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NEUROPATHIC PAIN (A. ABD-ELSAYED, SECTION EDITOR)

Radiofrequency Ablation for Treating Headache

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Abstract
Purpose of Review Examining the efficacy of radiofrequency ablation in treating headache conditions.
Recent Findings The efficacy of radiofrequency ablation in treating headache conditions is not well studied.
Summary Chronic headache conditions can be difficult to treat with little consensus on management of headaches associated with pericranial neuralgias. In this retrospective study, we found that radiofrequency ablation is an effective and safe treatment for resistant headache conditions. This study is important as it describes a novel treatment for chronic headache which can benefit a large number of patients.

Keywords Radiofrequency ablation · Headache conditions · Migraine

Introduction

Neuralgia is an intense, intermittent pain caused by a nerve. Pain commonly results from nociceptive afferents but can be generated inside the nervous system without sufficient stimulation [1]. The cause of neuralgia specifically is not completely understood. Pericranial neuralgias are categorized by facial and cranial pain in regions corresponding to the pathway of a particular nerve [2]. These neuralgias can be difficult for physicians to treat, resulting in patients with chronic pain conditions refractory to treatment [3]. One common symptom of pericranial neuralgias is headache. Many patients will suffer chronic migrainous and non-migrainous headaches in head regions associated with neuralgias [4]. Patients may be diagnosed with a headache condition without paying attention to the associated or causative neuralgia. While headache can be a central process and neuralgia can be simply a peripheral sensitization following the central sensitization process, some reports indicated that peripheral sensitization can be the leading factor to headache and can be followed by central sensitization. Traditional treatments for neuralgia-associated headache include pain medications, neuropathic agents, steroid injections, and nerve blocks [5]. For subset of patients, these treatment modalities have little or temporary efficacy. More invasive treatments such as microvascular decompression and gamma knife surgery have been used in certain patients with pericranial neuralgias successfully but carry several risks including surgical complications and failure. In addition, they do not produce permanent pain control, and typically, pain will recur. Radiofrequency ablation (RFA) is a minimally invasive procedure that has been recently applied to headache associated with pericranial neuralgias with promising results [6–8].

In this retrospective study, we evaluated the efficacy and safety of RFA as a treatment modality for patients with headache conditions associated with pericranial neuralgia.

Methods

This was a retrospective study that included collection of data from electronic medical records. Study was performed after obtaining IRB exemption. We identified 168 patients who received 244 radiofrequency ablations for pericranial nerves between January 1, 2015 and January 31, 2018. Then, two medical students collected data related to the procedures, blocks performed before RFA, comorbidities, and patient demographics. Data was then entered on an excel sheet and then was transported to SPSS version 22 (IBM). Data was presented as mean ± standard deviation or median and percentiles for numeric data and number and percent for categorical data. Analysis was performed comparing pre-procedure pain scores

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and post-procedure pain scores using paired *t* test, *p* value was considered significant at level ≤ 0.05. Also, percent improvement after procedure (a composite outcome indicating improvement in pain, symptoms, and function) was reported. Follow-up was performed mostly by other health care providers other than providers who performed the procedure.

Procedure

All patients received one or two diagnostic nerve blocks using lidocaine 1% or bupivacaine 0.25%. All patient included in this analysis had more than 50% improvement in their pain with diagnostic blocks. RFA was performed for most patients in the lesion mode, at 80 °C, and for a duration of 180 s. Few patients received pulsed RF (patients who received trigeminal nerve treatment) and few patients had few variations in duration or temperature as indicated in the results section (Table 1). RFA was performed using 21-gauge insulated needles with 4-mm active tip. Sensory testing was performed to confirm stimulation in the distribution of pain. Motor testing was performed only in patients who received trigeminal nerve radiofrequency ablation.

Results

This study included 168 patients who received 244 RFA procedures. Patients' average age was 43.6 ± 15.0 years (Table 2). Results will be drawn from different number of RFAs due to the presence of missing data in certain outcomes but the number of RFAs for each variable will be indicated in the results.

Of the 168 patients, the most common diagnosis was migrainous headaches at 56.5% (Table 3). The most common symptom at presentation was chronic daily headaches which was reported by 97% of patients. Other diagnoses and symptoms in association with headaches are shown in Table 2. Of all 244 RFAs, most (*n* = 142, 58.2%) were associated with no prior trauma or head surgeries, Table 4.

