Peripheral Nerve Stimulation for Knee Pain: A Systematic Review of Emerging Evidence

Grace Brandhurst, Rafael Guzman-Arevalo (LSUHSC), Erik Piedy (LSUHSC), and Vinod Dasa (PI)
School of Medicine, Department of Orthopedics, Louisiana State University Health Sciences Center – New Orleans

LSU Health NEW ORLEANS
School of Medicine
Department of Orthopaedics

Introduction

Chronic knee pain is a prevalent condition that impairs mobility, function, and quality of life, with osteoarthritis (OA) and persistent post-surgical pain following total knee arthroplasty (TKA) being leading causes. Conventional treatments such as NSAIDs, corticosteroids, and opioids often provide temporary relief but are limited by side effects and long-term risks. While TKA remains the standard for advanced OA, it is not suitable for all patients and does not guarantee pain resolution.

Peripheral nerve stimulation (PNS) has emerged as a minimally invasive, non-opioid treatment that targets genicular and saphenous nerves to modulate pain pathways. Recent advances have introduced both temporary systems (e.g., 60-day percutaneous leads) and permanent implantable devices (e.g., Freedom®, Nalu™, Stimwave®), expanding treatment options for diverse patient populations.

This systematic review uniquely evaluates both temporary and permanent PNS systems in adults with chronic knee pain, including those after TKA and those managed non-surgically, with a focus on pain relief, functional improvement, and opioid reduction. By analyzing 18 studies (9 temporary, 9 permanent), this review highlights the current evidence base and identifies gaps for future research.

Objective and Significance

This review aims to compare clinical outcomes—including pain reduction, opioid use, and functional improvement—among adults with chronic pain following total knee arthroplasty (TKA) or non-surgical etiologies such as osteoarthritis.

This is the first systematic review to explicitly compare temporary and permanent PNS devices and to include patients with chronic post-TKA pain as well as those who did not undergo surgery, a population often underrepresented in prior literature.

Methods

A systematic review was conducted using PubMed, Embase, and Scopus to identify studies published since 2010 evaluating peripheral nerve stimulation (PNS) for chronic or post-surgical knee pain. The search strategy was designed to capture both temporary (e.g., SPRINT) and permanent (e.g., Freedom, Nalu, Stimwave) PNS systems. Studies were eligible if they included adults (≥18 years) with chronic knee pain—either post-total knee arthroplasty (TKA) or managed non-surgically—and reported outcomes on pain relief, functional improvement, or opioid use. Randomized trials, case series, and case reports were included.

After duplicate removal, 275 unique articles were screened. A total of 88 full texts were reviewed, and 18 studies met inclusion criteria. Studies were categorized into two groups: 9 using temporary 60-day systems and 9 using permanent implantable PNS systems. A PRISMA 2020 flow diagram outlines the full screening process.

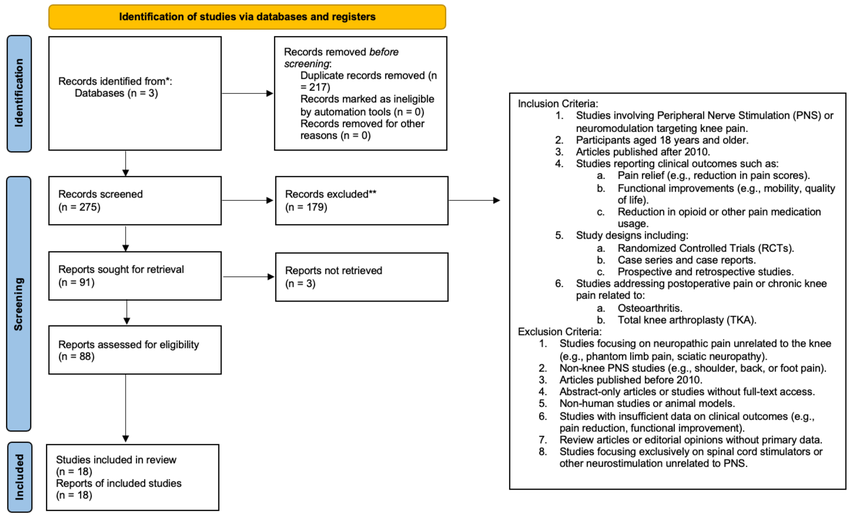

Figure 1. PRISMA 2020 flow diagram illustrating the systematic identification, screening, eligibility assessment, and inclusion of studies evaluating peripheral nerve stimulation (PNS) for knee pain. *Adapted from: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.*

