

Observational Study

Comparison of the Efficacy of Ultrasound-Guided Repeated Greater Occipital Nerve Blocks and Greater Occipital Nerve Pulsed Radiofrequency in Migraine Treatment

Sukriye Dadali, MD, Gulcin Babaoglu, MD, Ulku Sabuncu, MD and Erkan Yavuz Akcaboy, MD

From: Ankara Bilkent City Hospital, Pain Clinic, Ankara, Turkey

Address Correspondence: Sukriye Dadali, MD
Pain Medicine and Neurology Specialist
Ankara Bilkent City Hospital
Pain Clinic, Ankara, Turkey
E-mail: sukriyedadali@gmail.com

Disclaimer: There was no external funding in the preparation of this article.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Article received: 12-25-2024
Revised article received: 01-06-2025
Accepted for publication: 03-05-2025

Free full article:
www.painphysicianjournal.com

Background: Greater occipital nerve (GON) blocks and pulsed radiofrequency (PRF) are commonly used in migraine management.

Objectives: This study compares the clinical outcomes of migraine patients who underwent repeated GON blocks (GONBs) and pulsed radiofrequency of the greater occipital nerve (GONPRF), both of which were performed using a proximal technique with ultrasound (US)-guidance.

Study Design: Single-center, prospective, comparative, observational cohort study.

Setting: Tertiary referral center.

Methods: Patients who were diagnosed with migraines based on the criteria from the International Classification of Headache Disorders III, experienced migraine attacks at least once a week or 5 times per month, did not respond to preventive migraine medications, and had a positive response to diagnostic GONB treatment (2-4 mL of 0.25% bupivacaine) were included in the study.

The first group (the GONBs group) consisted of patients who could visit the clinic regularly. In this group, a GONB was administered at the C2 level using a proximal technique under US-guidance once a week for 4 weeks. The second group (the GONPRF group) included patients who, for various reasons, had only a limited ability to attend weekly treatments. In this group, GONPRF was performed at the C2 level using a proximal technique under US-guidance.

For both groups, the following outcomes were evaluated at the first, second, and third months after treatment: headache attack duration, monthly frequency of headache attacks, number of headache days, and average monthly headache visual analog scale (VAS) scores. All side effects and adverse events related to the treatments were recorded, as were those effects' and events' duration.

Results: A total of 68 patients were included in the study, with 35 in the GONPRF group and 33 in the GONBs group. No significant differences were observed between the 2 groups in terms of baseline demographic and clinical characteristics. Over the study period, the duration of headache attacks showed much greater improvement in the GONPRF group than in the GONBs group. In the first month, headache duration decreased in both groups, but the difference between them was not significant. However, in the second month, the GONPRF group exhibited a significantly shorter median headache duration. As for attack frequency, no significant differences were noted at baseline. By the first month, the GONPRF group showed a significantly lower median attack frequency than did the GONBs group. This trend continued into the second and third months. The mean number of headache days also showed more significant reductions in the GONPRF group than in the GONBs group, and this difference remained significant at both the second and third months. VAS pain scores were comparable at baseline. By the second month, the GONPRF group had significantly lower pain scores, and this difference persisted into the third month. Side effects were mild and transient, with no persistent or serious adverse events observed in either group.

Limitations: A small sample size, a relatively short 3-month follow-up period, and a single-center location are the main limitations of this study.

Conclusion: This study demonstrates that, when compared to GONBs, ultrasound-guided proximal GONPRF yields significantly greater reduction headache duration, frequency, and severity for migraine patients, providing at least 3 months of relief.

Key words: Migraine, treatment, greater occipital nerve (GON), GON block, pulsed radiofrequency, ultrasound-guided, proximal technique, C2 level

Pain Physician 2025: 28:337-346

Migraine is a prevalent, multifactorial neurological disorder with significant individual and societal impacts. The World Health Organization ranks migraine as the second leading cause of years lived with disability and the primary cause thereof in individuals under the age of 50 (1). Characterized by severe, often unilateral, pulsating headaches, migraine attacks are frequently accompanied by nausea, vomiting, and hypersensitivity to light, sound, and odors, and may also be associated with aura (2). Treatment strategies for migraine include acute and preventive pharmacotherapy, lifestyle changes, and educational interventions (3). It is now widely accepted that the trigeminovascular system plays a central role in the pathophysiology of this complex neurological disorder, forming the basis for many contemporary treatment approaches (4).

Peripheral nerve blocks have been used to treat many headache disorders and cranial neuralgias, including migraine (5,6), cluster headache (7,8), and cervicogenic headache (9,10). The greater occipital nerve (GON) is the most common target for headache disorders. Local anesthetics block conduction in sensory nerve fibers in the mixed nerves, but headache relief usually lasts much longer than the duration of the effect of local anesthesia (11). While the exact mechanism behind this prolonged benefit remains unclear, it is believed to involve central pain modulation (12,13).

The GON arises primarily from the dorsal primary ramus of the second cervical nerve (C2) and partially from the third cervical nerve (C3), providing cutaneous innervation to the posterior scalp (14). The GON blockade is hypothesized to modulate pain pathways via its connections in the trigeminocervical complex (TCC) (8,15). Within the TCC, there is convergence between trigeminal and upper cervical sensory afferents, which in turn are connected to higher pain-modulating structures in the brain stem and rostral pain pathways (16,17). A functional imaging study by Hoffmann et al

demonstrated that an occipital nerve block with 1% lidocaine significantly reduced nociceptive activation within the trigeminocervical complex (18).

