Dry Needling with Electrical Stimulation: Physiology and Clinical Effectiveness

- Brian V. Hortz, PhD, ATC, SFDN

Speaker Disclosure

- Conflict of Interest
  - RecoverURfunction, PLLC
    - Owner
  - Structure & Function Education, PLLC
    - Director of Research and Education
    - Structure and Function Education
    - Dry Needling CEU provider
  - The statements and opinions in this presentation are my own and may not be the same as Structure and Function, colleagues, or clients.

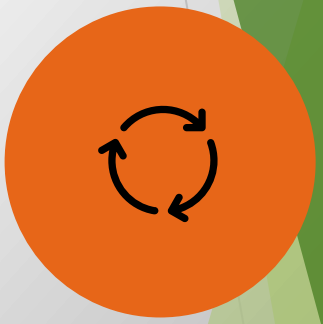
What is Electric Dry Needling (EDN)?



COMBINES DRY NEEDLING WITH ELECTRICAL STIMULATION



EXPANDS AND PROLONGS ANALGESIC EFFECTS



TRIGGERS LOCAL, SEGMENTAL, AND SYSTEMIC RESPONSES

How EDN Works

- Activates spinal opioids, serotonin, noradrenaline
- Engages supraspinal neurons for descending inhibition
- Effects depend on frequency, intensity, placement, duration

Core Clinical Indications

- Pain management
- Muscle activation (NMES)
- Reducing tone and spasticity
- Mechanotransduction for tissue healing

Local Biochemical Effects

- Early increases in Substance P and CGRP
- Negative feedback on afferent receptors
- Low-level CGRP provides anti-inflammatory action

Receptor & Ion Channel Modulation

- Downregulates TRPV1 and TRPV4
- Reduces nociceptive firing
- Increases ß-endorphin and acetylcholine peripherally