Study	Population	Device	Pain Relief	Opioid Reduction	Adverse Events
Ilfeld et al., 2017	Post-TKA chronic pain	SPRINT® (temporary)	93% ↓ at rest	Not reported	None
Ilfeld et al., 2019	Post-TKA acute pain	SPRINT® (temporary)	86% <4/10 NRS early; 85% WOMAC score improvement	>50% ceased opioid use within first week	No serious AEs
Hasoon et al., 2021	TKA declined, OA	SPRINT® (temporary)	~100% ↓ post-implant	Not reported	Lead dislodged
Chitneni et al., 2021	Post-TKA pain	SPRINT® (temporary)	90% pain score improvement	Complete cessation	None
Van Acker et al., 2021	Knee OA	SPRINT® (temporary)	KOOS QoL ↑ from 0 to 63	Not reported	None
Pingree et al., 2022	Mixed OA/post-TKA	SPRINT® (temporary)	73% ≥50% ↓ responders	35% stopped opioids	None
Zhu et al., 2023	Knee OA	SPRINT® (temporary)	~50–80% ↓	Not reported	1 inadequate lead
Kelly et al., 2023	Chronic knee pain	SPRINT® (temporary)	52% ↓ at 6 months	Not reported	None
Goree et al., 2024	Post-TKA persistent pain	SPRINT® (temporary)	60% ≥50% ↓ at 1 month	1 patient reported decreased use	No serious AEs

Table 1. Temporary PNS Systems (60-Day Leads) for Chronic Knee Pain. Summary of studies using short-term percutaneous PNS (e.g., SPRINT®) in post-TKA and non-surgical knee pain. Most showed ≥50% pain relief and minimal adverse events.

Study	Population	Device	Pain Relief	Opioid Reduction	Adverse Events
Amorizzo et al., 2021	Neuropathic knee pain	StimRouter®	NRS ↓ 9→3 (case 1), 9→2 (case 2)	50%reduction (case 1), complete cessation (case 2)	None
Abd-Elsayed et al., 2023	OA + mixed cohort	Freedom®	NRS ↓ 7.3→2.5; 82% mean pain improvement at follow-up	40% ↓ opioid use	Minor complications (2)
Chauhan et al., 2023	Post-TKA pain	Stimwave®	>80% sustained ↓ at 6 months	Complete cessation	None
Vu et al., 2024	Post-TKA chronic pain	Nalu™	60% improvement at 3-month follow-up	Complete cessation	None
Castine et al., 2024	Post-TKA refractory pain	Not reported	Pain 0/10; ↑function (Oswestry Disability Index)	Not reported	None
Hathway et al., 2024	Peripheral knee pain + mixed cohort	Nalu™	70% ↓ at 6 months (PNS group)	20% ↓ opioid use	No serious AEs
Kilbride et al., 2024	CRPS & OA knee	Freedom®	50% pain improvement; VRS 9.8-->1.3	Not reported	None
Mates et al., 2024	Neuropathic knee + mixed cohort pain	Freedom®	7.8-->2.1 ↓	Not reported	Minor complications (2)
Kalia et al., 2022	Mixed chronic pain including knee	Nalu™	≥50% ↓ in 4/5 knee patients	Not reported	Mild stimulation issue (1)

Table 2. Permanent PNS Systems for Chronic Knee Pain. Summary of studies using fully implanted or externally powered PNS systems (e.g., Freedom®, Nalu™, Stimwave®). Effective across post-TKA and non-TKA patients with sustained relief and rare complications.

Results

A total of 18 studies (including RCTs, case series, case reports, and feasibility studies) involving patients with chronic or post-surgical knee pain were included. Nine studies evaluated temporary systems (e.g., SPRINT®) and nine evaluated permanent systems (e.g., Freedom®, Nalu™, Stimwave®), targeting genicular, saphenous, or femoral nerves.

All studies reported pain reduction, with ≥50% improvement common across both device types. Functional gains and opioid reduction were frequently observed, particularly in permanent system cohorts. Adverse events were rare and typically minor. See Tables 1 and 2 for detailed outcomes by study.

Discussion and Conclusions

Peripheral nerve stimulation (PNS) offers a minimally invasive, opioid-sparing treatment for chronic knee pain—including in patients who are not candidates for total knee arthroplasty (TKA) or continue to experience pain postoperatively. Across 18 included studies, both temporary and permanent PNS systems were associated with clinically meaningful pain relief, improved function, and opioid reduction, with a low rate of adverse events.

Despite encouraging outcomes, most studies were small and observational, with only one randomized trial. Comparative effectiveness between device types, long-term outcomes, and ideal patient selection remain areas for future research.

PNS appears to be a promising and safe option for refractory knee pain, both post-TKA and in non-surgical patients. Larger, controlled studies are needed to validate these findings and inform clinical guidelines.

