Possible Roles of Radiofrequency Ablation in Management of Trigeminal Neuralgia

Ahmed Hazem Saad Soliman, Tarek Hassan Abd el-Bary, Ahmad Mohammad Easa Elsharkawy, Ahmed Abdallah EL-Mamun Sarhan

Neurosurgery Department, Faculty of Medicine, Zagazig University
Corresponding author: Ahmed Abdallah EL-Mamun Sarhan
E-mail: Ahmadsarhan97@gmail.com
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Abstract

Background: The biggest of the cranial nerves—the trigeminal nerve—is affected by the chronic pain syndrome known as trigeminal neuralgia (TN). Extreme, abrupt, and repeated facial pain that flares up with the slightest touch or wind is a hallmark of this condition. Medication, nerve blocks, and surgery are all options for treating TN, but a new and intriguing alternative is radiofrequency ablation (RFA). Radiofrequency ablation (RFA) is a minimally invasive technique that employs heat radiation to obliterate the tiny section of the trigeminal nerve that is in charge of the discomfort. It is possible to undertake the treatment as an outpatient procedure while under local anesthetic. With a low risk of complications, RFA has proven to alleviate TN patients' pain for the long haul. On the other hand, TN patients who experience discomfort at more than one place may not get relief with RFA. However, for TN patients who have not found relief with other treatments, RFA remains a worthwhile alternative. Additionally, if a patient is not a good candidate for surgery, RFA is a viable alternative. To determine whether patients are ideal candidates for RFA and to learn more about its long-term effectiveness, additional study is required.
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Introduction:

Unilateral neuropathic face pain involving the fifth cranial nerve and the potential for physical and/or psychological dysfunction are hallmarks of trigeminal neuralgia (TN), a chronic illness [1,2]. Approximately 12 cases per 100,000 people are reported each year, and the disease's prevalence ranges from 0.03% to 0.3% of the population [1,3]. Although it can happen to anyone at any age, the usual onset age is 50 for women [4,5]. The majority of TN cases are either undetermined or caused by the

trigeminal nerve's protective myelin layer deteriorating due to external vascular compression. Multiple sclerosis, neural tumors, facial trauma/surgery, and systemic disorders are all potential causes of nerve injury, which can then progress to TN [1,2].

One or more branches of the damaged trigeminal nerve can cause abrupt, intermittent, severe burning or stabbing pain on one side of the face; this is the hallmark of TN [2]. The painful episodes might happen for no apparent reason or in reaction to something completely harmless, such as when making facial expressions or other motions [1,6]. They typically last anywhere from a few seconds to a few minutes. Also, it gets harder to regulate symptoms and there are fewer pain-free periods as the attacks get worse over time [2,4]. The results of the clinical examination and the patient's medical history are the main factors that establish a TN diagnosis [4]. The symptoms are comparable to those of many other disorders that produce facial discomfort, making an accurate diagnosis difficult [1,5]. These illnesses include cluster headaches, post-herpetic neuralgia, and temporomandibular joint disorder. Consequently, it is common practice to conduct a battery of neurological testing in order to eliminate potential alternative diagnoses [5].

Many patients get relief from TN discomfort with the use of anti-epileptic or tricyclic antidepressant medication [4,6]. However, when the disease advances, conservative treatment may not be able to adequately control the symptoms [7]. Neurolysis, microvascular decompression, radiofrequency ablation (RFA), stereotactic radiosurgery, and balloon compression are some of the interventional techniques used to treat TN [2,4]. Radial femoral angioplasty (RFA) is a technique that uses radio waves to target the nerve and block pain signals [5,8]. Its low invasiveness, high therapeutic success rate, and favorable safety profile have made it a viable option for treating TN [1,5,7,8]. There are two main varieties of radiofrequency antennas: continuous (CRF) and pulsed (PRF). In contrast to CRF, which involves the continuous administration of high temperatures to cause thermocoagulation and necrosis in the targeted tissue, PRF uses a pulsed sequence of radio waves delivered to the nerve at lower temperatures [8]. Although RFA has shown promise in treating TN, it is important to be aware that patient characteristics, the cause of the TN, and other factors can increase the risk of consequences [7,8]. To gain a better understanding of RFA's function as a minimally invasive therapy option for such a complicated condition, this article aims to perform a thorough literature review on its indications and utility for the long-term treatment of intractable TN in adults.