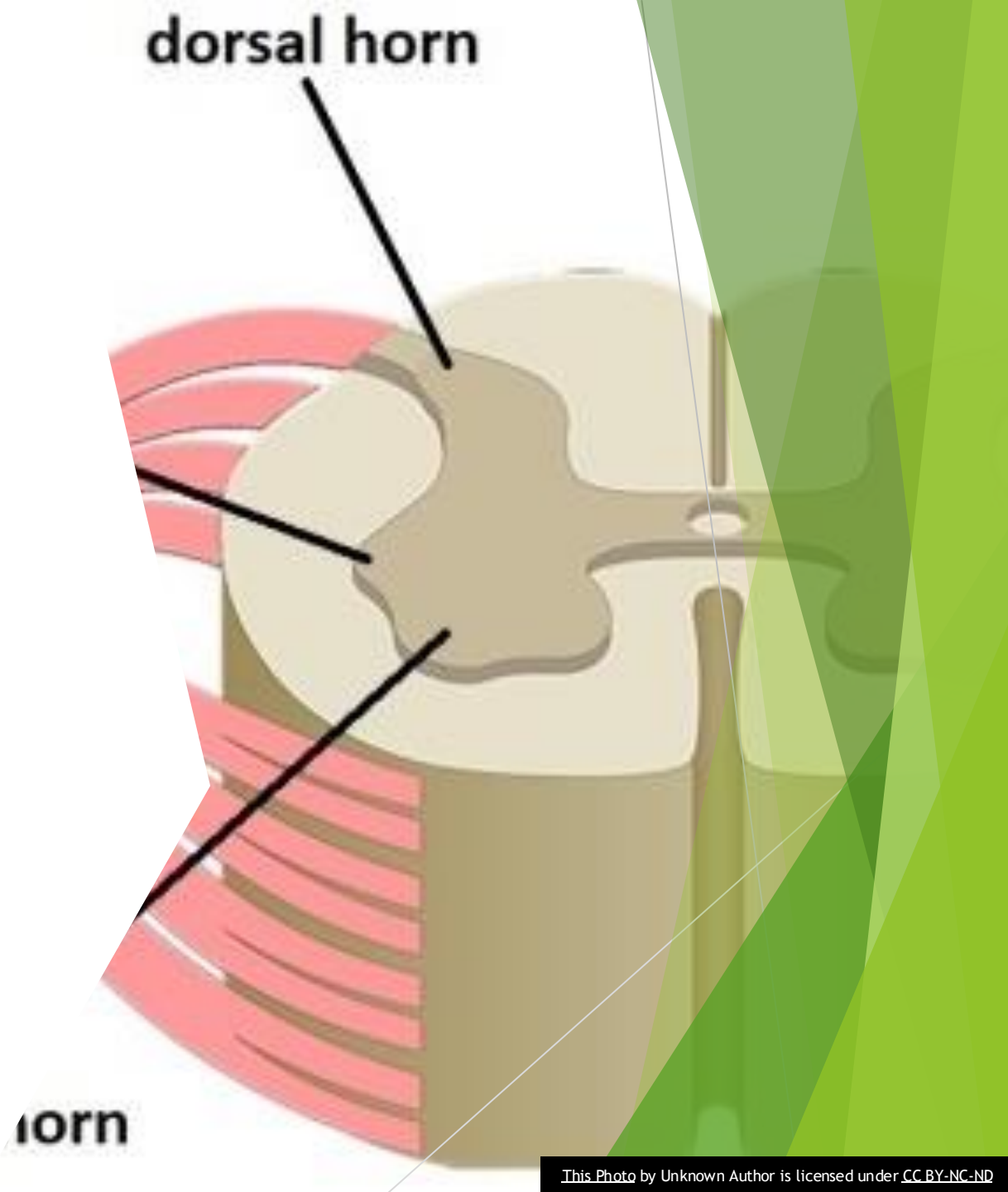


Cannabinoid & Opioid System Activation

- Upregulates CB2 receptors
- Elevates anandamide
- Activates opioid-containing leukocytes

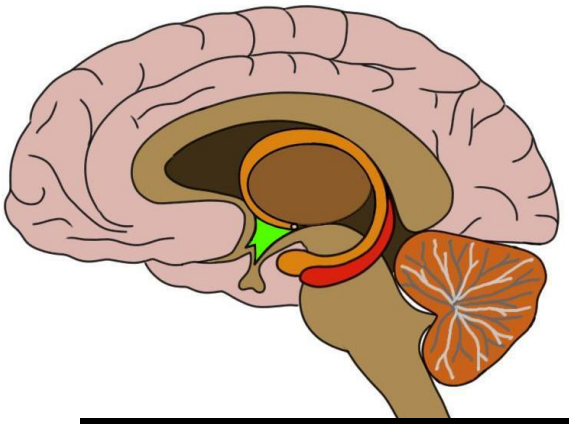
Segmental (Spinal) Effects

- Influences dorsal horn interneurons
- Activates adenosine A1 and μ-opioid receptors
- Reduces pain within specific dermatomes



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Supraspinal (Systemic) Mechanisms

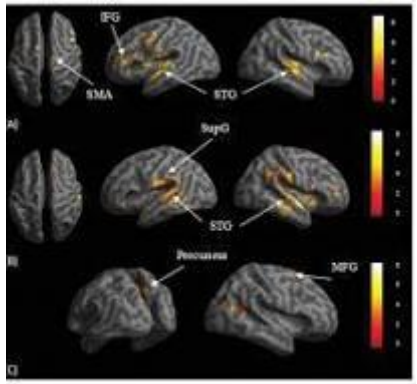


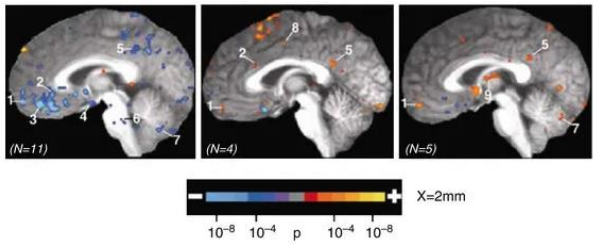
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- Hypothalamus releases AVP and oxytocin
- Activates PAG and NRM
- Produces descending monoamine inhibition