Currently, 2 ultrasound (US)-guided techniques for administering a GON block (GONB) are defined: the proximal technique, targeting the GON at the level of the second cervical vertebra (C2), and the distal technique, targeting the superior nuchal line. Furthermore, both GONBs and pulsed radiofrequency (PRF) of the GON (GONPRF) procedures performed under US-guidance have been reported to be more effective than approaches guided by anatomical landmarks (19,20).

While the GONB, with local anesthetics and steroids, has demonstrated benefits in the treatment of headache disorders, its therapeutic effects are typically limited to a few weeks or months (21,22). PRF neuromodulation, meanwhile, has been proposed to prolong these benefits. Although the exact mechanism remains unclear, PRF is believed to exert a neuromodulatory effect by altering synaptic transmission. Despite the widespread use of GONPRF in migraine treatment, evidence supporting the effectiveness of this procedure remains limited.

This study aimed to compare the clinical outcomes of migraine patients treated with GONPRF to those treated with repeated GON blocks (GONBs) using the US-guided proximal technique.

METHODS

The study was conducted at the pain clinic of the University of Health Sciences Ankara Bilkent City Hospital between January 2023 and October 2023, following approval from the Bilkent City Hospital Clinical Research Ethics Committee (E1-22-3155/11.01.2023). Written informed consent was obtained from all patients, and the study adhered to the principles outlined in the 2013 Helsinki Declaration. The trial was registered at ClinicalTrials.gov (NCT06345326).

Patient Selection

Initially, 97 patients diagnosed with episodic or chronic migraine according to the ICHD-3 criteria were evaluated. After screening, 22 patients were excluded for not meeting the inclusion criteria. Seventy-five patients who responded positively to the diagnostic GONB were subsequently allocated to 2 groups: 38 patients in the GONBs group and 37 patients in the GONPRF group.

In the GONBs group, 33 patients completed the study. Five patients were excluded for the following reasons: one patient was lost to follow-up, one patient had missing data, one patient did not meet the study criteria, and 2 patients were transferred to the other group.

In the GONPRF group, 35 patients completed the study. Four patients were excluded for the following reasons: one patient was lost to follow-up, one patient had missing data, and 2 patients did not meet the study criteria. Additionally, 2 patients were transferred from the other group.

As a result, 68 patients (33 in the GONBs group and 35 in the GONPRF group) completed the study and were included in the final analysis (Fig. 1).

Because of the exploratory nature of the study, a formal power analysis was not conducted. The sample size was determined based on the number of eligible patients available.

Inclusion Criteria

Volunteer patients aged 18–65 years who experienced migraine attacks at least once weekly or 5 times monthly and did not benefit sufficiently from migraine-preventive medications or botulinum toxin type A (BoNT-A) injections were included in the study.

Exclusion Criteria

Patients were excluded from the study based on the following criteria:

- a history of primary headache disorders other than migraine, according to the ICHD-3 classification,
- use of antimigraine medications and/or botulinum toxin type A (BoNT-A) treatment within the past 3 months,
- receipt of nonpharmacological treatments (e.g., acupuncture, ozone therapy, cognitive behavioral therapy) within the past 6 months,
- presence of infection at the planned injection site,

- a history of cardiac pacemaker implantation,
- pregnancy or suspected pregnancy,
- known allergy to local anesthetic agents,
- a history of malignancy or prior cranial or cervical surgical interventions,
- presence of bleeding or clotting disorders, or ongoing use of oral anticoagulants,
- comorbid conditions that might have contributed to headaches (e.g., uncontrolled hypertension, intracranial lesions),
- conditions that might have interfered with treatment compliance (e.g., psychiatric disorders, dementia).

Group Allocation

Patients demonstrating a positive response ($\geq 50\%$ improvement in headache) to an initial US-guided GONB at the C2 level were assigned to one of 2 groups:

1. GONBs group: patients receiving repeated GONB once weekly for 4 weeks,
2. GONPRF group: patients receiving a single PRF treatment due to limited follow-up opportunities (e.g., distance, work, school commitments).

Procedure

Prior to the intervention, routine laboratory tests were conducted, and peripheral vascular access was

