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Original Research Article

Genicular nerve radiofrequency ablation for the treatment of chronic knee joint pain: a real-world cohort study with evaluation of prognostic factors

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Abstract

Background: Genicular nerve radiofrequency ablation (GNRFA) is an effective treatment for chronic knee pain. However, there has been minimal investigation of real-world, long-term outcomes and factors that predict treatment success after GNRFA.

Objectives: To evaluate the effectiveness of GNRFA for chronic knee pain in a real-world population and identify predictive factors.

Methods: Consecutive patients who underwent GNRFA at a tertiary academic center were identified. Demographic, clinical, and procedural characteristics were collected from the medical record. Outcome data were numeric rating scale (NRS) pain reduction and Patient Global Impression of Change (PGIC). Data were collected by standardized telephone survey. Predictors of success were evaluated with logistic and Poisson regression analyses.

Results: Of the 226 total patients identified, 134 (65.6 ± 12.7; 59.7% female) were successfully contacted and analyzed, with a mean follow-up time of 23.3 ± 11.0 months. Of those, 47.8% ($n = 64$; 95% CI: 39.5%–56.2%) and 61.2% ($n = 82$; 95% CI: 52.7%–69.0%) reported ≥50% NRS score reduction and ≥2-point NRS score reduction, respectively, and 59.0% ($n = 79$; 95% CI: 50.5%–66.9%) reported "much improved" on the PGIC questionnaire. Factors associated with a greater likelihood of treatment success ($P < .05$) were higher Kellgren–Lawrence osteoarthritis grade (2–4 vs 0–1); no baseline opioid, antidepressant, or anxiolytic medication use; and >3 nerves targeted.

Conclusion: In this real-world cohort, approximately half of the participants experienced clinically meaningful improvements in knee pain after GNRFA at an average follow-up time of nearly 2 years. Factors associated with higher likelihood of treatment success were more advanced osteoarthritis (Kellgren–Lawrence Grade 2–4); no opioid, antidepressant, or anxiolytic medication use; and >3 nerves targeted.

Keywords: genicular nerve radiofrequency ablation; knee pain; treatment outcome

Introduction

Symptomatic knee osteoarthritis (OA) is a prevalent and costly condition with a lifetime prevalence of approximately 45%, and it contributes to more than $27 billion in annual health care expenditures in the United States.[1,2] With an aging population, the burden of knee OA is expected to increase, which highlights the urgent need for effective long-term treatments.[3] Although total knee arthroplasty (TKA) can be an effective treatment for some patients with knee OA, nonsurgical treatments are often used for patients who might not be candidates for surgery or prefer nonsurgical alternatives.[4] Currently, nonsurgical treatments such as intra-articular corticosteroids and nonsteroidal anti-inflammatory drugs are used commonly, but the durability of their effectiveness is variable and often suboptimal; furthermore, these therapies are associated with well-documented side effects.[5–9]

Genicular nerve radiofrequency ablation (GNRFA) is a percutaneous treatment option that has gained popularity for managing chronic knee pain. This procedure aims to alleviate pain and restore function by creating partial sensory denervation of the anterior capsule of the knee joint through targeted thermal radiofrequency neurotomy of a subset of the genicular nerves. A seminal 2011 randomized, double-blind, sham-controlled trial by Choi et al. demonstrated the efficacy of GNRFA in improving pain and function by targeting 3 nerves that provide anterior sensory innervation to the knee joint.[10] At 12 weeks, 59% of those treated by GNRFA reported ≥50% pain relief, compared with zero in the sham group. Subsequent studies and systematic reviews have confirmed these findings, showing that genicular radiofrequency ablation (RFA) is superior to alternative nonsurgical interventions, such as intra-articular corticosteroids, intra-articular hyaluronic acid, and oral nonsteroidal anti-inflammatory drugs, in terms of pain, function, and composite patient-reported outcomes from 3–12 months.[11,12] However, patient selection and GNRFA technical methods need to be refined

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compared with original descriptions, particularly given recent negative studies that have shown unfavorable outcomes when fewer coagulation zones were used, as opposed to expanded lesioning protocols based on improved understanding of the knee neuroanatomy.[13–20] Expanded protocols, targeting additional sensory nerves beyond the classic targets, and performance of multiple ablations at specific sites appear to be associated with an increased probability of treatment success.[15,21] Although localized adverse events, such as septic arthritis, pes anserine tendon injury, third-degree skin burns, and periarticular hematoma, have been reported, GNRFA has been consistently well tolerated, with a low prevalence of major adverse outcomes.[21–25]

The present observational cross-sectional study sought to evaluate (1) the effectiveness of GNRFA in managing chronic knee pain in a real-world population and (2) prognostic factors associated with treatment success.

