Retrospective Study

The Comparison of Intraarticular Bipolar Pulsed Radiofrequency and Genicular Nerve Thermal Radiofrequency Ablation for Pain Caused by Osteoarthritis of the Knee

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Background: Information on the use of intraarticular bipolar pulsed radiofrequency (IA-bPRF) for treating knee osteoarthritis (KOA) is currently limited, and the effectiveness of this technique is not well established. The most effective nonsurgical approach for alleviating pain caused by KOA is still not well-defined.

Objectives: Our aim was to investigate the effects of genicular radiofrequency (G-RFT) and IA-bPRF on pain relief and functional improvement in patients with advanced KOA.

Study Design: Records of 86 patients with KOA who received either G-RFT or IA-bPRF were evaluated retrospectively.

Setting: The pain clinic of a state hospital.

Methods: KOA patients who received either G-RFT or IA-bPRF were included in the study. The files of patients who were given such interventions between September 2021 and February 2024 were analyzed. Walking pain was evaluated on the numeric rating scale (NRS). Functional assessments were performed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Lequesne Algofunctional Index for Knee (LAI-knee). These evaluations were carried out before the intervention, as well as 2 weeks and 6 months after it.

Results: The IA-bPRF group showed significant improvement in NRS scores when pre-intervention scores were compared to those recorded at the sixth month after the surgery, dropping from 8.62 ± 1.01 to 3.81 ± 1.18, while the scores of the G-RFT group improved from 8.90 ± 1.20 to 5.25 ± 3.40. At the sixth month, WOMAC scores decreased from 75.79 ± 16.00 to 34.21 ± 23.12 in the IA-bPRF group and from 79.02 ± 14.73 to 48.43 ± 30.87 in the G-RFT group. From the pre-intervention period to the sixth month after the procedure, LAI-knee scores went from 18.64 ± 4.16 to 9.90 ± 5.78 in the IA-bPRF group and from 18.89 ± 3.84 to 12.55 ± 7.33 in the G-RFT group. All decreases were significant ($P < 0.05$). However, WOMAC physical function scores decreased more in the IA-bPRF group than in the G-RFT group ($P < 0.05$). No serious adverse events occurred.

Limitations: Our study is subject to several limitations. Primarily, there is a paucity of extensive literature regarding the application of IA-bPRF for KOA. Additionally, our study's sample size is relatively small. This study was conducted at a single center and was retrospective in nature, rather than prospective and randomized, making it challenging to fully control for nuisance variables. Finally, there is a scarcity of comparable studies. These factors may constrain the external validity of our findings.

Conclusions: Pain incurred while walking on flat surfaces and up and down stairs was further reduced with IA-bPRF. IA-bPRF is as effective as G-RFT and even more effective than the latter in some subheadings. Furthermore, the former is a safe alternative for relieving pain in and improving daily life for individuals with advanced KOA. With further research, IA-bPRF may be included in future guidelines for managing chronic KOA pain.

Key words: Radiofrequency, knee joint, osteoarthritis, chronic pain, activities of daily living

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Osteoarthritis (OA) is the most common chronic joint condition worldwide, predominantly affecting the knee joint (1). The public health impact of OA is increasing significantly due to lengthening life expectancy, which leads to the aging of the global population and rising obesity rates. Knee osteoarthritis (KOA) affects the joint that bears the body's greatest weight and is closely linked with age and obesity. Symptomatic KOA affects a total of 14 million people in the United States (2) and approximately 23% of adults aged over 40 worldwide. The total number of individuals with KOA is estimated to be over 600 million (3). Previous knee injuries and a family history of osteoarthritis are risk factors linked to KOA, especially in women (4). Patients with KOA face higher mortality rates, largely due to limitations in physical activity. There is currently no treatment that can completely cure or resolve the condition permanently. The first-line approach for managing KOA typically involves patient education, physical exercise, and, if required, weight loss, proceeding to utilize systemic medications and intraarticular injections.

In addition to lifestyle changes and pharmacological therapies such as symptomatic slow-acting drugs for osteoarthritis (SYSADOA) (e.g., cartilaginous matrix precursors [glucosamine, chondroitin sulfate, and hyaluronic acid] and cytokine modulators [diacerein]) and disease-modifying osteoarthritis drugs (DMODA) (e.g., teriparatide, zoledronic acid, denosumab, vitamin D, methotrexate, hydroxychloroquine, etanercept, tocilizumab, liraglutide, bisphosphonates, metformin, and GLP-1 agonists), a personalized approach to managing weight is anticipated to enhance the outcomes for OA patients (5).