Neuroimaging Evidence

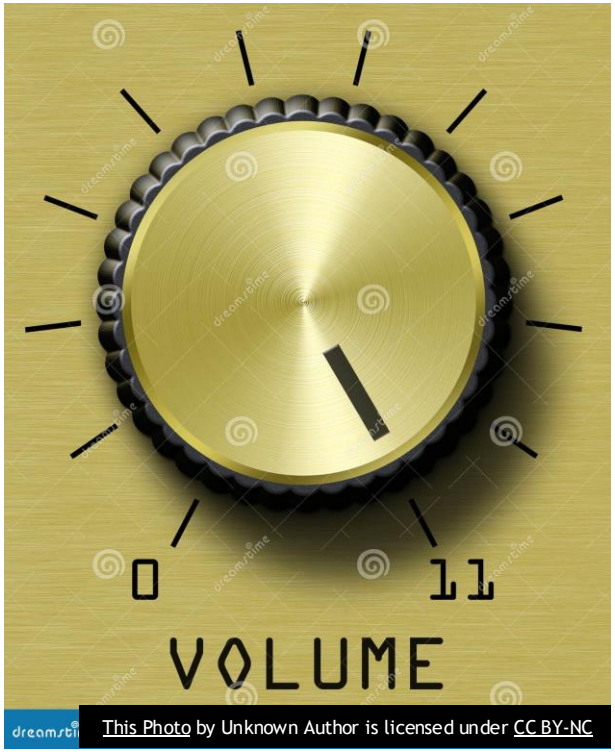
- Somatosensory cortex activation patterns
- Reduces neuropathic excitatory signaling
- Confirms systemic, durable pain modulation





Rodrigues et al. "Electro-Acupuncture Effects Measured by Functional Magnetic Resonance Imaging—A Systematic Review of Randomized Clinical Trials." *Healthcare* 12, no. 1 (2023): 2. https://doi.org/10.3390/healthcare12010002.

Importance of Intensity



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- Low intensity: A-beta fiber stimulation
- High intensity: A-delta and C fiber activation
- Higher intensity = stronger systemic effects

Frequency Parameters



Low frequency (2–10 Hz): Endorphin release, anti-inflammatory



High frequency (100 Hz): Dynorphin activation



2–10 Hz optimal for inflammatory/neuropathic pain



Duration of Treatment

- Peripheral effects: ~5 minutes
- Segmental/CNS effects: ~30 minutes
- Longer duration = stronger supraspinal response



Optimal Pain Parameters

- Frequency: 2–10 Hz
- Duration: 30 minutes
- Intensity: Strong, maximally tolerated

Evidence for Segmental Analgesia

- Increased pressure pain thresholds
- Bilateral and contralateral effects
- Supports Gate Control and descending inhibition

Han, Ji-Sheng. "Neuropeptide Release Produced by Electrical Stimulation of Different Frequencies." *Trends in Neurosciences* 26, no. 1 (2003): 17–22. https://doi.org/10.1016/S0166-2236(02)00006-1.

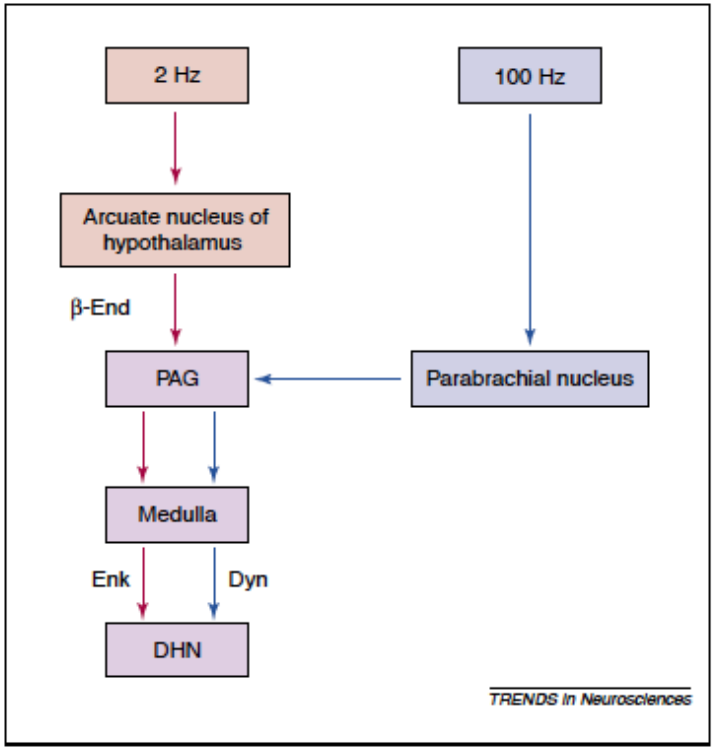


Fig. 2. Neural pathways mediating the analgesic effect elicited by low-frequency (2 Hz, red) or high-frequency (100 Hz, blue) electroacupuncture stimulation. Abbreviations: DHN, dorsal horn neuron of the spinal cord; Dyn, Dynorphin A; β-End, β-endorphin; Enk, enkephalin; PAG, periaqueductal grey matter. Modified, with permission, from Ref. [23].