Methods

Data collection

This study was conducted at a single tertiary academic spine and musculoskeletal center. The protocol was approved by the University of Utah Institutional Review Board (IRB# 138414). Medical records of 226 consecutive patients who underwent GNRFA between October 2015 and March 2021 were identified by CPT codes 64624 and 64640 and subsequently reviewed. Patient inclusion criteria were age 18–80 years, symptomatic knee OA or persistent postsurgical pain, having undergone at least 1 prognostic genicular nerve block (with at least 50% pain relief), and having subsequently undergone GNRFA. Exclusion criteria were refusal or inability to participate in the phone call–based standardized outcome survey (deceased or not an English speaker) and missing or low baseline numeric rating scale (NRS) scores ($\leq$3) 2 months before the index GNRFA procedure. Data collected from the electronic medical records included age, body mass index, duration of pain, gender, smoking status, workers' compensation status, active opioid prescription for $\geq$6 months at the time of GNRFA, current use of antidepressant or anxiolytic medication, presence and laterality of knee replacement, number of nerves targeted by prognostic block and the index GNRFA procedure, diagnostic block response, GNRFA laterality, and number of GNRFA procedures before the index GNRFA treatment. Participants were contacted via telephone, and long-term outcomes for the most recent GNRFA procedure were captured through a standardized survey that included NRS scores and self-reported improvement measured by Patient Global Impression of Change (PGIC) score. The primary outcomes were the proportions of participants with $\geq$50% NRS score reduction and $\geq$2-point NRS score reduction. The secondary outcomes were the proportion of participants who reported a PGIC score of $\geq$6, consistent with a rating of improvement that was at least "much improved"; opioid cessation; and demographic, clinical, and procedural characteristics associated with treatment success.

Radiographic evaluation

Pre-procedural anterior–posterior weight-bearing knee radiographs were evaluated and assigned a Kellgren–Lawrence (KL) classification system grade by a board-certified musculoskeletal radiologist (M.M.).

Procedures

Procedures were performed by physical medicine and rehabilitation physicians with subspecialty fellowship training in pain medicine, sports medicine, or interventional spine and musculoskeletal medicine.

Genicular nerve blocks

Patients were placed in a supine position on a standard fluoroscopy table with a knee bolster to support the knee, which was flexed at approximately 30 degrees. The knee was then prepared for the procedure by exposing, cleaning, and draping it in a sterile manner. To ensure accurate needle placement, all diagnostic blocks were performed under fluoroscopic guidance. For all genicular nerve blocks, at least 3 nerves were targeted, which included the superior medial, superior lateral, and inferior medial genicular nerves. In addition, the treating physician selected any additional nerve targets on the basis of the patient's pain distribution. One percent lidocaine was used to anesthetize the skin and subcutaneous tissues superficial to the targeted genicular nerve. After local anesthesia had been administered to the skin and subcutaneous tissues, a 25-gauge, 2.5- to 3.5-inch Quincke needle was advanced under fluoroscopic guidance to each target genicular nerve. Target sites were based on the known anatomic locations of the nerves and were previously described by McCormick et al. in 2021.[15]

Correct needle placement was confirmed in both true lateral (in which the femoral condyles were superimposed) and anterior–posterior views. A small amount of iodinated contrast medium or gadolinium-based contrast medium was injected to confirm proper positioning and to exclude vascular uptake, unless contraindicated because of an allergy. Subsequently, 0.5 mL of either 4% lidocaine or 0.5% bupivacaine was injected at each target site. After the procedure, patients were given a pain log and instructed to track their pain relief at 15-minute intervals for a duration of 4 hours, specifically during movements or activities that usually provoked pain. The blocks were classified as positive if they led to a pain reduction of 50% or more.

Radiofrequency ablation

Patients were positioned supine on a standard fluoroscopy table, with the knee bolstered and flexed at approximately 30 degrees. The knee was exposed, cleaned, and draped in a sterile manner. Moderate sedation with midazolam and fentanyl was used on an as-needed basis at the discretion of the treating physician. GNRFA was performed under fluoroscopic guidance to ensure accurate needle placement. The genicular nerve targets were determined by the patient's pain distribution and prognostic block response.

