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Original Research

Comparison of radiofrequency ablation and phenol neurolysis for genicular nerve ablation in end-stage knee osteoarthritis

Genicular ablation: RFA versus phenol

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Abstract

Aim: Knee osteoarthritis (OA) is one of the most common causes of chronic pain and disability in older adults. When patients have advanced knee OA and do not respond to conservative treatments, yet are not candidates for surgery, genicular nerve interventions have emerged as minimally invasive options.

Methods: In this retrospective cohort study, records of 54 patients with end-stage knee OA and chronic knee pain who underwent genicular nerve ablation at a pain clinic were reviewed (29 patients received fluoroscopy-guided RFA under sedation, and 25 received ultrasound-guided injections of 6% phenol under local anesthesia). Pain was assessed on an 11-point Numeric Rating Scale, and knee function was measured using the Lequesne Index. These outcomes were recorded before the intervention and at the 3-month post-procedure follow-up.

Results: By 3 months, both treatments produced significant pain relief and functional improvement. In the RFA group, mean NRS pain scores fell from 8.5 ± 0.7 at baseline to 5.0 ± 1.8 at 3 months. Similarly, the phenol group's NRS score dropped from 8.6 ± 0.5 to 4.6 ± 1.7. Lequesne Index scores improved in parallel: RFA patients went from 18.7 ± 2.3 to 12.3 ± 4.5, and phenol patients from 18.9 ± 1.7 to 13.1 ± 3.4. There were no statistically significant differences between the RFA and phenol groups.

Conclusion: In this study, both genicular RFA and phenol neurolysis provided significant short-term pain reduction and functional improvement.

Keywords

chronic pain, osteoarthritis, knee, radiofrequency ablation, phenol

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Introduction

Knee osteoarthritis is the most common form of arthritis and a leading cause of chronic pain and disability in older people.[1] Total knee arthroplasty is the definitive treatment for end-stage (advanced) knee OA, but many patients either cannot undergo surgery or prefer not to.[2] This leaves a treatment gap for individuals who have exhausted conservative measures (such as analgesic medications, physical therapy, and intra-articular injections) yet still suffer from severe knee pain and are not surgical candidates.[3,4] In recent years, clinicians have explored minimally invasive nerve-targeting interventions to bridge this gap by providing analgesia through denervation of the knee's sensory nerves.[5] One such intervention is genicular nerve radiofrequency ablation (RFA), an established technique for managing refractory knee OA pain.[6] RFA involves applying heat (typically around 80°C for 60–90 seconds per target) to the articular branches of the genicular nerves, thereby creating a controlled lesion that disrupts nerve function.[7] Until recently, the effectiveness and safety of genicular nerve phenol neurolysis had not been well established in large-scale studies.[8] The present study aimed to directly compare the outcomes of conventional RFA versus phenol genicular nerve neurolysis in patients with end-stage knee OA (Kellgren–Lawrence grade 3–4).

Materials and Methods

Study Design and Patients

This retrospective cohort study was conducted at a single tertiary pain clinic and reviewed patient records from 2024 to 2025. Patients diagnosed with severe knee OA (Kellgren– Lawrence grade 3 or 4) who had chronic knee pain unresponsive to conservative therapy, a positive response to a genicular nerve block test, and who underwent genicular nerve ablation for pain relief were included. Patients without complete 3-month follow-up data were excluded. A total of 54 patients met the inclusion criteria, of whom 29 were treated with RFA and 25 with phenol neurolysis. The choice of RFA versus phenol was determined by the treating physician's preference and patient-specific factors. Baseline characteristics of the two groups are summarized in Table 1. The RFA and phenol groups were similar in age, sex distribution, and baseline pain and function scores (all P values > 0.5). Approximately 70% of patients in each group had Kellgren–Lawrence grade 4 disease, indicative of extremely severe osteoarthritis.

Interventions

For the RFA group, genicular nerve ablation was performed in a day-surgery operating room under fluoroscopic guidance. The superior medial, superior lateral, and inferior medial genicular nerve regions were targeted at the typical bony landmarks near the junction of the femur and tibia. Proper needle placement was confirmed (e.g., via sensory stimulation), and an RFA probe was then used to create a thermal lesion at each site (approximately 80°C for 90 seconds). Patients were under moderate intravenous sedation during these procedures to improve comfort, as creating the lesions can be painful.