RFA was performed on multiple different nerves (Table 5) with the greater and lesser occipital, supraorbital, and supratrochlear nerves composing the majority of RFA sites. We also included analysis of 12 pulsed RFs of trigeminal nerve.

Pain scores decreased from 5.69 ± 2.23 pre-procedure to 2.86 ± 2.29 post-procedure ($P < 0.001$, $n = 207$) (Table 6). Thirty-seven RFAs did not have post-pain scores due to lack of documentation or loss of follow-up.

Table 1 Radiofrequency ablation procedure technique (*n* = 244)

Variable	*n* (%)
RFA temperature (°C)	
60	3 (1.2)
80	239 (98)
90	2 (0.8)
RFA duration (s)	
60	2 (0.8)
75	27 (11.1)
90	2 (0.8)
150	2 (0.8)
165	1 (0.4)
180	210 (86.1)
Non-pulsed vs pulsed RFA	
Non-pulsed	231 (94.7)
Pulsed	13 (5.3)

Table 2 Demographic data for patients receiving radiofrequency ablation (*n* = 168)

Variable	*n* (%)
Race	
White	161 (95.8)
Black or African American	6 (3.6)
Patient declines to answer	1 (0.6)
Sex	
Male	41 (24.4)
Female	127 (75.6)
Mean age, years ± SD (range)	43.6 ± 15.0 (16–83)

Table 3 Individual patient pre-operation presentation (*n* = 168)

Variable	*n* (%)
Diagnosis	
Migrainous headache	95 (56.5)
Non-migrainous headache	69 (41.1)
Chronic pain (face, head, and neck)	38 (22.6)
Facial pain	8 (4.8)
TMJ syndrome	7 (4.2)
Post-concussion syndrome	5 (3)
Post-herpetic neuralgia	1 (0.6)
Symptoms	
Chronic daily headaches	163 (97)
Dizziness	80 (47.6)
Insomnia	63 (37.5)
Myalgias	45 (26.8)
Nausea/vomiting	31 (18.5)
Nervous/anxious	27 (16.1)
Sensitivity to light/sounds	25 (14.9)
Sensitivity to temperature	20 (11.9)
Sensory change	13 (7.7)
Tingling	10 (6)
Weakness	3 (1.8)

Table 4 Trauma or head surgeries prior to radiofrequency ablation ($n = 244$)

Trauma/surgery	*n* (%)
None	142 (58.2)
Trauma	81 (33.2)
Ear, nose, or throat surgery	26 (10.7)
Cranial surgery	12 (5)

All patients who reported numeric improvement (number of RFAs = 164) reported an average percent improvement of 62.6% ± 33.7 (range, 0–100%), Table 7. Fifty RFAs resulted in no numeric improvement value but patients stated significant improvement through less severity, frequency, or duration of pain and symptoms (outcomes were collected after procedure in a different clinic that reported outcomes this way). Thus, the majority of RFAs ($n = 191$, 89.3%) led to some degree of improvement while 23 RFAs led to no improvement. Thirty RFAs resulted in unavailable percent improvement values due to lack of documentation or loss of follow-up.

Table 5 Nerves targeted by radiofrequency ablation ($n = 244$)

Site of radiofrequency ablation	*n* (%)
Bilateral greater and lesser occipital	82 (33.6)
Bilateral supraorbital and supratrochlear	39 (16)
Right greater and lesser occipital	18 (7.4)
Bilateral supraorbital	10 (4.1)
Left greater and lesser occipital	9 (3.7)
Left supraorbital and supratrochlear	9 (3.7)
Right supraorbital and supratrochlear	9 (3.7)
Right trigeminal (pulsed)	7 (2.9)
Bilateral occipital	6 (2.5)
Right supraorbital	6 (2.5)
Left trigeminal (pulsed)	5 (2)
Bilateral greater occipital	4 (1.6)
Right greater occipital	4 (1.6)
Bilateral infraorbital	3 (1.2)
Left supraorbital	3 (1.2)
Right supraorbital and infraorbital	3 (1.2)
Bilateral infratrochlear	2 (0.8)
Bilateral supraorbital and infraorbital	2 (0.8)
Left greater occipital	2 (0.8)
Left infraorbital	2 (0.8)
Left supratrochlear	2 (0.8)
Right occipital and supraorbital	2 (0.8)
Right occipital	2 (0.8)
Bilateral greater occipital and left lesser occipital	1 (0.4)
Left infraorbital and infratrochlear	1 (0.4)
Left occipital	1 (0.4)
Left V3 and supraorbital	1 (0.4)
Right inferior alveolar (Pulsed)	1 (0.4)
Right nasopalatine	1 (0.4)
Right supraorbital, supratrochlear, and infraorbital	1 (0.4)
Bilateral external branch of anterior ethmoidal	1 (0.4)
Bilateral lesser occipital	1 (0.4)
Left supraorbital and infraorbital	1 (0.4)
Left supraorbital (pulsed)	1 (0.4)
Right infraorbital	1 (0.4)
Right supraorbital, supratrochlear, and lesser occipital	1 (0.4)

