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Original Research Article

Effectiveness of the Cooled Radiofrequency Ablation of Genicular Nerves in Patients with Chronic Knee Pain

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Abstract:

Background: Multiple modalities are existing for chronic knee pain management. Genicular nerve neurolysis/Rhyzotomy and intra-articular steroid injection (IASI) are available treatment options for patients with knee osteoarthritis. There is increasing evidence supporting the effectiveness of cooled radiofrequency ablation (RFA) in treating genicular nerves for patients with chronic knee osteoarthritis (OA). This study aims to compare the efficacy of cooled RFA with that of intra-articular steroid injection (IASI) in patients with knee pain caused by OA.

Aims and Objectives: The primary objective of this observational, prospective study was to evaluate the long-term outcomes, including pain, function, and perceived effect of treatment, in subjects undergoing cooled radiofrequency ablation (CRFA) who have pain due to osteoarthritis (OA) of the knee.

Methods: The prospective observational type of study was carried out on thirty patients with Kellgren–Lawrence grade 2–4 knee OA in the department of Anaesthesiology at Gandhi Medical College Bhopal after the approval of Institutional Ethics Committee of our hospital. The patients were assigned into 2 groups randomly as IASI (N=15) and CRFA (N=15) group. All the patients were evaluated with Visual analogue score (VAS) for pain intensity and Western Ontario and Mc Master Universities Osteoarthritis Index (WOMAC) for functional status of the patients. All assessments were measured and compared at baseline, 1 month, 3 month and 6th month after treatment. Furthermore, patient satisfaction was also recorded.

Results: All evaluation parameters were significantly improved in IASI and CRFA groups. Both VAS and WOMAC score of CRFA group were significantly lower than VAS and WOMAC score of IASI group during all the intervals of time ($p<0.001$). Satisfaction grades did not differ between the two groups.

Conclusions: Cooled radiofrequency ablation (CRFA) of the genicular nerve and intra-articular steroid injection (IASI) are potential treatments for knee joint pain in osteoarthritis. However, CRFA provides better pain relief and enhances functional capacity in patients with knee joint pain from osteoarthritis compared to IASI.

Keywords: Knee, Osteoarthritis, Intra-articular, Steroid, Triamcinolone, Genicular nerve, Cooled Radiofrequency ablation.

Introduction

Knee osteoarthritis (OA) is a progressive degenerative condition of the knee joints, commonly diagnosed in individuals aged 50 and older [1]. Due to the aging population, the lifetime prevalence of knee OA is rising, affecting millions worldwide [2]. Knee OA is a leading cause of knee pain, which can severely impact an individual's quality of life, leading to reduced physical activity, disability, poor sleep, and depression [1].

Conservative treatments are typically used to manage knee pain caused by OA before considering total knee arthroplasty. These treatments include non-pharmacological options such as exercise programs and weight management, as well as pharmacological treatments like topical non-steroidal anti-inflammatory drugs, oral analgesics, and intra-articular injections of steroids or hyaluronic acid [1,3]. However, these measures areoften insufficient in relieving knee pain or may not be feasible due to adverse effects [3].

Radiofrequency ablation (RFA) of genicular nerves was introduced in 2010 as an effective alternative to conservative treatments [4,5]. Recently, the development of cooled RFA, which uses a controlled cooling system, has emerged as a more advanced technique. The cooling mechanism helps minimize damage to surrounding structures and increases the size of the lesions, potentially enhancing both the safety and effectiveness of the procedure. These advantages have led to the growing use of cooled RFA for genicular neurotomy [6,7]. Additionally, there is increasing evidence supporting the clinical effectiveness of cooled RFA targeting genicular nerves in treating knee OA [8]. Therefore, the aim of this study was to assess the effectiveness of cooled RFA of genicular nerves in comparison to IASI in patients with chronic knee pain caused by OA.

Materials and Methods

Study Design and Participants: An observation type of study was conducted at the pain clinic in the Department of Anaesthesiology at Gandhi Medical College, Bhopal Madhya Pradesh. Prior to the study, a power analysis was performed by a statistician and it is confirmed that the number of the participants was suitable for the study. The study received approval from our institutional Ethics Committee, and written informed consent was obtained from each participant. Participant privacy and confidentiality were maintained throughout the study.

Participants: Patients with unilateral chronic knee pain due to osteoarthritis (OA) who visited the pain clinic at our centre between May 2024 and October 2024 were screened for eligibility.

