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Genicular nerve radiofrequency ablation practice patterns: A survey study of the International Pain and Spine Interventional Society

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ABSTRACT

Introduction: Chronic knee pain often results from degenerative conditions such as knee osteoarthritis (OA) and can worsen after surgical interventions like total knee arthroplasty (TKA). Knee OA affects approximately 86 million individuals globally, leading to decreased function, mobility limitations, and disability. While TKA is a common surgical treatment for refractory knee OA, though up to 20 % of patients experience chronic post-operative knee pain worse than their pre-operative pain. Genicular nerve radiofrequency ablation (GnRFA) has emerged as a promising intervention for knee OA pain unresponsive to conservative management and for chronic post-TKA pain. GnRFA is an evidence-based technique supported by multiple prospective cohort studies and randomized controlled trials (RCTs). However, practice patterns and GnRFA techniques vary, and no peer-reviewed publication has yet quantified these variations in real-world clinical practice.
Objective: This study aims to understand the practice patterns of interventional pain physicians regarding patient selection, use of prognostic blocks, imaging, nerve targets, GnRFA types, and GnRFA techniques in treating knee pain secondary to OA or persistent post-TKA pain.
Methods: An anonymous 29-question survey was distributed via electronic mail to members of the International Pain and Spine Intervention Society (IPSIS) from January 16, 2024, to February 29, 2024. The survey assessed practice patterns related to patient selection, prognostic block use, and GnRFA techniques. Data were collected and stored using REDCap software, with descriptive statistics calculated.
Results: A total of 150 completed surveys were analyzed, representing a completion rate of 2.0 % of surveys sent, 3.5 % of emails opened, and 56.8 % of those who clicked on the survey link. Respondents generally use common selection protocols regarding OA grade (Kelgren-Lawrence 3 and 4), duration of failed conservative care (3–6 months), a single anesthetic block paradigm, and use of fluoroscopic guidance for the GnRFA procedure. More variability was reported between respondents regarding the volume of anesthetic used during prognostic blocks, the threshold to consider a prognostic block “positive,” the technology used, and nerves targeted during the GnRFA procedure.
Conclusion: The study provides valuable insights into the current practice patterns of GnRFA among interventional pain physicians. While there is consensus on some aspects of patient selection and procedural techniques, significant variability exists in prognostic block protocols and nerve targets for GnRFA. These findings highlight the need for further research to explore the long-term efficacy and safety of GnRFA and to standardize techniques and protocols across different practice settings, ultimately improving patient outcomes and quality of life. The low response rate may limit generalizability, and the survey did not include data on active tip sizes used for ablation or whether other procedures should be exhausted before resorting to GnRFA. Additionally, a survey to IPSIS membership only may not fully represent a diverse cohort of pain management specialists, potentially

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introducing sampling bias. Future studies should include members from a broader range of professional organizations to enhance representativeness.

1. Introduction

Chronic knee pain commonly occurs due to degenerative conditions such as knee osteoarthritis (OA) or after surgical intervention, particularly knee arthroplasty (TKA). Severe symptomatic knee OA affects approximately 86 million individuals worldwide, and its prevalence is expected to rise as the population continues to age [1]. This condition is associated with decreased function, limited mobility, and disability [2–7]. OA may be primary (i.e. arising from joint degeneration) or secondary (i.e. post-traumatic osteoarthritis or secondary to rheumatologic etiology). TKA remains the traditional surgical intervention for managing both primary and secondary symptomatic knee OA refractory to conservative measures such as activity modification, physical therapy, pharmacological therapies (i.e. meloxicam, ibuprofen, celecoxib, etc.), and injections [8]. While many patients with severe knee OA improve with surgical intervention care, up to 20 % of patients continue to experience chronic post-operative knee pain often greater than their pain prior to the surgical intervention [9–11].

Genicular nerve radiofrequency ablation (GnRFA) has emerged as a promising intervention for both knee OA pain resistant to conservative management and for chronic post-TKA pain [12,13]. Continuous radiofrequency ablation (GnRFA) methods offers an avenue for disrupting neural pathways associated with knee pain via targeted heat-related coagulation of axons [14–17]. GnRFA has two subtypes: conventional and lesion-enhancing radiofrequency ablation. During the conventional GnRFA, structural alterations in the nerve begin at 45^{o}C and complete denaturation of neural tissue is achieved at 80^{o}C [14–17]. The water-cooled probe used for the cooled RFA, a lesion-enhancing subtype, reaches 60^{o}C but creates a forward projecting lesion with an intralesional temperature of 80^{o}C for more expansive area of denervation than smaller conventional monopolar techniques [18]. Tined probes, another lesion-enhancing method, use multiple prongs extending from the main shaft to create a larger, more spherical lesion, further broadening the area of nerve destruction [19]. There exist numerous variations in the techniques utilized for targeting the sensory innervation of the knee with GnRFA procedures. These variations encompass choices between fluoroscopically guided and ultrasound-guided visualization and options such as conventional monopolar, bipolar, and multi-tined techniques for disrupting sensory innervation [20–24]. These variations offer different benefits and may be chosen based on factors such as the patient-specific presentation and anatomy, physician experience, the desired lesion size, visualization technique available (fluoroscopy or ultrasound), and cost.