To anesthetize the skin and subcutaneous tissues superficial to the targeted genicular nerve, 1% lidocaine was used. The target sites were determined by the known anatomic locations of the nerves and were previously described by McCormick et al. in 2021.[15] For cooled GNRFA, a 17-gauge introducer needle was advanced to the target site, and an 18-gauge probe with a 4-mm active tip (Coolief Cooled Radiofrequency Kit, Halyard Health, Alpharetta, GA, United States) was inserted. The appropriate electrode placement was confirmed in lateral and anterior–posterior fluoroscopic views. Before lesioning,

1–2 mL of 2% lidocaine was injected for genicular nerve anesthesia, and cooled RFA lesions were performed for 165 seconds each at a generator setting of 60°C. For conventional RFA lesioning, 18-gauge 3-tined cannulae with 5-mm active tips (Diros RF Trident, Markham, ON, Canada) or 17-gauge dual-tined cannulae with 10-mm active tips (Nimbus, Stratus Medical, Magnolia, TX, United States) were guided to each target site. One to two milliliters of 2% lidocaine was injected for anesthesia before lesioning. Conventional RFA was performed with a lesion time of 120 seconds (including a 30-second ramp-up time) at a temperature of 80°C at each targeted nerve location.

Data and statistical analysis

Data were collected at baseline from chart review and at follow-up by cross-sectional phone call survey assessment at 6–12 months, 12–24 months, and ≥24 months. Participants were evaluated at only one of these time points, which was based on the time from GNRFA relative to the time of the telephone survey. Participant demographics and clinical characteristics were summarized with descriptive statistics, quantitative variables were represented with means and standard deviations (SDs), and categorical variables were represented with frequencies and percentages. A 95% confidence interval (CI) for the statistics of select variables was also calculated.

A 1-sample *t* test was used to determine whether continuous NRS scores improved significantly from baseline to follow-up, whereas a 1-sample test of proportion was used for the following categorical outcome variables to examine whether the proportion was significantly different from 0.50 or 50%: (1) ≥50% NRS score reduction from baseline to follow-up and (2) ≥2-point NRS score reduction from baseline to follow-up. A tornado diagram was created to illustrate percentage change in NRS scores for all follow-up time points combined. Contingency table analysis was used to determine whether ≥50% NRS score reduction and ≥2-point NRS score reduction significantly differed by follow-up times. As a secondary outcome variable, contingency table analysis was used to analyze the proportion of patients who reported a PGIC score of ≥6 at follow-up. McNemar's test was used to examine opioid use at baseline and follow-up.

Multivariate logistic regression analysis was used to explore the relationships between outcome variables (≥50% NRS score reduction, ≥2-point NRS score reduction, and ≥6 in PGIC score) and selected covariates. Covariates used were follow-up time frame, worst compartment KL grade, opioid use at baseline, antidepressant/anxiolytic medication use at the time of RFA, history of knee replacement, number of nerves targeted by RFA, and age. An odds ratio (OR) and 95% CI were calculated for each covariate. Additionally, Poisson regression analysis was performed to examine the associations between the select covariates and NRS score change from baseline to follow-up. Incidence rate ratios (IRRs) and 95% CIs were calculated for each coefficient. An α level was set at 0.05 for statistical significance, and all analyses were conducted in Stata/MP 17.0 (StataCorp, LLC, College Station, TX, United States).

Results

Of the 226 patients identified, a total of 134 participants were included in this study. Participant demographics and clinical characteristics are presented in Tables 1 and 2. Participant follow-up outcome data were collected at 6–12 months (15.7%, $n = 21$), 12–24 months (44.8%, $n = 60$), and ≥24 months (39.5%, $n = 53$) after GNRFA. NRS scores at baseline and follow-up are shown in Table 3. The mean NRS score at baseline was 6.2 ± 1.7 (95% CI = 6.0–6.5). The analyses revealed significant reductions in NRS score at 6–12 months (1.6 ± 3.0), 12–24 months (2.9 ± 3.7), and ≥24 months (3.1 ± 3.6) compared with baseline ($P < .05$), indicating a significant decrease in NRS scores at all follow-up time points. Figure 1 displays the percent NRS score reduction for all 134 patients at a mean follow-up of 23.3 ± 11.0 months. Of the 134 patients, 64 (47.8%; 95% CI = 39.5%–56.2%) and 82 (61.2%; 95% CI = 52.7%–69.0%) reported ≥50% NRS score reduction and ≥2-point NRS score reduction, respectively, at a mean follow-up time of 23.3 ± 11.0 months (Table 4).

