Neurology Asia 2022; 27(4) : 991 – 999

Using GON block as a diagnostic block: Investigation of clinical efficacy of GON radiofrequency treatment for migraine patients

[1]Mustafa Karaoğlan, [2]Bilge Küçükçay

[1]Ordu State Hospital, Department of Algology, Ordu; [2]Niksar State Hospital, Department of Anesthesiology and Reanimation, Niksar, Tokat, Turkey

Abstract

Objective: This retrospective study aimed to investigate the clinical efficacy of GON pulsed radiofrequency (PRF) treatment in migraine patients who did not respond adequately to treatment with greater occipital nerve (GON) blockade. *Method:* Twenty-seven patients with recurrent episodic migraines or chronic migraines were included in the study. GON blockade was performed bilaterally once a week – four times over a one-month duration. PRF treatment was performed once for those patients who did not show an adequate response to GON blockade, and the treatment was directed at the same sites as the GON blockade. The number of migraine attacks in the preceding 30 days, the total number of triptan tablets taken, the average duration of headache and the highest VAS scores at the first, third and sixth-month visits were recorded. *Results:* The number of severe migraine attacks, total analgesic use and the maximum duration of migraine episodes were recorded in this study. All these parameters showed a significant decrease from the first month after GON PRF treatment as compared to both the baseline as well as to treatment one month after GON block. In addition, this clinical improvement was sustained up to six months after PRF treatment.
Conclusion: Our results suggest that GON PRF treatment is a viable treatment approach in the case of migraine patients who do not respond adequately to treatment with GON blockade.

Keywords: Migraine, greater occipital nerve, GON block, pulsed radiofrequency

INTRODUCTION

Migraine is a common neurological disorder that is prone to becoming chronic.[1] It greatly impairs a patient's quality of life. Antidepressants, antiepileptics, beta-blockers, calcium channel blockers, cognitive behavioural therapy and botulinum toxin are generally used in management.[2-6]

The rationale for using GON block as a treatment for headaches is derived from the proximity of the sensory neurons in the upper cervical spinal cord to the trigeminal nucleus caudalis (TNC) and the convergence of sensory input to TNC neurons from both cervical and trigeminal fibres. The evidence for this has been shown by several studies.[7] In an animal study, stimulation of the GON was shown to increase metabolic activity in the TNC and the upper cervical dorsal horn.[8] The same neural sites are activated after mechanical or electrical stimulation of trigeminally innervated structures such as the superior sagittal sinus.[9] This observation suggests that a convergence of sensory input from cervical and trigeminal afferents occurs at the level of the second neurons in the TNC. Further supporting this hypothesis, Bartsch and Goadsby[10] demonstrated in a rat model of cranial nociception that dorsal horn neurons at the C2 level respond to dural stimulation. In line with these findings, it has been shown in humans that GON block may alleviate pain even outside of the skin territory supplied by the nerve.[11] Available data show that the GON block procedure is effective, safe, easy to perform and well-tolerated by the majority of patients.[12]

Pulsed radiofrequency (PRF) therapy, which Sluijter first described[13] in 1997, is currently used as an effective and safe treatment in chronic pain syndromes.[14] PRF therapy works by delivering an electrical current and bursts of heat to the targeted tissues without damaging them. On the other hand, conventional radiofrequency (RF) exposes the

Address correspondence to: Mustafa Karaoğlan, Ordu State Hospital, Department of Algology, 52100, Ordu, Turkey. Tel: +905414437703, Email: mkaraoglan@gmail.com

Date of Submission: 2 June 2022; Date of Acceptance: 17 June 2022

https://doi.org/10.54029/2022sxa

target nerves or tissues to continuous electrical stimulation and causes tissue damage on the target tissue by increasing the temperature around the RF needle tip.[15] Unlike conventional RF, PRF applies a short electrical stimulation followed by a long rest phase. Thus, PRF does not generate enough heat to cause structural damage. The proposed mechanism of PRF is that the electric field produced by PRF can alter pain signalling.[16] A few studies on PRF therapy have shown its efficacy in relieving neuralgia and joint pain – symptoms that are unresponsive to conventional treatments.[17-19] In addition, PRF applied to the greater occipital nerve has been used to effectively treat various headache syndromes, including occipital neuralgia, cervicogenic headache and intracranial hypotension.[20-23] Although the effectiveness of this treatment has been known for a long time, its beneficial effects on relieving migraine pain have not been sufficiently studied.[24]

METHODS

Out of 115 patients who were diagnosed with migraine and treated with GON block at the Ordu State Hospital Pain Center from October 2020 to January 2022, 29 patients without an adequate response were identified. These patients completed headache diaries recommended by the National Headache and Pain Study Association before and after treatment. Migraine was diagnosed according to the diagnostic criteria of the International Classification of Headache Disorders 3rd Edition criteria (ICHD-3).[10] Bilateral GON blockade was applied to 115 migraine patients once a week for one month – a total of four times. A single session of GON PRF was applied to 29 patient groups who did not get an adequate response within 30 days after the end of GON blockade treatment. Following GON PRF, the number of migraine attacks, the total number of triptan tablets used, the average duration of headache episodes and the highest visual analogue scale (VAS) score of episodes in the preceding 30 days at the first, third and sixth-month visits following PRF were recorded.