Historical protocols for GnRFA involve targeting the sensory innervation of the knee, including the superomedial (SMGN), superolateral (SLGN), and inferomedial (IMGN) genicular nerves [25]. However, evolving evidence suggests that inclusion of additional targets including the terminal articular branch of the common fibular nerve (CFN), inferior lateral genicular nerve (ILGN), recurrent fibular nerve, nerve to vastus medialis (NVM), nerve to vastus lateralis (NVL), nerve to vastus intermedius (NVI), and the infrapatellar branch of the saphenous nerve (IPBSN) is possible and will reduce nociception from the knee to a greater extent [26–30].

GnRFA is an evidence-based technique supported by multiple prospective cohort studies and randomized controlled trials (RCTs) [12,13,31,32]; however, there are variable practice patterns and GnRFA techniques. There has been no peer-reviewed publication quantifying these variations in real-world clinical practice. As such, we conducted a survey study of the International Pain and Spine Intervention Society (IPSIS) membership to understand practice patterns of interventional pain physicians in relation to patient selection, use of prognostic blocks, and GnRFA technique related to the treatment of knee pain secondary to OA or persistent post-TKA pain. This study aims to inform future practice guidelines relating to treatment strategies for these debilitating conditions.

2. Methods

2.1. Survey design and dissemination

An anonymous 29-question English-language survey was designed in order to assess respondent practice patterns related to (1) patient selection, (2) use of prognostic blocks, and (3) GnRFA technique and parameters in patients with primary knee OA or persistent pain post-TKA (Fig. 1). Additionally, the survey included questions on respondent demographics, practice volume, and adverse events observed by the respondents in association with GnRFA procedures. This survey was distributed via electronic mail to members of the IPSIS, representing specialists within Anesthesiology, Physical Medicine and Rehabilitation (PM&R), Radiology, Neurology, Neurosurgery, and Orthopaedic Surgery from January 16, 2024 to February 29, 2024.

2.2. Institutional review board (IRB) status

This study was deemed exempt by the University of Utah Institutional Review Board (IRB_00169798) as it involved anonymous survey data collection without any intervention or interaction with human subjects.

2.3. Data collection

Study data was collected and stored using Research Electronic Data Capture (REDCap) software hosted at The University of Utah in Salt Lake City. REDCap is a secure, web-based software platform tailored to facilitate data acquisition for research endeavors. Its features include: 1) an intuitive interface for validated data collection; 2) audit trails to monitor data manipulation and export procedures; 3) automated export functions for seamless data retrieval into common statical packages; and 4) protocols for data integration and interoperability with external sources.

3. Results

3.1. Demographics and proceduralist characteristics

A total of 7547 surveys were sent via email on January 16, 2024. Of these, 4467 emails were opened (59.2 % of surveys sent), and 264 recipients clicked on the survey link (3.5 % of surveys sent or 5.9 % of emails opened). Ultimately, 150 completed surveys were received, which constitutes a completion rate of 2.0 % of surveys sent, 3.4 % of emails opened, and 56.8 % of those who clicked on the survey link. A total of 150 completed surveys were analyzed in this study. The demographics and proceduralist characteristics of survey respondents are summarized in Table 1. Most respondents were physicians (96.7 %; n = 145) practicing in the United States (79.3 %; n = 119). Respondents self-identified specialty/sub-specialty type most commonly as Pain Medicine at 42.0 % (n = 63) followed by PM&R (34.7 %; n = 52). The length of professional experience in years was fairly evenly distributed across the five categories. Half of the respondents (50.0 %; n = 75) reported performing up to 20 GnRFA annually, followed by those who performed between 21 and 40 procedures per year (27.3 %; n = 41). Only 4.0 % of providers (n = 6) indicated that fewer than 10.0 % of GnRFA procedures were performed as a treatment for knee pain associated with OA; the distribution of the remaining responses for the percentage of GnRFAs performed for this indication was relatively consistent across the remaining categories, which ranged from 11.0 to 100.0 %. Nearly half of respondents (48.0 %; n = 72) indicated that 11–50 % of GnRFA procedures were performed to treat persistent pain post-TKA.

3.2. Patient selection

Survey respondents' practices and preferences surrounding GnRFA patient selection, prognostic procedures, and ablation procedures are presented in Table 2. A majority of respondents (90.0 %; n = 135) used radiographic confirmation of OA to select patients for GnRFA, most commonly performed for more advanced OA cases (OA Grades 3 and 4 were each indicated by approximately 65.0 % of providers). More than half of respondents (55.3 %; n = 83) believed knee pain should persist for at least 6 months before a patient is considered for GnRFA. A duration of six months of persistent knee pain before considering GnRFA was preferred by 55.3 % of respondents (n = 83), followed by 20.0 % (n = 30), preferring 12 months. A duration of six months of attempted conservative treatment was preferred by 42.0 % of respondents (n = 63), followed by 32.0 % (n = 48), preferring 3 months. Most providers (67.3