An illness defined as "recurrent unilateral brief electric shock-like pain, abrupt in onset and termination, limited to the distribution of one or more than one division of the trigeminal nerve and triggered by innocuous stimuli" [9] is trigeminal neuralgia (TN), as stated by the International Headache Society. While the exact mechanisms behind TN are still a mystery, what is known is that demyelination and neuralgia are the results of pressure on the trigeminal root at the pons entry zone, which in turn creates an ectopic action potential. TN can arise for no apparent reason or as a complication of other diseases, such as MS, tumors of the cerebellopontine angle, or abnormal vascular loops that cause demyelination [10]. The average age at which symptoms first appear is 40, and the incidence rises steadily thereafter. Nevertheless, there have been little reports of instances among children. Additionally, disease incidence is not different by race or geography [9].

Two forms of TN exist: classical TN that is entirely paroxysmal and classical TN that is also accompanied by persistent face pain. There are tic-like cramps in the face muscle and the pain is characterized as superficial, abrupt, intense, acute, lancinating, and shock-like. Pain attacks happen

multiple times a day and can get worse with time, but they are triggered by non-noxious stimuli. It has been found that the right side of the face is more impacted compared to the left side, and that the V2 division of the trigeminal nerve is more commonly involved than V3 [9,10].

Forty years ago, the most successful method of treating TN was to inject caustic substances into the afflicted nerve branch or remove the sensory trigeminal root beneath the Gasserian ganglion, but this was no longer the case. Medical management and surgical management are currently used as therapy methods. Anticonvulsants, particularly carbamazepine or oxcarbazepine, are the cornerstone of medical treatment. After medical treatment has failed, the next step is surgical management. The most common reasons why medical treatment fails are intolerable side effects or ongoing pain. Microvascular decompression, balloon compression, and radiation are all forms of surgical therapy [1]. Microvascular decompression is the most intrusive surgical method for treating TN. This procedure eliminates the hypothesized nerve compression caused by an artery or vein, which is a vascular compression on the trigeminal root and the underlying cause of TN [11]. In the surgical treatment of TN, balloon decompression is an additional option. One non-invasive technique is balloon decompression, which involves inflating a tiny balloon at the Gasserian ganglion using a 14-gauge needle. The transmission of pain signals is prevented by this process, which creates a confined damage at the ganglion level [10]. Focusing on RFA, another non-invasive method, is what this review is all about [11].

The gold standard for minimally invasive TN treatment is RFA. When contrasted with balloon and microvascular decompression, it has been found to be safe, effective, and patient-satisfying [10,11]. This has led to its acceptance as a standard method for dealing with TN that has not responded to treatment [12]. Also, you might feel better right away after RFA at the level of the Gasserian ganglion [13]. Results from RFA for the treatment of TN ranged from 85 to 90% success and 5 to 10% recurrence, according to a 2016 systematic review of the literature. The success rate of RFA for TN was 89.2% and the recurrence rate was 7.9%, according to a 2017 meta-analysis of 13 trials and 1,146 patients [9]. Numerous further studies have also documented the efficacy of RFA for TN, in addition to the ones above cited. The Journal of Neurosurgery published a study in 2015 that included 104 patients. After an average follow-up of 16.8 months, the researchers found a success rate of 94%. With an average follow-up of 12 months, another 2019 study published in the Journal of Neurosurgery found a 98% success rate [1]. The study comprised 100 patients. Additionally, RFA has been shown to be economical. The Journal of Craniofacial Surgery published a study in 2020 comparing the cost-effectiveness of RFA and microvascular decompression for the treatment of TN [12,13].

There are two methods for applying radiofrequency at the level of the Gasserian ganglion: pulsed radiofrequency (PRF) and thermal radiofrequency (CRF). In contrast to PRF, which does not harm structures but may harm C-fiber microfilaments on a microscopic scale, thermal RF damages structures [10]. Both procedures typically involve the use of a C-arm equipment to provide fluoroscopic guidance. A lot of research focused on injectable lidocaine for pain relief. To prevent any potential damage to blood vessels or leakage of CSF fluid, aspiration is performed prior to placing the probe into the foramen ovale. For RF procedures, a cannula of 10 cm in length and 20-23 gauge with an active tip measuring 0.5 cm was utilized. The first step is to locate the coronoid process using the C-arm's sub-occipitomental view. After the coronoid process has been located, the foramen ovale can be viewed by slowly rotating the C-arm into an ipsilateral oblique position. The petroclival junction

is located on a lateral C-arm picture of the skull, which is used to determine the needle's depth. The cannula tip is maintained 5 mm proximal to the proximal carpal joint (PCJ) when the third division is the target. When aiming for the second division, it is important to keep the cannula tip at the PCJ. It is common practice to use sensory and motor stimulations to verify the cannula's placement after it has been carefully positioned. Achieving concordant sensory stimulation at 0.1-0.5 V/ 50-100 Hz is dependent on the patient's response. To avoid damaging the motor branch of V3, all investigations verified the motor response by evaluating the corneal reflex after applying 0.1-1.5 V/ 2 Hz stimulation [10,14].