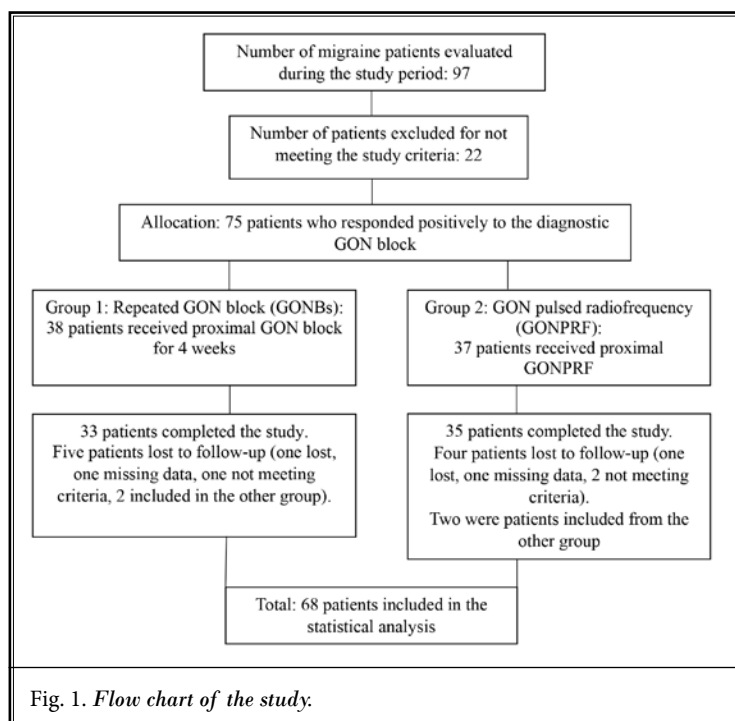


Fig. 1. Flow chart of the study.

established. All procedures were performed in a sterile operating room environment with routine anesthesia monitoring.

GON Block

For US-guided GONBs, patients were placed in prone positions with the neck flexed. Anatomical markers, including the obliquus capitis inferior muscle (OCIM) and the bifid spinous process of the C2 vertebra, were identified. An Aplio™ 500 linear ultrasound probe (Toshiba Medical) was placed transversely on the occipital prominence and advanced caudally to visualize the single spinous process of C1 and then the bifid C2 spinous process. The probe was then shifted laterally to image the OCIM and semispinalis capitis muscles (SSCM), where the GON appeared as an oval-shaped hypoechoic structure between the OCIM and SSCM. Using an in-plane technique, a 22-gauge spinal needle was advanced laterally-to-medially toward the GON, and a total of 2 mL of 0.5% bupivacaine (Buvasin, 5 mg/mL, VEM Pharmaceuticals) was injected on each side. This procedure was repeated weekly for 4 weeks in the GONBs group.

GONPRF

For PRF neuromodulation, the GON was identified under US-guidance using the same method. A 22-gauge radiofrequency (RF) cannula (5 cm with a 5-mm active tip) and RF electrode were placed adjacent to the GON via an in-plane lateral-to-medial approach. Sensory stimulation (below 0.3 V) was performed to elicit dysesthesia or tingling in the occipital region, confirming correct placement. PRF was applied at 45 V with a frequency of 5 Hz, a pulse width of 5 ms, and a temperature not exceeding 42°C for 360 seconds using an RF generator (NeuroTherm NT1100).

Post-Procedure Monitoring

After the GONB or PRF treatment, patients were monitored in an observation room for at least one hour. A general and neurological evaluation was performed before discharge.

Treatment Side

For patients with bilateral or alternating unilateral migraine pain, procedures were performed bilaterally. For those with consistent unilateral pain, the intervention was performed on the symptomatic side only.

Data Collection and Evaluation

To assess the study parameters accurately, a

“Monthly Headache Follow-Up Form” was provided to all patients who met the inclusion criteria. Patients were instructed on how to complete the form properly and were required to fill it out consistently for at least one month prior to treatment and throughout the follow-up period.

Demographic data, including age, gender, marital status, height, weight, education level, and occupation, were recorded for all patients.

Headache characteristics were as follows: age of migraine onset, headache localization (right or left unilateral, alternating unilateral, bilateral), average headache duration, average headache severity (according to VAS, 10-point VAS score of 0, no pain and 10, the highest tolerable pain), highest VAS score in a month, headache frequency, number of days with headache, whether any side effects developed during and after the treatment, what those side effects (if they occurred) were and how long they lasted. The aforementioned characteristics were all determined.

Patients were evaluated at the first, second, and third months after treatment. During these follow-ups, the following parameters were recorded: monthly number of headache days, average headache duration, average headache severity (VAS score), and highest VAS score within the month.

Outcome Assessment

At the end of the study, all collected data were compared between the pre-treatment and post-treatment follow-up periods, as well as between the 2 groups. “The Monthly Headache Follow-up Form” served as the primary tool for this evaluation.

Safety and Side Effects

Patients were instructed to report any adverse symptoms or side effects at any point during the study period. All reported side effects and complications and the durations thereof were documented carefully to ensure treatment safety.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS 25.0 (IBM Corp.). Continuous variables were presented as mean $\pm$ SD or median with interquartile range (IQR), depending on the data distribution, while categorical variables were expressed as frequencies and percentages. Normality of data was assessed using the Shapiro-Wilk test. For normally distributed continuous variables, group comparisons were performed using the indepen-

dent samples t-test, while the Mann-Whitney U test was used for nonnormally distributed data. Categorical variables were compared using the chi-squared test or Fisher's exact test. To assess intra-group changes over time, the Wilcoxon signed-rank test was employed. Inter-group differences at follow-up time points (the first, second, and third months) were analyzed using the Mann-Whitney U test. To control for type I error in post-hoc analyses of repeated measures, the Bonferroni correction was applied. A *P*-value of < 0.05 was considered statistically significant.

RESULTS

A total of 68 patients were included in the study: 35 in the GONPRF group and 33 in the GONBs group. The patients' demographic and baseline headache characteristics are summarized in Table 1.

