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Retrospective Review

Computed Tomography-Guided Radiofrequency Thermocoagulation of the Gasserian Ganglion Using an Alternative to Hartel Anterior Approach: A Bicentral Study

Dimitrios K. Filippiadis, MD, PhD[1], Dionysios Markoutsas, MD[2], Argyro Mazioti, MD, PhD[1], Grigorios Tsoukalos, MD[2], Olympia Papakonstantinou, MD, PhD[1], Panteleimon Stamatis, RN[2], Alexis Kelekis, MD, PhD[1], and Dimitrios Tzavoulis, MD[2]

From: [1]Second Department of Radiology, University General Hospital "ATTIKON" Medical School, National and Kapodistrian University of Athens, Athens, Greece; [2]Department of Interventional Radiology, Athens Naval Hospital, Athens, Greece

Address Correspondence: Dimitrios K. Filippiadis, MD, PhD Second Department of Radiology University General Hospital "ATTIKON" Medical School National and Kapodistrian University of Athens 1 Rimini Str. 12462 Haidari/Athens, Greece E-mail: dfilippiadis@yahoo.gr

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Background: Trigeminal neuralgia (TN) is associated with multiple mechanisms involving peripheral and central nervous system pathologies. Among percutaneous treatments offered, radiofrequency thermocoagulation (RFT) is associated with longer duration of pain relief. Mostly due to anatomic variation, cannulation of the foramen ovale using the Hartel approach has a failure rate of 5.17%.

Objectives: To report safety and efficacy of continuous RFT with an alternative to Hartel anterior approach under computed tomography (CT) guidance in patients with classic TN.

Study Design: Retrospective institutional database review; bicentral study.

Setting: Although this was a retrospective database research, institutional review board approval was obtained.

Methods: Institutional database review identified 10 patients (men 8, women 2) who underwent CT-guided RFT of the Gasserian ganglion. Preoperational evaluation included physical examination and magnetic resonance imaging. Under anesthesiology control and local sterility measures, a radiofrequency needle was advanced, and its approach was evaluated with sequential CT scans. Motor and sensory electrostimulation tests evaluated correct electrode location. Pain prior, 1 week, 1, 3, and 6 months after were compared by means of a numeric visual scale (NVS) questionnaire.

Results: Mean self-reported pain NVS score prior to RFT was 9.2 ± 0.919 units. One week after the RFT mean NVS score was 1.10 ± 1.287 units (pain reduction mean value of 8.1 units). At 3 and 6 months after thermocoagulation the mean NVS score was 2.80 ± 1.549 units and 2.90 ± 1.370 units, respectively. There were no postoperative complications. Three patients experienced facial numbness, which gradually resolved over a period of 1 month.

Limitations: Retrospective nature; small number of patients; lack of a control group undergoing a different treatment of TN.

Conclusions: Percutaneous CT-guided RFT of the Gasserian ganglion constitutes a safe and efficacious technique for the treatment of TN, with significant pain relief and minimal complication rates improving life quality in this group of patients.

Key words: Trigeminal nerve, neuralgia, pain, radiofrequency, ablation, percutaneous, computed tomography, imaging

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Trigeminal neuralgia (TN) is defined as sudden, unilateral, brief, stabbing, recurrent pain in the distribution of one or more branches of the trigeminal nerve (1-3). The diagnosis is performed using the history alone, based on characteristic features of the pain. Pain occurs in paroxysms, which can last from seconds to several minutes, and the frequency of the paroxysms range from a few to hundreds of attacks per day. The periods of remission can last from months to years but tend to get shorter over time. Routine daily activities that contact, mobilize, stretch, or even stimulate the trigger zone may result in intolerable pain (3). The age of onset for most patients is usually between 40 and 60 years and occurs more frequently in women than men with a ratio of 1.5:1 to 2:1, respectively (3).