Table 1. Patient demographics and clinical and procedure-related variables ($n = 134$; quantitative variables).

Quantitative variable	Mean	SD	Min	Max
Age	65.6	12.7	34	96
Body mass index, kg/m^2	33.4	7.9	20.1	59.0
Duration of pain, years	5.4	5.8	0.25	49.0
Follow-up time, months	23.3	11	5.0	56.0

Abbreviations: Max = maximum value; Min = minimum value; SD = standard deviation.

Overall, 79 (59.0%; 95% CI = 50.5%–66.9%) of 134 participants reported ≥6 in PGIC score at a mean follow-up time of 23.3 ± 11.0 months ($P = .038$; Table 5).

Of the total 134 study participants, 37 (27.6%) were consuming opioids at baseline (before GNFRA). At follow-up, the number of individuals consuming opioids decreased to 31, accounting for 23.1% of the participants (Table 6). McNemar's test showed no significant association between opioid use and treatment time ($P = .289$; Table 7). Specifically, the proportion of patients who started using opioid after the treatment was not significantly different from those who stopped using opioid after the treatment.

Logistic regression models for ≥50% NRS score reduction, ≥2-point NRS score reduction, and ≥6 in PGIC score by the select covariates are summarized in Table 8. A worst compartment KL grade of 4 was significantly associated with ≥50% NRS score reduction at follow-up (OR = 3.42, 95% CI = 1.03–11.38, $P = .045$). No covariates were significantly associated with ≥2-point NRS score reduction ($P > .05$). A history of knee replacement in the knee treated with GNRFA was significantly associated with lower odds of achieving a PGIC score ≥6 by 70% (OR = 0.30, 95% CI = 0.11–0.83), even after adjustment for the other covariates. In the Poisson regression model, participants with worst compartment KL grade of 4 (vs 0–1) and KL grade of 2–3 (vs 0–1) were expected to have lower NRS scores at follow-up by 37% (IRR = 0.63; 95% CI = 0.49–0.82; $P < .001$) and 30% (IRR = 0.70; 95% CI = 0.53–0.91; $P = .007$), respectively (Table 9). Furthermore, >3 nerves targeted by RFA (vs 3) was significantly associated with lower NRS scores at follow-up by 29% (IRR = 0.71; 95% CI = 0.54–0.93; $P = .014$). Opioid use and antidepressant/anxiolytic medication use at baseline were significantly associated with higher NRS scores at follow-up by 41% (IRR = 1.41; 95% CI = 1.16–1.71; $P = .001$) and 29% (IRR = 1.29; 95% CI = 1.06–1.56; $P = .010$), respectively.

Table 2. Patient demographics and clinical and procedure-related variables ($n = 134$; categorical variables).

Categorical variable	No.	%
Follow-up time period		
6–12 months	21	15.7
12–24 months	60	44.8
≥24 months	53	39.5
Gender		
Male	54	40.3
Female	80	59.7
Smoking		
Never	100	74.6
Current	3	2.2
Former	31	23.1
Opioid use		
Yes	37	27.6
No	97	72.4
Antidepressant/anxiolytic medication use		
Yes	63	47.0
No	71	53.0
Workers' compensation claim		
Yes	4	3.0
No	130	97.0
Worst compartment KL grade		
0	16	11.9
1	6	4.5
2	18	13.4
3	25	18.7
4	69	51.5
Nerves targeted with genicular blocks		
3	6	4.5
4	88	65.7
≥5	40	29.9
Nerves targeted GNRFA		
3	13	9.7
4	39	29.1
5	67	50.0
6	4	3.0
7	7	5.2
8	4	3.0
Prognostic block relief		
>50%	14	10.5
50%–79%	15	11.2
80%–99%	23	17.2
100%	82	61.1
RFA probe type		
Cooled	129	96.3
Conventional	5	3.7
History of knee replacement in knee treated with GNRFA		
Yes	25	18.7
No	109	81.3
Laterality of knee replacement		
Left	12	7.4
Right	12	7.4
Bilateral	5	3.1
GNRFA laterality		
Left	57	42.5
Right	49	36.7
Bilateral	28	20.1
Number of GNRFAs before the index procedure		
0	117	87.3
1	15	11.2
2	1	0.8

Abbreviations: GNRFA = genicular nerve radiofrequency ablation; KL = Kellgren–Lawrence; RFA= radiofrequency ablation.

