Pulsed electromagnetic field (PEMF)

PEMF therapy uses time-varying electromagnetic fields to induce weak electrical currents in tissues. **FDA-cleared since 1979** for bone healing, PEMF has the strongest evidence for **fracture nonunion, osteoarthritis pain, and postoperative pain/edema reduction**, with emerging data across several other domains.

Bone Healing and Fracture Nonunion — FDA-Cleared Indication

PEMF was first approved by the FDA in 1979 for ununited fractures, based on pioneering work showing an **81% success rate** in 1,007 ununited fractures and 71 failed arthrodeses at Columbia-Presbyterian, with 79% success internationally. A meta-analysis of 22 RCTs ($n = 1{,}468$) confirmed PEMF **increased healing rate by 22%** (79.7% vs. 64.3%; RR 1.22, 95% CI 1.10–1.35), with moderate-quality evidence also supporting pain relief (SMD −0.49) and accelerated healing time.

However, a 2024 systematic review update of more recent RCTs (3 trials, $n = 197$) found **no significant effect on acute fracture healing**, with contradictory results on pain — suggesting the benefit may be specific to delayed unions and nonunions rather than acute fractures. A Cochrane review similarly concluded there "may be a benefit" for nonunion but the evidence was insufficient for certainty.

Osteoarthritis — Best-Supported Pain Indication

A meta-analysis of 16 placebo-controlled RCTs found PEMF produced a **large effect on pain** (SMD 1.06, 95% CI 0.61–1.51), with smaller but significant improvements in stiffness (SMD 0.37) and physical function (SMD 0.46) in OA patients. Notably, PEMF parameters and treatment duration did not significantly influence outcomes.

Postoperative Pain and Edema — Consistent RCT Evidence

This is one of the most compelling clinical applications, with multiple double-blind, placebo-controlled trials:

- After **TRAM flap breast reconstruction**, PEMF reduced pain scores **4-fold at 72 hours** ($p < 0.01$), narcotic use **2-fold** ($p < 0.01$), wound

exudate volume **2-fold** ($p < 0.01$), and IL-1β concentration in wound exudates **5-fold** ($p < 0.001$).
- After **breast reduction**, PEMF produced a **57% decrease in pain at 1 hour** and **300% decrease at 5 hours** ($p < 0.001$), with a 2.2-fold reduction in narcotic use ($p = 0.002$). IL-1β in wound exudates was **275% lower** in the PEMF group.
- After **cesarean section** ($n = 72$), PEMF reduced severe postoperative pain from **72% to 36%** ($p = 0.002$), decreased analgesic use **2.1-fold** over 7 days ($p < 0.001$), and improved wound healing with less exudate, erythema, and edema.

The proposed mechanism involves PEMF modulation of the **calmodulin-dependent nitric oxide/cGMP signaling pathway**, which downregulates inflammatory cytokines — particularly IL-1β — in the wound bed.

Musculoskeletal Pain — Broader Applications

A 2025 systematic review of 8 RCTs across musculoskeletal conditions found most studies reported reductions in pain and improvements in functional outcomes (Oswestry Disability Index, WOMAC), with **no serious adverse events**. PEMF was linked to sustained analgesic and anti-inflammatory effects, while higher-intensity repetitive peripheral magnetic stimulation (rPMS) showed faster pain reduction.

A multicenter RCT ($n = 120$) of a commercially available PEMF device for joint and soft tissue pain showed a **36% pain reduction** in the PEMF group vs. 10% in the standard-of-care group ($p < 0.0001$), with a **55% reduction in pharmacologic use** (from 40% to 18%). Crossover patients experienced an additional 18% pain decrease and 63% reduction in medication use.

For **shoulder impingement syndrome**, a meta-analysis of 4 RCTs ($n = 252$) found PEMF significantly reduced short-term pain (SMD −0.34) and improved both short-term (SMD 0.40) and long-term functional capacity (SMD 0.60).

Diabetic Peripheral Neuropathy

A double-blind RCT ($n = 182$) found PEMF produced a clinically significant **30% reduction in pain** from baseline compared to sham ($p < 0.05$) in patients with painful diabetic symmetric peripheral neuropathy, with a trend toward improved skin perfusion pressure. However, a larger earlier trial (n = 225) found PEMF was **not effective** at reducing neuropathic pain intensity on VAS or NPS, though it did show a significant increase in epidermal nerve fiber density (29% vs. 0% in sham, $p = 0.04$) — suggesting a neurobiological effect on nerve regeneration even without clear symptomatic benefit.