Proceduralist Characteristics		
1.	What country do you practice medicine in?	◯ Australia ◯ Canada ◯ Netherlands ◯ New Zealand ◯ South Korea ◯ Spain ◯ United States ◯ Other
	Please state which country you practice medicine in.	________________
2.	What best describes your provider type?	◯ Physician ◯ Physician in Training ◯ Nurse Practitioner ◯ Physician Assistant
3.	What best describes your provider specialty?	◯ Anesthesiology ◯ Family Medicine ◯ General Surgery ◯ Interventional Radiology ◯ Musculoskeletal Radiology ◯ Neurosurgery ◯ Orthopedics ◯ Pain Medicine ◯ Psychiatry ◯ Physical Medicine and Rehabilitation ◯ Rheumatology ◯ Sports Medicine
4.	How many years have you been in practice?	________________
5.	Do you perform genicular nerve radiofrequency ablation (RFA) procedures in your practice?	◯ Yes ◯ No
6.	How many genicular nerve RFA procedures do you perform annually?	◯ 1-20 ◯ 21-40 ◯ 41-60 ◯ 61-80 ◯ 81-100 ◯ 100+
7.	What percentage of genicular nerve RFA procedures do you perform for knee pain caused by osteoarthritis (OA)?	◯ < 10% ◯ 11-50% ◯ 51-75% ◯ 76-90% ◯ 91-100%
8.	What percentage of genicular nerve RFA procedures do you perform for pain that persists after a TKA (total knee arthroplasty)?	◯ < 10% ◯ 11-50% ◯ 51-75% ◯ 76-90% ◯ 91-100%

Fig. 1. Standardized anonymous survey.

Patient Selection / Characteristics		
9.	Do you use radiographic confirmation of osteoarthritis (OA) when selecting patients for genicular nerve RFA (radiofrequency ablation)?	◯ Yes ◯ No
10.	If yes, what grade(s) of OA do you generally perform genicular nerve RF ablation on? Please check all that apply.	☐ Grade 1 ☐ Grade 2 ☐ Grade 3 ☐ Grade 4 ☐ Unknown
11.	How long should a patient have had persistent knee pain before being considered for genicular nerve RFA?	◯ 1 month ◯ 2 months ◯ 3 months ◯ 6 months ◯ 12 months ◯ More than 12 months
12.	How long should a patient have attempted other conservative treatment prior to genicular nerve RFA?	◯ Do not need to attempt conservative treatment ◯ 1 month ◯ 2 months ◯ 3 months ◯ 6 months ◯ 12 months ◯ More than 12 months
13.	Does your typical genicular nerve RFA patient have co-morbidities preventing more invasive intervention?	◯ Yes ◯ No

Diagnostic Procedure		
14.	Do you perform diagnostic blocks prior to ablating genicular nerves for OA knee pain?	◯ No block ◯ 1 block ◯ 2 blocks
15.	What medication do you use for the FIRST diagnostic genicular nerve block?	◯ Lidocaine 1% ◯ Lidocaine 2% ◯ Bupivacaine 0.25% ◯ Bupivacaine 0.5% ◯ Other
	Please state what medication you use for the FIRST diagnostic genicular nerve block.	______________________
16.	What volume (mL) of medication do you use when performing diagnostic genicular nerve blocks (per injection site)?	◯ ≤ 0.5 mL ◯ 1 mL ◯ 1.5 mL ◯ 2 mL ◯ > 2 mL
17.	What percentage of pain reduction do you consider as a positive response to the FIRST diagnostic genicular nerve block?	◯ ≥ 50% reduction in pain ◯ 60-80% reduction in pain ◯ ≥ 80% reduction in pain
18.	What medication do you use for the SECOND diagnostic genicular nerve block?	◯ Lidocaine 1% ◯ Lidocaine 2% ◯ Bupivacaine 0.25% ◯ Bupivacaine 0.5% ◯ I do not perform a second block ◯ Other
	Please state what medication you use for the SECOND diagnostic genicular nerve block.	______________________
19.	What type of imaging guidance do you use when performing diagnostic genicular nerve blocks?	◯ Anatomic Guidance ◯ Fluoroscopy ◯ Ultrasound ◯ Combination Fluoroscopy and Ultrasound
20.	Do you use contrast media when performing genicular nerve blocks?	◯ Yes ◯ No

Fig. 1. (*continued*).

Treatment / Ablative Procedure

21. What type of radiofrequency ablation technique do you most commonly use for treating genicular nerves?
   - ◯ Cooled RFA
   - ◯ Standard Conventional RFA
   - ◯ Multi-tined Conventional RFA
   - ◯ Pulsed RF
   - ◯ Other

Please state what type of radiofrequency ablation technique you most commonly use for treating genicular nerves. ____________________________

22. What technique do you typically use for genicular nerve RFA?
   - ◯ Monopolar
   - ◯ Bipolar

23. What needle gauge do you typically use for genicular nerve RFA?
   - ◯ 16-gauge
   - ◯ 17-gauge
   - ◯ 18-gauge
   - ◯ 20-gauge single needle
   - ◯ 22-gauge single needle
   - ◯ Other

Please state what needle gauge you typically use for genicular nerve RFA. ____________________________