To improve the accuracy of the surgery, more recent research has sought to use CT guidance rather than fluoroscopy. A novel method that employs CT guidance to target the peripheral trigeminal branches rather than the Gasserian ganglion itself was used in these clinical trials [15–18]. But there have been very few studies that have contrasted CT guidance with fluoroscopy recently. Wu et al. performed a systematic evaluation in which a meta-analysis of just two trials found no statistically significant difference in the cure rate between fluoroscopy and three-dimensional CT guiding.

There is an increased risk of coagulative tissue necrosis, neurological damage, and other consequences when the probe temperature is set between 60°C and 80°C during the intervention. CRF caused by high-frequency alternating currents can exacerbate these issues. A silent phase follows PRF's brief bursts of high voltage, which enable heat removal. Although limiting heat exposure may lessen problems, it will also limit therapy's efficacy. The effects of combining CRF and PRF have been found to be better in several studies [12,15]. The data is inconsistent with respect to the amount of time employed for the RF application; the duration is reported as anything from 90 seconds to 180 seconds, with either equal or stepwise intervals [10,15]. However, a method to avoid damaging needless Gasserian ganglion branches has been suggested by Lin et al. They employed a method of incremental heating from 55°C to 75°C in increments of 5°C for 30 seconds each. Unintentional trigeminal branch injuries did not cause any adverse consequences in this clinical research, while 21 out of 107 patients did develop hematomas [15].

Another variable that impacts RFA's efficacy is RF temperature. Unfortunately, there isn't a universally accepted method for determining the precise CRF temperature needed for TN at this time. A small number of studies have shown that 68°C is the ideal RF temperature for treating unilateral idiopathic TN, as well as idiopathic TN affecting the maxillary (V2) and mandibular (V3) divisions. Some others said that 70 degrees Celsius was ideal. Temperatures between 66 and 80 degrees Celsius boosted efficiency, while temperatures between 68 and 70 degrees Celsius increased patient satisfaction. Patients reported high levels of satisfaction in previous research when TN temperatures of 60–65°C were used for V1, 72°C for V2, and 75°C for V2/V3. The recommended temperature range for PRF in older patients is 45-50°C. Initial pain alleviation was reported by 77.8% to 100% of patients. On average, pain recurrence occurred between 8 and 40 months after treatment [19].

Wassim et al. observed a 67% recurrence-free interval following three months of treatment with three lesions at 70° for 60 seconds each in a separate investigation. Over time, this rate grew substantially. At the conclusion of the first year, 85.3% of patients reported no symptoms; at the end of the third year, 74.6 percent; and at the end of the fifth year, 68.0 percent; this translates to about 32% symptom recurrence [20]. Compared to CRF or PRF alone, combination therapy is superior and more satisfying, according to one study. Lower temperature regimen treatments have a higher recurrence rate following

the surgery. All of the RFA methods showed an improvement in quality of life. Depending on the study, symptom remission one year following the surgery can be anywhere from 60% to 95.1%. Patients were more likely to still be symptom-free at the two-year follow-up, with rates ranging from 83.3% to 92.3% [21,22].

Hypoesthesia, masticatory muscle weakening, visual disturbance, keratitis, dysacusis, temporal muscle atrophy, and facial hematoma are some of the problems that might occur with RF, despite its effectiveness [20]. Because RF uses a thermal cauterizing technique on the sensory branches of the trigeminal nerve, it is not surprising that fascial hypoesthesia or numbness was the most commonly reported side effect in all the trials that were examined. Atypical idiopathic TN incidence (OR = 0.36, 95% CI = 0.18-0.71, p = 0.004) and prior RF procedure on the affected side (odds ratio (OR) = 2.33, 95% confidence interval (CI) = 1.21-4.48, p = 0.011) were found to be associated with more severe fascial numbness in the study by Wang et al. [23].

