Comparison of Ultrasound-Guided Genicular Pulse Radiofrequency and Fluoroscopy-Guided Intra-Articular Pulse Radiofrequency for Knee Osteoarthritis-Related Pain

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ABSTRACT

Objective: To compare two different algological intervention technique outcomes with ultrasound-guided genicular pulse radiofrequency (PRF) and fluoroscopy-guided intra-articular pulse radiofrequency for knee osteoarthritis-related pain.

Study Design: Observational study.

Place and Duration of the Study: Izmir Bakircay University, Cigli Training and Research Hospital and Health Science University Tepecik, Training and Research Hospital, Izmir, Turkiye, between March 2022 and May 2023.

Methodology: Patients aged 60 years and above with stage 3 and 4 knee osteoarthritis, experiencing knee pain for more than six months, and non-responsive to conservative treatments were included. Patients with recent knee surgery or intra-articular injections and those ineligible for radiofrequency application were excluded. Ultrasound-guided genicular nerve PRF and fluoroscopy-guided intra-articular PRF were administered to the included patients. Pain and quality of life were evaluated using the visual analogue scale (VAS) and Western Ontario and McMaster Universities Index of Osteoarthritis (WOMAC) scores before and after the procedures.

Results: The study included 64 patients. Both ultrasound-guided genicular PRF and fluoroscopy-guided intra-articular PRF resulted in significant reductions in VAS and WOMAC scores at 1 and 3 months after the procedures. There was no significant difference in efficacy between the two techniques.

Conclusion: Ultrasound-guided genicular PRF and fluoroscopy-guided intra-articular PRF are effective and safe options for managing knee osteoarthritis-related pain.

Key Words: *Osteoarthritis, Pulse radiofrequency, Ultrasound, Fluoroscopy, Pain.*

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INTRODUCTION

Osteoarthritis (OA) is a degenerative disease characterised by progressive cartilage degradation, osteophyte formation, subchondral sclerosis, and a series of biochemical and morphological changes in weight-bearing joints influenced by genetic, mechanical, and biochemical factors.[1]

Osteoarthritis is one of the most common musculoskeletal disorders in the elderly patients and has become a global health issue.

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The increasing prevalence of knee osteoarthritis is associated with population ageing and rising obesity rates. The prevalence of chronic knee pain secondary to osteoarthritis is more than 12% in individuals over the age of 60 years. This rate is significantly higher in women (14.9%) than men (8.7%).[2]

The treatment goals for knee osteoarthritis are to reduce pain, eliminate existing joint movement limitations, and reduce secondary functional deficiencies. Various treatment methods are available, including conservative approaches and interventional procedures. Conservative approaches for knee pain include physical therapy, orthotics, weight loss, and pharmacological modalities such as acetaminophen, steroidal anti-inflammatory drugs (NSAIDs), opioids, and intra-articular drug injections.[3,4]

Although conservative methods are generally effective in managing osteoarthritis, they have limitations, such as temporary benefits, high costs, and frequent side effects, especially in elderly patients. For individuals with advanced symptoms and pathology, surgical options such as arthroscopy and joint replacement are available. However, these methods are associated with

morbidity, mortality, high costs, and inefficacy in a significant portion of patients, particularly in postsurgical chronic pain.[5,6]

Significant challenges arise in managing pain related to osteoarthritis, particularly in cases where conservative treatments are nonresponsive and surgical procedures are not suitable. Patients suffering from chronic knee pain due to osteoarthritis are restricted in their daily activities, and their quality of life is diminished, along with potential side effects from the agents used for treatment.[7,8] Therefore, radiofrequency (RF) applications have drawn attention in treating knee osteoarthritis due to their minimal invasiveness, low side effect profile, and rapid onset of efficacy.[9]

Radiofrequency thermocoagulation (RFT) uses hyperthermia to destroy the integrity of peripheral nerves. In this way, the transmission of pain signals can be reversibly blocked.