Complex Regional Pain Syndrome

In CRPS, one RCT reported a **46–53% reduction in pain** at post-intervention and 1-month follow-up with PEMF compared to sham, representing "moderate" to "substantial" clinically important benefit.

Wound Healing

PEMF facilitates wound healing through increased macrophage and fibroblast migration, reduced inflammation, and enhanced collagen deposition. Clinical evidence is strongest in the postoperative setting (as above), while Cochrane reviews for venous leg ulcers and pressure ulcers found insufficient evidence to draw firm conclusions about PEMF as a standalone wound therapy.

Depression

An 8-week cohort study of transcranial PEMF (T-PEMF) in treatment-resistant depression showed **49% response rate** (≥50% $HAM\text{-}D_{17}$ reduction) and **30% remission rate** in patients with nonchronic episodes. However, a subsequent sham-controlled double-blind RCT found **no difference between active and sham T-PEMF**, though this may have been related to lower magnetic field strength.

****Safety Profile**

Across all reviewed studies, PEMF therapy demonstrates an **excellent safety profile** with no serious adverse events reported. The most common complaint is minor skin irritation at the application site. **PEMF is generally contraindicated in patients with implanted electronic devices (pacemakers, defibrillators) and during pregnancy.**

References

Aziz Z, Cullum N. Electromagnetic therapy for treating venous leg ulcers. Cochrane Database of Systematic Reviews 2015, Issue 7. Art. No.: CD002933. DOI: 10.1002/14651858.CD002933.pub6. Accessed 02 July 2026.

Aziz Z, Bell‐Syer SEM. Electromagnetic therapy for treating pressure ulcers. Cochrane Database of Systematic Reviews 2015, Issue 9. Art. No.: CD002930. DOI: 10.1002/14651858.CD002930.pub6. Accessed 02 July 2026.

Bassett, C. A., Mitchell, S. N., & Gaston, S. R. (1982). Pulsing electromagnetic field treatment in ununited fractures and failed arthrodeses. *JAMA*, *247*(5), 623–628.

Griffin, X.L., Costa, M.L., Parsons, N., Smith, N. Electromagnetic field stimulation for treating delayed union or non‐union of long bone fractures in adults. Cochrane Database of Systematic Reviews 2011, Issue 4. Art. No.: CD008471. DOI: 10.1002/14651858.CD008471.pub2. Accessed 02 July 2026.

Hackel, J. G., Paci, J. M., Gupta, S., Maravelas, D. A., North, T. J., & Paunescu, A. (2025). Evaluating Noninvasive Pulsed Electromagnetic Field Therapy for Joint and Soft Tissue Pain Management: A Prospective, Multi-center, Randomized Clinical Trial. *Pain and therapy*, *14*(2), 723–735. https://doi.org/10.1007/s40122-025-00711-z

Iwasa, K., & Reddi, A. H. (2018). Pulsed Electromagnetic Fields and Tissue Engineering of the Joints. *Tissue engineering. Part B, Reviews*, *24*(2), 144–154. https://doi.org/10.1089/ten.TEB.2017.0294

Khooshideh, M., Latifi Rostami, S. S., Sheikh, M., Ghorbani Yekta, B., & Shahriari, A. (2017). Pulsed Electromagnetic Fields for Postsurgical Pain Management in Women Undergoing Cesarean Section: A Randomized, Double-Blind, Placebo-controlled Trial. *The Clinical journal of pain*, *33*(2), 142–147. https://doi.org/10.1097/AJP.0000000000000376

Larsen, E. R., Licht, R. W., Nielsen, R. E., Lolk, A., Borck, B., Sørensen, C., Christensen, E. M., Bizik, G., Ravn, J., Martiny, K., Vinberg, M., Jankuviené, O., Jørgensen, P. B., Videbech, P., & Bech, P. (2020). Transcranial pulsed electromagnetic fields for treatment-resistant depression: A multicenter 8-week single-arm cohort study. *European psychiatry : the journal of the Association of European Psychiatrists*, *63*(1), e18. https://doi.org/10.1192/j.eurpsy.2020.3

Picelli, A., DI Censo, R., Tomasello, S., Scaturro, D., Letizia Mauro, G., Smania, N., Filippetti, M., & Physical Modalities Section of the Italian Society of Physical and

Rehabilitation Medicine (2024). Effects of pulsed electromagnetic fields on bone fractures: a systematic review update. *European journal of physical and rehabilitation medicine*, *60*(6), 989–994. https://doi.org/10.23736/S1973-9087.24.08226-1