Sociodemographic data such as age, gender, and body mass index (BMI) were documented and recorded. Inclusion criteria were patients aged between 18 and 70 years, with chronic or episodic migraine according to the ICHD-3 criteria, no prophylactic treatment for migraine for at least one month prior to GON blockade[15] and who had at least one migraine attack per week.

GON blockade and GON PRF treatment were administered to patients who met the aforementioned criteria. Written consent was obtained, exclusion criteria were: no infection at the injection site, no coagulation disorder, not pregnant and no history of previous surgery at the injection site. Although they received GON PRF treatment, two patients who did not complete the six-month follow-up were excluded from final analysis (Figure 1). All GON blockades and GON PRF were administered by the same physician.

For GON blockade, the external occipital protuberance was palpated and the area cleaned with an antiseptic solution while the patient was in either a sitting or prone position. Bilateral injections were performed 2 cm lateral and 2 cm inferior to the occipital protuberance. If there was no hypoesthesia in the area of distribution of the GON after the application, the procedure was repeated. This interventional treatment was applied to both sides once a week – four times for one month, using 1.5 millilitres (ml) 0.5 per cent bupivacaine on each side with the help of a 22-gauge spinal needle. The patients were hospitalised for 30 minutes for observation after the procedure.

GON PRF treatment was applied to the patients who did not obtain an adequate therapeutic response at the end of one month despite the GON blockade. For this treatment, the external occipital protuberance was palpated, and the area cleaned with an antiseptic solution while the patient was in a prone or sitting position (Figure 2). Bilateral treatment was performed 2 cm lateral and 2 cm inferior to the occipital protuberance with a 21-gauge 5-millimetre (mm) 50 mm radiofrequency needle with an active tip. A 50 Hz sensory stimulation was applied to localise the GON, with which the patient reported dysesthesia and a tingling sensation at the ipsilateral vertex. PRF procedure was performed on the GON with45 volts (V) applied for 360 seconds at 5 Hz and a 5 mm pulse width, with the temperature of the electrode tips not exceeding 42 degrees.[24] After the procedure, the patients were hospitalised and observed for 60 minutes.

The gender, age, BMI, duration of migraine diagnosis (in years), the number of migraine attacks, total triptan use (number of tablets taken), total analgesic use (number of tablets taken), maximum attack duration and the highest VAS scores of the subjects were recorded in the 30 days before treatment. Subsequently, these parameters were obtained a 1, 2, 3 and 4 weeks after GON blockade as well as at 1, 3 and 6 months after PRF treatment and compared with the pre-treatment