Intraarticular injections are used to manage joint conditions by reducing inflammation, improving lubrication, or promoting tissue repair. Substances used in these injections include a variety of options, such as corticosteroids, hyaluronic acid, prolotherapy, platelet-rich plasma (PRP), and adipose-derived mesenchymal stem cells.

Radiofrequency (RF) ablation of the genicular nerves is a therapeutic procedure used to manage chronic knee pain that has not responded to conservative treatments such as medications, physical therapy, or injections. This technique involves using heat generated by RF waves by producing thermal lesions to disrupt transmission of nociceptive signals from the genicular nerves, providing relief for patients with persistent pain. Genicular nerves are usually proposed targets for RF ablation in patients with KOA (6). Intraarticular pulsed RF (IAPRF), which delivers high-voltage pulsed currents directly into the joint space, is a simpler and more straightforward procedure to perform than genicular pulsed radiofrequency (PRF) and another option in reducing pain caused by KOA (7,8). Evidence indicates that intraarticular bipolar pulsed RF (IA-bPRF) may be more effective than unipolar IA-PRF in improving functional recovery and alleviating chronic pain in patients with KOA (7).

The optimal interventions that constitute nonsurgical treatment of KOA pain remain uncertain (9). As far as we know, no clinical studies have yet evaluated the long-term analgesic effects of IA-bPRF and genicular RF thermocoagulation (G-RFT) when those interventions are used to target the superolateral, superomedial, and inferomedial genicular nerves. For several years, we have used both G-RF ablation and IA-bPRF as effective treatments for KOA-associated chronic pain in our practice.

Given the unresolved question of which nonsurgical modality ameliorates chronic KOA pain most effectively, a direct comparative evaluation of G RFT and IA bPRF is both necessary and timely. These 2 techniques diverge fundamentally in their therapeutic mechanisms and procedural execution, suggesting potential differences in analgesic onset, duration, and safety profiles, and thus warrant systematic comparison (8).

Although separate meta analyses and systematic reviews have established the efficacy and safety profiles of G-RFT and PRF interventions individually, no prospective, head to head trials or longitudinal studies currently compare these techniques directly (10,11).

Furthermore, leading clinical practice guidelines, including the National Institute for Health and Care Excellence's interventional procedures guidance and the American Academy of Orthopedic Surgeons' KOA guidelines, advocate RF denervation for refractory knee pain but do not differentiate between nerve targeted and intra articular approaches (12,13).

Our institution's repository of multi year, real world outcomes for both modalities provides an ideal foundation for a retrospective cohort analysis that is more time and cost efficient than initiating a new randomized trial, while still capturing long term pain scores, functional measures, and adverse event rates (14).

Such comparative effectiveness research stands to refine patient specific treatment algorithms, optimize the utilization of health care resources, and ultimately enhance patient satisfaction in KOA management. By conducting this retrospective cohort analysis, we will directly address a critical knowledge gap—namely, the absence of comparative data on 2 increasingly utilized, mechanistically distinct RF interventions—thereby empowering clinicians and patients to make evidence-based choices in the management of KOA pain (15).

Methods

A single pain specialist at the pain clinic of a state hospital examined all patients and made diagnoses. After the acquisition of informed consent from the patients, the interventions were carried out by that same physician. The medical records of patients who underwent these interventions between September 2021 and February 2024 were reviewed independently by a physician who was not involved in the diagnosis and treatment process.

To be included in the study, patients had to meet the following requirements:

- Having been diagnosed with KOA according to the criteria established by the American College of Rheumatology (ACR)—pain in the knee and at least 3 of the following: age over 50 years, morning stiffness of less than 30 minutes, crepitus on active motion, bony tenderness, bony enlargement, and no palpable warmth of synovium.
- Presenting with KOA from grades 2 to 4, as classified by the Kellgren-Lawrence (KL) radiological grading system (16).
- Not having consented to knee joint replacement.
- Having presented no or inadequate response to conservative treatments that were utilized for at least 6 months, thus being defined as those with less than a 20% improvement in their Lequesne Algofunctional Index for Knee (LAI-knee) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores (17,18).

