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Effectiveness comparison of genicular nerve ablation for knee osteoarthritic versus post-total knee arthroplasty pain☆

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ABSTRACT

Background: Genicular nerve radiofrequency ablation (GNRFA) is a popular and effective procedure to treat arthritic knee pain. For refractory arthritic pain that fails conservative treatment, total knee arthroplasty (TKA) has been an excellent option. Unfortunately, 15–30% of people who undergo a TKA continue to experience pain and stiffness in the knee. The treatment options for post-TKA knee pain are limited. Pain providers have been trialing GNRFA on this pain condition. However, convincing evidence of its efficacy in treating post-TKA pain is still lacking.

Methods: This is a retrospective study of 73 patients who had undergone genicular nerve RFA, 46 (63.01%) with osteoarthritic pain, and 27 (36.99%) with post-TKA pain. We compared the outcomes (pain relief, function, and complications) between these two groups at 3 months and 6 months after RFA.

Results: Before RFA, there was no significant difference in initial pain and functional level between these two groups. After RFA, the two groups had comparable pain relief at 3 months ($p = 0.68$) and 6 months ($p = 0.53$), and similar functionality at 3 months ($p = 0.36$) and 6 months ($p = 0.65$).

The overall success rate (≥50% pain relief after RFA) was 80.82%, 95% CI: 70.34%–88.22% (osteoarthritic group 80.43%, 95% CI: 66.83%–89.35%, post-TKA 81.48%, 95% CI: 63.30%–91.82%, $P = 0.91$) at 3-month follow-up and 56.16%, 95% CI: 44.76%–66.95% (osteoarthritic group 56.52%, 95% CI: 42.25%–69.79%, post-TKA 55.56%, 95% CI: 37.31%–72.41%, $P = 0.94$) at 6-month follow-up.

There were no reported complications in either group.

Conclusions: Genicular Nerve Radiofrequency Ablation (GNRFA) holds the potential to be equally effective for both post-TKA knee pain and osteoarthritic knee pain.

1. Introduction

Knee osteoarthritis (OA) is a common joint disease and is characterized by chronic pain and functional disability [1–3]. It accounts for almost 80% of OA worldwide and increases with obesity and age [1]. Over 14 million Americans suffer from symptomatic knee arthritis [4]. Knee arthroplasty is considered an effective treatment for advanced stage OA. A growing number of these patients are opting for total knee arthroplasty with about 500,000 procedures being performed annually [5]. Unfortunately, 15–30% of people who undergo a knee replacement continue to experience pain and stiffness in the knee [6]. The treatment options for post-TKA knee pain are limited since most TKA candidates exhausted all conservative treatments prior to surgery. Pain relief after an additional surgery is not guaranteed. In reality, outcomes are often poorer after revision TKR compared with primary TKR; nearly half of patients report severe chronic post-operative pain [7].

Genicular nerve radiofrequency ablation (GNRFA) has emerged as a popular and effective procedure to treat arthritic knee pain [8–10].

☆ Permission to conduct this study was granted by the Institutional Review Board of our institute.

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Interventional pain providers have been trialing GNRFA for post-TKA knee pain [11,12]. Two published studies show the efficacy of GNRFA in treating chronic knee pain but are relatively preliminary. One was a double-blind, randomized study with only 14 patients on each arm, compared effect between traditional RFA and local anesthetic with corticosteroid block, and found pain relief and joint function improvement during the first 3–6 months were similar with both techniques [11]. The other was a single institution pilot study, which showed promising result with image-guided genicular nerve cooled radiofrequency ablation in treating chronic pain/stiffness in the setting of uncomplicated TKA [12]. Since traditional RFA still remains the most commonly used RFA modality, it is important to evaluate its efficacy in treating post-TKA knee pain.

This retrospective study compares the effectiveness of traditional thermal GNRFA for post-TKA knee pain to the effectiveness of GNRFA for osteoarthritic knee pain.