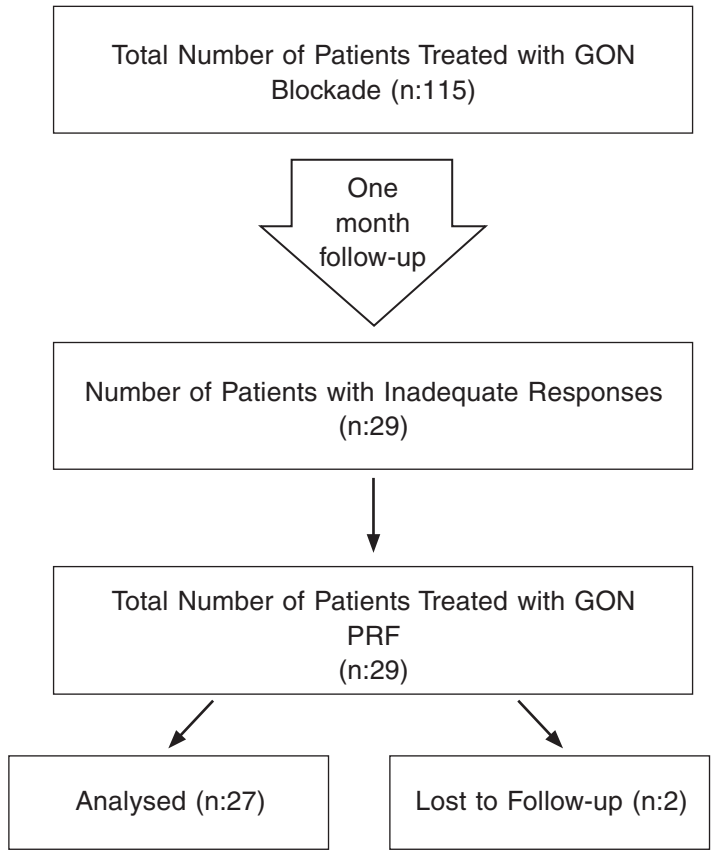

Figure 1. Follow-up diagram

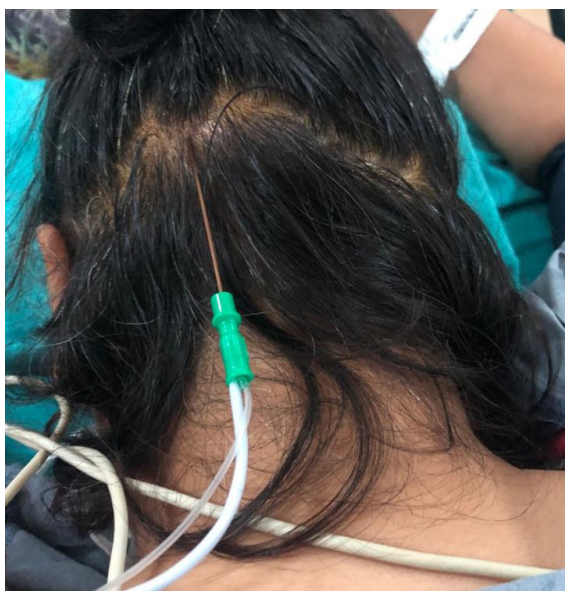

Figure 2. GON PRF application

values. The normality of data distribution was evaluated using the Shapiro–Wilk test. Age, BMI, duration of migraine diagnosis (in years), the number of migraine attacks, total triptan use (number of tablets taken) and total analgesic use (number of tablets taken) data showed a parametric distribution, whereas other data (maximum attack duration, highest VAS) showed a non-parametric distribution. The t-test was used for normally distributed data of related (dependent) groups, whereas the 'Wilcoxon' test was used for non-parametrically distributed data. All analyses were evaluated at a 95 per cent confidence interval and $p < 0.05$ significance level.

RESULTS

In total, 23 women and 4 men totalling 27 patients participated in the study, and the mean age of the participating patients was 35.70 years, (range =- 24-43). The mean BMI of the patients was 24.57kg/m^2(range = 19-31). The mean duration of migraine was 8.37 years (range = 3-15) (Table 1).

Table 2 shows data at 1 month after GON blocks well as at 1 month, 3 months and 6 months after GON PRF. There was a statistically significant difference between the number of migraine attacks before treatment and at the first month after GON block ($p < 0.01$). Z values showed a statistically significant difference in the number of attacks in at the first, third and sixth months after GON PRF application as compared to the number of attacks before treatment ($p < 0.01$). Furthermore, this difference was greater than the difference after treatment with GON blockade.

There was no statistically significant difference between the number of mild attacks pre-treatment and one month after GON block ($p > 0.05$). However, the number of mild attacks at the first, third and sixth months after GON PRF showed significant improvement compared to before treatment ($p < 0.01$).

The number of severe attacks before treatment and at a month after GON block were also not statistically different ($p > 0.05$). However, the first, third and sixth-month values of severe attacks after GON PRF were significantly decreased when compared to both pre-treatment and first-month GON block values ($p < 0.01$).

There was a significant difference in total triptan use before treatment and at a month after GON block ($p < 0,01$). Z values showed a significant decrease was observed in total triptan use in the first, third and sixth months after GON PRF administration as compared to total triptan use before treatment ($p < 0,01$). This decrease was greater than that following GON block.

The total analgesic use of the patients before treatment and at the end of the first month after GON block was not statistically significant ($p > 0.05$). However, a statistically significant decrease was observed in total analgesic use values at the first, third and sixth months after GON PRF. ($p < 0.01$).

The maximum headache duration before and at a month after GON block was not statistically different ($p > 0.05$). However, headache duration at the first, third and sixth months after GON PRF showed a significant decrease when compared to before and at the first month after GON block ($p < 0.01$).

The highest VAS score in patients showed a significant difference before and one month after GON block treatment ($p < 0.01$). Z values showed reduced VAS scores in the first, third and sixth months after GON PRF as compared to VAS scores before and one month after GON block ($p < 0.01$).