The following criteria were employed for exclusion from the study:

- Presenting with KOA of KL grade 1
- Having general contraindications to invasive interventions
- Having received previous RF treatment
- Having opioid dependence or opioid use disorder
- Having a psychiatric disorder
- Having OA because of inflammatory rheumatological disease
- Receiving physical therapy, intraarticular injections, or other procedures during the follow-up period
- Using gabapentinoids, opioids, or antidepressants during the follow-up period

A total of 86 patients were found eligible and enrolled in the study. All patients were provided with detailed information about the procedures, and written informed consent was obtained prior to the planned interventions. In our clinical setting, IA-bPRF is preferred for patients with contraindications to nerve ablation, distorted genicular anatomy, or post-surgical changes, while G-RFT is selected for patients who have focal pain correlating with genicular nerve distribution. Some patients prefer to avoid nerve ablation procedures, while others are reluctant to undergo intraarticular interventions and consent to alternative procedures instead, constituting another factor for choice of procedure. Data on age, gender, duration of symptoms, KL grade, and laterality of the affected knee were collected. The interventions were performed by a single specialized pain physician under local anesthesia in the same pain clinic setting.

Pain levels were assessed using the numeric rating scale (NRS). The severity of KOA and patient functionality were assessed using the LAI-knee and WOMAC metrics (17,18).

The LAI-knee is a disease- and joint-specific questionnaire structured in an interview format. It consists of 3 sections designed to assess pain, function, and disability related to knee conditions. The first section includes 5 questions focused on pain or discomfort, the second section measures the patient's maximum walking distance, and the third section evaluates functional abilities or daily living activities through 4 specific items (17).

The WOMAC is a well-established, self-administered questionnaire valued for its validity and reliability. It consists of 24 items divided into 3 subscales: pain, stiffness, and physical function (18). In this study, a validated version of WOMAC 3.1, translated into the patients' native language, was employed (19).

After thorough povidone-iodine preparation, sterile draping, and adherence to standard gown and glove protocols, the patients were placed in a supine position for IA-bPRF. Each patient's knee was then flexed prior to cannula insertion. The patellofemoral space was localized by palpating the lateral patellar border while medial pressure was applied to the patella. At the midpoint of the medial border, 2 mL of 0.5% lidocaine was infiltrated to achieve local anesthesia at the access points of the RF cannulas on both the medial and lateral sides of the patellar ligament, aligning with the genicular joint space. An anteroposterior image of the knee joint was obtained by using fluoroscopy. Then 21-gauge RF electrode cannulas (TOP Neuropole® Needle, TOP Corporation), 6 cm long with 5 mm active tips, were selected to ensure adequate lesioning while minimizing procedural discomfort and intraarticular trauma. To avoid damage to intraarticular structures such as the anterior cruciate ligament, posterior cruciate ligament, or menisci, the RF cannulas were inserted into the patellofemoral recess between the patella and femoral condyles from the medial and lateral sides of the tibiofemoral joint anterior to the intercondylar notch, near the patellar ligament, under fluoroscopic guidance (Fig. 1). Proper intraarticular placement was confirmed by injecting a small volume of sterile saline: unobstructed flow and joint distension indicated correct positioning, whereas resistance—suggesting ligamentous, tendinous, or osseous contact—prompted withdrawal and redirection of the cannula until smooth saline injection was achieved. The cannulas were guided carefully to the midpoint between the epicondyles in the transverse plane (Fig. 2). Correct intraarticular placement was confirmed by injecting a radiocontrast agent and verifying its distribution using fluoroscopy. The tips were placed approximately 10 mm apart from each other in the articular space. After correct positioning of the cannulas, pulsed RF (bPRF) was administered for a duration of 360 seconds, utilizing an RF generator device (TOP Lesion Generator TLG-10) at a temperature of 42°C and a voltage of 45 V, with a pulse width of 20 milliseconds and a frequency of 2 Hz.

For G-RFT, the patients were also placed in a supine position. A high-frequency linear probe (11L-D, Voluson™ E6, GE HealthCare) was placed parallel to the long bone shaft with ultrasound guidance. The probe went caudally and cranially on the medial and lateral parts of the knee in the superior area and on the medial part of the knee in the inferior area (Figs. 3,4) . After the placement of a 21-gauge, 6 cm RF cannula with a 5 mm active tip (TOP Neuropole® Needle, TOP Corporation), parallel to targeted genicular nerves, sensory stimulation was applied at 50 Hz and 0.5 V to determine whether the patient felt pain, tingling, or discomfort around the knee. Consequently, 2 V motor stimulation was applied at a frequency of 2 Hz to determine the absence of fasciculation. The RF procedure was applied separately to each genicular nerve in lesion mode for 90 seconds at 80°C.