2. Methods

Permission to conduct this study was granted by the Institutional Review Board at our institute STUDY (00019923). All procedures and follow-up visits were performed between September 2019 and February 2023. A total of 91 patients underwent knee genicular nerve radiofrequency ablation (GNRFA) during this time and were screened.

Inclusion criteria were 1) ages between 18 and 90 years; 2) greater than six months of knee pain; 3) failure of conventional therapy, including oral medications, physical therapy, and intra-articular injection therapy; 4) history of either knee OA or total knee arthroplasty with or without revision, but were not candidates for further knee surgery or wanted to avoid surgery.

Exclusion criteria were 1) contraindications to genicular nerve block or genicular nerve RFA (active infection, bleeding disorders, current anticoagulant or antiplatelet medication use that cannot be safely stopped, allergy to medications, pregnancy, or use of a pacemaker); 2) clinically significant cognitive deficit, unstable medical or psychiatric illness; 3) failure in providing follow-up information at the six-month duration of the study; 4) any extrinsic causes of knee pain, including neurovascular etiologies, referred pain, periarticular bursitis, tendinopathies, iliotibial (IT) band syndrome, complex regional pain syndrome (CRPS), and heterotopic ossification [13].

Seventy-three patients met inclusion criteria. Prior to GNRFA, patients were asked to report their pain on a numerical rating scale (NRS) and patient-specific functional scale (PSFS) [14–16], between 0 and 10. Three major functions were evaluated using PSFS, including: standing, walking, and stair negotiation.

Diagnostic genicular nerve blocks were performed by the same interventional pain physician who performed the GNRFA procedures in this study. No superficial local anesthesia was used for diagnostic blocks. The needle placement followed as described in literature [17,18]. We primarily adhere to the proposed needle placement proposed by McCormick et al. [18], with the exception of the recurrent fibular nerve, which we described earlier [17]. The number of nerves targeted was based on the patient's pain locations (Table 2). Up to 9 nerves could be targeted, which are superolateral, superomedial, inferolateral, and inferomedial genicular nerves, recurrent fibular nerve, infrapatellar branch of the saphenous nerve, nerve to vastus lateralis, nerve to vastus medialis, and nerve to vastus intermedius medial branch [18]. One mL of 0.25% bupivacaine was injected to block each nerve. If the patient reported a $\geq$50% reduction in baseline pain for about 6 h following the injection, then the patient is a candidate for genicular ablation.

For RFA, patient was positioned supine with the target knee flexed at 20–30° using a bolster. The target knee was also maintained in neutral position to ensure good anteroposterior (AP) view: the femoral and tibial condyles should be symmetrical, with the fibular head slightly superimposed on the lateral tibial condyle. All patients received monitored anesthesia care prior to the procedure. The cannula was placed in a near-parallel position. Sensory testing was conducted at 50 Hz and up to 0.6 V to confirm correct placement of the cannula, with subsequent assessment of the absence of motor response at a voltage of up to 2 V and a frequency of 2 Hz. The pre-RFA motor response test was highly crucial for the recurrent fibular nerve and the inferolateral branch. Traditional thermal RFA with 18-gauge cannula with 10-mm active tip was performed at 85 °C for 150 s at an outpatient surgery center. To target the superolateral and superomedial branches, the cannula was advanced to the lateral and medial aspects of the femur at the junctions of the shaft and the epicondyle where the metaphysis meets the diaphysis until the tip was halfway across the femoral shaft and 2 mm superficial to the periosteum. For inferolateral branch, the cannula was advanced above the fibular head at or slightly below tibial plateau on AP view and about 3/4 depth to the posterior border. For inferomedial branch, on AP view, the cannula was directed toward the confluence of the medial tibial shaft and tibial flare, and advanced three-quarters of the distance across the tibial shaft on lateral view [18]. For recurrent fibular nerve, the cannula was inserted towards the medial aspect of the fibular neck but stopped at or above the neck of the fibular head, laterally between the tibia and fibula [17]. To target infrapatellar branch of the saphenous nerve, the cannula was advanced toward the mid-point between the patella and medial margin of the tibial plateau, up to the level of the plateau. To target branch from the nerve to vastus lateralis, advance the cannula about 5 cm superior to upper patella, 5 mm toward midline from lateral border of femur, about 1 cm superficial to the periosteum. To target the medial branch of the neve to vastus medialis, withdraw the cannula from the target for superomedial branch to about 1/3 the dimeter of the femoral shaft, 1 cm superficial to periosteum. To target the medial branch of the nerve to vastus intermedius, the cannula was targeted 5 cm superior to the upper patellar pole and 5 mm toward midline from the medial border of the femoral shaft, 2 mm superficial to the periosteum [18].