No serious adverse effects or complications related to the genicular nerve blocks or GNRFA were recorded in the medical record for any participant.

Table 3. Quantitative NRS scores at baseline and follow-up.

Quantitative variable	Mean	SD	Min	Max	95% CI (mean)
NRS score (baseline; $n = 134$)	6.2	1.7	4	10	6.0–6.5
NRS score (follow-up)					
6–12 months ($n = 21$)	4.0	2.7	0	8	2.8–5.2
12–24 months ($n = 60$)	3.5	3.0	0	10	2.7–4.2
≥24 months ($n = 53$)	3.2	3.2	0	10	2.4–4.1
NRS score reduction (baseline NRS score minus follow-up NRS score)					
6–12 months ($n = 21$)*	**1.6**	**3.0**	**–3**	**8**	**0.2–3.0**
12–24 months ($n = 60$)*	**2.9**	**3.7**	**–4**	**10**	**2.0–3.8**
≥24 months ($n = 53$)*	**3.1**	**3.6**	**–5**	**10**	**2.2–4.1**

Abbreviations: CI = confidence interval; Max = maximum value; Min = minimum value; NRS = numerical rating scale; SD = standard deviation. Bold values denote statistical significance at $P < .05$.

* Significantly different from baseline by 1-sample t test ($P < .05$).

Discussion

The primary objective of this study was to assess the long-term effectiveness of GNRFA for chronic knee pain in a real-world population, as well as to identify prognostic factors associated with treatment success. Long-term, clinically significant pain relief was observed at a mean follow-up duration of nearly 2 years. Notably, 47.8% of patients experienced a reduction in NRS score of 50% or greater and 61.2% of patients experienced a reduction in NRS score of 2 points or greater without the need for a repeat GNRFA between the index procedure and the time of follow-up (mean duration of nearly 2 years).

These findings align with the existing literature on heterogeneous patient populations treated with GNRFA in real-world settings, which have reported success rates ranging from 35% to 65% for achieving a minimum of 50% pain relief pain during 6- to 12-month follow-ups.[26,27] In a 2017 study, McCormick et al. observed a 35% success rate in achieving 50% pain relief at the 6-month follow-up.[26] Additionally, Kapural et al. documented a 65% success rate for achieving ≥50% pain relief at a 12.5-month follow-up.[27] In addition to the reported reductions in NRS scores, our study found that 59.0% of patients who underwent GNRFA reported at least a "much improved" global impression of change. Our results appear roughly in line with these estimates and provide further evidence for the long-term effectiveness of GNRFA.

Despite early success in clinical trials, more recent neuroanatomic and clinical studies indicate that the ideal technical implementation of the GNRFA procedure includes targeting additional nerves and more tissue territory than historical protocols have previously described. The most frequently targeted nerves in older clinical studies have been the superior medial, superior lateral, and inferior medial genicular nerves, with a single lesion placed in the region of each nerve. However, reported outcomes from subsequent randomized controlled trials have failed to demonstrate similar efficacy when only those 3 nerves were targeted.[13,14]

Recent research has revealed that the knee joint is innervated by 14 nerves, with 10 nerves providing sensory innervation to the anterior capsule, which indicates a more complex innervation pattern than was previously believed.[28–30] This complexity has piqued interest in exploring whether targeting