Multiple mechanisms involving peripheral pathologies at the nerve root level (compression or traction), dysfunction of the brainstem, basal ganglion and cortical pain modulatory mechanisms could have a role in the pathogenesis of TN; the most widely accepted theory is the neurovascular conflict, which refers to an artery or vein compressing the trigeminal nerve near the pons causing neural hyperactive function (3). Other proposed pathophysiologic causes include demyelination of sensory fibers within the nerve root or the root entry zone, or less commonly in the brainstem and benign tumors of the posterior fossa, such as neuroma, meningioma, and epidermoid cyst (4).

Therapeutic armamentarium includes conservative therapy (carbamazepine considered to be the first-line choice), percutaneous (balloon compression, glycerol rhizotomy, and radiofrequency thermocoagulation [RFT]) and surgical (such as microvascular decompression and stereotactic radiosurgery) approaches (1-7). All percutaneous treatments are generally safe, efficient, and effective relying on the principle of inducing pain relief by direct injury to the trigeminal nerve; RFT is associated with longer duration of pain relief (8,9). The nonmyelinated nociceptive fibers of the trigeminal nerve (Aδ and C fibers) will undergo degeneration when heated to 70°C to 75°C, whereas the myelinated sensory fibers (Aα and Aβ fibers) can tolerate a higher temperature (10,11). Therefore by controlling the output power of the radiofrequency instrument, thermocoagulation can selectively destroy pain fibers of the Gasserian ganglion while leaving the sensory fibers intact (10,11).

The purpose of the present study is to report our experience with the use of continuous RFT under the guidance of computed tomography (CT) in patients with classic TN.

Methods

All patients were informed about the technique itself, as well as possible benefits and complications, and signed a relevant written informed consent form prior to the procedure. Authors have no conflict of interest to declare. No industry support was received for this study. Although this was a retrospective database research, institutional review board approval was obtained. All procedures performed in studies involving human patients were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Patient Selection and Evaluation

Institutional database research (study period 2015–2018) identified 10 patients (men 8, women 2) suffering from classic TN who underwent CT-guided RFT of the Gasserian ganglion. Mean patient age was 52.5 ± 8.086 years. Diagnosis of TN was based on clinical history, physical examination, and imaging findings. Magnetic resonance imaging scans were performed in all patients to exclude other causes of pain. The diagnosis was made by 2 interventional radiologists with 10 years of experience respectively, or by the referring neurologists who identified the potential patients and verified their eligibility. All patients had undergone carbamazepine therapy in the past 6 months without success. Exclusion criteria for the procedure included untreatable coagulopathy; active, systemic, or local infections; and patient unwilling to consent to the procedure.

RFT

All procedures were conducted in a disinfected CT examination room. Patients were in supine position; vital signs were monitored during the entire procedure. CT guidance with sequential scanning (120 Kv peak, 240 mAs wavelength, and 2-mm slice thickness) was used for planning, targeting, and intraprocedural modification during the therapeutic session. After the initial CT scan, skin entry point to the foramen ovale from the lateral side near the zygomatic bone was selected. After sterilization, the insertion point was anesthetized with 3 to 5 mL of lidocaine hydrochloride 2%. A 22-gauge radiofrequency needle with a 5-mm active tip (Diros OWL RF Probe, Diros Technology Inc., Ontario, Canada) was advanced, and its approach until