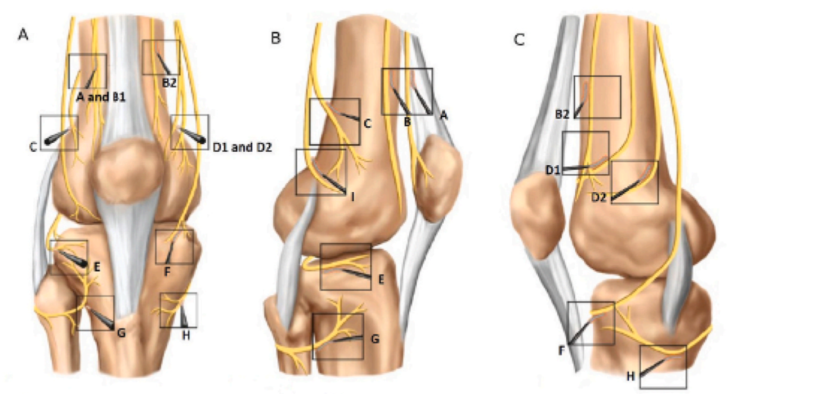

Figure 2 Innervation of the anterior knee joint with target nerves. (A) Anterior view, (B) lateral view, (C) medial view. (A) Nerve to vastus lateralis, B1. Lateral branch of nerve to vastus intermedius, B2 medial branch nerve to vastus intermedius, C. Superior lateral genicular nerve, D1. Nerve to vastus medialis, D2. Superior medial genicular nerve, E. Inferior lateral genicular nerve, F. Infrapatellar branch of saphenous, G. Recurrent fibular nerve, H. Inferior medical genicular nerve, I. Terminal articular branch of the common fibular nerve.

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24. Which nerves do you typically ablate when performing genicular nerve RFA (see figure for reference)?
   - ☐ Inferomedial
   - ☐ Inferolateral
   - ☐ Superomedial
   - ☐ Superolateral
   - ☐ Infrapatellar branch of the saphenous nerve
   - ☐ Recurrent fibular nerve
   - ☐ Nerve to vastus medialis
   - ☐ Nerve to vastus intermedius
   - ☐ Nerve to vastus lateralis
   - ☐ Terminal articular branch of the common fibular nerve

Fig. 1. (*continued*).

%; n = 101) reported that their typical GnRFA patients had comorbidities that prevented more invasive interventions.

3.3. Prognostic procedures

Performing prognostic genicular nerve blocks before ablation was almost unanimously reported by survey respondents (94.7 %; n = 142), who largely favored a single block paradigm (70.0 %; n = 105) over a dual-block approach. For the first prognostic block, 0.5 % bupivacaine was the most commonly used local anesthetic (30.7 %; n = 46) followed by 2 % lidocaine (22.7 %; n = 34) and 0.25 % bupivacaine (21.3 %; n = 32). Similar trends in medication utilization emerged among the 24.7 % of respondents (n = 37) who perform a second prognostic block: 0.5 % bupivacaine (n = 17) was most frequently used for the second block, followed by 2 % lidocaine (n = 9) and 0.25 % bupivacaine (n = 9). Accordingly, injectate volumes of 1.0 mL and ≤0.5 mL per site were reported by 40.7 % (n = 61) and 25.3 % of respondents (n = 38), respectively. Most providers (44.0 %; n = 61) considered ≥50 %

25. Do you perform motor testing prior to RFA lesioning?
- ◯ Yes
- ◯ No

26. What generator setting do you use to perform genicular nerve radiofrequency ablation?
- ◯ < 60 degrees C
- ◯ 60 degrees C
- ◯ 61-79 degrees C
- ◯ 80-85 degrees C
- ◯ 86-90 degrees C
- ◯ > 90 degrees C
- ◯ Other

Please state what generator setting you use to perform genicular nerve radiofrequency ablation. ________________

27. What is the minimum duration of time you use for each ablation?
- ◯ 60 seconds
- ◯ 90 seconds
- ◯ 120 seconds
- ◯ 150 seconds
- ◯ 180 seconds
- ◯ Other

Please state the minimum duration of time (in seconds) you use for each ablation. ________________

28. What type of imaging guidance do you use when performing genicular nerve RFA?
- ◯ Anatomic Guidance
- ◯ Fluoroscopy
- ◯ Ultrasound
- ◯ Combination Fluoroscopy and Ultrasound

Adverse Events

29. Which complications have your patients have experienced from genicular nerve RFA?
- ☐ Infection
- ☐ Vascular injury
- ☐ Hematoma
- ☐ Extensive bruising
- ☐ Burn
- ☐ Paralysis
- ☐ Weakness
- ☐ Loss of Sensation
- ☐ Tingling
- ☐ Pain at the procedure site that became chronic
- ☐ None
- ☐ Other

Please state complications your patients have experienced from genicular nerve RFA. ________________

Fig. 1. (*continued*).

reduction of index pain as constituting a positive block response, while another 33.3 % (n = 50) implemented a higher cutoff threshold of ≥80 % relief. Fluoroscopy was the predominant form of imaging guidance used during genicular nerve blocks (77.3 %; n = 116); however, only 42.0 % of survey respondents (n = 63) reported using contrast media while performing blocks.