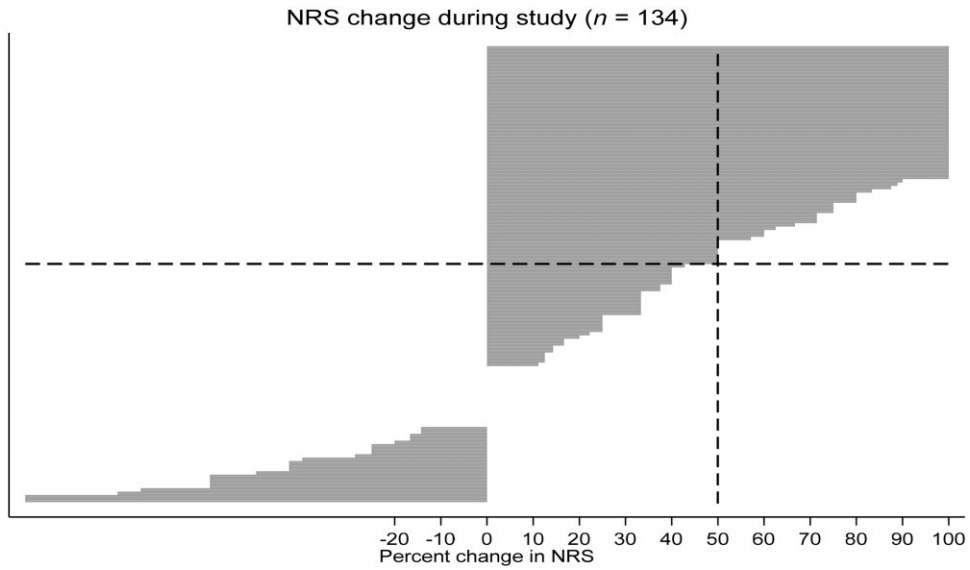

Figure 1. Tornado diagram of percent numerical rating scale (NRS) score reduction for patients at a mean follow-up of 23.3 ± 11.0 months after genicular radiofrequency ablation. Each bar represents an individual patient.

Table 4. Patient-reported NRS score outcomes.

Outcome and follow-up period	Yes	No	*P*	95% CI (yes)
≥50% NRS score reduction				
6–12 months	7 (33.3)	14 (66.7)	.246*	17.2–54.6
12–24 months	28 (46.7)	32 (53.3)		34.6–59.1
≥24 months	29 (54.7)	24 (45.3)		41.5–67.3
23.3 ± 11.0 (mean ± SD)	64 (47.8)	70 (52.2)	.604**	39.5–56.2
≥2-point NRS score reduction				
6–12 months	11 (52.4)	10 (47.6)	0.536	32.4–71.7
12–24 months	36 (60.0)	24 (40.0)		47.4–71.4
≥24 months	35 (66.0)	18 (34.0)		52.6–77.3
23.3 ± 11.0 (mean ± SD)	**82 (61.2)**	**52 (38.8)**	**.010****	**52.7–69.0**

Abbreviations: CI = confidence interval; NRS = numerical rating scale; SD = standard deviation.
Bold values denote statistical significance at $P < .05$.
* From Pearson chi-squared test.
** From 1-sample test of proportion (vs 0.50 or 50%).

Table 5. Patient Global Impression of Change.

Outcome and follow-up period	Yes	No	*P*	95% CI (yes)
≥6 PGIC				
6–12 months	13 (61.9)	8 (38.1)	.303*	40.9–79.2
12–24 months	39 (65.0)	21 (35.0)		52.4–75.8
≥24 months	27 (50.9)	26 (49.1)		37.9–63.9
23.3 ± 11.0 (mean ± SD)	**79 (59.0)**	**55 (41.0)**	**.038****	**50.5–66.9**

Abbreviations: CI = confidence interval; PGIC = Patient Global Impression of Change; SD = standard deviation.
PGIC scores ≥6 indicate at least "much improved."
Bold values denote statistical significance at $P < .05$.
* From Pearson chi-squared test.
** From 1-sample test of proportion (vs 0.50 or 50%).

additional nerves and improving target accuracy can increase the effectiveness of GNRFA.

Positive predictors

Our present findings support the notion that a more comprehensive lesioning protocol increases the likelihood of treatment success after GNRFA. Specifically, we found that targeting a greater number of nerves (>3) led to improved outcomes compared with the classic protocol (3 nerves). This finding is consistent with evidence from other studies that targeting additional nerves improves treatment outcomes, and targeting 5 or more nerves might result in higher responder rates in real-world populations compared with the conventional 3-nerve protocol.[21,26,31–33]

Research on clinical and radiographic factors associated with treatment success after GNRFA has been limited to date. Although some evidence suggests that patients with severe knee OA, classified as grade 4 on the KL scale, might have lower odds of successful treatment outcomes, we found the opposite in the present study.[21,34] We noted a significant relationship between patients with at least 1 compartment KL grade of 4 and a greater than 50% pain reduction in NRS score at follow-up (OR = 3.42, 95% CI = 1.03–11.38, $P = .045$), which supports the notion that GNRFA is an effective intervention for alleviating nociceptive OA-mediated knee pain, even in patients with end-stage OA. Notably, prior studies used less comprehensive lesioning protocols than those used in the present study. We speculate that patients who had lesser degrees of OA, yet significant enough knee pain to seek intervention, might have had more complex or multifactorial pain than can be reliably addressed by reducing local nociceptive afferent pathways with GNRFA. Given the conflicting evidence on this point, further investigation is warranted to identify specific patient populations that are most likely to benefit from GNRFA treatment and to optimize its therapeutic potential, particularly when more comprehensive lesioning protocols are implemented.