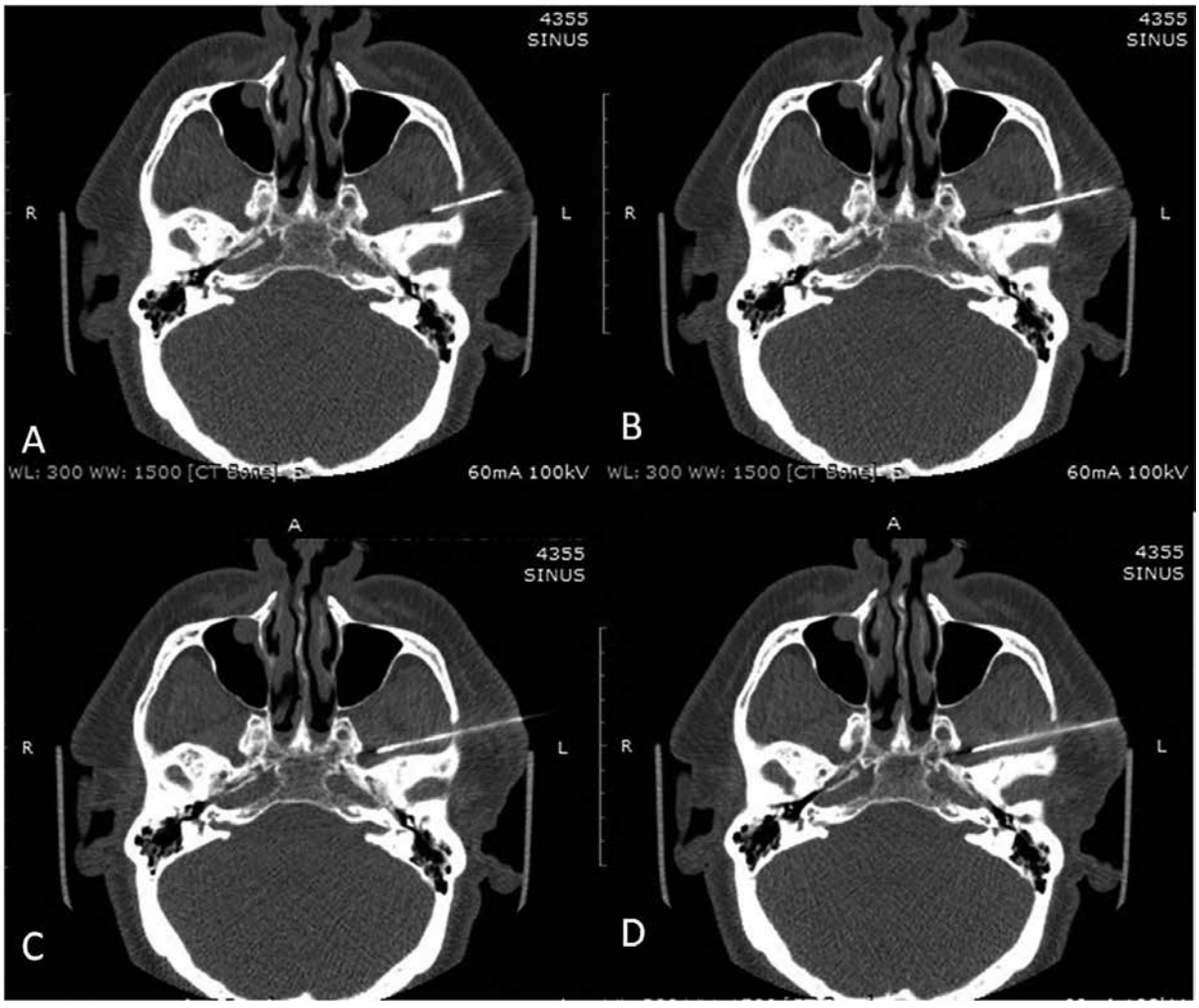

Fig. 1. *After sterilization, the insertion point and advancement of a 22-gauge radiofrequency needle with a 5-mm active tip was evaluated with sequential CT scans (A-D).*

the exit of the foramen ovale was evaluated with sequential CT scans (Fig. 1).

Once the electrode was placed in the target location, motor (2 Hz, 1 ms) and sensory (50 Hz, 0.1 ms) tests were performed to confirm or readjust the needle tip position. After positive stimulation tests, patients were administered intravenous anesthesia with fentanyl (50 µg/mL) and midazolam (1 mg/mL). No tracheal intubation was performed. The Gasserian ganglion was thermally coagulated at 75°C for 120 seconds. Patients remained in the hospital overnight and then were discharged.