The inclusion criteria were as follows: degenerative knee OA of Kallgren–Lawrence grades II–IV, confirmed by radiographic examination; persistent knee pain for at least six months despite conservative treatments such as physiotherapy, exercise therapy, or analgesics; age between 50 and 80 years; a pain intensity score of ≥6 (out of 10) on the Visual analogue score (VAS) (0 = no pain, 10 = unbearable pain); at least 50% pain relief for more than 24 hours following a diagnostic genicular nerve block with local anaesthetics under fluoroscopy or ultrasound guidance [4,9]; and patients who voluntarily consented in writing to participate in this clinical trial.

The exclusion criteria included: acute knee pain lasting less than six months; bilateral knee pain; previous knee surgery; other connective tissue diseases affecting the knee; sciatica affecting the knee; hypersensitivity to local anaesthetics or steroids; knee injections with steroids or hyaluronic acid within the past three months; coagulopathy, use of anticoagulants, or infection; and refusal to participate in the trial.

Randomization and Blinding: Patients were randomly assigned to either receive cooled RFA of the knee (cooled RFA group, n = 20) or intra-articular steroid injection (IASI group, n = 20). The randomization sequence was kept concealed throughout the study from both participants and the outcome assessor, with the exception of the physician administering the pain treatment during the procedure.

Intervention: The patient was positioned in a supine position on a fluoroscopy table with a pillow placed under the affected knee's popliteal fossa to achieve a flexion of 10–15°. The procedure was performed under sterile conditions with all aseptic precautions under routine monitoring. The targeted nerves for treatment included the superomedial, superolateral, and inferomedial genicular nerves in both groups, with the target points following a standardized approach as described in previous studies [4]. A true anteroposterior fluoroscopic view of the tibiofemoral joint was obtained to ensure an open joint space with equal-width interspaces on both sides. Once the target points were identified, the skin and subcutaneous tissues were anesthetized with 2 mL of 2% lidocaine.

The Cooled Radiofrequency Kit, which includes a 100 mm-long, 17-gauge straight RF introducer with a 4 mm active tip and an 18-gauge cooled RF probe with a saline circuit, was used for the procedure. The cannula was advanced percutaneously toward the junction between the femoral or tibial shaft and the epicondyle under fluoroscopic guidance until contact with the bony cortex was made (Figure 1). Sensory stimulation at < 0.6 V at 50 Hz was performed to confirm nerve location, followed by motor stimulation at 2.0 V at 2 Hz to check for the absence of fasciculation in the corresponding lower extremity area. To anesthetize the denervation area, 2% lidocaine was injected through each introducer cannula.

In the cooled RFA group, the cooled RF electrode was inserted through the cannula, and the RF generator was activated. The electrode tip temperature was increased to 60°C for 90 seconds, creating one RFA lesion for each genicular nerve. After the procedure, 2 mL of 1% lidocaine and 5 mg of triamcinolone were injected into each treated site. In other IASI group of participants, a volume of 2-3 ml 2% lignocaine and intra-articular triamcinolone 40 mg was injected with a 22 G needle from the superior medial aspect of the knee in supine position with 30 degree flexion at knee joint.

Following the procedure, all patients were instructed to maintain their current medications for knee OA, with only minimal adjustments to medications and physiotherapy allowed during the follow-up periods. The procedures were performed by a pain physician,

and patients were kept unaware of the type of treatment they received.

Outcome Measures and Data Collection: At baseline, various characteristics such as age, sex, height, weight, body mass index, and coexisting medical conditions (including hypertension, diabetes, and depression) were assessed and recorded. Data regarding the affected knee side were also collected. Outcome assessments were conducted by a blinded assessor at baseline, as well as at one, three, and six months post-procedure. Pain intensity in the affected knee was measured using the Visual Analogue Scale (VAS). Physical function was evaluated using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) [10]. Patient satisfaction and improvement were assessed using the Global Perceived Effect of Satisfaction (GPES) scale, a seven-point Likert scale (1 = worst ever, 2 = much worse, 3 = worse, 4 = no change but not worse, 5 = improved, 6 = much improved, 7 = best ever) [12].