Following RFA, all participants were followed up by the same interventional pain physician, either in person or virtually (via video or phone), at 2 weeks, 3 months, and 6 months to assess pain relief (NRS) and functional improvement (PSFS). The NRS and PSFS scores reported before and after ablation (2 weeks, 3 months, and 6 months) were used to calculate a percentage of pain relief and functional improvement. The average PSFS score of the three functions (standing, walking, and stair negotiation) was used for functional evaluation. The percentage change in pain relief was calculated by dividing the change in pain score after RFA by the pain score before the RFA. The percentage change in PSFS score was calculated by dividing the actual change in score by the maximum change required to achieve a 100% improvement. For instance, a change in PSFS score from 5 to 8 would represent a 60% improvement. Here, the actual change is 3, and the maximum change is 5 [15]. We used a $\geq$50% in pain reduction as a positive outcome post-RFA. Patients with incomplete follow-up data were not included.

3. Statistical analysis

A Wilcoxon rank sum test was performed to analyze the difference in the pain relief and function recovery after RFA in patients with osteoarthritic pain compared to patients with post-TKA knee pain. Additionally, the Hodges-Lehmann estimator of location shift and associated 95% confidence interval were calculated to provide the magnitude of the difference between the two groups with respect to pain relief and function recovery after RFA. A chi-square test was performed to compare the success rate between these two groups. All hypothesis tests were two-sided and significance levels were set at 0.05.

A two-week follow-up appointment was scheduled for post-procedural checks. Given ongoing recovery and soreness at the injection site, patient efficacy data was not analyzed at the two-week timeframe to avoid confounding variables.

4. Results

In total, 73 patients met the inclusion criteria: 22 males (30.14%), 51 females (69.86%), average age 56.21 years, average BMI 33.31 kg/m^2, and 13 (17.81%) with diabetes mellitus, 46 (63.01%) with osteoarthritic pain, and 27 (36.99%) with post-TKA pain (Table 1). The prior pain level and functional status are similar in these two groups: pain ($p = 0.73$) and PSFS ($p = 0.10$) (Table 3). A total of 18 patients were excluded from this study (OA: 11, post-TKA: 7).

The Wilcoxon rank sum test showed no significant difference in pain relief between the groups with osteoarthritic pain and with post-TKA pain at 3-month ($p = 0.68$) and 6-month ($p = 0.53$) follow-ups. Additionally, there was no significant difference in functional improvement at 3-month ($p = 0.36$) and 6-month ($p = 0.65$) follow-ups (Table 3).

The overall success rate (≥50% pain relief after RFA) was 80.82%, 95% CI: 70.34%–88.22% (osteoarthritic group 80.43%, 95% CI: 66.83%–89.35%, post-TKA 81.48%, 95% CI: 63.30%–91.82%, $P = 0.91$) at 3-month follow-up and 56.16%, 95% CI: 44.76%–66.95% (osteoarthritic group 56.52%, 95% CI: 42.25%–69.79%, post-TKA 55.56%, 95% CI: 37.31%–72.41%, $P = 0.94$) at 6-month follow-up (Table 4).

Both groups reported no complications after RFA except minor superficial bruises at the cannula entry sites observed at the 2-week follow-up.