The patients were assessed during follow-up visits scheduled for the fifteenth day, second month, and sixth month after the procedures by a pain physician. Additionally, follow-ups were carried out by telephone to extend further assistance and support. Baseline NRS, LAI-knee, and WOMAC scores were provided. The scores were reassessed, and any side effects or complications,

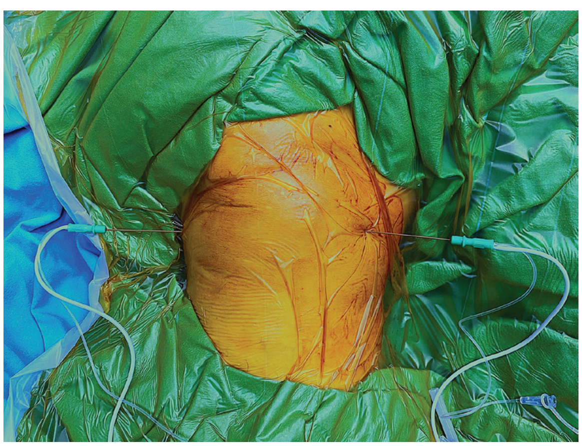

Fig. 1. *After the clinician performs a full sterile preparation of the knee with povidone-iodine and applies sterile drapes, RF cannulas are advanced under fluoroscopic guidance into the genicular articular cavity via the medial and lateral sides of the patellar ligament. The tips are positioned against the femoral condyles and tibial plateau for optimal nerve targeting.*

Fig. 2. *Anteroposterior fluoroscopic view illustrating the final position of the RF cannulas placed bilaterally into the intraarticular cavity of the knee joint, confirmed by radiocontrast injection.*

such as sensory or motor deficits, were evaluated and recorded during the follow-up evaluations.

The study was conducted following approval from the Mersin University Ethical Board of Clinical Research (dated May 22, 2024; Approval Number: 2024-458) and was designed as a retrospective, noncontrolled investigation.

Statistical Analysis

IBM SPSS Statistics Version 23.0 (IBM Corporation) was used to analyze the data. One sample Kolmogorov-Smirnov test was used to evaluate normal distribution of the data. Demographic information, the existence of coexisting medical conditions, and pre-procedural assessments were examined using descriptive statistical analysis. The patients were divided into 2 groups based on their treatment procedures: the G-RFT group and the IA-bPRF group. In the analysis of the effects of intervention and time, the repeated-measures ANOVA test was used for parameters that exhibited a normal distribution. Qualitative or categorical data are presented as numerical counts and/or percentages (%). Numerical variables are expressed as mean ± standard deviation (x ± SD) or mean ± standard error (x ± SE), and, where relevant, as minimum to maximum values. A *P*-value of less than 0.01 was considered statistically significant.

Results

Demographic Features

The mean age of the patients was 67.48 ± 10.46 years in the IA-bPRF group and 66.11 ± 10.03 years in the G-RFT group. Most of the patients in both groups were female. Group IA-bPRF consisted of 42 patients. IA-bRF was applied to a total of 73 knees, bilaterally, in 31 patients. Group G-RFT consisted of 44 patients. Intraarticular G-RFT was applied to a total of 77 knees, bilaterally, in 33 patients. KL grades were higher in the IA-bPRF group (Table 1).

Pain and Functional Scores

Between the groups, NRS scores for walking pain were similar before the interventions and decreased eventually afterward. Mean pain scores decreased from 8.62 ± 1.01 to 3.81 ± 2.18 in the IA-bPRF group and from 8.90 ± 1.20 to 5.25 ± 3.40 in the G-RFT group by the end of the sixth month. A statistically significant reduction over time was observed in both groups ($P < 0.01$), but no significant differences were found between them (Table 2).

Fig. 3. *After the clinician performs a full sterile preparation of the knee with povidone-iodine and sterile drapes, 3 RF cannulas are advanced under image guidance to lie parallel and adjacent to the superior medial, inferior medial, and superior lateral genicular nerves.*

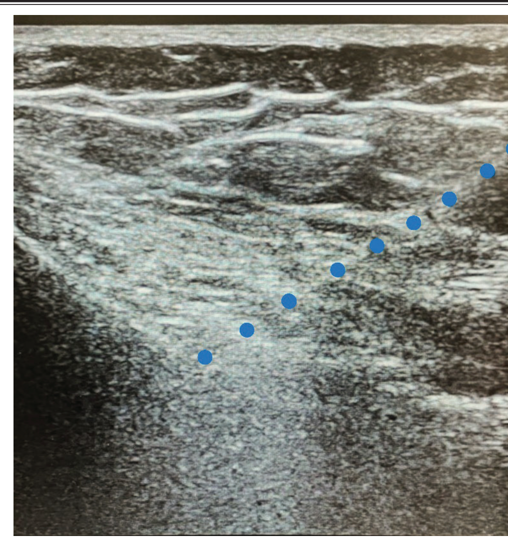

Fig. 4. *Longitudinal ultrasonographic image illustrating the inferior medial genicular nerve. Blue points display the needle.*