The mean age was similar between the groups (GONPRF: 40.7 ± 10.5 years; GONBs: 41.2 ± 11.9 years; *P* = 0.85). Most patients in both groups were female (GONPRF: 80.0%; GONBs: 78.8%; *P* = 0.90), and there was no significant difference in the distribution of marital status (*P* = 0.10). While the mean BMI was slightly lower in the GONPRF group (26.0 ± 4.3) than in the GONBs group (27.9 ± 4.6), this difference did not reach statistical significance (*P* = 0.075).

Headache Characteristics at Baseline

The duration of migraine disease was comparable between the groups (17.0 years in both groups; *P* = 0.811). Similarly, the average headache duration per attack in each group was 24 hours, with no significant difference (*P* = 0.242). The monthly frequency of headache attacks and the number of headache days were also similar between the groups (*P* = 0.748, *P* = 0.807, respectively). Additionally, baseline headache severity (VAS score) was not significantly different (GONPRF: 7.0 ± 0.9; GONBs: 6.7 ± 1.0; *P* = 0.152) (Table 2).

Changes in Headache Duration

The duration of headache attacks improved significantly in the GONPRF group compared to the GONBs group over the study period (Table 2). In the first month, both groups exhibited reduced headache durations, with no significant difference between them. By the second month, the GONPRF group had a significantly shorter median headache duration (GONPRF: 10 [2-36] hours vs. GONBs: 20 [4-36] hours; *P* = 0.044). This trend persisted into the third month (GONPRF: 10 [2-36] hours vs. GONBs: 24 [4-36] hours; *P* = 0.03) (Fig. 2).

Table 1. *Demographics of patients.*

	GONPRF (n = 35)	GONBs (n = 33)	<i>P</i> -value
Age (SD)	40.7 (10.5)	41.2 (11.9)	0.8551
Female n (%)	28.0 (80.0%)	26.0 (78.8%)	0.9022
Marital Status			0.1052
Married	20.0 (57.1%)	25.0 (75.8%)	
Single	15.0 (42.9%)	8.0 (24.2%)	
BMI (SD)	26.0 (4.3)	27.9 (4.6)	0.0751
Education			0.099
Elementary	7 (20.0)	10 (30.3)	
Middle School	0 (0.0)		
High School	10 (28.6)	6 (18.2)	
University	18 (51.4)	13 (39.4)	
Localization			0.564
Right	2 (5.7)	2 (6.1)	
Left	1 (2.9)	3 (9.1)	
Alternate	23 (65.7)	17 (51.5)	
Bilateral	9 (25.7)	11 (33.3)	
Migraine duration, years, median (IQR)	17.0 (10.5 to 27.5)	17.0 (11.0 to 25.0)	0.811
Headache duration, hours, median (IQR)	24.0 (24.0 to 48.0)	24.0 (16.0 to 24.0)	0.242
Attack frequency per month, median (IQR)	15.0 (10.0 to 25.0)	16.0 (10.0 to 20.0)	0.748
Days with headache per month, median (IQR)	20.0 (15.0 to 30.0)	20.0 (16.0 to 30.0)	0.807
Severity of headache, VAS (SD)	7.0 (0.9)	6.7 (1.0)	0.1521
Maximum headache severity score, VAS (SD)	9.6 (0.6)	9.3 (0.9)	0.1881

Abbreviations: n: Number, %: Percentage, BMI: Body Mass Index, Education: Educational Level, Localization: Headache localization (Right, Left, Alternate, Bilateral), Migraine duration: Duration of migraine in years, median (IQR*), Headache duration: Duration of headache in hours, median (IQR*), Attack frequency per month: Median (IQR*), Days with headache per month: Median (IQR*), Severity of headache: VAS (Visual Analog Scale) (SD), Maximum headache severity score: VAS (Visual Analog Scale) (SD), *P*-value: probability value indicating statistical significance, 1: Group 1 or comparison 1, 2: Group 2 or comparison 2. Note: IQR = Interquartile Range.

Changes in Headache Frequency

At baseline, the frequency of headache attacks was comparable between the groups (Table 3). However, significant differences emerged during the follow-up period. In the first month, the GONPRF group demonstrated a significantly lower median attack frequency (GONPRF: 3 [1-21] vs. GONBs: 7 [1-21]; *P* = 0.010). This improvement

continued into the second (GONPRF: 3 [1-24] vs. GONBs: 11 [1-23]; $P = 0.001$) and third months (GONPRF: 4 [1-19] vs. GONBs: 14 [1-29]; $P < 0.001$) (Fig. 3).

Changes in Monthly Headache Days

Baseline monthly headache days were similar between the 2 groups (Table 4). Significant reductions in

headache days were observed in the GONPRF group throughout the follow-up period. In the first month, the GONPRF group had fewer headache days than did the GONBs group (GONPRF: 3 [1-21] vs. GONBs: 8 [1-30]; $P = 0.004$). This difference remained significant in the second month (GONPRF: 3 [1-24] vs. GONBs: 12 [1-30]; $P = 0.001$) and third month (GONPRF: 4 [1-19] vs. GONBs: 14 [1-30]; $P < 0.001$) (Fig. 4).