5. Discussion

GNRFA has been effectively utilized to treat osteoarthritic knee pain for over a decade. Its application in treating post-TKA knee pain is not yet well established. The pathophysiology of pain can be different in post-TKA knee compared to native knee. Unlike musculoskeletal pain and osteoarthritic knee pain, one unique pathophysiology of post-TKA knee pain is formation of a neuroma. For example, the standard surgical incision used in total knee arthroplasty almost always severs the infrapatellar branch of saphenous nerve. The severed nerve residual can become trapped in the incision's closure or in subsequent scar tissue, leading to a neuroma as noted by orthopedic surgeons [19]. Studies show surgical excision of these neuromas not only provide pain relief but also improve knee function [20,21]. Compared to surgical denervation, GNRFA offers a more conservative approach to achieve similar efficacy. By simply interrupting the nociceptive pathway, this modality can relieve arthritic pain, neuropathic pain and other pain sources as well. Theoretically, GNRFA will effectively treat post-TKA knee pain with similar efficacy as treating osteoarthritic knee pain. This study confirmed this hypothesis in both pain relief and function improvement.

GNRFA in post-TKA knee pain is more technically challenging than GNRFA in arthritic knee pain. The surgery changes the knee anatomy resulting in scar tissue formation and the surgical hardware blocks fluoroscopic view of the needle instrumentation. For example, the inferior lateral genicular nerve (ILGN) courses deep to the lateral collateral ligament and turns anteriorly just inferior to the lateral femoral condyle to innervate the knee joint [22]. The ideal cannula placement location should be at the joint level according to its anatomy, between the lateral femoral condyle and tibial plateau. For a post-TKA knee, the ideal landmarks may disappear. In this case, we often use the tip of the fibular head as reference, ensure the cannula is medial to the tip of fibular head (just underneath the lateral collateral ligament) while remaining below the articular joint line to avoid incidental intraarticular involvement and prevent subsequent infection (Fig. 1). Prosthetic knee infection is a devastating complication and may lead to additional surgical interventions including hardware removal [23].

The success rate (≥50% pain relief after RFA) varies across studies that utilized GNRFA to treat knee pain [10–12,24,25]. A study showed clinical and technical factors associated with better treatment outcomes included targeting more nerves, performing a prognostic block, no history of opioid use, and no history of depression [26]. A cohort study confirmed targeting a greater number of nerves (>3) led to improved outcomes compared with the classic protocol (3 nerves) [27]. In our study, the number of nerves ablated was based on the patient's pain locations; up to 9 nerves could be ablated. Patients who were on opioids

Table 1
Demographic and clinical summary.

	%	Mean ± SD
Gender	Male: 22/73, 30.14% Female: 52/73, 69.86%	
Age		56.21 ± 14.30
BMI (kg/m^2)		33.31 ± 7.26
OA or TKA	OA: 46/73, 63.01% TKA: 27/73, 36.99%	
Diabetes Mellitus	13/73, 17.81%	
Revision in TKA group	10/27, 37.04%	

BMI: body mass index; OA: osteoarthritis; TKA: total knee arthroplasty; SD: standard deviation.

Table 2
Number of genicular nerves ablated.

Genicular Nerves	TKA	OA	Total
Superolateral	19	31	50
Superomedial	20	31	51
Inferolateral	17	27	44
Inferomedial	23	41	64
Infrapatellar	18	31	49
Recurrent fibular	18	26	44
Nerve to vastus medialis	8	11	19
Nerve to vastus lateralis	6	7	13
Nerve to Vastus intermedius	6	5	11
Average (number of nerves per knee)	*5*	*4.57*	*4.73*

OA: osteoarthritis; TKA: total knee arthroplasty.

Table 3
Wilcoxon rank-sum test – OA versus TKA.