At the sixth month after the intervention, WOMAC scores decreased from 75.83 ± 16.00 to 34.21 ± 23.12 in the IA-bPRF group and from 79.02 ± 14.73 to 48.43 ± 30.87 in the G-RFT group (Table 2). No statistically significant differences were observed in the total WOMAC scores or in the pain and stiffness subscale scores among patients with varying KL grades. However, after the intervention, the IA-bPRF group showed slightly lower WOMAC physical function scores than did the G-RFT group(P = 0.041) (Table 3). While the physical function score decreased from 55.0 to 25.67 in the IA-bPRF group, it decreased from 58.07 to 36.32 in the G-RFT group. In the IA-bPRF group, patients experienced greater decreases in pain when walking on flat surfaces (P = 0.033) and when going up and down stairs (P = 0.033). There was no difference between the groups in night pain (P = 0.206) and increased walking distance (P = 0.256).

LAI-knee scores decreased from 18.64 ± 4.16 to 9.90 ± 5.78 in the IA-bPRF group and from 18.89 ± 3.84 to 12.55 ± 7.33 in the G-RFT group (Table 2). No statistically significant differences in the LAI-knee scores or any of the questionnaire's sub-scores were found between the groups (Tables 3,4). We observed no complications, including thermal injury, infection, hemorrhage, or worsening of prevailing symptoms.

Table 1. *Demographic characteristics and initial status of the knee joints of the patients.*

		Intraarticular PRF (n = 42)	Genicular RFT (n = 44)	Significance*
Age	Years (Mean ± SD)	67.48 ± 10.46	66.11 ± 10.03	P = 0.539
Gender	Male / Female (frequency)	9/33	17 / 27	P = 0.084
Right Knee KL Grade	Mean ± SE	3.26 ± 0.70	2.90 ± 0.78	P = 0.042
Left Knee KL Grade	Mean ± SE	3.35 ± 0.80	2.95 ± 0.80	P = 0.030
Upmost KL Grade	Mean ± SE	3.48 ± 0.59	3.00 ± 0.81 *	P = 0.003
Aspect of RF	Number (Unilateral/ Bilateral)	11 / 31	11 / 33	P = 0.901

*Genicular RFT group compared to intraarticular bipolar pulsed radiofrequency group.
SD: standard deviation, SE: standard error of mean, KL: Kellgren-Lawrence classification, RFT: radiofrequency thermocoagulation

Table 2. *Results of the patients' algofunctional evaluations.*

		GROUP		
		Intraarticular PRF	Genicular RFT	Significance*
NRS Score	Pre-intervention	8.62 ± 1.01	8.90 ± 1.20	P = 0.124
	Second week after intervention	4.33 ± 2.28#	4.61 ± 3.14#	
	Sixth month after intervention	3.81 ± 2.18#	5.25 ± 3.40#	
WOMAC Score	Pre-intervention	75.83 ± 16.00	79.02 ± 14.73	P = 0.061
	Second week after intervention	36.95 ± 24.43#	45.27 ± 29.79#	
	Sixth month after intervention	34.21 ± 23.12#	48.43 ± 30.87#	
LAI Knee Score	Pre-intervention	18.64 ± 4.16	18.89 ± 3.84	P = 0.225
	Second week after intervention	10.14 ± 5.87#	11.32 ± 6.83#	
	Sixth month after intervention	9.90 ± 5.78#	12.55 ± 7.33#	

Mean ± standard deviation (x ± SD), NRS: patients' numeric rating scale pain scores, LAI-knee: Lequesne Algofunctional Index for Knee, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index
*When intraarticular PRF and genicular RFT groups are compared.
# $P < 0.001$: effect of intervention within time (repeated-measures ANOVA).

Discussion

OA is a chronic degenerative condition marked by subchondral bone changes and the deterioration of articular cartilage, ultimately leading to impaired joint function. The global prevalence of OA has been increasing over time (20). In a comprehensive 2020 systematic review and meta analysis of 88 population based studies, Cui et al (21) estimated the pooled global prevalence of KOA at 16.0 % among individuals aged ≥ 15 years, a figure that rose to 22.9 % in those aged ≥ 40 years. In 2021, another comprehensive study conducted by Nelson et al (22) reported that prevalence rates were 18.7% in women and 13.5% in men. Gonarthrosis is generally more prevalent in women, which explains the higher proportion of female patients in our study (23).