3.4. Ablation procedure

Respondents reported typically performing GnRFA procedures under fluoroscopic guidance (85.3 %; n = 128) using standard conventional RFA technology (62.0 %; n = 93) with a monopolar technique (86.0 %; n = 129). The most commonly used GnRFA needle diameter was 18g (45.3 %; n = 68). Nearly all participants reported targeting the inferomedial (97.3 %; n = 146), superomedial (100 %; n = 150), and superolateral (98.0 %; n = 147) genicular nerves in accordance with the ablation protocol originally described by Choi et al. [25] Considerably fewer respondents routinely ablated additional sensory nerves. Of the seven additional possible neural targets described previously, the nerve to vastus medialis was most frequently included at 16.0 % (n = 24), while the least was the recurrent fibular nerve at 4.7 % (n = 7) [28]. Motor testing was conducted by over half of respondents (57.3 %; n = 86). Most providers applied lesions using a generator temperature setting between 80 and 85°C (66.0 %; n = 99) for a minimum duration of 90 s per ablation (67.3 %; n = 101). A minority of respondents reported use of non-ablative (pulsed) radiofrequency generator parameters (3.3 %; n = 5).

3.5. Adverse events

Adverse events (AEs) encountered by survey respondents are summarized in Table 3. While 55.3 % of respondents (n = 83) reported no knowledge of AEs associated with GnRFA procedures in their patients, greater than 10 % of repondents reported hematoma (n = 23), extensive bruising (n = 21), loss of sensation (n = 19), or tingling (n = 17). Four percent of respondents also reported experience with transient but unusually intense pain associated with the GnRFA procedure (n = 6).

Table 1
Survey respondent demographics and proceduralist characteristics ($N = 150$).

Characteristic	Frequency	%
Country		
Australia	6	4.0
Canada	6	4.0
Netherlands	1	0.7
United States	119	79.3
Other	18	12.0
Provider type		
Physician	145	96.7
Physician Assistant	1	0.7
Physician in Training	4	2.7
Specialty		
Anesthesiology	25	16.7
Interventional Radiology	1	0.7
Musculoskeletal Radiology	3	2.0
Orthopedics	3	2.0
Pain Medicine	63	42.0
Physical Medicine and Rehabilitation	52	34.7
Rheumatology	1	0.7
Sports Medicine	2	1.3
How long in practice		
0–2 years	26	17.3
3–5 years	24	16.0
6–10 years	34	22.7
11–20 years	29	19.3
>20 years	37	24.7
Genicular nerve RFA procedures performed annually		
1-20	75	50.0
21-40	41	27.3
41-60	18	12.0
61-80	10	6.7
81-100	4	2.7
>100	2	1.3
Genicular nerve RFA procedures for OA pain		
<10 %	6	4.0
11–50 %	32	21.3
51–75 %	29	19.3
76–90 %	47	31.3
91–100 %	36	24.0
Genicular nerve RFA procedures for persistent post-TKA pain		
<10 %	47	31.3
11–50 %	72	48.0
51–75 %	22	14.7
76–90 %	5	3.3
91–100 %	4	2.7

Abbreviations: OA = osteoarthritis; RFA = radiofrequency ablation; TKA = total knee arthroplasty.

4. Discussion

The present study is the first to describe international practice patterns of GnRFA through a survey of the IPSIS membership. The findings reveal several trends in current practice patterns, which inform needs regarding clinical practice guideline development to define evidence-based treatment strategies, aiming to improve patient outcomes and enhance quality of life.

4.1. Patient selection

Radiographic confirmation of OA was widely utilized for patient selection, with most providers selecting individuals with advanced OA (Grades 3 and 4) as candidates for GnRFA. The majority of respondents preferred a duration of at least 6 months of persistent knee pain before considering GnRFA, emphasizing the importance of thorough conservative management trials. Our study revealed several consensus points among interventional pain physicians regarding the indications and practices surrounding GnRFA. Notably, a significant proportion of practitioners consider at least 6 months of persistent knee pain and 6 months of trialed conservative care as appropriate indications for GnRFA. We did not ask providers to quantify exactly what they

Table 2
Summary of practices and preferences related to genicular nerve RFA ($N = 150$).

Characteristic	Frequency	%
Patient selection		
Radiographic confirmation of OA		
Yes	135	90.0
No	15	10.0
OA grade(s)		
Grade 1	24	16.0
Grade 2	47	31.3
Grade 3	103	68.7
Grade 4	95	63.3
Unknown	26	17.3
Knee pain duration		
1 month	1	0.7
2 months	0	0.0
3 months	24	16.0
6 months	83	55.3
12 months	12	8.0
>12 months	30	20.0
Conservative treatment duration		
1 month	6	4.0
2 months	5	3.3
3 months	48	32.0
6 months	63	42.0
12 months	16	10.7
>12 months	3	2.0
Do not need to attempt conservative treatment	3	2.0
Co-morbidities preventing more invasive intervention		
Yes	101	67.3
No	49	32.7
Prognostic procedures		
Prognostic blocks		
1 block	105	70.0
2 blocks	37	24.7
No block	8	5.3
First block medication		
Lidocaine 1 %	14	9.3
Lidocaine 2 %	34	22.7
Bupivacaine 0.25 %	32	21.3
Bupivacaine 0.5 %	46	30.7
Other	16	10.7
Medication volume per site		
≤0.5 mL	38	25.3
1 mL	61	40.7
1.5 mL	14	9.3
2 mL	16	10.7
>2 mL	13	8.7
Positive block response pain reduction		
≥50 % reduction	66	44.0
60–80 % reduction	26	17.3
≥80 % reduction	50	33.3
Second block medication		
Lidocaine 1 %	2	1.3
Lidocaine 2 %	9	6.0
Bupivacaine 0.25 %	9	6.0
Bupivacaine 0.5 %	17	11.3
No second block	113	75.3
Imaging guidance for blocks		
Anatomic guidance	1	0.7
Fluoroscopy	116	77.3
Ultrasound	19	12.7
Combination fluoroscopy and ultrasound	6	4.0
Contrast media used for blocks		
Yes	63	42.0
No	79	52.7
Treatment/ablative procedure		
RFA type		
Cooled RFA	18	12.0
Standard conventional RFA	93	62.0
Multi-tined conventional RFA	30	20.0
Pulsed RF	5	3.3
Other	4	2.7
RFA technique		
Monopolar	129	86.0
Bipolar	21	14.0
Needle gauge		