Conversely, by generating electric fields to regulate neurological function and relieve pain, pulse radiofrequency (PRF) reduces the production of immunoinflammatory substances (IL-1, TNF-a, IL-6) involved in pain transmission. In addition, both methods can reduce peripheral pain transmission to the central nervous system.[10]

Achieving analgaesia without destroying neural tissue is a desired target in pain treatment. This understanding makes non-neurodestructive methods such as PRF applications appealing. PRF modulates pro-inflammatory cytokines and suppresses excitatory C-fiber activation and the spread of pain impulses in synaptic connections, making it an attractive neuro-modulatory approach.[11,12] When this technique is applied to genicular (GN) or intra-articular (IA) nerves, it significantly reduces symptoms of knee OA.[13,14]

However, the number of studies comparing the effectiveness of these two techniques in osteoarthritis symptoms without other pharmacological approaches and intra-articular agent injections is limited. The aim of this study was to evaluate the effectiveness of ultrasound-guided genicular nerve and fluoroscopy-guided intra-articular PRF treatment in patients with knee pain resistant to conservative treatments due to osteoarthritis.

METHODOLOGY

The study was conducted between March 2022 and May 2023 at Izmir Bakircay University, Cigli Training and Research Hospital and Health Science University Tepecik, Training and Research Hospital. After obtaining approval from the Hospital Ethics Committee, data from patients who underwent interventional algological procedures for knee pain were retrospectively collected from the hospital records system. Patients aged 60 years and above with a radiological diagnosis of stage 3 and 4 knee osteoarthritis, according to the Kellgren-Lawrence classification, experiencing knee pain for more than six months and not responding to conservative treatments were included in the study. Patients who underwent knee surgery received intra-articular injections within the last three months, and those ineligible for radiofrequency application for various reasons (e.g., infection, coagulation disorders and cardiac pacemaker) were excluded from the study. Patients with a history of knee surgery were also not included. Demographic data such as age, height, weight, gender, clinical diagnoses, surgical histories, pharmacological treatments received, and interventional algological procedures applied were recorded for the included patients.

During the algology clinic follow-ups, the visual analogue scale (VAS) values and Western Ontario and McMaster Universities Index of Osteoarthritis (WOMAC) test scores were routinely assessed for the patients before the procedure, at one month and three months after the surgery. The VAS was used to evaluate pain, ranging from 0 (no pain) to 10 (extreme pain), while the WOMAC measured the improvement in quality of life, including pain, stiffness, and physical function.[15] Numbness, paraesthesia, neuralgia, and motor weakness were also documented as adverse effects.

A standard monitoring and preparation procedure was performed before the interventional procedure for patients undergoing intra-articular PRF under fluoroscopic guidance and genicular PRF under ultrasound guidance. After being admitted to the procedure room, patients were placed supine with appropriate knee support to achieve the optimal knee position for the interventional procedure. Monitoring was implemented, encompassing pulse oximetry, electrocardiogram, and arterial blood pressure measurement. The procedure area was prepared according to surgical asepsis-antisepsis rules, and 1 ml of 0.5% lidocaine was applied to the skin before injection. To perform intra-articular PRF application under fluoroscopy, a 22-gauge, 10-cm hybrid RF cannula (Diros, USA) with a 10-mm active tip was introduced into the joint. Fluoroscopic anteroposterior and lateral imaging confirmed the accuracy of needle localisation within the joint. When no motor (2 Hz) or sensory (50 Hz) stimulation response was observed, a 42°C PRF application (45 volts) was performed for 10 minutes. After the application, the needle was removed, and the access point was dressed.

High-frequency linear transducer from a Toshiba (Canan) double-probe Doppler-enabled ultrasonography device was used to perform PRF application on the genicular nerves under ultrasound guidance. The transducer was utilised to locate the superior medial, superior lateral, and inferior medial genicular nerves near the genicular arteries. The probe was aligned parallel to the long axes of the femur and tibia.