In the phenol group, patients underwent chemical neurolysis of the same genicular nerve regions (superomedial, superolateral, and inferomedial) using ultrasound guidance. After a local anesthetic was applied to numb the skin, a needle was advanced under ultrasound visualization to each target area near the periosteum. At each site, about 1.5 mL of a 6% phenol-in-glycerol solution was slowly injected after careful aspiration to ensure the needle was not in a blood vessel. Phenol causes protein coagulation within nerve fibers, effectively producing a chemical ablation of the nerve. These phenol procedures were done in an outpatient clinic setting with the patient awake (no sedation needed). All patients were observed for a short period after the intervention and then discharged the same day with standard post-procedure care instructions.

Outcomes

Two primary outcomes were defined: knee pain intensity and knee functional status. Pain intensity was measured using an 11-point Numeric Rating Scale (NRS), where 0 represents no pain, and 10 represents the worst imaginable pain. Functional status was measured using the Lequesne Algofunctional Index for knee OA, which ranges from 0 to 24 points (higher scores indicate more severe pain and disability). Both measures were recorded at baseline (before the intervention) and at the 3-month follow-up visit. The primary endpoints for analysis were the change in NRS pain score and the change in Lequesne Index from baseline to 3 months. Any procedure-related complications observed during the 3-month follow-up period (for example, signs of infection, nerve injury, or persistent numbness/paresthesia) were also documented.

Ethical Approval

This study was approved by the Ethics Committee of Süleyman Demirel University (Date: 18.08.2025, Decision No: 35).

Statistical Analysis

IBM SPSS version 26 was used for data analysis. Within-group changes were assessed with the Wilcoxon signed-rank test, and between-group changes were compared with the Mann–Whitney U test. Because the Shapiro–Wilk test indicated that some change scores were not normally distributed, non-parametric methods were chosen. A significance level of $P < .05$ was adopted. Cohen's d was calculated for effect sizes, and 95% confidence intervals were provided where appropriate.

Reporting Guidelines

This study was reported in accordance with the STROBE guideline.

Results

Patient Characteristics

A total of 54 patients (mean age approximately 68 years) were analyzed, with 29 in the RFA group and 25 in the phenol group. As shown in Table 1, the two groups were well matched at baseline. On average, patients in both groups reported severe knee pain before treatment (mean baseline NRS pain was about 8.5 out of 10 in each group), and they had very high disability from OA (mean Lequesne Index around 19 out of 24, indicating "extremely severe" OA-related impairment). The distribution of radiographic severity

Table 1. Baseline Characteristics of RFA and Phenol Groups

Characteristic	RFA (*n* = 29)	Phenol (*n* = 25)	*P*
Age, years (mean ± SD)	68.4 ± 9.1	67.3 ± 8.4	.64
Female sex, *n* (%)	11 (37.9)	6 (24.0)	.42
Kellgren–Lawrence grade 4, *n* (%)	21 (72.4)	17 (68.0)	.96
Baseline NRS pain (0–10)	8.5 ± 0.7	8.6 ± 0.5	.64
Baseline Lequesne Index (0–24)	18.7 ± 2.3	18.9 ± 1.7	.68

Note: No statistically significant differences were observed between groups in any baseline parameter. NRS, Numeric Rating Scale.IP31_P2(interpeak latency of wave III and wave I in Protocol 2)

Table 2. Pain (NRS) Outcomes at Baseline and 3 Months

Group	Baseline NRS	3-month NRS	Mean Change ΔNRS (95% CI)	*P* value
	Mean ± SD			
RFA (*n* = 29)	8.48 ± 0.69	4.97 ± 1.78	–3.52 (–4.08 to –2.95)	< .001
Phenol (*n* = 25)	8.56 ± 0.51	4.64 ± 1.68	–3.92 (–4.50 to –3.34)	< .001

Abbreviations: *NRS, Numeric Rating Scale; Leq, Lequesne Algofunctional Index; CI, confidence interval; ns, not significant. (Between-group p-values compare the RFA vs Phenol groups on the change scores.) Between-group ΔNRS: Mann–Whitney P = .22 (ns)*

was also similar: roughly 70% of each group had Kellgren–Lawrence grade 4 disease (the highest severity), with the remainder at grade 3. The RFA group was 38% female and the phenol group 24% female, but this difference was not statistically significant given the sample size. No significant differences in any baseline pain or functional measures were observed between the RFA and phenol patients (all $P > .60$), indicating the groups were comparable before the interventions.

