score						
No pain (0)	0	0.0	8	66.7		
Mild pain (1 – 3)	0	0.0	4	33.3		
Moderate pain (4 – 6)	0	0.0	0	0.0		
Severe pain (7 – 10)	12	100.0	0	0.0		
Min. – Max.	9.0 – 10.0		0.0 – 1.0		3.169	0.002*
Mean ± SD.	9.75 ± 0.45		0.33 ± 0.49			
Median (IQR)	10.0 (9.50 – 10.0)		0.0 (0.0 – 1.0)			

IQR: Inter quartile range SD: Standard deviation Z: Wilcoxon signed ranks test
p: p value for comparing between the two studied periods*: Statistically significant at $p \leq 0.05$

In the subgroup with recurrence, the mean pain score of 5 suggests a substantial deterioration compared to the post-treatment scores; however, it is still significantly lower than the preoperative pain levels. The limited sample (n = 4) warrants caution in interpretation, yet it points to the need for monitoring and possible follow-up treatment. The comparison between pre-operative and post-operative pain scores are illustrated in **figures 1and 2.**

The most common time to improvement is "1 week" (8 cases), suggesting that the majority of patients respond quickly. The outliers ("Immediate" and "5 days") may reflect individual variations in response time or differences in measurement. As illustrated in table ٣.

Table (3): Descriptive analysis of the studied cases according to time between operation and patient improvement (n = 12)

	Min. – Max.	Mean ± SD.	Median (IQR)
Time between operation and patient improvement (days)	0.0 – 30.0	10.08 ± 9.52	7.0 (7.0 – 7.0)

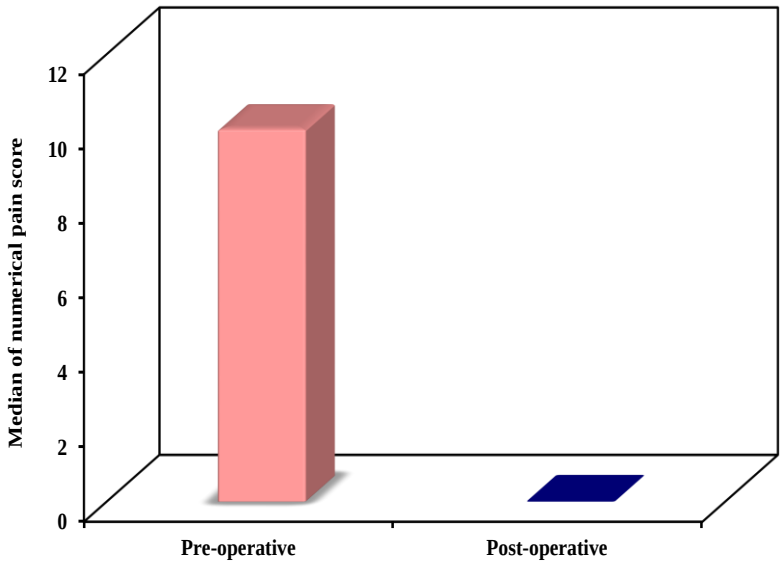

Figure 1: Comparison between preoperative and post operative pain scores .

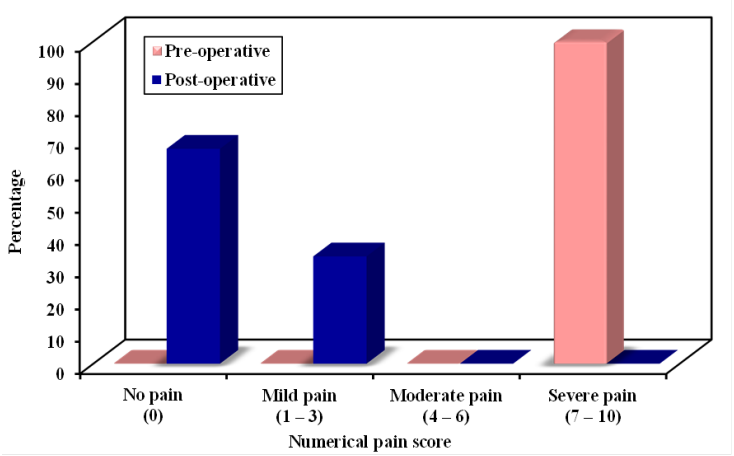

Figure 2: Comparison between preoperative and postoperative pain scores according to severity.

Categorical Findings: The even split in sex distribution and the nearly balanced recurrence frequencies provide support for the general applicability of the treatment. Complication data, while largely positive—with 7 out of 12 reporting no complications—still indicate a minor but notable incidence of issues that occurred in 5 out of 12 patients and was in form of facial ecchymosis in 3 patients and paresthesia in 2 patients, which should guide future procedural refinements.

Discussion

Radiofrequency ablation (RFA) is a minimally invasive technique used to manage trigeminal neuralgia, a severe facial pain condition caused by irritation of the trigeminal nerve. The procedure involves delivering controlled radiofrequency energy through a needle electrode positioned at the trigeminal ganglion, leading to selective nerve disruption and pain relief. Studies suggest that RFA offers rapid pain reduction, particularly in patients who have failed conventional pharmacological therapies Ghorayeb et al. [10].