Table 3.1 shows the descriptive data of the 27 study subjects, recorded every week at GON block application. The number of severe attacks decreased significantly in the first and second weeks after GON block as compared to the third and fourth weeks after treatment ($p < 0.01$). A significant decrease was observed in the fourth week when compared to the third week ($p < 0.01$). The number of severe attacks in the fourth week showed a significant decrease as compared to the first week ($p < 0.01$; Figure 3).

No complications were observed with all procedures performed.

Table 1: Demographic data

	N	Average	SD	Median	Lowest	Highest
Age	27	35.70	4.45	36.00	24	43
BMI	27	24.57	3.26	24.60	19	31
Duration of migraine (years)	27	8.37	3.58	9.00	3	15

Table 2: Before the treatment of the patients; Values after GON block application and after GON PRF application

				95% CI			
	N	Average	Standard Deviation	Lower	Upper	Z	P Value
Number of migraine attacks							
Before Treatment	27	12.04	2.83				
First month post-GON block	27	10.89	3.07	0.005	0.008	-2.682	0.007
First month post-GON PRF	27	1.96	4.56	0.000	0.000	-4.527	0.000
Third month post-GON PRF	27	2.48	4.09	0.000	0.000	-4.528	0.000
Sixth month post-GON PRF	24	2.00	1.00	0.000	0.000	-4.302	0.000
VAS < 4 (Mild) Attack							
Before Treatment	27	2.48	2.26				
First month post-GON	27	1.85	1.26	0.216	0.233	-1.235	0.217
First month post-GON PRF	27	0.81	1.49	0.001	0.002	-2.960	0.003
Third month post-GON	27	1.26	1.23	0.012	0.017	-2.380	0.017
Sixth month post-GON PRF	24	1.00	1.00	0.015	0.020	-2.385	0.017
VAS < 4 (severe to moderate) attack							
Before Treatment	27	9.44	1.87				
First month post-GON block	27	9.07	2.54	0.358	0.377	-0.935	0.350
First month post-GON PRF	27	1.22	3.38	0.000	0.000	-4.568	0.000
Third month post-GON PRF	27	1.26	3.19	0.000	0.000	-4.492	0.000
Sixth month post-GON PRF	24	1.00	1.00	0.000	0.000	-4.308	0.000
Total triptan use (Total number of tablets)							
Before Treatment	27	6.74	1.75				
First month post-GON block	27	8.26	2.54	0.001	0.003	-2.819	0.005
First month post-GON PRF	27	0.96	2.85	0.000	0.000	-4.516	0.000
Third month post-GON PRF	27	1.00	2.84	0.000	0.000	-4.477	0.000
Sixth month post-GON PRF	24	0.00	1.00	0.000	0.000	-4.355	0.000
Total analgesic use (Total number of tablets)							
Before Treatment	27	11.00	4.10				
First month post-GON block	27	11.56	3.90	0.569	0.588	-0.577	0.564
First month post-GON PRF	27	2.48	6.36	0.000	0.000	-4.297	0.000
Third month post-GON PRF	27	2.30	3.81	0.000	0.000	-4.549	0.000
Sixth month post-GON PRF sixth month	24	2.00	1.00	0.000	0.000	-4.294	0.000
Maximum attack duration (Hours)							
Before treatment	27	49.33	19.78				
First month post-GON block	27	47.56	19.82	0.498	0.517	-0.973	0.330
First month post-GON PRF	27	7.74	20.72	0.000	0.000	-4.311	0.000
Third month post-GON PRF	27	9.93	17.72	0.000	0.000	-4.377	0.000
Sixth month post-GON PRF	24	6.00	6.00	0.000	0.000	-4.288	0.000
Highest VAS score							
Before Treatment	27	8.89	0.75				
First month post-GON block	27	8.63	0.49	0.012	0.016	-2.646	0.008
First month post-GON RF	27	1.44	3.24	0.000	0.000	-4.342	0.000
Third month post-GON RF	27	2.56	3.24	0.000	0.000	-4.226	0.000
Sixth month post-GON RF	24	4.00	2.00	0.000	0.000	-4.128	0.000

Table 3.1: Weekly values after GON block application

	N	Average	SS	Median	Lowest	Highest
Number of migraine sttacks						
First week post-GON block	27	2,00	1,27	2	0	4
Second week post-GON block	27	1,56	1,01	2	0	3
Third week post-GON block	27	3,89	1,05	4	2	7
Fourth week post-GON block	27	3,59	1,19	4	2	6
VAS <4 (Mild) attack						
First week post-GON block	27	0.48	0.64	0	0	2
Second week post-GON block	27	0.63	0.56	1	0	2
Third week post-GON block	27	0.11	0.32	0	0	1
Fourth week post-GON block	27	0.63	0.84	0	0	3
VAS> 4 (Moderate to severe) attack						
First week post-GON block	27	1.52	1.16	1	0	4
Second week post-GON block	27	0.96	0.76	1	0	2
Third week post-GON block	27	3.78	0.97	4	2	6
Fourth week post-GON block	27	2.93	0.92	3	2	5