References

1. Hasoon J, Chitneni A, Urits I, Viswanath O, Kaye AD. Peripheral Stimulation of the Saphenous and Superior Lateral Genicular Nerves for Chronic Knee Pain. Cureus. 2021;13(4):e14753. DOI: 10.7759/cureus.14753.
2. Früh A, Sargut TA, Hussein A, et al. Peripheral nerve stimulation for the treatment of chronic knee pain. Sci Rep. 2023;13(1):15543. DOI: 10.1038/s41598-023-42608-x.
3. Kelly TD, Pazzol ML, Rahimi Darabad R. Peripheral Nerve Stimulation in Chronic Knee Pain: A Case Series. Cureus. 2023;15(12):e50127. DOI: 10.7759/cureus.50127.
4. Goree JH, Grant SA, Dickerson DM, et al. Randomized Placebo-Controlled Trial of 60-Day Percutaneous Peripheral Nerve Stimulation Treatment Indicates Relief of Persistent Postoperative Pain, and Improved Function After Knee Replacement. Neuromodulation. 2024;27(5):847-861. DOI: 10.1016/j.neurom.2024.03.001.
5. Chitneni A, Berger AA, Orhurhu V, Kaye AD, Hasoon J. Peripheral Nerve Stimulation of the Saphenous and Superior Lateral Genicular Nerves for Chronic Pain After Knee Surgery. Orthop Rev (Pavia). 2021;13(2):24435. DOI: 10.52965/001c.24435.
6. Chauhan G, Srinivasan SK, Khanduja S. Wireless High-Frequency Peripheral Nerve Stimulation for Chronic Refractory Knee Pain Post-total Knee Replacement. Cureus. 2023;15(3):e35759. DOI: 10.7759/cureus.35759.
7. Vu PD, Gul F, Robinson CL, Chen GH, Hasoon J. Peripheral Nerve Stimulation After Total Knee Arthroplasty and Non-Operable Patella Fracture. Orthop Rev (Pavia). 2024;16:115599. DOI: 10.52965/001c.115599.
8. Zhu CC, Gargya A, Haider N. A Case Report of Three Patients Who Underwent Temporary Peripheral Nerve Stimulation for Treatment of Knee Pain Secondary to Osteoarthritis. Cureus. 2023;15(6):e40473. DOI: 10.7759/cureus.40473.
9. Ilfeld BM, Ball ST, Cohen SP, et al. Percutaneous Peripheral Nerve Stimulation to Control Postoperative Pain, Decrease Opioid Use, and Accelerate Functional Recovery Following Orthopedic Trauma. Mil Med. 2019;184(Suppl 1):557–564. DOI: 10.1093/milmed/usy378.
10. Ilfeld BM, Grant SA, Gilmore CA, et al. Neurostimulation for Postsurgical Analgesia: A Novel System Enabling Ultrasound-Guided Percutaneous Peripheral Nerve Stimulation. Pain Pract. 2017;17(7):892–901. DOI: 10.1111/papr.12539.
11. Van Acker G, Wilson RD, Kim CH. Peripheral nerve stimulation for treatment of painful osteoarthritis of the knee: a case report. Pain Med Case Rep. 2021;5(4):201-204.
12. Pingree, M. J., Hurdle, M. F., Spinner, D. A., Valimahomed, A., Crosby, N. D., & Boggs, J. W. (2022). Real-World Evidence of Sustained Improvement Following 60-day Peripheral Nerve Stimulation Treatment for Pain: A Cross-Sectional Follow-up Survey. Pain Management, 12(5), 611–621. https://doi.org/10.2217/pmt-2022-0005
13. Amorizzo E, Colini-Baldeschi G. Peripheral Nerve Stimulation: Two Cases of Intractable Neuropathic Pain. Anesth Pain Med. 2021;11(2):e113162. Published 2021 May 1. doi:10.5812/aapm.113162
14. Abd-Elsayed A, Moghim R. Efficacy of Peripheral Nerve Stimulation with a High Frequency Electromagnetic Coupled (HF-EMC) Powered Implanted Receiver in Treating Different Pain Targets/Neuralgias. J Pain Res. 2023;16:589-596. Published 2023 Feb 23. doi:10.2147/JPR.S399532
15. Castine AM, Robinson CL, Fair RN, Varrassi G, Shekoohi S, Kaye AD. Left Infrapatellar Branch of the Saphenous Peripheral Nerve Stimulation Relieves Refractory Pain Following Total Knee Replacement. Cureus. 2024;16(8):e67223. Published 2024 Aug 19. doi:10.7759/cureus.67223
16. Hatheway J, Hersel A, Song J, et al. Clinical study of a micro-implantable pulse generator for the treatment of peripheral neuropathic pain: 3-month and 6-month results from the COMFORT-randomised controlled trial. Reg Anesth Pain Med. Published online May 31, 2024. doi:10.1136/rapm-2023-105264
17. Kilbride MK, Presson N, Sherman SL. Chronic Knee Pain in Primary Care: Diagnosis and Treatment. Pain Medicine. 2024;8(2):49-53.
18. Mates A. Peripheral Nerve Stimulation in the Treatment of Peripheral Neuropathy. Pain Med Case Rep. 2024;8(2):173-177.