Table 2. *Duration of headache attacks.*

	GONPRF		GONBs		MWU
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	
Baseline	30 (16.5)	24 (6-72)	25.4 (15.7)	24 (6-72)	0.242
First Month	13 (8.2)	10 (3-36)	16.5 (9.4)	18 (4-36)	0.166
2nd	12.4 (8.3)	10 (2-36)	17.1 (9.3)	20 (4-36)	0.044
3rd	13 (8.4)	10 (3-36)	17.9 (9.2)	24 (4-36)	0.03

Abbreviations: Mean: Mean, Median (Range): Median (Range), MWU: Mann-Whitney U test (a non-parametric test used to compare differences between 2 independent groups), Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

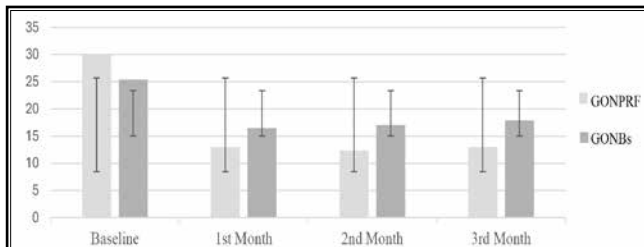


Fig. 2. *Comparison of headache duration.*

Abbreviations: Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

Table 3. *Frequency of headache attacks.*

	GONPRF		GONBs		MWU
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	
Baseline	17.5 (8.4)	15 (7-30)	17.4 (7.3)	16 (7-30)	0.74
First Month	4.8 (4.8)	3 (1-21)	8.7 (6.5)	7 (1-21)	0.010
2nd	5.5 (5.3)	3 (1-24)	10.8 (6.8)	11 (1-23)	0.001
3rd	5.7 (4.8)	4 (1-19)	13.2 (7.9)	14 (1-29)	< 0.001

Abbreviations: Mean: Mean, Median (Range): Median (Range), MWU: Mann-Whitney U test (a non-parametric test used to compare differences between 2 independent groups), Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment

Changes in Headache Severity (VAS Score)

As for the mean monthly VAS scores, the GONPRF group showed a more significant reduction in headache severity than did the GONBs group (Table 5). At baseline, the VAS scores were comparable (GONPRF: 7.0 ± 0.9 ; GONBs: 6.7 ± 1.0 ; $P = 0.152$). By the second month, the GONPRF group had significantly lower pain scores (GONPRF: 4.7 ± 1.2 vs. GONBs: 5.5 ± 1.1 ; $P = 0.005$). This significant difference persisted into the third month (GONPRF: 5.0 ± 1.3 vs. GONBs: 5.9 ± 1.1 ; $P = 0.002$) (Fig. 5).

Side Effects and Safety

Both groups experienced minimal and transient side effects of short duration, including dizziness, headache, and localized pain at the injection site. No serious or permanent adverse events were reported. The longest-lasting side effect was a headache lasting 24 hours in 2 patients. The shortest-lasting side effect was dizziness, which resolved within 2 minutes.

All side effects were resolved completely without intervention, demonstrating the safety of both procedures.

DISCUSSION

This study demonstrates that, when compared to repeated GONBs, GONPRF applied with the proximal technique under US-guidance significantly reduces the duration and frequency of headache attacks, the number of monthly headache days, and the headache severity as measured by VAS. These findings suggest that GONPRF may offer more sustained migraine relief over a 3-month period than do repeated GONBs. No permanent and serious complications were observed during GONBs or GONPRF applications under US-guidance, and both applications were found to be safe. These results align with the growing body of evidence supporting greater occipital nerve-based interventions in migraine treatment.

The first randomized, multicenter, double-blind, placebo-controlled study demonstrating the efficacy of repeated GONBs was conducted by Inan et al (23). In that study, repeated GONBs with bupivacaine were shown to be more effective than placebos for chronic migraine patients, and were reported as safe, effective, and cost-efficient for the treatment of chronic migraine (23). Similarly, a prospective randomized controlled trial by Karadas et al (24) involving 40 migraine patients found that GONB applications with local lidocaine were effective in migraine treatment and that repeated GONBs were more effective than a single-session blockade. Most randomized controlled trials comparing GONBs with placebos for migraine treatment have demonstrated that GONBs are associated with at least partial benefits. The growing body of evidence supports the use of GONBs as a valid treatment option for both the acute treatment and short-term prevention of migraines (25). In consistency with these findings, our study also demonstrates that repeated GONBs result in significant reductions in headache duration, frequency, and severity by the end of the first month. However, these effects tend to regress during the second and third months.

Palamar et al (26) reported that applying GONBs with bupivacaine under US-guidance for migraine treatment was safe, simple, and effective, and recommended the use of US-guidance to enhance the effectiveness of the injection and apply isolated GONBs.

GONPRF, applied for the purpose of extending the therapeutic benefits of GONBs, is believed to reduce nociceptive signal transmission by means of RF waves generated by electric currents around target nerves without damaging the nerve or surrounding tissues

(27). In addition to its peripheral modulatory effects, PRF may also exert analgesic effects via central modulation by way of noradrenergic, serotonergic, and endogenous opioid inhibitory pathways (22).