Outcome Measures

Patients were followed by clinical visits prior, at 1 week, 1, 3, and 6 months after thermocoagulation. Questions asked during the follow-up period concerned the pain reduction and whether the procedure had decreased or totally relieved the symptoms they were treated for. Pain was compared by means of a numeric visual scale (NVS) questionnaire. The primary outcome was defined as pain reduction, which was measured with NVS questionnaires prior, 1 week, 1, 3, and 6 months after therapy. The NVS is a scale10-cm long, divided into 10 equal parts

Table 1. *Demographics and pain prior and post-RFT.*

Patients	Gender	Age (years)	Pain Prior RFT (NVS units)	Pain 1 Week Post-RFT (NVS units)	Pain 3 Months Post-RFT (NVS units)	Pain 6 Months Post-RFT (NVS units)
1	Male	52	10/10	0/10	03/10	03/10
2	Male	38	10/10	01/10	04/10	04/10
3	Female	69	08/10	01/10	04/10	04/10
4	Male	45	10/10	02/10	04/10	04/10
5	Male	57	08/10	02/10	03/10	03/10
6	Male	56	09/10	0/10	0/10	01/10
7	Male	54	08/10	0/10	02/10	02/10
8	Male	50	09/10	01/10	02/10	02/10
9	Male	50	10/10	0/10	01/10	01/10
10	Female	54	10/10	04/10	05/10	05/10

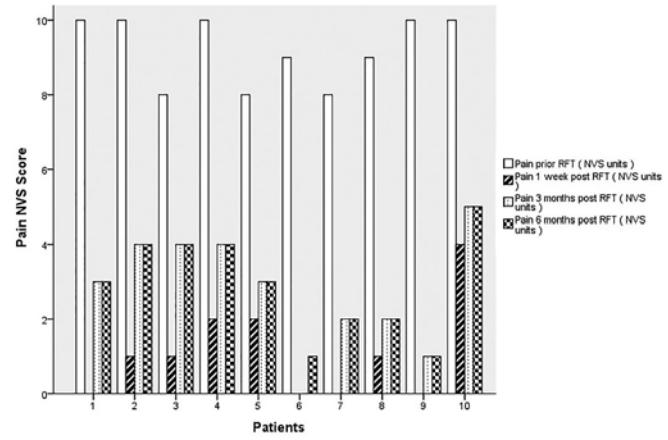

Fig. 2. *Pain NVS score prior and after RFT.*

with each 1 cm from the other, on which the patient subjectively assigns his or her pain on a scale of 0 (no pain) to 10 (worst pain patient can imagine). Complications were classified and graded according to the CIRSE classification system (12).

Statistical Analyses

Pain scores are expressed as mean ± standard deviation. Confidence interval was 95%. Variables were tested against normality with the Kolmogorov–Smirnov and the Shapiro–Wilk tests of normality. The related samples Wilcoxon signed-rank test was used to compare pain scores before thermocoagulation and during follow-up. P values < 0.05 were considered to indicate a statistically significant difference. Statistical analyses were performed with IBM SPSS Statistics 23 (IBM Corporation, Armonk, NY).

Results

Demographics and pain scores of the study's population are reported in Table 1 and Fig. 2. Technical success (i.e., correct electrode location) was achieved in all 10 patients who underwent the thermocoagulation procedure. Three patients experienced facial numbness, which gradually resolved over a period of 1 month. All patients reported significant pain relief after the procedure. Mean self-reported pain NVS score prior to RFT was 9.2 ± 0.919 units. One week after the RFT mean NVS score was 1.10 ± 1.287 units (pain reduction mean value of 8.1 units). At 3 and 6 months after thermocoagulation the mean NVS score was 2.80 ± 1.549 units and 2.90 ± 1.370 units, respectively. The median amount of sequential CT scans performed to control the correct position of the needle was 12. Pain reduction was significant from the first morning post-RFT lasting during the follow-up period. End point was 6 months after treatment.