Table 6 Pain scores before and after radiofrequency ablation ($n = 207$)

Variable	Pre-RFA	Post-RFA	*p* value
Pain scores			
Mean ± SD	5.69 ± 2.23	2.86 ± 2.29	< 0.001
Median	5	2	
Percentiles (25–75)	4–8	1–5	
Range	0.5–10	0–10	

Pain was scored on a scale of 0–10, with 0 corresponding to no pain and 10 corresponding to worst pain imaginable ($n = 207$)

Patients who reported a definitive end of pain relief (number of RFAs = 154) recorded a mean duration relief of 182.8 days ± 154.5 days (range, 0–730). Fifty patients reported ongoing improvement after their procedure at last time of follow-up; the durations of improvement are reported in Table 8 with the max being 831 days. Forty RFAs did not have corresponding duration of relief due to lack of documentation or loss of follow-up.

Three patients reported swelling of eyelids after bilateral supraorbital and supratrochlear RFAs. All cases were self-limited and resolved within 1 week. Two patients reported worsening of headache-related symptoms post-RFA. One patient returned to baseline headache pain within 3 weeks and the other was lost to follow-up. One patient reported superficial infection at site of procedure which was treated with antibiotics with no further consequences.

Discussion

Pericranial neuralgias are painful and often longstanding disorders that can result in headaches and can be associated with headache conditions. These headaches are commonly daily and debilitating for many patients and are associated with a

Table 7 Percent improvement and duration relief after radiofrequency ablation

Variable	Post-RFA value
Percent improvement (range)[a]	62.6 ± 33.7 (0–100)
Duration relief, days (range)[b]	182.8 ± 154.5 (0–730)

[a] Percent improvement was scored from 0 to 100% and reflects improvement in severity, frequency, and duration of pain ($n = 164$)

[b] Duration relief reported by patient with concluded relief ($n = 154$)

Table 8 Duration of improvement for patients who reported ongoing improvement at time of follow-up ($n = 50$)

Duration of improvement in days (and ongoing)	*n* (%)
< 50	9 (18)
50–99	8 (16)
100–149	6 (12)
150–199	6 (12)
200–249	2 (4)
250–299	2 (4)
300–349	3 (6)
350–399	2 (4)
400–449	4 (8)
450–499	0
500–549	2 (4)
550–599	1 (2)
600–649	2 (4)
650–699	1 (2)
700–749	1 (2)
750–799	0
> 800	1 (2)

decline in physical and mental health [9]. As noted previously, pharmacologic management of neuralgias must be taken continuously and can fail to achieve appropriate levels of pain management. Surgical treatments can achieve months to years of pain relief but carry risk of complications and may not be indicated for all patients. Our findings suggest that RFA is a promising modality for treating headache conditions associated with pericranial neuralgias.

Many patients pursue non-pharmacologic management for headache due to higher rates of pain improvement and failed response to first-line therapy. Our study found RFA of pericranial nerves resulted in patient-reported pain improvement of 62.6% ± 33.7. In addition to pain, patients reported improvement in symptoms such as chronic daily headaches, dizziness, and insomnia. Patients also reported significant lower pain scores post-RFA. These results complement findings from a retrospective study conducted by Abd-Elsayed et al., which found RFA of pericranial nerves resulted in a pain improvement of 71.7% ± 28.8% [10]. Compared to other treatment modalities, RFA fairs well. Therapeutic nerve blocks are commonly used for chronic headaches and can provide up to 100% pain relief but have limited duration of pain relief [11]. Treatment of migraines with onabotulinum toxin A has been reported to provide relief in double-blind randomized controlled trails but a Cochrane systemic review suggest botulinum toxin A may only reduce migraines by 2 days compared to placebo treatment [12, 13]. Although headaches can also be treated with Gamma Knife Surgery (GKS) with up to 80% resolution of symptoms, GKS has only been successful in the management of trigeminal and glossopharyngeal neuralgias [6, 14]. More invasive treatments such as microvascular decompression have been applied to trigeminal neuralgias with up to 71% of patient reporting complete pain relief at 10 years. However, the same cohort of patients reported a 4% incidence of postoperative morbidity [15]. Compared to other treatment options, RFA provides similar if not better pain reduction with markedly lower side effects and lower cost.