The primary outcome was the proportion of successful responders at three months after the procedure. Successful responders were defined as those who experienced at least a 50% or four-point reduction in knee pain, as measured by the VAS, at three months post-procedure [13]. Secondary outcomes included the proportion of participants who achieved at least a 50% or four-point reduction in knee pain at one and six months, as well as changes in pain intensity (VAS), WOMAC, and GPES scores at one, three, and six months. Adverse effects such as abnormal proprioception, numbness, paraesthesia, neuralgia, motor weakness, and burns were recorded during the follow-up period. All outcomes were assessed during each outpatient visit or via telephone consultations

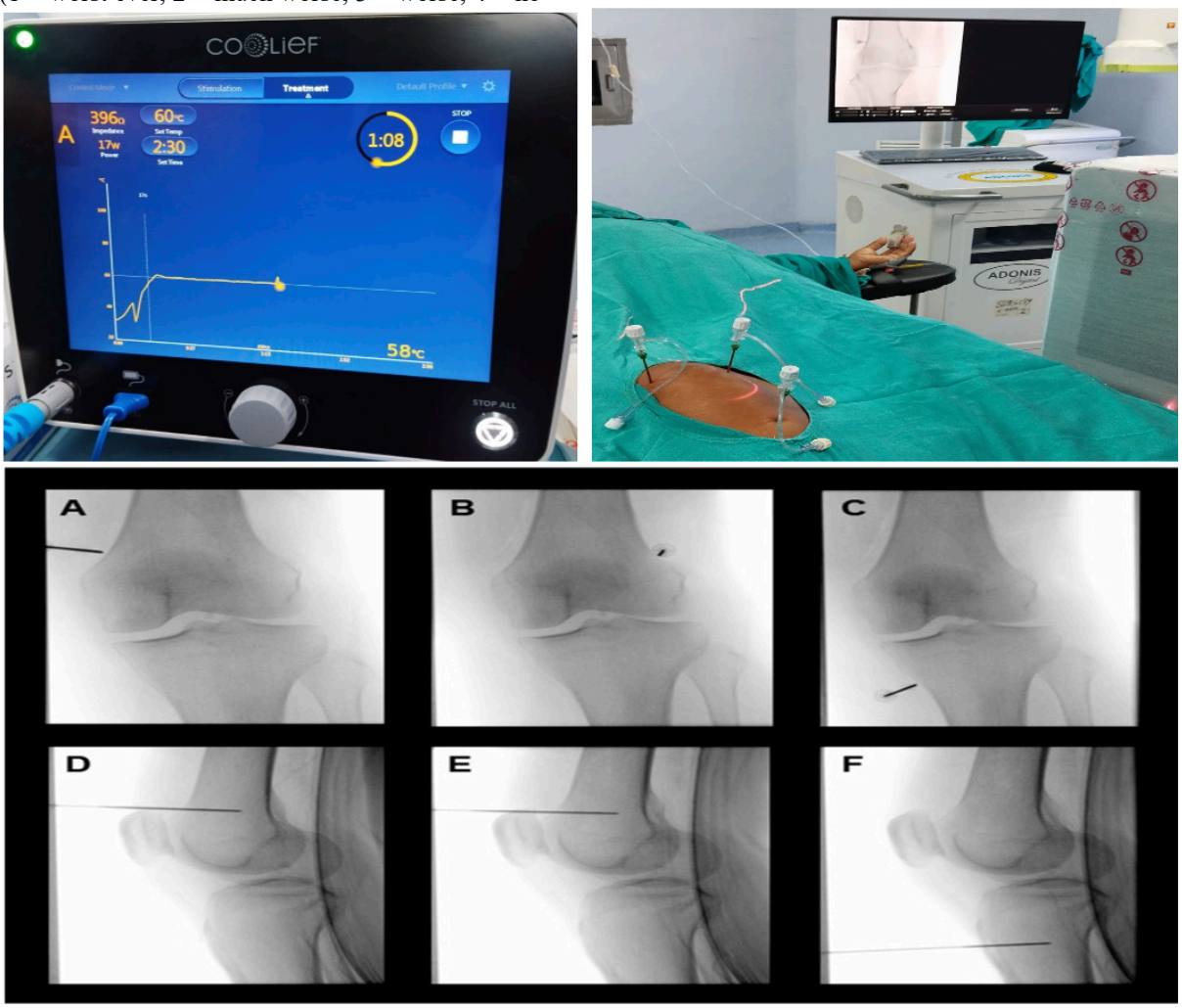

Figure 1: Representative fluoroscopic images of cooled RFA for the superomedial (A,D), superolateral (B,E), and inferomedial (C,F) genicular nerves of the left knee. Anteroposterior fluoroscopic view after cannula insertion for the placement of cooled radiofrequency electrodes into the junction between the shaft and epicondyle of the tibia and femur (A–C). Location of electrodes for the cooled RFA of genicular nerves in the lateral fluoroscopic image (D–F). RFA, radiofrequency ablation

Statistical Analysis: Data are expressed as mean ± standard deviation or number (%). Group comparisons were conducted using Student's t-test or chi-squared test, as applicable. Changes over time were assessed using the repeated measures general linear model. A p-value less than 0.05 was regarded as statistically significant.