Pain Relief (Within-Group)

Both interventions led to significant reductions in knee pain from baseline to the 3-month follow-up. In the RFA group, the mean NRS pain score improved from 8.48 ± 0.69 at baseline to 4.97 ± 1.78 at 3 months. This is an average decrease in pain of about –3.52 points (95% CI –4.08 to –2.95; $P < .001$, Wilcoxon signed-rank test), which is highly significant. The effect size for pain reduction with RFA was very large (Cohen's d ≈ 2.38), indicating a substantial clinical improvement. The phenol group showed a similarly large improvement: their mean NRS pain score dropped from 8.56 ± 0.51 at baseline to 4.64±1.68 at 3 months (an average decrease of –3.92 points, 95% CI –4.50 to –3.34; $P < .001$). This reduction in pain was also highly significant and had a very large effect size (d ≈ 2.78). Detailed pain outcomes are presented in Table 2.

Functional Improvement (Within-Group)

Knee function also improved significantly in both groups over the 3-month period, as measured by the Lequesne Algofunctional Index. In the RFA group, the mean Lequesne score declined from 18.69±2.30 at baseline to 12.28±4.52 at 3 months. This represents an average improvement of –6.41 points (95% CI –7.61 to –5.22; $P < .001$, Wilcoxon), which is statistically significant. The effect size for this functional improvement was large (paired Cohen's d ≈ 2.04). Similarly, the mean Lequesne score for the phenol group decreased from 18.92 ± 1.71 at baseline to 13.12 ± 3.39 at 3 months, an average improvement of –5.80 points (95% CI –6.91 to –4.69; $P < .001$), with a very large effect size (d ≈ 2.16). Detailed functional outcomes are presented in Table 3.

Comparison Between RFA and Phenol

2. When the outcomes of the RFA and phenol groups were compared, no significant differences were observed in pain relief or functional improvement at 3 months. The phenol group's average pain reduction was slightly larger than the RFA group's (–3.92 vs –3.52 NRS points), but this ~0.4-point difference was not statistically meaningful (Mann–Whitney U test, $P = .22$). The 95% confidence interval for the difference in NRS change between groups ranged from approximately –1.19 to +0.39, crossing zero and indicating no clear advantage of one treatment over the other. Similarly, the RFA group had a marginally greater mean improvement in the Lequesne Index (–6.41 vs –5.80 points), but this ~0.6-point difference was not significant either ($P = .53$). The 95% CI for the between-group difference in functional change (approximately –0.97 to +2.20) also crossed zero. In other words, within the limits of the sample, no statistically significant difference was observed between the two interventions.

Safety and Tolerability

Both treatments were generally well tolerated, with no serious adverse events observed in either group. Three patients (5.6% of the cohort) experienced minor complications, with a similar incidence in each group: 1 patient (3.4%) in the RFA group and 2 patients (8.0%) in the phenol group (this difference was not significant, $P = .60$). All of the noted complications were transient sensory disturbances consistent with mild neuritis.

Discussion

In this retrospective series of patients with advanced knee osteoarthritis, both genicular nerve RFA and phenol neurolysis yielded meaningful pain relief and functional improvement over a 3-month period. The two treatments performed almost identically in terms of efficacy: on average, patients in each group experienced roughly a 3.5–4-point reduction in NRS pain, along with about a 6-point improvement in their Lequesne functional score. These changes were highly significant statistically and also appear to be clinically meaningful. Approximately half of the patients in both groups achieved at least a 50% reduction in pain.

A key finding of this study is that no significant difference in efficacy was observed between the RFA and phenol groups. In this study, genicular nerve ablation provided effective pain relief within each group, but neither treatment proved superior when directly compared. Likewise, no between-group disparity in functional improvement was found. These findings suggest that chemical neurolysis with phenol (6% concentration) had short-term outcomes comparable to RFA in this retrospective cohort.