The superior medial genicular nerve (SMGN) surrounds the medial aspects, while the superior lateral genicular nerve (SLGN) encircles the lateral aspects of the femur shaft. The inferior medial genicular nerve (IMGN) courses around the tibial neck, distal to the medial epicondyle. Before the procedure, 2 mL of 2% lidocaine was injected into the skin using a 25-gauge needle for local anaesthesia.

In the plane approach, a 22-gauge, 10-cm hybrid RF cannula (Diros, USA) with a 10-mm active tip was inserted to access the SMGN. Motor stimulation at 2 Hz with a pulse width of 1 ms and intensity set at 1 V was applied to confirm the absence of a motor response. Sensory stimulation was then conducted at 50 Hz with a 0.5 V setting. Upon patient-confirmed paraesthesia in the distri-

bution of the SMGN, pulsed RF at 42°C was administered for 120 seconds in three cycles. Subsequently, the same procedure was repeated for the SLGN and IMGN, respectively.

The same pain physician performed all ultrasound scanning and PRF procedures. Both groups were followed up after the procedure using the same post-procedure protocol. The patients did not use additional analgaesics for knee pain during the follow-up period.

The study's sample size was determined through the G-Power package programme, aiming for a statistical power of 80% at a Type-I error rate of $\alpha = 0.05$. It was calculated that 34 participants would be sufficient to detect a small-to-medium effect size (Cohen's $w = 0.2$). The statistical analyses were conducted using the SPSS 26.0 programme (IBM, Arizona, USA). The normality test was performed with the Kolmogorov-Smirnov test. Continuous variables were described using mean and standard deviation, while categorical variables were presented as frequency and corresponding percentage values. Intergroup comparisons of continuous variables were conducted using the Mann-Whitney U test, and categorical variables were performed with the Chi-square test. Statistical significance was set at $p < 0.05$.

RESULTS

The data of 78 patients in the study who underwent procedures for gonarthrosis were analysed retrospectively. After excluding 14 patients due to a history of previous knee surgery, recent intra-articular medicine injection within the last three months, and other reasons such as out-of-follow-up, the remaining 64 patients were examined.

The average age of the enrolled patients was 68.00 ± 5.90 years, and the mean body mass index (BMI) was 31.20 ± 4.46 Kg/m^2. Among the 64 patients, 51 (79.7%) were females, and 13 (20.3%) were males. Thirteen (20.3%) patients received treatment on a single knee, while 51 (79.7%) received treatment on both knees. Table I provides a summary of the demographic and clinical characteristics of the patients.

When evaluating the VAS scores of the patients at the time of hospital admission (Bazale VAS), one month after the procedure (VAS 1st month), and three months after the procedure (VAS 3rd month), the mean VAS scores were found to be as follows: Bazale VAS: 8.30 ± 0.95, VAS 1st month: 3.94 ± 1.81, and VAS 3rd month: 2.81 ± 1.71 (Table II).

Similarly, in the assessment of the WOMAC scores among patients at the time of hospital admission (Baseline WOMAC), one month after the procedure (WOMAC 1st month), and three months after the procedure (WOMAC 3rd month), the mean WOMAC scores were computed as follows: Baseline WOMAC: 65.29 ± 14.98, WOMAC 1st month: 33.49 ± 18.03, and WOMAC 3rd month: 25.30 ± 18.16. Table II and Figure 1 and 2 summarise each group's VAS and WOMAC scores.

DISCUSSION

This study found no significant difference in the effectiveness of ultrasound-guided genicular PRF and fluoroscopy-guided intra-articular PRF techniques at 1 and 3 months after the procedures. Comparing the changes in VAS and WOMAC scores after the treatments, the intra-articular PRF application, a newer technique reported in the literature, showed equivalent efficacy to genicular PRF in reducing knee pain and improving knee function.

Table I: Demographic and clinical features of the patients according to the groups.