Study Population: Between May 2024 and October 2024, a total of 36 patients with chronic knee pain due to osteoarthritis (OA) were screened for eligibility. Of these, 30 patients who met the inclusion and exclusion criteria agreed to participate in the trial. After randomization, 15 patients were assigned to each group. As shown in Table 1, there were no significant differences in the baseline characteristics between the two groups.

Table 1: Baseline characteristics of the study participants.

		CRFA Group (n=15)	IASI Group (n=15)	p
Age (years)		45.31±8.85	44.76±9.88	0.82
Gender	Male	35%	45%	0.59
	Female	65%	55%	
BMI		27±5.86	24.86±7.07	0.22
ASA	I	86%	93%	0.67
	II	14%	7%	
	III	38%	45%	0.79
	IV	62%	55%	
Osteoarthritis side	Right	59%	59%	1
	Left	41%	41%	
Durations (years)		4.48±1.18	4.1±0.9	0.18

In both groups, the total WOMAC score decreased from the baseline. However, the CRF group demonstrated significantly better scores at the 2-, 3-, and 6-month follow-up visits compared to the steroid group, suggesting that CRF may provide a longer duration of pain relief than steroids ($p < 0.001$). These results are presented in Table 2.

Table 2: WOMAC score of the patients.

WOMAC Score		CRFA Group (n=15)	IASI Group (n=15)	p
WOMAC PAIN	Basal	11.72 ± 1.907	11.34 ± 2.159	0.444
	Two weeks	7.48 ± 1.617	7.52 ± 1.214	0.927
	One month	5.90 ± 1.012	7.00 ±1.512	0.003
	Two months	5.83 ± 1.560	7.17 ±1.713	0.003
	Three months	7.00 ± 1.982	8.07 ±2.329	0.114
	Six months	7.86 ± 2.295	8.90 ±2.396	0.080
WOMAC Stiffness	Basal	2.62 ± 0.942	2.55 ± 1.152	0.840
	Two weeks	0.41 ± 0.628	0.69 ± 0.930	0.305
	One month	0.28 ± 0.455	0.45 ± 0.632	0.328
	Two months	0.14 ± 0.351	0.41 ± 0.628	0.057
	Three months	0.55 ± 0.632	0.72 ± 0.797	0.470
	Six months	1.03 ± 0.680	1.07 ± 0.961	0.980
WOMAC Function	Basal	40.76 ± 6.004	40.21 ± 3.144	0.488
	Two weeks	33.97 ± 4.395	34.52 ± 3.612	0.601
	One month	26.90 ± 4.135	27.38 ± 3.590	0.637
	Two months	23.28 ± 3.217	25.31 ± 2.316	0.002
	Three months	28.28 ± 3.239	32.48 ± 3.562	<0.001
	Six months	32.59 ± 4.005	35.31 ± 4.630	0.008
WOMAC Total	Basal	54.72 ± 5.812	53.86 ± 5.242	0.350
	Two weeks	42.24 ± 5.356	42.72 ± 4.008	0.699
	One month	33.83 ± 4.310	34.83 ± 4.132	0.371
	Two months	28.14 ± 4.397	33.93 ± 4.464	<0.001
	Three months	35.17 ± 4.833	40.48 ± 6.801	<0.001
	Six months	41.07 ± 4.114	46.17 ± 5.478	<0.001

Although VAS scores decreased from baseline in both groups, the CRF group showed significantly lower VAS scores during the last three follow-up visits ($p < 0.05$). Based on the VAS and WOMAC score results, improved patient satisfaction was anticipated during the final three visits. However, no

difference in patient satisfaction was observed between the two groups. This may be due to the improvement in scores compared to baseline, which likely had a positive impact on the patients' daily lives.