Cohen et al (28) employed the anatomical landmark technique in their randomized, double-blind study that compared PRF therapy to steroid injections

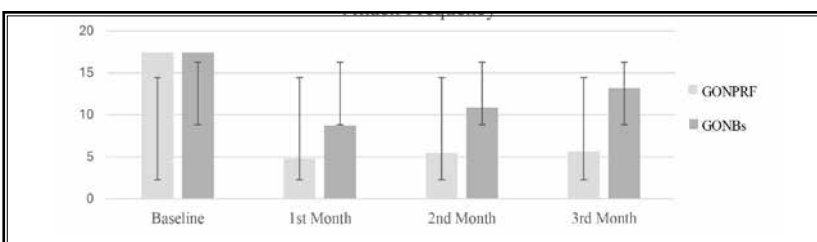


Fig. 3. Headache attack frequency.

Abbreviations: Attack Frequency: the number of headache attacks per month, Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

Table 4. Comparison of number of monthly headache days.

	GONPRF		GONBs		Wilcoxon-MWU
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	
Baseline	20.9 (7.2)	20 (8-30)	21.1 (7)	20 (10-30)	0.807
First Month	4.9 (4.9)	3 (1-21)	9.9 (7.9)	8 (1-30)	0.004
2nd	5.6 (5.4)	3 (1-24)	12.1 (8.3)	12 (1-30)	0.001
3rd	5.8 (5.1)	4 (1-19)	14.5 (8.9)	14 (1-30)	< 0.001

Abbreviations: Mean (SD): Mean (Standard Deviation), Median (Range): Median (Range), Wilcoxon-MWU: Wilcoxon signed-rank test and Mann-Whitney U test, Wilcoxon Signed-Rank Test: a non-parametric test used to compare 2 related samples (used for paired or dependent samples), Mann-Whitney U test: a non-parametric test used to compare differences between 2 independent groups, Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

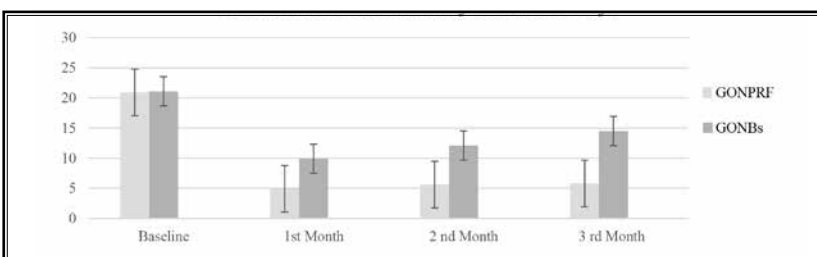


Fig. 4. Mean number of monthly headache days.

Abbreviations: Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

Table 5. Monthly mean VAS pain scores of the groups.

	GONPRF		GONBs		T test
	mean (SD)	Median (Range)	Mean (SD)	Median (Range)	
Baseline	7.0 (0.9)	7 (5-9)	6.7 (1.0)	7 (5-9)	0.152
First Month	4.9 (1.3)	5 (3-9)	5.5 (1.7)	5 (3-8)	0.132
2nd	4.7 (1.2)	5 (3-8)	5.5 (1.1)	6 (3-8)	0.005
3rd	5.0 (1.3)	5 (3-8)	5.9 (1.1)	6 (3-8)	0.002

Abbreviations: Mean: Mean, Median (Range): Median (Range), T test: a statistical test used to compare the means of 2 groups to determine if they are significantly different from each other, Independent T test: compares the means of 2 independent groups, Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

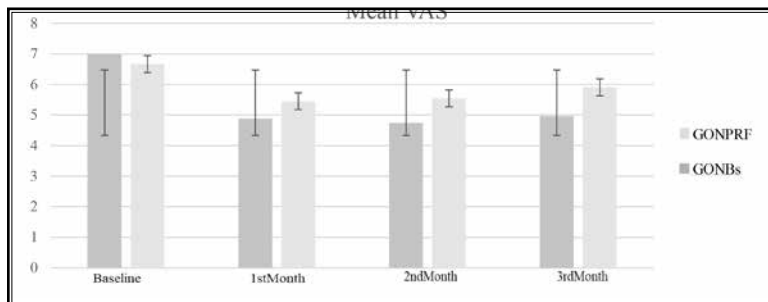


Fig. 5. Mean VAS pain scores.

Abbreviations: Mean VAS: Mean headache severity score, Visual Analog Scale, Baseline: the initial measurement period (before the treatment), First Month: the first month after the treatment, 2nd: the second month after the treatment, 3rd: the third month after the treatment.

for patients with migraine and occipital neuralgia. The results of the study demonstrated that PRF provided significantly better analgesia than did steroid injections, supporting the use of PRF for migraine patients with occipital tenderness. Similarly, our findings align with those supporting the effectiveness of PRF in migraine management. However, in our study, GONPRF was applied using a proximal technique, and no medications were administered during the treatment. This finding suggests that GONPRF may be an effective treatment for migraines even without the use of local anesthetics.

In a randomized controlled study by Ertlav et al (29) that compared the effectiveness of repeated GONBs to PRF therapy for chronic migraine patients, PRF was shown to be more effective than GONBs in treating chronic migraines at 6 months. Although there were differences in the distal application technique, use of prilocaine for blocks, the application of 240 seconds of PRF in a single cycle, and the follow-up period, the

results of this study, which were similar in terms of study design, were consistent with our findings. These commonalities suggest that there may be no significant difference between the distal and proximal techniques of US-guided GONPRF treatment.