Table 3.2: Comparisons between weeks after GON block application

	95% CI			
	Lower	Upper	Z	P Value
Number of migraine attacks				
First week and second week post-GON block	0.060	0.070	-1.955	0.051
First week and third week post-GON block	0.000	0.000	-4.061	0.000
First week and fourth week post-GON block	0.000	0.000	-3.963	0.000
Second week and third week post-GON block	0.000	0.000	-4.578	0.000
Second week and fourth week post-GON block	0.000	0.000	-4.413	0.000
Third week and fourth week post-GON block	0.236	0.252	-1.199	0.231
VAS <4 (Mild) attack				
First week and second week post-GON block	0.478	0.498	-0.943	0.346
First week and third week post-GON block	0.024	0.030	-2.352	0.019
First week and fourth week post-GON block	0.532	0.552	-0.691	0.490
Second week and third week post-GON block	0.000	0.001	-3.300	0.001
Second week and fourth week post-GON block	1.000	1.000	-0.025	0.980
Third week and fourth week post-GON block	0.006	0.010	-2.658	0.008
VAS >4 (Moderate to severe) attack				
First week and second week post-GON block	0.021	0.027	-2.299	0.021
First week and third week post-GON block	0.000	0.000	-4.371	0.000
First week and fourth week post-GON block	0.000	0.000	-3.747	0.000
Second week and third week post-GON block	0.000	0.000	-4.604	0.000
Second week and fourth week post-GON block	0.000	0.000	-4.512	0.000
Second week and fourth week post-GON block	0.000	0.001	-3.273	0.001

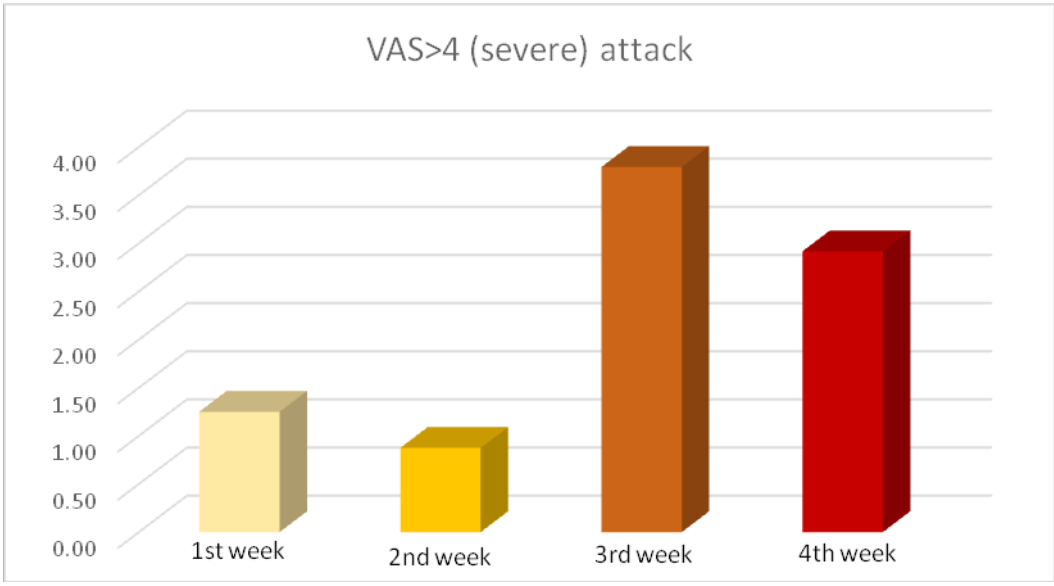

Figure 3. Number of moderate to severe attacks (VAS > 4) after GON block

The number of severe migraine attacks, total analgesic usage and maximum attack duration were not significantly different before and one month after GON blockade. However, the number of migraine attacks, total triptan use and maximum VAS score improved in the month after GON block. All these parameters improved further a month after GON PRF application. This improvement over pre- and 1-month post-GON blockade was sustained up to the sixth month after PRF application.