	Group 1 n = 34 (53.1%)	Group 2 n = 30 (46.9%)	p-value
Age, mean ± SD	68.65 ± 7.80	67.07 ± 6.85	0.410
Body mass ındex, mean ± SD	31.03 ± 4.13	30.72 ± 3.73	0.747
Gender, n (%)			0.070
Female	30 (88.2%)	21(70%)	
Male	4 (11.8%)	9(30%)	
Intervention location, n (%)			
Right	4 (11.8%)	4 (13.3%)	0.540
Left	2 (5.8%)	3 (10%)	0.850
Bilateral	28 (82.4%)	23 (76.7%)	0.573
Complication	N/A	N/A	

A comparison of median and IQR between groups was performed using the Chi-square test.

Table II: Pain scores comparison of groups.

	Group 1 (n = 34)	Group 2 (n = 30)	p-value
Bazale VAS, median, IQR	8.00 (95% CI: 7.77-8.40)	8.00 (95% CI: 8.17-8.90)	0.075
VAS 1st month, median, IQR	3.50 (95% CI: 3.19-4.40)	4.00 (95% CI: 3.38-4.12)	0.339
VAS 3rd month, median, IQR	2.00 (95% CI: 2.13-3.34)	3.00 (95% CI: 2.26-3.34)	0.387
Bazale WOMAC, median, IQR	61.95 (95% CI: 60.31-69.93)	66.80 (95% CI: 59.31-71.63)	0.614
WOMAC 1st month, median, IQR	25.00 (95% CI: 25.71-39.15)	35.60 (95% CI: 28.43-40.97)	0.407
WOMAC 3rd month, median, IQR	20.25 (95% CI: 20.59-35.01)	19.00 (95 CI: 16.97-27.94)	0.419

The Comparison of median and 95% CI between groups was tested with the Mann-Whitney U test.

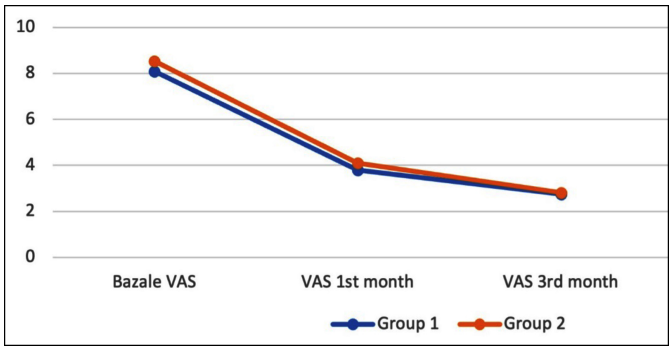

Figure 1: The graphical representation of the comparison of groups in terms of VAS score.

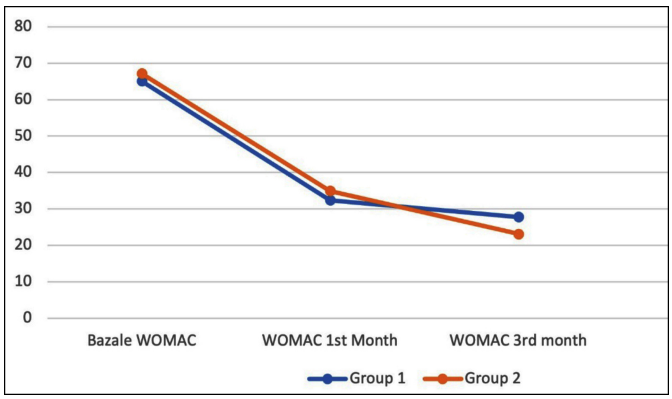

Figure 2: The graphical representation of the comparison of groups in terms of total WOMAC score.