	OA/TKA	Median (25th percentile, 75th percentile)	Hodges-Lehmann Location Shift Estimate (95% Confidence Interval)	p-value
Pain Pre-RFA	OA TKA	8.0 (7.0, 8.0) 8.0 (7.0, 8.0)	0 (0, 1.0)	0.73
PSFS Pre-RFA	OA TKA	4.0 (3.0, 4.0) 3.0 (3.0, 4.0)	0.0 (−1.0, 0)	0.10
Pain 3 months (%)	OA TKA	60.0 (50.0, 80.0) 60.0 (50.0, 80.0)	0 (−10.0, 10.0)	0.68
PSFS 3 months (%)	OA TKA	57.1 (33.3, 71.4) 66.7 (28.6, 66.7)	−5.4 (−19.0, 8.6)	0.36
Pain 6 months (%)	OA TKA	50.0 (30, 60.0) 50.0 (0, 60.0)	0 (−20.0, 10.0)	0.53
PSFS 6 months (%)	OA TKA	33.3 (20.0, 57.1) 28.6 (14.3, 50.0)	0 (−16.7, 12.5)	0.65

OA: osteoarthritis; TKA: total knee arthroplasty; RFA: radiofrequency ablation; PSFS: patient specific functional scale.

Table 4
Chi-square test – success rate (OA versus TKA).

Post-RFA	OA/TKA	Success rate (95% Confidence Interval)	p-value
3 months	Overall	80.82% (70.34%, 88.22%)	
	OA	80.43% (66.83%, 89.35%)	0.91
	TKA	81.48% (63.30%, 91.82%)	
6 months	Overall	56.16% (44.76%, 66.95%)	
	OA	56.52% (42.25%, 69.79%)	0.94
	TKA	55.56% (37.31%, 72.41%)	

OA: osteoarthritis; TKA: total knee arthroplasty.

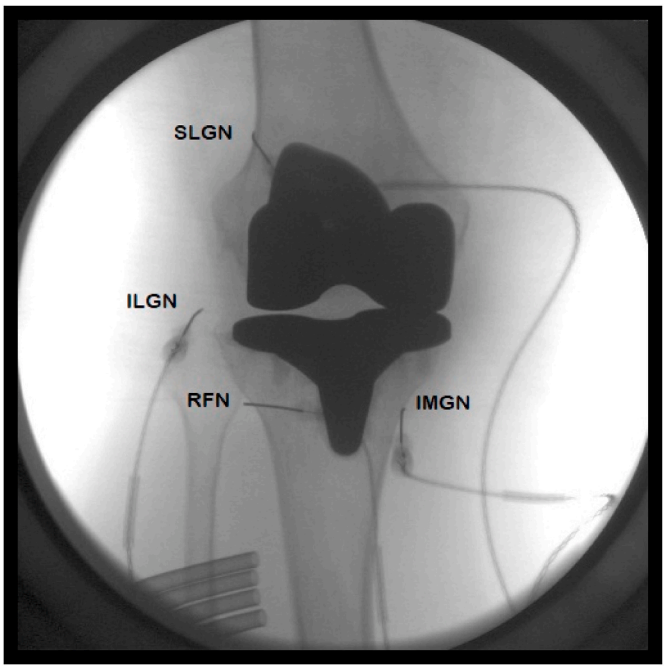

Fig. 1. On the anterior-posterior view, four cannulas are targeting the superolateral genicular nerve (SLGN), inferolateral genicular nerve (ILGN), recurrent fibular nerve (RFN), and infrapatellar branch of the saphenous nerve (IMGN). The tibial plateau is lower and at the level of the fibular head tip after total knee arthroplasty (TKA). To target the ILGN, the fibular head tip is used as a reference point to ensure the cannula is placed just medial to the tip of the fibular head. This precise placement is crucial to avoid incidental intra-articular involvement and prevent subsequent infection.

or with history of depression were not excluded from our study. The types of RFA also affect the outcome. Cooled-RFA produces larger lesion, presumably results in greater and longer-term pain relief and better knee function in comparison to traditional RF in treating post-TKA knee pain. It offered one-year pain relief in a small double-blind, randomized study [12]. Cooled RFA has been associated with about 70% success rate in treating chronic knee pain [28]. However, A randomized pilot trial in 2023 did not demonstrate statistically significant differences between techniques (cooled versus traditional RFA) in the proportion of patients experiencing $\geq$50% pain reduction after ablation (up to 6 months) [24]. In another comparative outcomes analysis, traditional RFA was associated with a higher probability of treatment success and a greater degree of pain relief than cooled RFA [29].