In another study of 25 refractory chronic migraine patients who underwent 6 minutes of US-guided GONPRF at the C2 level without local anesthetics or steroids, improvement in headache severity, frequency, and attack duration was reported for at least 3 months. In our GONPRF group, which was similar in terms of PRF technique, application, and duration, we observed similar results (20). A recent systematic review evaluating the efficacy of GONPRF for treating headache disorders concluded that there was some evidence supporting that PRF yielded an analgesic benefit for migraine patients with occipital tenderness (30).

In a retrospective study of 61 patients with chronic migraines, the patients received weekly distal GONBs for 4 weeks. In the final session, those patients were divided into 2 groups: one received steroids, while the other underwent GONPRF (31). Although the PRF group showed reductions in migraine-related headaches, attack frequency, duration, and analgesic use, no statistically significant difference was found between the groups. In contrast, our study observed a more significant decrease in the duration, frequency, severity of headache attacks, and the number of monthly headache days in the PRF group. Unlike the aforementioned retrospective study, we applied GONBs and GONPRF at the proximal level, used no local anesthetics during PRF, did not administer steroids to either group, and achieved statistically superior results in the PRF group.

The results of our study are consistent with previous research highlighting the effectiveness of GONPRF in managing migraines, especially for patients with occipital tenderness. While GONBs are effective in the short term, their benefits tend to diminish over time, whereas GONPRF appears to provide more sustained relief. The sustained effect of GONPRF may be attributed to its neuromodulatory impact, which may pos-

sibly alter pain transmission pathways more effectively than GONBs can.

Approximately 5-31% of patients undergoing GONBs experience adverse events (32,33). Post-injection side effects, such as pain, numbness, dizziness, headache, and local swelling, are generally mild and transient (34). A systematic review evaluating the safety and efficacy of GONPRF reported mild and transient adverse events in only 3.1% of the included patients, such as headache exacerbation, cervicalgia, local discomfort, dizziness, rash, and injection-site pain (30). All these effects resolved within 3 weeks, with no serious complications reported. Similarly, we observed mild and transient side effects in our patients, supporting the safety of GONBs and GONPRF. The use of US-guidance may have played a role in reducing adverse events.

Limitations

Potential sources of bias, including selection and performance bias, were minimized. Patients were selected based on a positive response to the diagnostic GONB, and both groups received treatment via a standardized US-guided technique. However, due to the observational nature of the study, blinding was not implemented. Objective measurement tools (e.g., VAS) were used, and follow-up periods were consistent. Strict exclusion criteria were applied to minimize confounding variables. Despite those efforts, some potential bias related to patient selection and reporting might have remained.

The small sample size (68 patients) may limit statistical power and generalizability. Additionally, the 3-month follow-up may not adequately assess the long-term efficacy of GONPRF and GONBS, emphasizing the need for extended follow-up studies. Furthermore, the single-center design may limit the external validity of the findings.

CONCLUSION

GONPRF appears to be a preferable treatment option for migraine patients in search of long-term relief with reduced treatment frequency. This approach has the potential to enhance patient adherence and overall satisfaction. Further studies with larger sample sizes and extended follow-up periods are needed to confirm these findings and better assess the long-term effects of GONPRF.

Author Contributions

SD: Conception and design of the study, study registration, data collection, manuscript writing, manuscript editing, and final approval of the manuscript.

GB: Study design, data analysis, and final approval of the manuscript.

US: Study design, manuscript editing, and final approval of the manuscript.

EYA: Data analysis, manuscript editing, and final revisions.

REFERENCES

- Steiner TJ, Stovner LJ, Jensen R, Uluduz D, Katsarava Z. Migraine remains second among the world's causes of disability, and first among young women: Findings from GBD 2019. *J Headache Pain* 2020; 21:137:1-4.
- Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition. *Cephalalgia* 2018; 38:1-211.
- Lipton RB, Silberstein SD. Episodic and chronic migraine headache: Breaking down barriers to optimal treatment and prevention. *Headache* 2015; 55:103-122.
- Ashina M, Hansen JM, Do TP, Melo-Carrillo A, Burstein R, Moskowitz MA. Migraine and the trigeminovascular system-40 years and counting. *Lancet Neurol* 2019; 18:795-804.
- Inan LE, Inan N, Unal-Artik HA, Atac C, Babaoglu G. Greater occipital nerve block in migraine prophylaxis: Narrative review. *Cephalalgia* 2019; 39:908-920.
- Dilli E, Halker R, Vargas B, et al. Occipital nerve block for the short-term preventive treatment of migraine: A randomized, double-blinded, placebo-controlled study. *Cephalalgia* 2015; 35:959-968.
- Gantenbein AR, Lutz NJ, Riederer F, Sandor PS. Efficacy and safety of 121 injections of the greater occipital nerve in episodic and chronic cluster headache. *Cephalalgia* 2012; 32:630-634.
- Ambrosini A, Vandenheede M, Rossi P, et al. Suboccipital injection with a mixture of rapid- and long-acting steroids in cluster headache: A double-blind placebo-controlled study. *Pain* 2005; 118:92-96.
- Naja ZM, El-Rajab M, Al-Tannir MA, Ziade FM, Tawfik OM. Occipital nerve blockade for cervicogenic headache: A double-blind randomized controlled clinical trial. *Pain Pract* 2006; 6:89-95.
- Bogduk N, Govind J. Cervicogenic headache: An assessment of the evidence on clinical diagnosis, invasive tests, and treatment. *Lancet Neurol* 2009; 8:959-968.
- Afridi SK, Shields KG, Bhola R, Goadsby PJ. Greater occipital nerve injection in primary headache syndromes—Prolonged effects from a single injection. *Pain* 2006; 122:126-129.
- Bartsch T, Goadsby PJ. The