DISCUSSION

Peripheral nerve blocks have been long been used in the treatment of headaches. The most commonly used procedure for this purpose is GON blockade. Many studies have proven that GON blockade is an effective treatment method for migraine.[25,26,27] The rationale for using a GON block in headache treatment is derived from evidence of the convergence of sensory input to the trigeminal nucleus caudalis neurons from both cervical and trigeminal fibres[28,29], and its role in antagonising a putative "wind-up-like effect," which may explain the headache improvement.[30] Although there is no standard procedure for GON blockade, the nerve is usually blocked with a mixture of local anaesthetic and corticosteroid using a blind technique. The bupivacaine dose and method used in the double-blind placebo-controlled study conducted by Inan *et al*.[25] on 84 patients were similar to those used in our study.

Our study findings are founded on numerous pre-clinical studies showing antinociceptive effects for PRF in various neuropathic pain models, as well as on placebo-controlled clinical trials in pain-inducing conditions such as postherpetic neuralgia and cervical radiculopathy.[21,31,32] In these studies, patients were treated with PRF to the dorsal root ganglia instead of the peripheral nerves. The researchers found that PRF treatment provided longer lasting superior analgesia as compared to nerve blockade.

GON PRF treatment for chronic migraine treatment is not well-studied. The largest study of PRF in headache[33] was in occipital neuralgia. In this study of 102 patients, only 51 per cent of patients benefited from PRF treatment. The PRF technique was similar to that used in our study.

Several mechanisms may explain the greater efficacy and longer-term benefit of GON PRF treatment as compared to GON blockade. Blocks with steroids or local anaesthetics generally provide transient benefits for a few weeks, with their effects rapidly diminishing and disappearing thereafter.[34-37] PRF treatment is a viable option to prolong the efficacy of a GON block. Our finding that the number of severe attacks in the first two weeks after GON blockade was significantly lower than in the third and fourth weeks indicates that the effectiveness of the GON blockade may indeed decrease within a month. Some studies in the literature[27,38-40], also show that although the effectiveness of GON blockade does not disappear, its effectiveness gradually decreases over time.

The literature describes occasional side effects with GON blockade. These include injection

site infection, hematoma, vertigo, nausea, rare cardiac arrhythmia, epileptic seizures, respiratory suppression and a hypersensitivity reaction to local anaesthetic.[41] We did not encounter any unusual side effects in all interventional procedures during our study.

Although our study supports PRF treatment of GON as a treatment for chronic migraines, it also has some limitations. GON PRF treatment the study was performed on a specific population that had already failed GON blockade. This was retrospective study with a limited number of patients.

In summary, our results suggest that GON PRF is a viable treatment option in migraine patients who do not display an adequate therapeutic response to GON blockade. Future studies should attempt to identify patients who are more likely to respond to treatment and consider the use of a true placebo group in the study design.

DISCLOSURE

Conflict of interest: None

Ethic approval: The study was registered by the local ethical committee Ordu University Ethical Committe, Ordu, Turkey (Komite Etik No:11.02.2022/29)