The other factor that may largely affect the outcome of RFA is pre-procedural patient evaluation. Rainey et al. described the etiologies and related diagnostic considerations of post-TKA knee pain and made a great point regarding patient evaluation for post-TKA knee pain [13]. In particular, the extrinsic factors possibly responsible for ongoing symptoms should be identified before GNRFA. Our patients have been worked up well by our orthopedic surgeons and sports medicine specialists. However, we still encounter patients who have extrinsic factors untreated, such as bursitis, CRPS, and IT band syndrome, when they were sent for GNRFA. This applies to patients with arthritic knee pain as well.

In the aforementioned cohort study, although patients with a history of TKA who underwent GNRFA had 70% lower odds of achieving a Patient Global Impression of Change (PGIC) score of 6 or greater, no significant association was observed between a history of TKA and reduction in pain scores [27]. The pain reduction result was consistent with our findings even though their TKA sample size was also relatively small, only 25 cases among total 134 cases.

6. Limitations

This retrospective study is subject to inherent disadvantages, such as recall bias and observer bias. Additionally, there is a 20% loss to follow-up, and the study sample size is relatively small. Consequently, we cannot rule out the possibility that clinically significant differences may not have been detected due to the lack of statistical power. To address the limitation of a limited sample size, we employed non-parametric statistics, specifically Wilcoxon rank-sum tests. We also utilized corresponding Hodges-Lehmann location shift estimators and 95% confidence intervals for data analysis. The Hodges-Lehmann location shift estimator provides an estimate of magnitude, while the 95% confidence interval offers a measure of precision for differences in pain between groups. This approach provides the reader with sufficient information to assess the strength of any observed differences.

7. Conclusion

Genicular Nerve Radiofrequency Ablation (GNRFA) holds the potential to be equally effective for both post-TKA knee pain and osteoarthritic knee pain. However, to substantiate this assertion, a large-scale, blinded, randomized controlled trial is imperative.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Disease GBD, Injury I. C. Prevalence, Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392(10159):1789–858.
[2] Cui A, et al. Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies. EClinicalMedicine 2020;29–30:100587.
[3] Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. Lancet 2019;393(10182):1745–59.
[4] Deshpande BR, et al. Number of persons with symptomatic knee osteoarthritis in the US: impact of race and ethnicity, age, sex, and obesity. Arthritis Care Res 2016;68(12):1743–50.
[5] Vos T, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380(9859):2163–96.
[6] Tran A, Gonzalez FM. Review of cooled radiofrequency ablation utilization for the treatment of symptomatic advanced knee arthritis and total knee arthroplasty. Skeletal Radiol 2023;52(5):941–9.
[7] Petersen KK, et al. Chronic postoperative pain after primary and revision total knee arthroplasty. Clin J Pain 2015;31(1):1–6.
[8] Kidd VD, et al. Genicular nerve radiofrequency ablation for painful knee arthritis: the why and the how. JBJS Essent Surg Tech 2019;9(1):e10.
[9] Fogarty AE, et al. The effectiveness of fluoroscopically guided genicular nerve radiofrequency ablation for the treatment of chronic knee pain due to osteoarthritis: a systematic Review. Am J Phys Med Rehabil 2022;101(5):482–92.
[10] McCormick ZL, et al. Cooled radiofrequency ablation of the genicular nerves for chronic pain due to knee osteoarthritis: six-month outcomes. Pain Med 2017;18(9):1631–41.
[11] Qudsi-Sinclair S, et al. A comparison of genicular nerve treatment using either radiofrequency or analgesic block with corticosteroid for pain after a total knee arthroplasty: a double-blind, randomized clinical study. Pain Pract 2017;17(5):578–88.
[12] Khan FM, et al. Management of uncomplicated total knee arthroplasty chronic pain and stiffness utilizing cooled radiofrequency ablation: a single institution pilot study. Skeletal Radiol 2022;51(6):1215–23.
[13] Rainey J, et al. A letter to the editor regarding genicular nerve radiofrequency ablation for the treatment of the painful primary total knee arthroplasty. Pain Med 2022;23(3):603–4.
[14] Chatman AB, et al. The Patient-Specific Functional Scale: measurement properties in patients with knee dysfunction. Phys Ther 1997;77(8):820–9.
[15] Nicholas P, Hefford C, Tumilty S. The use of the Patient-Specific Functional Scale to measure rehabilitative progress in a physiotherapy setting. J Man Manip Ther 2012;20(3):147–52.
[16] Pathak A, et al. Measurement properties of the patient-specific functional scale and its current uses: an updated systematic Review of 57 studies using COSMIN guidelines. J Orthop Sports Phys Ther 2022;52(5):262–75.