Parallel to this study, previous research evaluating the efficacy of intra-articular PRF in osteoarthritis treatment has reported significant reductions in VAS and WOMAC scores at 1, 3, 6, and 12 months after the procedure.[14] Similarly, studies investigating the effect of genicular PRF on knee osteoarthritis pain have also reported significant reductions in VAS and WOMAC scores at one and three months after the procedure.[13]

The number of studies on the efficacy of PRF in knee joint pain treatment is limited in the literature. PRF has recently gained popularity due to its safer profile compared to RF thermocoagulation regarding side effects.[11] In contrast to RF thermocoagulation, PRF does not induce neurodestructive effects since it sustains tissue temperature below 42°C, preventing irreversible tissue damage.[16] Nevertheless, histological studies have revealed ultrastructural changes in nociceptive fibres following PRF.[17,18] On the contrary, intra-articular PRF application has demonstrated a reduction in the response of C fibres and pro-inflammatory cytokines, including interleukin-1β and interleukin-6.[19] The therapeutic efficacy of PRF in intra-articular applications is associated with the impact of electric fields on immune cells, particularly in joints with an open geometry, such as the knee, where the electric field is confined to the joint space.[12]

Radiofrequency ablation (RFA) is a technique employed for alleviating chronic pain by using thermal energy to ablate sensory nerve fibres, especially at the distal insertions of nerves. One of PRF's primary advantages is its ability to avoid an increase in the mean target tissue temperature, thereby preventing irreversible tissue destruction. PRF treatment is not anticipated to result in nerve destruction or complications such as neuropathic pain or Charcot's joints. Moreover, PRF is safer than RFA for neuritis-like reactions and motor deficits, as it influences motor and autonomic nerve fibres.[20]

In many randomised controlled studies, the effectiveness of genicular ablation using RF thermocoagulation in improving knee pain and function has been demonstrated.[21,22] In a study comparing the efficacy of genicular RF thermocoagulation with intra-articular PRF at 3 and 6 months, both methods were found to be equally effective in relieving knee pain, while genicular RF thermocoagulation was found to be more effective in improving knee function.[23]

A study assessing the efficacy of genicular PRF and intra-articular and genicular PRF in alleviating knee osteoarthritis pain at 1, 6, and 12 months post-intervention revealed noteworthy enhancements in VAS and WOMAC scores in both groups. The study concluded that both methods substantially improved knee pain and function.[24]

Although there are individual evaluations of PRF in intra-articular and genicular nerve applications in the literature, no previous study compared these two applications' efficacy and side effects, as in the present study. A study, in which genicular nerve PRF and a combination of intra-articular and genicular nerve pulse RF were applied, showed similar results in NRS scores at 3 and 6 months, while the WOMAC score was lower in the group where intra-articular and genicular nerve pulse RF was applied.[25]

While evaluating for complications, the authors did not observe any complications, which is consistent with the available literature. Therefore, the pulsed RF method is safe in treating osteoarthritis-related knee pain. This study found that intra-articular and genicular PRF applications were effective and reliable methods for reducing knee pain and improving knee function. Both methods can be opted as safe interventional procedures based on individual patient characteristics such as surgical history and comorbidities.

This study has several limitations, including the patients' limited follow-up period of 3 months. Owing to the study's retrospective design, it took more than one year to acquire follow-up data, which could have offered more comprehensive insights into long-term efficacy results. Extended follow-up periods are crucial for providing more comprehensive insights into the long-term effectiveness of interventions.

CONCLUSION

There was a significant reduction in the VAS and WOMAC scores at 1 and 3 months following the procedures. However, there was no significant difference in efficacy between the two techniques. Given these findings, both

methods are effective and safe options for interventional procedures, particularly in situations where the patient's clinical characteristics may limit the choice of the procedure.

ETHICAL APPROVAL:
An ethical approval was obtained with decision number 86J from Izmir Bakircay University's Ethical Committee.

PATIENTS' CONSENT:
Informed consent was obtained from all the patients.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
BOH, DG: Data collection, data processing, statistical analysis and writing of the manuscript.
Both authors approved the final version of the manuscript to be published.

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