The evaluation of the knee joint usually includes a weight-bearing x-ray taken with the knee fully straightened, allowing the patient to stand evenly on both legs. Radiography continues to be the simplest and most straightforward method for evaluating the joints of OA patients, although imaging techniques are improving. This assessment consists of the evaluation of osteophyte formation and reduction of the joint space, using the 5-grade KL classification scheme (24). In our research, 22 patients in the IA-bRF group and 12 patients in the G-RFT group had KOA of KL grade 4. Our findings indicate that RF treatment can still be effective even at this advanced stage of the condition. The significant decrease in NRS scores experienced by both groups after the RF applications suggests that RF may serve as an alternative to surgery. While there was no statistically significant difference between the groups' NRS scores, the IA-bRF group experienced a greater reduction than did the G-RFT group. This improvement is noteworthy when evaluating the enhancement of patients' quality of life.

Table 3. ***WOMAC sub-scale scores.***

		GROUP		
		Intraarticular PRF	**Genicular RFT**	**Significance***
WOMAC Pain	Pre-intervention	15.29 ± 3.92	15.68 ± 3.96	$P = 0.156$
	Second week after intervention	7.05 ± 4.98#	8.36 ± 6.03#	
	Sixth month after intervention	6.40 ± 4.67#	8.82 ± 6.31#	
WOMAC Stiffness	Pre-intervention	5.55 ± 2.47	5.27 ± 2.61	$P = 0.265$
	Second week after intervention	2.29 ± 2.20#	3.05 ± 2.65#	
	Sixth month after intervention	2.14 ± 2.04#	3.30 ± 2.76#	
WOMAC Physical Function	Pre-intervention	55.00 ± 10.97	58.07 ± 9.84	$P = 0.041$
	Second week after intervention	27.62 ± 17.85*#	33.86 ± 20.98*#	
	Sixth month after intervention	25.67 ± 17.02*#	36.32 ± 22.36*#	

Mean ± standard deviation (x ± SD).
*When intraarticular PRF and genicular RFT groups are compared.
# $P < 0.001$: effect of intervention within time (repeated-measures ANOVA).
WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Table 4. ***LAI-knee subscale scores: pain, maximum distance walked, and difficulties of daily life.***

		GROUP		
		Intraarticular PRF	**Genicular RFT**	**Significance***
Pain or discomfort	Pre-intervention	7.00 ± 1.51	7.05 ± 1.49	$P = 0.167$
	Second week after intervention	3.48 ± 2.33#	4.11 ± 2.61#	
	Sixth month after intervention	3.38 ± 2.33#	4.48 ± 2.80#	
Maximum distance walked	Pre-intervention	4.69 ± 1.77	4.98 ± 1.53	$P = 0.256$
	Second week after intervention	2.88 ± 1.98#	3.14 ± 2.05#	
	Sixth month after intervention	2.69 ± 1.87#	3.45 ± 2.14#	
Difficulties in daily life	Pre-intervention	6.95 ± 1.65	6.86 ± 1.68	$P = 0.409$
	Second week after intervention	3.79 ± 2.30#	4.07 ± 2.58#	
	Sixth month after intervention	3.83 ± 2.29#	4.61 ± 2.79#	

Mean ± standard deviation (x ± SD).
* $P > 0.05$: when intraarticular PRF and genicular RFT groups are compared.
# $P < 0.001$: effect of intervention within time (repeated-measures ANOVA).
LAI-knee: Lequesne Algofunctional Index for Knee.