Discussion

The percutaneous treatments of TN are safe and effective options that provide excellent pain relief (13). RFT of the Gasserian ganglion, as a less invasive and effective treatment, has gained widespread acceptance in the treatment of TN in patients who are refractory to medical therapy (14). Compared with other treatments of TN, RFT remains the most common procedure because it is characterized

by short hospitalization and by the lack of need for endotracheal anesthesia. Additionally, this procedure is especially suitable for patients with poor fitness or those refusing to undergo microvascular decompression (15). Although when compared with microvascular decompression the recurrence rate appears to be higher, percutaneous radiofrequency thermocoagulation can be selected for elderly patients, who reject invasive procedures or for those experiencing recurrences after other percutaneous or surgical treatments (16). Another significant advantage of percutaneous thermocoagulation is the repeatability of the technique in case of recurrence (17). Furthermore, PRT has proven to be an effective and safe treatment in patients with the dual diagnosis of TN and multiple sclerosis, in whom higher recurrence rates and treatment failures have been reported (13).

Several side effects associated with the application of radiofrequency energy include sensory loss (the most common), corneal reflex, masseter weakness or paralysis, dysesthesia, anesthesia dolorosa, keratitis, and transient paralysis of cranial nerves III and IV (18,19). Other complications that are observed occasionally include diplopia, meningitis, and carotid-cavernous fistula. There has been one reported case of intracranial hemorrhage after PRT (18-21). Tang et al (22) reported in a series of 1,137 patients that the optimal radiofrequency temperature to maximize pain relief and minimize facial numbness and dysesthesia seemed to be 75°C; this was the temperature applied in the present study as well.

Comparison of pulsed to continuous radiofrequency application results in less postoperative complications, however, with shorter recurrence time (23). Additionally, Li et al (24) compared low temperature plasma to standard radiofrequency energy, reporting that the former results in lower risk of postoperative numbness. Fluoroscopy-guided puncture is accompanied by potential occurrence of misdirected insertion of the needle into the spinous foramen, jugular foramen, inferior orbital fissure, and the internal carotid artery. In contrast, the configuration of bones and soft tissue is clearly visualized on CT. Thus CT-guided puncture has an advantage over fluoroscopy. CT-guided Gasserian ganglion puncture has been considered as a safe, low-risk, and effective method (14). In our study, all patients were successfully punctured under CT-guidance without any side effects.

RFT is commonly performed using the Hartel anterior approach, according to which the preferred puncture point is 2.5 to 3 cm lateral to the oral commissure (25,26). Using the Hartel approach, foramen ovale cannulation has a failure rate of 5.17% due to anatomic variation in morphology (25). In our study, we used an alternative to the Hartel anterior approach. The present study is one of the few in the literature applying an infrazygomatic approach under CT guidance for puncturing the foramen ovale; Huang et al (27) have applied a similar approach, however, performing needle bending (in a personalized modification way) in 29.55% of the patients. No needle bending was performed in the present study. After scanning, we determined the best puncture approach to the foramen ovale, and our puncture point was from the lateral side near the zygomatic bone. The postoperative success is comparable with the one produced by the Hartel approach, with no complications so far. In more recent studies, different approaches have been described, including neuronavigation-guided puncture from a mandibular angle or intraoperative CT either alone or with magnetic resonance imaging guidance, reporting promising results so far (25,28). The approach described in the present study seems simpler lacking the need for extra software and hardware necessary for navigation, although no data are presented on accuracy of different approaches with or without navigation.

Limitations of our study include its retrospective nature and the small number of patients. Additionally, because of the lack of a control group undergoing a different treatment of TN results, there was no comparison of safety and success rates with conventional techniques of trigeminal neurolysis (e.g., fluoroscopy). Further studies are required to compare large series of patients with conservative, surgical, or other minimally invasive approaches.

Conclusions

According to the results of the present study, percutaneous CT-guided RFT of the Gasserian ganglion constitutes a safe and efficacious technique for the treatment of TN, with significant pain relief and minimal complication rates improving life quality in this group of patients. CT guidance and the alternative to the Hartel anterior approach from the lateral side near the zygomatic bone seem to be governed by high technical and clinical efficacy rates.

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and take responsibility for the integrity of the data and the accuracy of the data analyses. Drs. Tsoukalos, Kelekis, and Markoutsas designed the study protocol. Drs. Mazioti, Papakonstantinou, and Stamatis managed the literature searches and summaries of previous related work and wrote the first draft of the manuscript. All authors provided revision for intellectual content and final approval of the manuscript.

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