REFERENCES

1. Puledda F, Messina R, Goadsby PJ. An update on migraine: Current understanding and future directions. *J Neurol 2017; 264.9*, 2031-9. doi: 10.1007/s00415-017-8434-y.
2. Diener HC, Dodick DW. Headache research in 2015: Progress in migraine treatment. *Lancet Neurol 2016; 15(1):*4-5. doi: 10.1016/S1474-4422(15)00341-5.
3. Warhurst S, Rolf CJ, Brew BJ, *et al*. Effectiveness of the progestin-only pill for migraine treatment in women: A systematic review and meta-analysis. *Cephalalgia* 2018; 38(4):754-64. doi: 10.1177/0333102417710636.
4. Sun-Edelstein C, Rapoport. AM. Update on the pharmacological treatment of chronic migraine. *Curr Pain Headache Rep* 2016; 20(1):6. doi: 10.1007/s11916-015-0533-9.
5. Diener HC, Dodick DW, Goadsby PJ, Lipton RB, Olesen J, Silberstein SD. Chronic migraine—classification, characteristics and treatment. *Nat Rev Neurol 2012; 8(3):*162-71. doi: 10.1038/nrneurol.2012.13.
6. Olesen J, Bousser MG, Steiner TJ, *et al.* New appendix criteria open for a broader concept of chronic migraine. *Cephalalgia*, 2006;*26(6):*742-6. doi: 10.1111/j.1468-2982.2006.01172.x.
7. Ashkenazi A, Levin M. Greater occipital nerve block for migraine and other headaches: Is it useful? *Curr Pain Headache Rep* 2007; 11(3):231-5. doi: 10.1007/s11916-007-0195-3.
8. Goadsby PJ, Knight YE, Hoskin KL. Stimulation of the greater occipital nerve increases metabolic activity in the trigeminal nucleus caudalis and cervical dorsal horn of the cat. *Pain* 1997; 73(1):23-8. doi: 10.1016/s0304-3959(97)00074-2.
9. Goadsby PJ, Zagami AS. Stimulation of the superior sagittal sinus increases metabolic activity and blood flow in certain regions of the brainstem and upper cervical spinal cord of the cat. *Brain* 1991;114(2):1001-11. doi: 10.1093/brain/114.2.1001.
10. Bartsch T, Goadsby PJ. Stimulation of the greater occipital nerve induces increased central excitability of dural afferent input. *Brain* 2002; 125(7):1496-509. doi: 10.1093/brain/awf166.
11. Peres MFP, Stiles MA, Siow HC, Rozen TD, Young WB, Silberstein SD. Greater occipital nerve blockade for cluster headache. *Cephalalgia* 2002; 22(7), 520-2. doi: 10.1046/j.1468-2982.2002.00410.x.
12. Inan LE, Inan N, Unal-Artık HA, Atac C, Babaoglu G. Greater occipital nerve block in migraine prophylaxis: Narrative review. *Cephalalgia* 2019;39(7):908-20. doi: 10.1177/0333102418821669.
13. Wartolowska K, Schweinhardt P, Wordsworth P, Chizh B, Tracey I. EFIC 2006-5th. Congress of The European Federation of IASP® Chapters (EFIC), Istanbul, Turkey, September 13–16, 2006. Europe Against Pain, Don't Suffer in Silence.
14. Chua NHL, Vissers KC, Sluijter ME. Pulsed radiofrequency treatment in interventional pain management: mechanisms and potential indications—a review. *Acta Neurochir* 2011;153(4):763-71. doi: 10.1007/s00701-010-0881-5.
15. Chang MC. Efficacy of pulsed radiofrequency stimulation in patients with peripheral neuropathic pain: A narrative review. *Pain Physician* 2018; 21(3):E225–E234.
16. Zundert JV, de Louw AJA, Joosten EAJ, *et al*. Pulsed and continuous radiofrequency current adjacent to the cervical dorsal root ganglion of the rat induces late cellular activity in the dorsal horn. *Anesthesiology* 2005;102(1):125-31. doi: 10.1097/00000542-200501000-00021.
17. Kwak SY, Chang MC. Effect of intradiscal pulsed radiofrequency on refractory chronic discogenic neck pain: A case report. *Medicine* 2018; 97:16. doi: 10.1097/MD.0000000000010509.
18. Do KH, Ahn SH, Cho YW, Chang MC. Comparison of intra-articular lumbar facet joint pulsed radiofrequency and intra-articular lumbar facet joint corticosteroid injection for management of lumbar facet joint pain: A randomized controlled trial. *Medicine* 2017; 96(13): e6524. doi: 10.1097/MD.0000000000006524. Erratum in: *Medicine* (Baltimore). 2017;96(23):e7232.
19. Chang MC. Effect of bipolar pulsed radiofrequency on refractory chronic cervical radicular pain: A report of two cases. *Medicine* 2017; 96(15): e6604. doi: 10.1097/MD.0000000000006604.
20. Cohen SP, Peterlin BL, Fulton L, *et al.* Randomized, double-blind, comparative-effectiveness study comparing pulsed radiofrequency to steroid injections