Negative predictors

A considerable body of literature has reported a correlation between psychiatric comorbidities and poorer outcomes in both interventional and noninterventional procedures.[35–37] In accordance with prior research, our findings suggest that patients taking anxiolytic or antidepressant medications at baseline are more likely to report higher pain scores during follow-up after GNRFA. This observation highlights the potential impact of psychiatric factors on pain perception and

Table 6. Opioid use.

Opioid use	No	%	95% CI (yes)
Baseline	37	27.6	20.7–35.7
Follow-up	31	23.1	16.8–31.0

Abbreviation: CI = confidence interval.

Table 7. Opioid use.

Opioid use (baseline)	Opioid use (follow-up)			
	Yes	No	*P**	Ratio (95% CI)
Yes	18	19	.289	0.84 (0.60–1.16)
No	13	84		

Abbreviation: CI = confidence interval.
* From McNemar test.

treatment outcomes and emphasizes the importance of addressing mental health in conjunction with pain management strategies.

Similarly, opioid use has also been associated with lower treatment success rates.[38–40] Our results corroborate this finding, as taking opioid medications for at least 6 months before undergoing GNRFA was found to be a negative predictor of treatment success. This relationship could be attributable to various factors, including but not limited to the development of opioid-induced hyperalgesia or the potential masking of treatment effectiveness by persistent opioid use. These findings underscore the need for a comprehensive, multidisciplinary approach to pain management, which could include interventions to address opioid use and dependence, as well as the incorporation of behavioral and psychological therapies alongside interventional procedures like GNRFA.

Table 8. Logistic regression models on ≥50% NRS score reduction, ≥2-point NRS score reduction, and ≥6 PGIC; $n = 134$.

Outcome	Predictor	OR	95% CI	*P*
≥50% NRS score reduction	Follow-up (vs 6–12 months)			
	12–24 months	1.92	0.65–5.70	.241
	≥24 months	2.67	0.88–8.13	.083
	Worst compartment KL grade (vs 0–1)			
	2–3	3.29	0.96–11.31	.059
	4	**3.42**	**1.03–11.38**	**.045**
	Opioid use at baseline (vs no)			
	Yes	0.68	0.30–1.54	.352
	Antidepressant/anxiolytic medication at baseline (vs no)			
	Yes	0.80	0.38–1.69	.560
	History of knee replacement in knee treated with GNRFA (vs no)			
	Yes	0.61	0.22–1.72	.348
	Nerves targeted with GNRFA (vs 3)			
	>3	1.42	0.37–5.44	.607
	Age	1.03	0.99–1.06	.108
≥2-point NRS score reduction	Follow-up (vs 6–12 months)			
	12–24 months	1.32	0.47–3.73	.600
	≥24 months	1.98	0.68–5.81	.212
	Worst compartment KL grade (vs 0–1)			
	2–3	1.73	0.57–5.26	.334
	4	2.02	0.68–5.97	.203
	Opioid use at baseline (vs no)			
	Yes	0.85	0.38–1.94	.705
	Antidepressant/anxiolytic medication at baseline (vs no)			
	Yes	0.57	0.27–1.22	.148
	History of knee replacement in knee treated with GNRFA (vs no)			
	Yes	0.75	0.28–2.00	.570
	Nerves targeted with GNRFA (vs 3)			
	>3	2.17	0.62–7.61	.226
	Age	1.00	0.97–1.03	.808
≥6 in PGIC	Follow-up (vs 6–12 months)			
	12–24 months	1.01	0.34–3.00	.988
	≥24 months	0.58	0.19–1.75	.335
	Worst compartment KL grade (vs 0–1)			
	2–3	0.57	0.17–1.95	.372
	4	0.47	0.14–1.55	.215
	Opioid use at baseline (vs no)			
	Yes	1.14	0.50–2.59	.754
	Antidepressant/anxiolytic medication at baseline (vs no)			
	Yes	0.84	0.39–1.80	.653
	History of knee replacement in knee treated with GNRFA (vs no)			
	Yes	**0.30**	**0.11–0.83**	**.020**
	Nerves targeted GNRFA (vs 3)			
	>3	3.17	0.85–11.89	.087
	Age	1.00	0.97–1.03	.750

Abbreviations: CI = confidence interval; GNRFA = genicular nerve radiofrequency ablation; KL = Kellgren–Lawrence; NRS = numerical rating scale; OR = odds ratio; PGIC = Patient Global Impression of Change.
PGIC scores ≥6 indicate at least "much improved."
Bold values denote statistical significance at $P < .05$.