(*continued on next page*)

Table 2 (*continued*)

Characteristic	Frequency	%
16g	15	10.0
17g	15	10.0
18g	68	45.3
20g single needle	42	28.0
22g single needle	10	6.7
Other	0	0.0
Nerves		
Inferomedial	146	97.3
Inferolateral	10	6.7
Superomedial	150	100.0
Superolateral	147	98.0
Infrapatellar branch of the saphenous nerve	17	11.3
Recurrent fibular nerve	7	4.7
Nerve to vastus medialis	24	16.0
Nerve to vastus intermedius	17	11.3
Nerve to vastus lateralis	11	7.3
Terminal articular branch of the common fibular nerve	13	8.7
Motor testing		
Yes	86	57.3
No	64	42.7
Generator setting		
<60 °C	2	1.3
60 °C	16	10.7
61–79 °C	10	6.7
80–85 °C	99	66.0
86–90 °C	18	12.0
>90 °C	3	2.0
Other	2	1.3
Minimum duration		
60 s	13	8.7
90 s	101	67.3
120 s	15	10.0
150 s	12	8.0
180 s	7	4.7
Other	2	1.3
Imaging guidance for RFA		
Anatomic guidance	0	0.0
Fluoroscopy	128	85.3
Ultrasound	11	7.3
Combination fluoroscopy and ultrasound	11	7.3

Abbreviations: OA = osteoarthritis; RFA = radiofrequency ablation.

Table 3
Adverse events reported by respondents during cumulative experience with genicular nerve radiofrequency ablation ($N = 150$).

Characteristic	Number of Respondents reporting Experience with this AE	%
Adverse Event		
Infection	2	1.3
Vascular injury	1	0.7
Hematoma	23	15.3
Extensive bruising	21	14.0
Burn	7	4.7
Paralysis	0	0.0
Weakness	4	2.7
Loss of sensation	19	12.7
Tingling	17	11.3
Pain at the procedure site that became chronic	6	4.0
None	83	55.3
Other	7	4.7

considered appropriate conservative treatment prior to considering GnRFA, but commonly recommended treatments include self-directed exercise, physical therapy, topical and oral NSAIDs, and intra-articular injections [33–36]. However, a recent network meta-analysis of 21 RCTs reported substantially more robust improvements in pain and function in those with painful knee OA when treated with GnRFA as compared to exercise alone, NSAIDs, intra-articular platelet rich plasma (IAPRP), intra-articular steroid (IAS), or intra-articular hyaluronic acid (IAHA) [22]. This is perhaps not surprising given that the magnitude of effect and responder rates at 6 months post-GnRFA are high releative to those of other conservative care treatments [37,38]. To our knowledge, no study has directly compared the relative risks, benefits, and costs of early GnRFA treatment compared to prolonged real-world, multifaceted conservative care.

4.2. Prognostic procedures

Our survey identfied significant variability in the number of genicular nerve blocks, volume of anesthetic, and the type of anesthetic clinicians are using within their patient selection paradigm. In a recent systematic review by Fogarty et al., five of six studies used response to prognostic blockade as an inclusion criterion. The authors noted that the volume of injectate used for blocks was highly variable across individual study protocols ranging from 0.6 to 2 mL (Fogarty et al., 2022). Recent literature suggests that there is a high false-positive rate (low positive predictive value) for prognostic blocks to predict pain relief after RFA (McCormick et al., 2018). This may be attributed in part to the volume of local anesthetic, which can spread to areas beyond the boundaries of typical RFA lesions, particularly with volumes greater than 0.5 mL [39]. Large cohort studies are needed to establish the standardization of prognostic nerve blocks.

Nearly all respondents performed prognostic genicular nerve blocks prior to ablation, with a preference for a single block paradigm. Respondents favored local anesthetics like bupivacaine and lidocaine for prognostic blocks, with fluoroscopy being the primary imaging modality used. Despite the prevailing practice of performing a single prognostic block, there is data suggesting limited value in this approach, particularly when utilizing a traditional three-lesion protocol with 1 mL of injectate at each site [40,41]. This highlights a potential area for reconsideration and further investigation in refining patient selection criteria for GnRFA.