OA is one of the leading causes of physical disability and impairment in activities of daily life among senior adults. The condition is also a major public health problem throughout the world. Park et al (25) found that KOA was linked to impaired mental health and a lower health-related quality of life in Korean men and women. These patients experience restricted movement, difficulty with personal care and daily activities, and high levels of pain and anxiety, which may lead to depressive moods and, consequently, further thoughts of suicide. This finding emphasizes the importance of enhancing the quality of life in management of OA. Indications for knee arthroplasty include pain that cannot be managed with conservative treatments, functional constraints, and a KL grade of 3 or higher on radiographs (26). While age is often considered a risk factor for developing OA, our study included 5 patients under the age of 50 and 36 patients under 65. In patients under 65, a total number of 67 knees were intervened upon, 15 knees were classified as grade 4, and 37 were classified as grade 3. Given the increased risk of complications and odds of revision surgery, it is more reasonable to manage pain with minimally invasive techniques, such as RF procedures, which may be considered as appropriate options for younger patients. Furthermore, patients with KOA have a greater rate of falling than the general population, with annual fall rates reaching up to 50% for those with KOA and 63% for those with severe KOA (27). Even though total knee arthroplasty usually reduces the pain of and amends joint deformities in KOA, some patients may still experience falls. Therefore, RF treatment should be kept in mind as an alternative to surgery in patients who do not respond to conservative treatment. Research indicates that RF therapy may serve as an effective approach for reducing KOA-linked pain (28). This approach is particularly noteworthy for patients who have not seen adequate improvement with standard treatments or for those who prefer to avoid total knee replacement surgery. While intraarticular human mesenchymal stem cells and PRP have shown promise, they are not suitable for all patients, such as those with malignancies, making RF a potentially advantageous option. Nevertheless, the most effective treatment technique using RF has not yet been clearly established. A recent meta-analysis comparing 3 RF ablation techniques—conventional, pulsed, and cooled RF—found all methods effective for treating KOA, with no significant differences in outcomes (14). Another meta-analysis indicated that intraarticular RF ablation produced similar improvements in knee pain and function to genicular RF ablation in pulsed mode (29). These effects may result from neuromodulation and the suppression of inflammatory cytokines in the knee joint.

Neuropathic pain is accompanied by a marked upregulation of proinflammatory mediators, notably interleukins (e.g., IL 1β, IL 6) and tumor necrosis factor alpha (TNF α) (30). In a chronic constriction injury model, Jiang et al (31) administered PRF to either the L5 DRG or the sciatic nerve in rats and reported significant reductions in both mechanical allodynia and thermal hyperalgesia, along with decreased peripheral concentrations of IL 1β and TNF α. These findings indicate that PRF exerts an anti inflammatory effect that correlates with improved pain behaviors.

In vitro studies using human keratinocytes and fibroblasts confirm that PRF fields induce a significant increase in the expression of opioid precursor genes that encode proenkephalin, proopiomelanocortin, and prodynorphin, and peptide release, suggesting a dual immunomodulatory and neurochemical mechanism underlying PRF's long lasting analgesic effects (32). This induction of endogenous opioid gene expression suggests that PRF contributes to analgesia not only by dampening inflammatory cytokine activity but also by promoting local synthesis of natural opioid ligands.

The combined reduction in proinflammatory cytokines and elevation of endogenous opioids provides a dual mechanism by which PRF exerts prolonged analgesia without causing neurodestructive thermal lesions. Reviews of PRF's mechanistic underpinnings corroborate these findings, highlighting its capacity to modulate inflammatory mediators, cellular signaling proteins, and gene expression profiles relevant to pain transmission (33,34).

PRF in particular is regarded as a trustworthy and dependable choice for treating KOA. This technique has been demonstrated to reduce clinical symptoms effectively and decrease levels of inflammatory markers, such as IL-1, TNF-α, and MMP-3, in the synovial fluid (35). Although the understanding of the physiological basis of IA-bPRF remains incomplete, it is hypothesized that neuromodulatory effects, suppression of inflammatory cytokines, and changes in local microenvironment play a role in the treatment's analgesic effect.

Early clinical investigations into intraarticular pulsed radiofrequency for KOA demonstrate progressive improvements in pain relief over time. Sluijter et al (36) first applied PRF for intractable arthrogenic pain and achieved durable analgesia out to 10 months. In 2011, a retrospective review by Karaman et al (7) showed that 35.5% of KOA patients attained at least a 50% reduction in VAS scores 6 months after intraarticular PRF. In a monopolar RF setup, the electrical current flows from the active tip of one electrode to a distant separate grounding pad placed elsewhere. It has been suggested that bipolar PRF (bPRF) may be more effective than monopolar PRF due to the former's ability to generate denser and larger electrical fields. Using PRF directly within the knee joint is a promising and effective method for managing chronic pain associated with KOA. In contrast, the current in a bipolar setup flows directly between 2 electrode tips that are placed near each other (37). Güleç et al (38) conducted a randomized, double blind trial comparing bipolar versus unipolar PRF; at 3 months, 84% of the patients in the bipolar arm experienced ≥ 50% pain reduction, compared with only 50% of the patients in the unipolar group. The effect was attributed to the larger electrical field generated by bipolar electrode configurations. However, the absence of a sham-controlled arm in the study design precludes definitive attribution of the analgesic effects to the intervention itself, since a placebo response cannot be excluded.