Table 9. Poisson regression on NRS score reduction at follow-up; $n = 134$.

Outcome	Predictor	IRR	95% CI	*P*
NRS score at follow-up	NRS score at baseline	0.95	0.89–1.00	.068
	Follow-up (vs 6–12 months)			
	12–24 months	0.86	0.66–1.11	.245
	≥24 months	0.78	0.60–1.02	.067
	Worst compartment KL grade (vs 0–1)			
	2–3	**0.70**	**0.53–0.91**	**.007**
	4	**0.63**	**0.49–0.82**	**.000**
	Opioid use at baseline (vs no)			
	Yes	**1.41**	**1.16–1.71**	**.001**
	Antidepressant/anxiolytic medication at baseline (vs no)			
	Yes	**1.29**	**1.06–1.56**	**.010**
	History of knee replacement in knee treated with GNRFA (vs no)			
	Yes	1.06	0.83–1.35	.648
	Nerves targeted GNRFA (vs 3)			
	>3	**0.71**	**0.54–0.93**	**.014**

Abbreviations: CI = confidence interval; GNRFA = genicular nerve radiofrequency ablation; IRR = incidence rate ratio; KL = Kellgren–Lawrence; NRS = numerical rating scale.
Bold values denote statistical significance at $P < .05$.

Prognostic nerve blocks have been widely used as a predictive tool to assess the long-term efficacy of RFA in managing facet joint and sacroiliac complex mediated pain.[41–46] However, recent studies have cast doubt on the value of these blocks in predicting outcomes of GNRFA. Studies that have used prognostic blocks and those that have selected participants on the basis of clinical and radiographic criteria alone demonstrate comparable reductions in pain and disability.[47–49] Prognostic genicular blocks are known to result in substantial spread of local anesthetic within tissue planes when moderate volumes (1 mL) are injected.[50] To mitigate this issue, patients included in the present study received a smaller anesthetic injection volume of 0.5 mL. Despite this, 89% of our cohort ($n = 119$) reported ≥50% pain relief after the anesthetic blocks. In contrast, only 48% of participants experienced a similar level of pain relief with subsequent GNRFA at the same locations. Our study highlights the limitations of prognostic nerve blocks in predicting the therapeutic effect of GNRFA under current protocols.

Previous research has demonstrated that GNRFA might be less efficacious in patients with a history of a TKA than in those with native knees.[51] Our study supports these findings, as we observed that patients with a history of TKA who underwent GNRFA had 70% lower odds of achieving a PGIC score of 6 or greater. Interestingly, no significant association was observed between a history of TKA and reduction in NRS scores. This discrepancy between PGIC and NRS outcomes could suggest that other factors beyond pain intensity contribute to the overall perception of improvement in this patient population. Further research is needed to better understand the reasons behind the reduced effectiveness of GNRFA in post-TKA patients and to explore alternative or adjunctive treatments that might better address their specific needs. Ultimately, identifying the optimal therapeutic approach for patients with a history of TKA is essential for enhancing their impression of clinical improvement and overall treatment outcomes.

Limitations

Our study has several limitations. The findings of our study might not be generalizable to other populations, as it is based on patients treated at a single institution. Additionally, as with any retrospective study, missing data and inconsistent reporting could limit conclusions about the results. Moreover, the lack of a control group makes it difficult to separate specific versus nonspecific effects of GNRFA. In addition, we measured pain outcomes by cross-sectional telephone survey at a single point in time. Although cross-sectional data can determine the prevalence of participants who achieved the reported outcome at a specific time, it does not indicate the cumulative incidence of subjects who report treatment success at another time point.

Lastly, our definition of treatment success was limited to subjective pain reduction and global improvement because validated functional and health-related quality of life measures were not present at baseline before GNRFA.

Conclusion

The findings of this study suggest that GNRFA is a safe and effective treatment option for patients with chronic knee pain that provides clinically significant pain relief for up to 2 years in approximately half of the patients. Patients who underwent GNRFA of more than 3 nerves, as well as those with advanced degenerative disease, were more likely to report greater pain reduction at follow-up. Conversely, the use of opioids, antidepressants, or anxiolytic medications at baseline was a negative predictor of treatment success.

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