Variability in defining a "positive" response to prognostic blocks was observed among practitioners, with thresholds ranging from ≥50 % to ≥80 % pain relief. This variability may reflect differing clinical philosophies, with some physicians prioritizing pragmatic thresholds while others aim to optimize responder rates. This variability mirrors debates seen in other procedural interventions, such as medial branch blocks, that have classically highlighted optimizing access to a relatively safe treatment compared to optimizing the treatment responder rate of a given procedure [42–44].

4.3. Radiofrequency procedure

GnRFA procedures were predominantly performed under fluoroscopic guidance, with standard conventional RF technology (GnRFA) being the preferred technique. Providers typically targeted the inferomedial, superomedial, and superolateral genicular nerves, with varying frequencies for additional neural targets. To date, only one study has undertaken a direct comparison between GnRFA utilizing ultrasound guidance as opposed to fluoroscopic guidance. This study revealed that individuals randomized to either modality exhibited similar levels of pain relief and functional improvement at three months when only targeting the SLGN, IMGN, and SMGN, it should be noted that the study may have not had enough power to detect significant differences between the groups [45] and that many would consider the legacy 3-lesion protocol suboptimal compared to expanded lesioning protocols [26,28]. There is literature supporting the targeting of more than the standard IMGN, SMGN, and SLGN, as including ablation of the RFN, NVM, NVL, IPBSN, and NVI has demonstrated better outcomes in patients with both native and non-native knees [46,47]. In a TKA, periprocedural transection of the IPBSN can lead to neuralgia over the front of the knee due to neuroma formation, resulting in persistent pain post-total knee arthroplasty and stiffness which can be treated with targeted intervention of the IPBSN [48–50]. In conventional practice, the ILGN and RFN are typically avoided in standard GnRFA protocols due to their proximity to the common peroneal nerve in the fibular neck. Injury to these nerves carries a significant risk of subsequent foot drop. However, recent investigations have delineated protocols aimed at safely targeting the RFN and other pertinent nerves implicated in knee pain [51,52,52]. Notably, Chen et al. undertook a focused approach, specifically targeting both the ILGN and RFN and reported no complications [47].

In our survey, motor testing was commonly conducted, and parameters like generator temperature and ablation duration showed consistency among respondents. These are interesting findings since there were only 4 cases of weakness reported by respondents, many did not perform motor testing, and there are no published case reports of motor deficits after GnRFA in the literature. Further, studies of GnRFA and genicular nerve blocks have shown stable or improved values for single leg stance performance, isokinetic quadriceps muscle strength test, knee joint proprioception test and 2-min walking test [53,54].

Our study also sheds light on the predominant use of fluoroscopy over ultrasound for both prognostic blocks and GnRFA procedures. This preference aligns with the historical validation of anatomical landmarks using fluoroscopy and raises interesting considerations due to lack of ionizing radiation, absence of contrast reactions, and increased accessibility of ultrasound relative to fluoroscopy in some regions [55,56]. Newer ultrasound-guided protocols for GnRFA have been devised to enhance precision in targeting the SMGN, SLGN, and IMGN, as well go specifically address the recurrent fibular nerves and IPBSN, though these protocols are awaiting prospective studies to validate their efficacy and safety profiles (Fonkoue et al., 2021). In a retrospective study performed by Lash et al. a new technique was developed to perform cooled radiofrequency ablation (CRFA) using US-guidance, a total of 51 patients received US-guided CRFA of the SMGN, SLGN, IMGN, and SPGN using a 17-gauge electrode, 82 % of patients reported 50–100 % improvement of their pain at 10 months, although only 43 % of patients were available for follow-up [57]. Further exploration of the comparative efficacy and safety of ultrasound-guided approaches may offer valuable insights into optimizing procedural techniques, as ultrasound-guided GnRFA can prove to be useful in patient populations where fluoroscopy is contraindicated or not accessible.

Notably, conventional fluoroscopically-guided monopolar ablative technique with non-16g radiofrequency needles remains the preferred technique for GnRFA among respondents. This concerns arise regarding the potential for missed capture of nerve targets. Previous studies highlight the limitations of this approach, suggesting that the current standard protocol may result in less extensive denervation due to smaller lesion volumes and ill-suited geometry for targeting genicular nerves [27,30,58–61]. The inclusion of additional nerves and larger lesions, whether through cooled, bipolar conventional, or multi-tined probes, may offer a more comprehensive denervation approach and warrant further investigation for optimization of GnRFA techniques [31, 32,37,38,62].

4.4. Adverse events

The majority of respondents reported no adverse events, though complications such as hematoma, extensive bruising, weakness, and sensory disturbances were encountered in a subset of patients. While the studies on GnRFA for persistent pain post-TKA have shown promise without any serious adverse events, there have been reported rare complications of GnRFA in native knee osteoarthritis, including iatrogenic hematoma, third-degree skin burns, injury to the pes anserine tendon, and septic arthritis [63–66]. Large cohort studies are needed to confirm the safety of genicular nerve interventions for persistent pain post-TKA. However, insights from research on GnRFA in patients experiencing pain in the native knee suggest a promising safety record, although further confirmation through larger-scale investigations is required. An issue noted by Mazor et al. is that patients who suspect that an adverse event has occurred in their treatment do not report this to their treating physician [67]. Moreover, healthcare professionals may refrain from reporting adverse events due to insufficient training, a culture of assigning blame, or concerns regarding potential medicolegal consequences [68–70]. Additional investigation is needed to ascertain the incidence of these significant yet rare complications [51,71,72]. Notably, findings of a comprehensive retrospective cohort study involving over 1000 patients who underwent GnRFA demonstrate that the risks of superficial infection, septic arthritis, bleeding, and nerve injury are indistinguishable to those associated with standard intra-articular injections of either corticosteroid or hyaluronic acid [73].