- trigemino-cervical complex and migraine: Current concepts and synthesis. *Curr Pain Headache Rep* 2003; 7:371-376.
13. Hoffmann J, Mehnert J, Koo EM, May A. Greater occipital nerve block modulates nociceptive signals within the trigemino-cervical complex. *J Neurol Neurosurg Psychiatry* 2021; 92:1335-1340.
14. Kwon HJ, Kim HS, O J, et al. Anatomical analysis of the distribution patterns of occipital cutaneous nerves and the clinical implications for pain management. *J Pain Res* 2018; 25:11:2023-2031.
15. Naja ZM, El-Rajab M, Al-Tannir MA, Ziade FM, Tawfik OM. Occipital nerve blockade for cervicogenic headache: A double-blind randomized controlled clinical trial. *Pain Pract* 2006; 6:89-95.
16. Bogduk N, Govind J. Cervicogenic headache: An assessment of the evidence on clinical diagnosis, invasive tests, and treatment. *Lancet Neurol* 2009; 8:959-968.
17. Bartsch T, Goadsby PJ. The trigemino-cervical complex and migraine: Current concepts and synthesis. *Curr Pain Headache Rep* 2003; 7:371-376.
18. Hoffmann J, Mehnert J, Koo EM, May A. Greater occipital nerve block modulates nociceptive signals within the trigemino-cervical complex. *J Neurol Neurosurg Psychiatry* 2021; 92:1335-1340.
19. Flamer D, Alakkad H, Soneji N, Tumber P, Peng P, Kara J, Hoydonckx Y, Bhatia A. Comparison of two ultrasound-guided techniques for greater occipital nerve injections in chronic migraine: A double-blind, randomized, controlled trial. *Reg Anesth Pain Med* 2019; 44:595-603.
20. Güner D, Eyigör C. Efficacy of ultrasound-guided greater occipital nerve pulsed radiofrequency therapy in chronic refractory migraine. *Acta Neurol Belg* 2023; 123:191-198.
21. Kissoon NR, O'Brien TG, Bendel MA, et al. Comparative effectiveness of landmark-guided Greater Occipital Nerve (GON) block at the superior nuchal line versus ultrasound-guided GON block at the level of C2. *Clin J Pain* 2022; 38:271-278.
22. Chua NH, Vissers KC, Sluijter ME. Pulsed radiofrequency treatment in interventional pain management: mechanisms and potential indications-A review. *Acta Neurochir (Wien)* 2011; 153:763-771.
23. Inan LE, Inan N, Karadas O, 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; 132:270-277.
24. Karadas O, Ozturk B, Inan L, Inan N. Comparison of single and repeated blockade of the greater occipital nerve in migraine treatment. *Neurol Sci Neurophysiol* 2018; 35: 97-101.
25. Stern JL, Chiang C-C, Kissoon NR, Robertson CE. Narrative review of peripheral nerve blocks for the management of headache. *Headache* 2022; 62:1077-1092.
26. Palamar D, Uludüz D, Saip S, Erden G, Unalan H, Akarirmak U. Ultrasound-guided greater occipital nerve block: An efficient technique in chronic refractory migraine without aura? *Pain Physician* 2015; 18:153-162.
27. Park D, Chang MC. The mechanism of action of pulsed radiofrequency in reducing pain: A narrative review. *J Yeungnam Med Sci* 2022; 39:200-205.
28. 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; 156:2585-2594.
29. Ertilav E, Aydin ON. Comparison of the efficacy of repeated greater occipital nerve block and pulsed radiofrequency therapy in chronic migraine patients: A randomized controlled study. *J Oral Facial Pain Headache* 2024; 38:100-107.
30. Oliveira KD, Dhondt N, Englesakis M, Goel A, Hoydonckx Y. Pulsed radiofrequency neuromodulation of the greater occipital nerve for the treatment of headache disorders in adults: A systematic review. *Can J Pain* 2024; 8:2355571.
31. Karaduman Y, Serçe A, Muz A, Yıldırım S, Durmuş İE, Takmaz SA. Comparison of greater occipital nerve blockade with radiofrequency and steroid in chronic migraine. *Clin Neurol Neurosurg* 2024; 242:108325.
32. Weibelt S, Andress-Rothrock D, King W, Rothrock J. Suboccipital nerve blocks for suppression of chronic migraine: Safety, efficacy, and predictors of outcome. *Headache* 2010; 50:1041-1044.
33. Chowdhury D, Datta D, Mundra A. Role of greater occipital nerve block in headache disorders: A narrative review. *Neurol India* 2021; 69:228-256.
34. Friedman BW, Irizarry E, Williams A, et al. A randomized, double-dummy, emergency department-based study of greater occipital nerve block with bupivacaine vs intravenous metoclopramide for treatment of migraine. *Headache* 2020; 60:2380-2388.