The magnitude of pain relief observed in this study (approximately

Table 3. Functional (Lequesne Index) Outcomes at Baseline and 3 Months

Group	Baseline Lequesne	3-month Lequesne	Mean Change ΔNRS (95% CI)	*P* value
	(mean ± SD)			
RFA (*n* = 29)	18.69 ± 2.30	12.28 ± 4.52	–6.41 (–7.61 to –5.22)	< .001
Phenol (*n* = 25)	18.92 ± 1.71	13.12 ± 3.39	–5.80 (–6.91 to –4.69)	< .001

Abbreviations: *NRS, Numeric Rating Scale; Leq, Lequesne Algofunctional Index; CI, confidence interval; ns, not significant. (Between-group p-values compare the RFA vs Phenol groups on the change scores.) Between-group ΔNRS: Mann–Whitney P = .22 (ns)*

a 3.5–3.9-point drop in NRS) is similar to that reported in many RFA studies in the literature.[9,10] With regard to phenol neurolysis, a prospective study demonstrated that phenol genicular injections provided sustained benefits for at least 6 months.[8] The 3-month results (pain from roughly 8.6 to 4.6; Lequesne from 19 to 13) observed in the present study are consistent with these findings, indicating that phenol can produce substantial reductions in pain and disability in the intermediate term.

Both treatments were well tolerated, with only minor, transient adverse events noted. RFA allows more precise control of lesion size and placement.[11] Phenol, a liquid neurolytic agent, may diffuse into adjacent tissues if not carefully deposited, though using small volumes and meticulous technique can mitigate this risk.[12,13]

Because the follow-up in this study was limited to 3 months, the longer-term durability of these interventions cannot be determined. Clinically, after genicular nerve ablation, pain relief often lasts 6–12 months before nerve regeneration and recurrence of pain.[8,14] A recent meta-analysis in knee osteoarthritis rated the certainty of evidence for RFA as very low and found modest, short-term, non-sustained benefits, advising against routine use pending stronger evidence.[15] The ongoing RADIOPHENOL randomized trial comparing RFA, phenol, and conservative care with ≥6-month follow-up should yield higher-level data on efficacy and durability.[3]

Limitations

This study is retrospective in design, which introduces potential biases, including selection bias due to the absence of randomization. Treatment allocation (RFA vs. phenol) was based on clinical decision-making rather than random assignment, and the sample size (54 patients in total) was relatively modest. The follow-up period was limited to 3 months, so only short-term outcomes were captured. Only patient-reported outcome measures were collected, without including objective functional tests. Furthermore, outcomes like quality of life or changes in analgesic medication use after the procedures were not formally assessed, which might have provided a more comprehensive view of each treatment's impact.

Conclusion

Both radiofrequency ablation and phenol neurolysis were associated with short-term pain reduction and functional improvement in this cohort. In this study, each treatment resulted in significant pain reduction and functional improvement at 3 months, and neither was found to be superior to the other in terms of outcomes. Ultrasound-guided phenol neurolysis (using a 6% phenol solution) seems to be a feasible, less resource-intensive alternative to conventional RFA for patients with severe knee OA who need pain relief but either cannot undergo surgery or wish to delay it. The safety profiles of both procedures were favorable, with only minor transient neuropathic symptoms observed (slightly more frequent with phenol). Future prospective studies with larger sample sizes and longer follow-up will be needed to confirm the long-term comparative efficacy and safety of phenol versus RFA.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments, or comparable ethical standards.

Informed Consent

The requirement for informed consent was waived by the Ethics Committee due to the study's retrospective design.

Data Availability

The data supporting the findings of this study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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Author Contributions (CRediT Taxonomy)

Conceptualization: A.H.G.
Methodology: A.H.G.
Investigation: A.H.G.
Data Curation: A.H.G.
Formal Analysis: A.H.G.
Writing – Original Draft: A.H.G.
Writing – Review & Editing: A.H.G.
Supervision: A.H.G.

AI Usage Disclosure

The authors declare that no AI-assisted technologies were used.

Abbreviations

CI: Confidence interval
NRS: Numeric rating scale
OA: Osteoarthritis
RFA: Radiofrequency ablation

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