for occipital neuralgia or migraine with occipital nerve tenderness. *Pain* 2015; 156(12):2585-94. doi: 10.1097/j.pain.0000000000000373.
21. Huang JHY, Galvagno Jr SM, Hameed M, *et al*. Occipital nerve pulsed radiofrequency treatment: A multi-center study evaluating predictors of outcome. *Pain Med* 2012; 13(4):489-97. doi: 10.1111/j.1526-4637.2012.01348.x.
22. Niraj G, Critchley P, Kodivalasa M, Dorgham M. Greater occipital nerve treatment in the management of spontaneous intracranial hypotension headache: A case report. *Headache* 2017;57(6): 952-5. doi: 10.1111/head.13095.
23. Vanderhoek MD, Hoang HT, Goff B. Ultrasound-guided greater occipital nerve blocks and pulsed radiofrequency ablation for diagnosis and treatment of occipital neuralgia. *Anesth Pain Med* 2013; 3(2):256-9. doi: 10.5812/aapm.10985.
24. Kwak SY, Chang MC. Management of refractory chronic migraine using ultrasound-guided pulsed radiofrequency of greater occipital nerve: Two case reports. *Medicine* 2018; 97(45):e13127. doi: 10.1097/MD.0000000000013127.
25. Inan L, Inan N, Karadaş Ö, *et al*. Greater occipital nerve blockade for the treatment of chronic migraine: A randomized, multicenter, double- blind, and placebo-controlled study. *Acta Neurol Scand* 2015;132(4): 270-7. doi: 10.1111/ane.12393.
26. Karaoğlan M, Durmuş IE, Küçükçay B, Takmaz SA, İnan LE. Comparison of the clinical efficacy of bilateral and unilateral GON blockade at the C2 level in chronic migraine. *Neurol Sci* 2022;43(5):3297-303. doi:10.1007/s10072-021-05739-5.
27. Karaoğlan M, İnan LE. A comparison of the clinical efficacy of GON block at the C2 level and GON block at the classical distal occipital level in the treatment of migraine. *Clin Neurol Neurosurg* 2022;215:107190. doi:10.1016/j.clineuro.2022.107190.
28. Young W, Cook B, Malik S, Shaw J, Oshinsky M. The first 5 minutes after greater occipital nerve block. *Headache* 2008; 48:1126-8. doi: 10.1111/j.1526-4610.2008.01146.x.
29. Bartsch T, Goadsby PJ. Stimulation of the greater occipital nerve induces increased central excitability of dural afferent input. *Brain* 2002; 125: 1496-509. doi: 10.1093/brain/awf166. PMID: 12077000.
30. Vincent MB, Luna RA, Scandiuzzi D, Novis SA. Greater occipital nerve blockade in cervicogenic headache. *Arq Neuropsiquiatr 1998; 56:*720-5. doi: 10.1590/s0004-282x1998000500004.
31. Amr Yasser M. Pulsed radiofrequency for chronic inguinal neuralgia. *Pain Physician* 2015; 18: E147-E155.
32. Van Zundert J, Patijn J, Kessels A, Lamé I, van Suijlekom H, van Kleef M. Pulsed radiofrequency adjacent to the cervical dorsal root ganglion in chronic cervical radicular pain: A double blind sham controlled randomized clinical trial. *Pain* 2007;127(1-2):173-82. doi: 10.1016/j.pain.2006.09.002.
33. Cohen SP, Lee Peterlin B, Fulton L, *et al*. Randomized, double-blind, comparative-effectiveness study comparing pulsed radiofrequency to steroid injections for occipital neuralgia or migraine with occipital nerve tenderness. *Pain* 2015;156(12):2585-94. doi: 10.1097/j.pain.0000000000000373
34. Friedly JL, Comstock BA, Turner JA, *et al*. A randomized trial of epidural glucocorticoid injections for spinal stenosis. *N Eng J Med* 2014; 371(1):11-21. doi: 10.1056/NEJMoa1313265. Erratum in: *N Engl J Med* 2014;371(4):390.
35. Karppinen, Jaro, et al. (2001). Periradicular infiltration for sciatica: A randomized controlled trial. *Spine* 2001; 26(9):1059-67. doi: 10.1097/00007632-200105010-00015.
36. Marks, R. C., Houston, T., & Thulbourne, T. (1992). Facet joint injection and facet nerve block: A randomised comparison in 86 patients with chronic low back pain. *Pain* 1992; 49(3):325-8. doi: 10.1016/0304-3959(92)90239-8.
37. Tafazal S, Ng L, Chaudhary N, Sell P. Corticosteroids in peri-radicular infiltration for radicular pain: A randomised double blind controlled trial. One year results and subgroup analysis. *Eur Spine J* 2009; 18(8):1220-5. doi: 10.1007/s00586-009-1000-2.
38. Kashipazha D, Nakhostin-Mortazavi A, Mohammadianinejad SE, Bahadoram M, Zandifar S, Tarahomi S. Preventive effect of greater occipital nerve block on severity and frequency of migraine headache. *Glob J Health Sci* 2014; 6(6): 209-13. doi: 10.5539/gjhs.v6n6p209.
39. Okmen K, Dagistan Y, Dagistan E, *et al*. Efficacy of the greater occipital nerve block in recurrent migraine type headaches. *Neurol Neurochir Pol* 2016;*50:*151-4. doi: 10.1016/j.pjnns.2016.01.015.
40. Ruiz Pin˜ero M, Mulero Carrillo P, Pedraza Hueso MI, de la Cruz Rodríguez C, López Mesonero L, Guerrero Peral AL. Pericranial nerve blockade as a preventive treatment for migraine: Experience in 60 patients. *Neurologıa* 2016; 31: 445-51. doi: 10.1016/j.nrl.2014.10.001.
41. Young WB. Blocking the greater occipital nerve: Utility in headache management. *Curr Pain Headache Rep* 2010; 14(5): 404-8. doi: 10.1007/s11916-010-0130-x.