Peng, L., Fu, C., Xiong, F., Zhang, Q., Liang, Z., Chen, L., He, C., & Wei, Q. (2020). Effectiveness of Pulsed Electromagnetic Fields on Bone Healing: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Bioelectromagnetics*, *41*(5), 323–337. https://doi.org/10.1002/bem.22271

Rohde, C., Chiang, A., Adipoju, O., Casper, D., & Pilla, A. A. (2010). Effects of pulsed electromagnetic fields on interleukin-1 beta and postoperative pain: a double-blind, placebo-controlled, pilot study in breast reduction patients. *Plastic and reconstructive surgery*, *125*(6), 1620–1629. https://doi.org/10.1097/PRS.0b013e3181c9f6d3

Rohde, C. H., Taylor, E. M., Alonso, A., Ascherman, J. A., Hardy, K. L., & Pilla, A. A. (2015). Pulsed Electromagnetic Fields Reduce Postoperative Interleukin-1β, Pain, and Inflammation: A Double-Blind, Placebo-Controlled Study in TRAM Flap Breast Reconstruction Patients. *Plastic and reconstructive surgery*, *135*(5), 808e–817e. https://doi.org/10.1097/PRS.0000000000001152

Silva, L. D., Batista, J. D., Batista, J. D., Pereira, G. S., & da Silva, M. L. (2026). Efficacy and safety of low- and high-intensity magnetic field therapies for orthopedic pain: a systematic review. *Frontiers in pain research (Lausanne, Switzerland)*, *7*, 1760721. https://doi.org/10.3389/fpain.2026.1760721

Smart, K.M., Ferraro, M.C., Wand, B.M., O'Connell, N.E. Physiotherapy for pain and disability in adults with complex regional pain syndrome (CRPS) types I and II. Cochrane Database of Systematic Reviews 2022, Issue 5. Art. No.: CD010853. DOI: 10.1002/14651858.CD010853.pub3. Accessed 02 July 2026.

Strauch, B., Herman, C., Dabb, R., Ignarro, L. J., & Pilla, A. A. (2009). Evidence-based use of pulsed electromagnetic field therapy in clinical plastic surgery. *Aesthetic surgery journal*, *29*(2), 135–143. https://doi.org/10.1016/j.asj.2009.02.001

Su, D. B., Zhao, Z. X., Yin, D. C., & Ye, Y. J. (2024). Promising application of pulsed electromagnetic fields on tissue repair and regeneration. *Progress in biophysics and molecular biology*, *187*, 36–50. https://doi.org/10.1016/j.pbiomolbio.2024.01.003

Tassone, E. E., Page, J. C., & Slepian, M. J. (2025). Assessing the Effects of Pulsed Electromagnetic Therapy on Painful Diabetic Distal Symmetric Peripheral Neuropathy:

A Double-Blind Randomized Controlled Trial. *Journal of diabetes science and technology*, *19*(2), 361–369. https://doi.org/10.1177/19322968231190413

van Belkum, S. M., de Boer, M. K., Opmeer, E. M., Kortekaas, R., Mulder, T., Woonings, F., Hoenders, H. J. R., Kamphuis, H., Aleman, A., & Schoevers, R. A. (2021). No antidepressant effects of low intensity transcranial pulsed electromagnetic fields for treatment resistant depression. *Journal of affective disorders*, *294*, 679–685. https://doi.org/10.1016/j.jad.2021.07.087

Wang, H. Y., Chen, Y. J., Huang, I. C., Lin, C. R., Lin, K. L., & Chen, C. H. (2025). The effectiveness of pulsed electromagnetic field therapy in patients with shoulder impingement syndrome: A systematic review and meta-analysis of randomized controlled trials. *PloS one*, *20*(5), e0323837. https://doi.org/10.1371/journal.pone.0323837

Weintraub, M. I., Herrmann, D. N., Smith, A. G., Backonja, M. M., & Cole, S. P. (2009). Pulsed electromagnetic fields to reduce diabetic neuropathic pain and stimulate neuronal repair: a randomized controlled trial. *Archives of physical medicine and rehabilitation*, *90*(7), 1102–1109. https://doi.org/10.1016/j.apmr.2009.01.019

Yang, X., He, H., Ye, W., Perry, T. A., & He, C. (2020). Effects of Pulsed Electromagnetic Field Therapy on Pain, Stiffness, Physical Function, and Quality of Life in Patients With Osteoarthritis: A Systematic Review and Meta-Analysis of Randomized Placebo-Controlled Trials. *Physical therapy*, *100*(7), 1118–1131. https://doi.org/10.1093/ptj/pzaa054