4.5. Study limitations

This study has several limitations that merit discussion. First, the response rate of 150 completed surveys represents 2.0 % of surveys sent, 3.5 % of emails opened, and 56.8 % of those who clicked on the survey link. While the completion rate among those who accessed the survey link is relatively good compared to typical electronic survey responses in medical literature, the overall response rate may limit the generalizability of findings to the broader population of interventional pain physicians. Moreover, respondents may not fully represent all practice patterns within the International Pain and Spine Intervention Society (IPSIS), potentially introducing selection bias.

Our response rate is consistent with other IPSIS surveys published in the medical literature. For example, Southerland et al. reported a 3.14 % response rate (193 respondents from 6136 emails), Huynh et al. had an 8 % response rate (2295 emails), Gill et al. achieved a 3.15 % response rate (193 respondents from 6136 emails), and Brenner et al. reported a 14.3 % response rate [74–77]. These low response rates are common in medical survey research, often due to respondent fatigue from frequent survey requests. Our response rate aligns with these trends, indicating it is comparable to other published studies.

Additionally, the survey did not gather data on the active tip size used for ablations. While active tip size can influence lesion size, our focus was on gauge size, which is a more critical determinant. Questions on technology type (cooled, multi-tined, conventional) and monopolar vs bipolar also inform lesion size. Given that both a 5 mm and a 10 mm active tip of a 22g RF cannula result in small lesions, the omission of specific active tip size details does not substantially affect the overall interpretation of our results. However, this limitation does restrict the depth of our analysis and our ability to make more granular recommendations regarding the procedural aspects of GnRFA. Future studies could benefit from including active tip size to provide a more comprehensive understanding of its impact on procedural outcomes.

Furthermore, our study lacks detailed information regarding providers' beliefs about whether other procedures, such as intra-articular steroid injections or platelet-rich plasma (PRP) therapy, should be exhausted before resorting to GnRFA. However, we had to balance the granularity of this survey with respondent burden. We agree that a future survey that focuses on this question would be valuable, but it was outside our chosen scope in the present study. Understanding these beliefs would be helpful in interpretation of our results and the perceived appropriateness of GnRFA within the broader context of available treatments and procedural decision-making. Future studies could expand on this to develop a stronger understanding on preferences of procedures performed prior to initiating therapy with GnRFA.

IPSIS was historically known as a "spine" organization, and while it has had a significant number of interventional pain physicians as members, there is a potential for sampling bias due to its previous focus. This bias could affect the representativeness of our findings when compared to organizations traditionally considered comprehensive in pain management, such as the American Society of Regional Anesthesia and Pain Medicine (ASRA) or the American Academy of Pain Medicine (AAPM). Although there may be differences in practice patterns, it's important to highlight that the majority of IPSIS members are interventional pain physicians, not solely spine-focused practitioners. Future studies should consider including members from a broader range of professional organizations to further enhance the representativeness and applicability of the findings.

5. Conclusion

This survey study of the IPSIS membership revealed several important trends regarding GnRFA which have implications for the development of a clinical practice guideline. Respondents generally use common selection protocols with regard to OA grade (Kelgren-Lawrence 3 and 4), duration of failed conservative care (3–6 months), a single anesthetic block paradigm, and use of fluoroscopic guideance for the GnRFA procedure. More variability was reported between respondents with regard to the volume of anesthetic used during prognostic blocks, the threshold to consider a prognostic block "positive," and the technology used and nerves targeted during the GnRFA procedure. Clinical practice guidelines should focus on recommending evidence-based best practice standards with regards to all categories investigated in this study, but with particular focus on the areas of practice variabily observed here. Further research is warranted to explore the long-term efficacy and safety of GnRFA and to standardize techniques and protocols across different practice settings, ultimately improving patient outcomes and quality of life.

However, this study has several limitations. A low overall response rate may limit the generalizability of the findings. Additionally, the survey did not capture data on active tip sizes used for ablation or on procedural beliefs regarding the exhaustion of other treatments before resorting to GnRFA. Surveying only IPSIS members may not adequately represent the diversity of practice patterns among pain management specialists, potentially introducing sampling bias. Future studies should include participants from a broader range of professional organizations to enhance representativeness.

Disclosures

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Co-Authors: 1) Taylor Burnham, DO MS receives research grant funding from DIROS technology (paid directly to the University of Utah) and does consulting work with AVANOS Medical. 2) Zachary L. McCormick, MD serves on the Board of Directors of the International Pain and Spine Intervention Society (IPSIS), has research grants from Avanos Medical, Boston Scientific, Relievant Medsystems, Saol Therapeutics, Spine Biopharma, SPR Therapeutics, Stratus Medical (paid directly to the University of Utah), and also consultancies with Avanos Medical, Saol Therapetuics, Stryker, and OrthoSon.If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inpm.2024.100432.

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