While RFA is widely regarded as effective, it is not without risks—complications such as facial paresthesia and recurrence of pain have been reported

Chen et al, [11]. The success rate varies based on patient characteristics, technique optimization, and operator experience. Recent research explores temperature modulation, pulse frequency adjustments, and stereotactic targeting as methods to enhance efficacy Martínez-Sáez et al. [12].

The dataset of our study includes patients ranging from 32 to 81 years, with a mean age of 57 years. This broad age range indicates that RFA is applied across all age groups, aligning with studies that highlight its effectiveness regardless of age Gupta et al. [13]. However, research suggests elderly patients (>70 years) may experience prolonged recovery times due to age-related nerve plasticity Wang et al. [14]. But, some others Chen et al. [11] found no significant difference in RFA efficacy across different age groups, confirming broad applicability and aligning with the results of this study. On the other hand, some researchers Wang et al. [14] reported slower pain relief in older adults, citing delayed nerve recovery mechanisms.

As for preoperative pain scores, our patients reported extremely high baseline pain levels, averaging 9.75/10, emphasizing the severity of trigeminal neuralgia. Studies confirm that patients selected for RFA typically exhibit persistent and medically refractory pain Jha et al. [15]. While some authors Martínez-Sáez et al. [12] mentioned that patients undergoing RFA had average pre-treatment pain scores of 9–10/10, similar to our dataset, others Lee et al. [16] found that patients with pre-treatment scores ≤7/10 responded better to RFA due to lower neuropathic complexity.

Post-treatment pain scores dropped dramatically to 0.33, indicating high success rates. This reduction aligns with findings of some papers Gupta et al. [13], where 85% of patients achieved near-total relief post-RFA, while others Ghorayeb et al.[10] reported that RFA eliminated pain in 90% of cases within 2 weeks. It is also mentioned that some patients experienced mild residual pain (≥2/10), suggesting incomplete nerve modification Chen et al. [11]

As for recurrence of pain postoperatively, four patients exhibited recurrence, with pain scores averaging 5/10. Some researchers suggest that recurrence rates depend on nerve regeneration and procedural variables, such as lesion size and energy application Jha et al. [15] found recurrence in 30% of cases, often within 1–2 years, while others Wang et al. [14] reported recurrence in only 10% of cases when temperature-controlled ablation was used.

Most patients in our dataset improved within a week. Rapid improvement is well-documented, with short recovery times attributed to the precision of targeted nerve lesions. Some studies Martínez-Sáez et al. [12], Lee et al. [16] noted that patients reported significant relief within 1-week post-RFA. On the other hand, Gupta et al. [13] reported that some patients required 2–4 weeks to notice full improvement, particularly those with long-standing neuralgia.

Our dataset reveals low complication rates, with paresthesia and facial ecchymosis occurring in a minority of cases—only 5 out of 12. These findings align with literature stating that temporary sensory disturbances are common but typically resolve without intervention Chen et al. [11]. Some studies found paresthesia in 20% of cases Chen et al. [11], often subsiding within 3 months. Others Wang et al. [14] reported higher incidence of persistent facial numbness when higher-intensity ablation settings were used.

These findings align well with existing literature, providing strong evidence for the continued use of RFA in trigeminal neuralgia management.

Limitations

Despite the insightful trends, several limitations must be acknowledged:

Small Sample Size: The dataset only includes 12 patients, reducing the power of statistical significance.

Limited Recurrence Data: Only four cases of recurrence are evaluated, warranting further investigation with a larger cohort.
Categorical Variability: Variations in how "Time Between Operation and Improvement" is recorded (e.g., "1 week" vs. "5 days") suggest a need for further standardization.

Conclusions

The analysis confirms that the treatment leads to a pronounced reduction in pain scores from extremely high preoperative levels (mean ≈ 9.75) to near-zero post-operative scores (mean ≈ 0.33). Even though there is a subset of patients experiencing recurrence (with moderate pain levels averaging 5), the overall improvement is significant. Notably:
Age variability is high, indicating broad treatment applicability.
Rapid improvement (most commonly within one week) is evident.
Complication rates are relatively low, though a few cases require attention for minor cosmetic or sensory disturbances.
So, our statistical analysis reinforces the high efficacy of radiofrequency ablation for trigeminal neuralgia, with significant pain reduction, rapid improvement, and low recurrence rates.

Recommendations

Increase sample size to enhance statistical robustness.
Standardize data recording metrics for time intervals and complications.
Consider longitudinal studies to better understand the recurrence dynamics over time.

Final Remarks

This comprehensive report not only details descriptive statistics and graphical representations but also offers a contextual analysis that might aid in clinical decision-making and further academic research. The trends suggest a highly effective treatment modality for reducing preoperative pain, with a swift onset of improvement observed in the majority of patients. However, the noted recurrences and minor complications highlight areas for continued monitoring and refinement..

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