[17] Shi W, et al. The safety and efficacy of genicular nerve radiofrequency ablation for pain in inferolateral quadrant of the knee. Interventional Pain Medicine 2023;2(2):100253.
[18] McCormick ZL, et al. Technical considerations for genicular nerve radiofrequency ablation: optimizing outcomes. Reg Anesth Pain Med 2021;46(6):518–23.
[19] Mistry D, O'Meeghan C. Fate of the infrapatellar branch of the saphenous nerve post total knee arthroplasty. ANZ J Surg 2005;75(9):822–4.
[20] Chalidis B, Kitridis D, Givissis P. Surgical treatment outcome of painful traumatic neuroma of the infrapatellar branch of the saphenous nerve during total knee arthroplasty. World J Orthoped 2021;12(12):1008–15.
[21] Shi SM, et al. Selective denervation for persistent knee pain after total knee arthroplasty: a report of 50 cases. J Arthroplasty 2017;32(3):968–73.
[22] Tran J, et al. Anatomical study of the innervation of anterior knee joint capsule: implication for image-guided intervention. Reg Anesth Pain Med 2018;43(4):407–14.
[23] Zahar A, Sarungi M. Diagnosis and management of the infected total knee replacement: a practical surgical guide. J Exp Orthop 2021;8(1):14.
[24] Vanneste T, et al. Comparison of cooled versus conventional radiofrequency treatment of the genicular nerves for chronic knee pain: a multicenter non-inferiority randomized pilot trial (COCOGEN trial). Reg Anesth Pain Med 2023;48(5):197–204.
[25] Choi WJ, et al. Radiofrequency treatment relieves chronic knee osteoarthritis pain: a double-blind randomized controlled trial. Pain 2011;152(3):481–7.
[26] Kose SG, et al. Predictive factors associated with successful response to ultrasound guided genicular radiofrequency ablation. Korean J Pain 2022;35(4):447–57.
[27] Caragea M, et al. Genicular nerve radiofrequency ablation for the treatment of chronic knee joint pain: a real-world cohort study with evaluation of prognostic factors. Pain Med 2023;24(12):1332–40.
[28] Chen AF, et al. Cooled radiofrequency ablation compared with a single injection of hyaluronic acid for chronic knee pain: a multicenter, randomized clinical trial demonstrating greater efficacy and equivalent safety for cooled radiofrequency ablation. J Bone Joint Surg Am 2020;102(17):1501–10.
[29] Wu BP, et al. Cooled and traditional thermal radiofrequency ablation of genicular nerves in patients with chronic knee pain: a comparative outcomes analysis. Reg Anesth Pain Med 2022.