In a study by Aly et al (39), intraarticular monopolar RF effectively reduced WOMAC scores and relieved pain. However, the RF duration was 15 minutes, and the patient group consisted of individuals whose KOA was classified as KL grades 2 and 3. In contrast, we used bipolar RF, applied it for only 6 minutes, and included patients with grade 4 OA as well, demonstrating effectiveness even in more advanced cases.

Hong et al compared genicular RF, intraarticular monopolar RF, and intraarticular steroid injections in patients with grade 2 and 3 gonarthrosis (40). Both RF groups showed better NRS scores at the third- and sixth-month marks than did the steroid group, though there was no difference between the 2 RF groups. The effect of the steroids lasted for a shorter duration than did that of RF. As for Oxford Knee Scale scores, the genicular RF group outperformed the other 2 groups at 3 and 6 months. In our study, the greater success of intraarticular RF can be attributed to the use of bPRF. Additionally, our study included patients with grade 4 OA.

The WOMAC index is a reliable and reproducible tool for assessing the clinical severity of OA, measuring the degree of impairment caused both by pain and by functional limitations (18,19). The LAI-knee is a validated scale that is also widely used to evaluate severity of KOA (12,41). Both indices were presented in the patients' native language, ensuring clarity and comprehension, and were been validated for use (17-19). While the WOMAC is designed primarily to evaluate the overall clinical severity of OA, focusing on pain, stiffness, and physical function, LAI-knee focuses specifically on functional disability caused by OA, especially in weight-bearing knee joints. LAI-knee emphasizes the "algofunctional" aspect, which combines pain and functional impairment. In our study, a decrease was observed in both groups' WOMAC and LAI-knee indices after the employed interventions. Although there is no statistical difference between the groups' total scores, an assessment of the subgroups of WOMAC scoring reveals differences in physical function. Additionally, the IA-bPRF patients experienced a greater reduction in pain while walking on flat surfaces and climbing stairs. We noticed a steady improvement in pain and function scores among patients with varying levels of KOA severity, suggesting that IA-bPRF could be a suitable treatment option for those who were not yet candidates for knee replacement surgery. IA-bPRF may serve as a practical alternative for patients seeking to avoid surgical intervention and opt for minimally invasive therapies. Earlier research demonstrates evenly that PRF is effective in managing knee pain, implying that this therapy may be a dependable choice for reducing pain experienced by patients with KOA (42). Nevertheless, it is crucial to validate the clinical effectiveness of IA-bPRF by carrying out further randomized controlled trials with larger sample sizes and a control arm, possibly including sham procedures or standard care comparators that are carefully planned and structured to ensure their reliability and accuracy.

Limitations

Our study is subject to several limitations. Primarily, there is a paucity of extensive literature regarding the application of IA-bPRF for KOA. Additionally, our study's sample size is relatively small. This study was conducted at a single center and was retrospective in nature rather than prospective and randomized, making it challenging to fully control for nuisance variables. Another limitation is the absence of a sham or medical treatment control group, which limits the ability to distinguish between true analgesic effects and placebo response. These factors may constrain the external validity of our findings. Moreover, since PRF ablation is not reimbursed by many Western health care systems, the generalizability of these findings may be constrained by insurance coverage limitations.

Conclusions

This study highlights that IA-bPRF technique is a more effective therapeutic option compared than G-RFT for the treatment of knee pain secondary to KOA. Furthermore, this study evaluates and compares 2 RF techniques commonly employed in our clinical practice to help guide treatment selection for patients with advanced cases of this condition. While the anatomical targets differ, both techniques aim to reduce chronic pain and improve function. IA-bPRF has the potential to reduce knee pain, improve joint function, and enhance the overall quality of life for patients suffering from painful KOA. No serious side effects or complications linked to the procedure were observed. As a result, IA-bPRF may be seen as a promising treatment for chronic knee pain in patients who have not benefited from standard osteoarthritis therapies, are not candidates for surgery, or wish to avoid surgical intervention. IA-bPRF may also be utilized for patients with advanced-stage cancer on whom certain procedures may not be feasible.

Data Availability

After acceptance, the corresponding author of the accepted research article will submit the datasets underlying the results of this paper to the editorial office.

Author Contributions

ÇY: Conceiving, designing the study, collecting data, editing, and approving the final manuscript.

MAS: Conceiving, designing the study, analyzing the data, writing, editing, and approving the final manuscript.

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