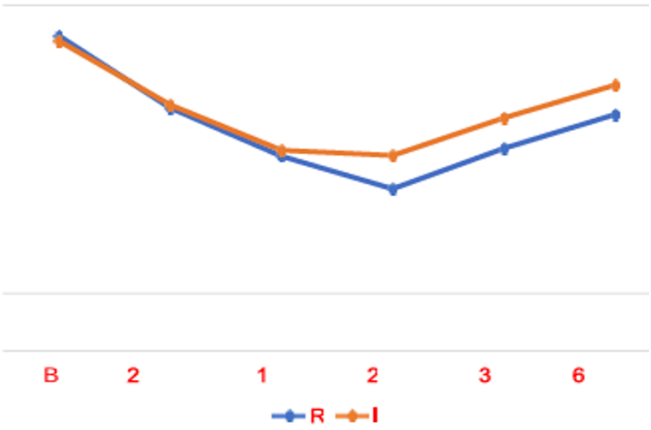

Figure 2: Total WOMAC score changes through the study period.

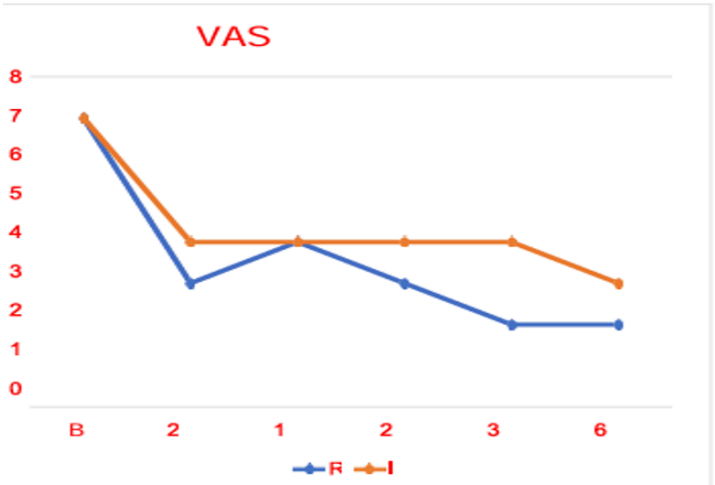

Figure 3: VAS score changes

Discussion

Osteoarthritis (OA) is the most prevalent chronic joint disease globally. Its symptoms include pain, joint dysfunction, and muscle atrophy. The knee joint, being weight-bearing, is the most commonly affected by this condition (10). Since the primary pathophysiological process of OA cannot be reversed, current treatment options, such as lifestyle modifications, physical therapy, medications, and surgery, are focused on symptom management (14). Cooled Radiofrequency (CRF) can be used to treat knee osteoarthritis in two ways: either through extra-articular ablation of the genicular nerves or intra-articular cooled radiofrequency (15, 16). This study, conducted in the department of Anaesthesiology at Gandhi Medical College Bhopal, aimed to evaluate the safety and efficacy of genicular nerve cooled radiofrequency ablation compared to intra-articular steroid injections in knee osteoarthritis patients. Unfortunately, there is a lack of studies directly comparing CRF neurotomy with intra-articular injections. A total of 30 patients were included in the study, divided into two equal groups: the CRFA group, who underwent genicular nerve CRF, and the IA group, who received steroid injections. No statistically significant differences were found between the two groups in terms of patient demographics (age, sex, BMI, and OA grade) ($p > 0.05$).

Another study on a similar topic did not report any significant differences in patient characteristics before the intervention (17), which is consistent with our study results. Our findings showed that both groups experienced a reduction in both VAS and WOMAC scores after the procedures. However, the CRFA group showed better scores, particularly at the 2, 3, and 6-month follow-ups ($p < 0.05$). Another study comparing RF with steroid injections for knee pain management also reported results similar to ours, with the RF group showing a significant reduction in both VAS and WOMAC scores at 1 and 3 months ($p < 0.001$) (17). On the other hand, another study found no significant difference between the

two approaches regarding pain and functional improvement 3 and 6 months after knee arthroplasty (19).

Our study does have some limitations, such as a relatively small sample size and a short follow-up duration. Additionally, the analgesic requirements of the patients were not assessed. These factors should be considered when planning future studies.

Conclusion

Both genicular nerve RF and intra-articular steroid injections are safe and effective for pain management in knee osteoarthritis. However, the effect of CRF appears to be more prolonged.

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