But more serious side effects include impaired corneal reflexes, face hematomas, and weakened masticatory muscles are not uncommon. The following complications were noted in the study by Gunduz et al.: intrabuccal hematoma (9.1% of the total), masseter muscle weakening (2.39% of the patients), corneal hypoesthesia (3.35% of the patients), and decreased corneal reflex (3.35% of the patients) [24]. Intracranial bleeding, intracranial infection, carotid-cavernous fistula, ocular ulcerations, transitory impairment of cranial nerves III and IV, and deafness are some of the more severe consequences that have been reported in previous studies [25,26]. Nevertheless, with the development of better needles, imaging, and surgical procedures, the occurrence of these problems during Gasserian ganglion thermocoagulation has been dramatically reduced [25].

According to our research, there are a number of potential variables that influence the seriousness of RF problems. The impact of procedure technique on these complications was the subject of Wu et al.'s research, for instance. One study indicated that CRF was linked to a greater risk of problems when compared to PRF (OR = 0.04; 95% CI = 0.01, 0.23, p = 0.0002) [22]. It was also determined in a separate sub-analysis that CCRF is considerably safer than CRF. According to Wu et al., there are fewer problems related with lower temperatures (68°C-70°C) in CRF compared to higher temperatures (71°C-75°C) (OR = 0.04; 95% CI = 0.02, 0.09; Z-value 8.17, p < 0.00001) [22]. Current RFA practice is unable to make use of the available data to establish a dominant approach clinically, despite these encouraging outcomes, due to the small sample sizes of the published research. To lessen the impact of any problems, several of our trials included new methods. To reduce the risk of intracranial infection or hemorrhage associated with entering the skull, Huang et al., Zeng et al., and Ran et al. investigated the effects of delivering heat waves extracranially at the afflicted trigeminal branches (V2, V3) instead of the Gasserian ganglion [16–18]. Zeng et al. contrasted PRF via the Gasserian ganglion radiofrequency (GRF) with that via the foramen rotundum (FR) and foramen ovale (FO) [17]. According to their findings, the two-year postoperative effective rate was not significantly different between the PRF and GRF groups, but the incidence of numbness was significantly different (45 vs. 21, unpaired t-test, p < 0.001) [17]. Also, 87 patients with V2 idiopathic TN were investigated by Ran et al. to see how well the FR radiofrequency method worked towards treatment. All patients had mild to severe hypoesthesia following the treatment, and ten patients, or 11.5% of the total, had a temporary face hematoma that went away after a few days [18]. Having said that, not a single patient experienced a loss of strength in their masticatory muscles, visual disturbance,

meningitis, or corneal areflexia [18]. Most adverse effects are short-lived and not severely disabling, proving that RFA is a clinically safe technique, according to this comprehensive safety profile evaluation. There are a number of possible surgical approaches that could reduce the negative effects. To alter the present RFA practice, however, larger studies and randomized controlled trials are required.

Several contraindications should be thoroughly investigated, even if RFA is a relatively small operation. A few studies used anesthesia as a criterion; patients were not included if their medical condition prevented them from safely undergoing the anesthetic. But severe sedation was the sole method utilized in the majority of investigations. In order to minimize the possibility of hemorrhage and hematoma, several studies omitted participants. Sepsis and cerebral infections are more likely to occur in individuals with local face infections, particularly during GRF treatments. The most prevalent reason why this method is not appropriate is that it relies on the patient's confirmation of the needle placement through nerve stimulation, which can be challenging for patients with mental or behavioral disorders who are unable to verbalize their subjective feelings [27].

While RFA has demonstrated efficacy in treating TN, it is not without its limitations. The lack of a cure for TN and other forms of chronic pain is one of the key drawbacks of RFA. Although RFA can alleviate discomfort considerably, it won't solve the problem permanently and won't get at the root of the problem. Following some procedures, patients may experience recurrence of pain, necessitating further treatments or exploration of alternative therapy [18]. One other thing: RFA isn't going to work for everyone. When other treatment options, such medicine or surgery, have failed, RFA is usually considered as a last resort.

Patients with specific medical issues, such as bleeding disorders or malignancies, should not undergo RFA [19]. Bleeding, infection, and nerve injury are among the possible problems and adverse effects of RFA. When considering RFA as a potential treatment, it is important to keep these relatively minor concerns in mind. Additionally, some patients may not be able to afford RFA because their insurance does not cover treatment [15,27]. There are certain restrictions to RFA, but overall it is a great alternative for treating chronic pain, including TN. Patients must be informed about these restrictions and have a conversation about them with their doctor before the operation.

Conclusions

For TN patients, RFA shows promise as a therapy option that can alleviate discomfort and enhance quality of life. To find the best patient selection criteria and compare RFA's long-term results to other therapies, additional research is required. But it's worth considering as a therapeutic option for TN patients because it's safer and more successful than other surgical treatments.

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