Patients suffering from pericranial neuralgias also seek non-pharmacologic management of headaches due to longevity of results. Our review found RFA of pericranial nerves resulted in a mean duration relief of 182.8 days ± 154.5 days for patients who reported a numeric duration of relief with a max duration of 730 days. Of all RFA patients, 50 reported ongoing improvement at time of follow-up with a maximum duration of 831 days. These findings support results from the previously mentioned Abd-Elsayed retrospective pericranial RFA study which found an average duration improvement of 127 days ± 79.2 days. Against most treatment modalities, RFA is a better temporal alternative. Only microvascular decompression and peripheral neurectomy resulted in longer pain relief with the majority of reviews reporting over 10 years of relief and over 2 years of relief respectively. However, both microvascular decompression and peripheral neurectomy are only indicated for specific pericranial neuralgias, due to operational access, and both procedures are also associated with invasive surgical complications [16]. Although RFA treatment may ultimately result in relapse of pain, RFA may be repeated multiple times with similar results.

Our findings support existing similar literature. In a randomized, double-blind trail comparing pulsed RF to steroid injections, Cohen et al. found that pulsed RF provided significant greater pain relief for occipital neuralgia and migraine compared to steroid injections [17]. Complementary retrospective studies, like a multi-center 102 patient study by Huang et al., report similar findings in pain relief of occipital neuralgia due to pulsed RF [18, 19]. Additionally, reviews of trigeminal nerve RFA largely suggest comparable findings. One study analyzing 1600 patients with idiopathic trigeminal neuralgia reported acute pain relief in 97.6% of patients and complete pain relief in 57.7% of patients at 5 years following lesion RFA [20]. Although there are a limited number of trails regarding RFA for pericranial neuralgia, our study builds on existing support for RFA efficacy and safety. Our study differs in that we used RFA as opposed to pulsed RF which was used on most previous reports.

Majority of our patients presented to the headache clinic and had the diagnosis of migraine headache or another type of headache. It is important to examine for pericranial neuralgias which can be the cause of headache or associated with headache. Obviously treating the pericranial neuralgias can lead to improvement in the headache condition.

Though our findings suggest RFA can be effective in the management of pericranial neuralgias, RFA should be performed by providers with appropriate training due to the proximity of many pericranial nerves to sensitive structures. Potential side effects of RFA include swelling of procedure site, residual numbness, and worsening of headache. In this study, we observed swelling of eyelids in 3 patients post-procedure which resolved within a week. Infection in one patient was resolved with oral antibiotics. We also observed worsening of headache in 2 patients post-procedure. Of all RFAs, 23 (10.7%) led to no improvement while the majority of RFAs led to improvement. This indicates that the procedure is both safe and effective.

It is important to mention that our patients were referred to our practice by the headache pain team after failure of all medication management options. The successful results we achieved in this resistant patient group indicated great efficacy of this procedure and provides another effective tool for the management of headache.

Limitations

The retrospective nature of data accounts only for available variables in the electronic medical records and the presence of missing data for some patients.

Strengths

While this was a retrospective data collection, the procedure was performed by providers who did not perform the majority of follow-ups and did not collect the outcomes. Outcomes were collected by other staff in the pain clinic and other clinics. In addition, data was collected by students who do not work with providers or support staff; this eliminates any bias in reporting outcomes or data collection.

Additionally, the sample size is large which also indicates consistency of results presented. Our outcomes were very accurately reported in our electronic medical records as majority of our patients receive their care only in our health system. Important outcomes as pain scores and percent improvement were available and accurately reported for most patients which strengthen our results.

Conclusion

Our study finds RFA is a safe and effective treatment for patients with chronic headache conditions associated with pericranial neuralgias. RFA is also an acceptable alternative to current treatment modalities for pericranial neuralgias. This technique may be a promising alternative for providing long-lasting symptomatic and pain relief through a minimally invasive procedure.

Compliance with Ethical Standards

Conflict of Interest Alaa Abd-Elsayed, Sean Nguyen, and Kenneth Fiala declare no conflict of interest. Dr. Abd-Elsayed is a consultant for Medtronic, Halyard, Sollis, SpineLoop, and StimWave.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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