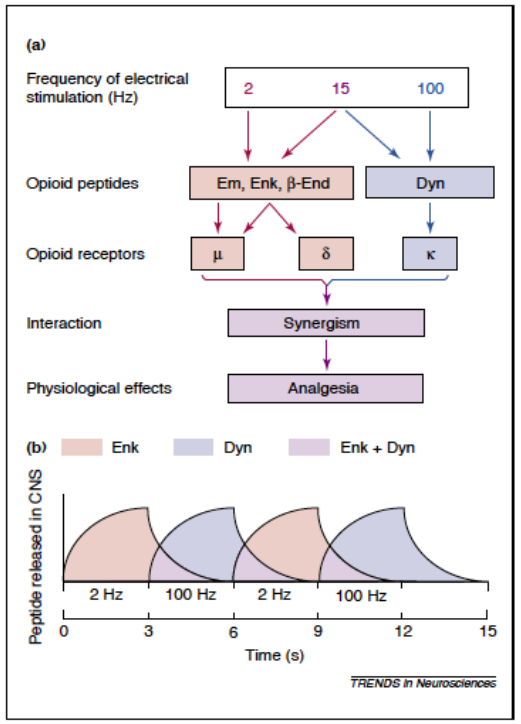


Fig. 3. Possible mechanisms for the analgesic effects of acupuncture. (a) Opioid peptides and opioid receptors involved in analgesia elicited by electroacupuncture of different frequencies. Opioids and receptors involved at 2 Hz are in red, those involved at 100 Hz, in blue. At 15 Hz, there is a partial involvement of components involved at both of the other two frequencies (purple). Abbreviations: Dyn, dynorphin A; β-End, β-endorphin; Em, endomorphin; Enk, enkephalins. Simultaneous activation of all three types of opioid receptor elicits a synergistic analgesic effect. Note that simultaneous receptor activation does not necessarily mean that the opioids are released simultaneously – it could be that the residual presence of one opioid overlaps with newly induced release of another. (b) Model for the synergistic analgesic effect produced by alternating low and high frequency stimulation (referred to as model A in the text). Stimulation at 2 Hz facilitates the release of enkephalin (red); that at 100 Hz stimulates the release of dynorphin (blue). The overlapping areas (purple) indicate the synergistic interaction between the two peptides. Modified, with permission, from Ref. [32].

Journal of Sport Rehabilitation, (Ahead of Print)
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Human Kinetics
CASE STUDY

Treating Lateral Epicondylopathy With Dry Needling and Exercise: A Case Series

Brian V. Hortz and Sue Falsone
Structure and Function Education, Department of Athletic Training, Arizona School of Health Sciences, A.T. Still University, Mesa, AZ, USA

- The dry needling intervention incorporated 8 locations in the upper-extremity with 2 electric stimulation channels.
- The patients had reduced pain as measured by a visual analog scale, increased function as measured by the Patient-Rated Tennis Elbow Evaluation Test, and increased grip strength over 6 weeks.
- This case series illustrates the use of dry needling and a home exercise program to provide a favorable outcome in a patient with LE.
- Patients had an 80% to 100% reduction in pain and similar improvements in function that were significantly beyond the minimum clinically important difference.



Figure 1 — Image of needle and electrical stimulation placement.

Hadizadeh *et al. Chiropr Man Therap* (2021) 29:40
https://doi.org/10.1186/s12998-021-00396-z

Chiropractic & Manual Therapies

SYSTEMATIC REVIEW Open Access

The efficacy of intramuscular electrical stimulation in the management of patients with myofascial pain syndrome: a systematic review

Monavar Hadizadeh[1], Abbas Rahimi[1*], Mohammad Javaherian[2], Meysam Velayati[3] and Jan Dommerholt[4,5,6]

- The aim of this study is to evaluate the effectiveness of intramuscular electrical stimulation (IMES) in patients with MPS through a systematic review method.
- There is preliminary evidence from a few small trials suggesting the efficacy of IMES for the care of myofascial pain syndrome. The data support the conduct of larger trials investigating the efficacy of IMES.

Hadizadeh, Monavar, Abbas Rahimi, Mohammad Javaherian, Meysam Velayati, and Jan Dommerholt. "The Efficacy of Intramuscular Electrical Stimulation in the Management of Patients with Myofascial Pain Syndrome: A Systematic Review." *Chiropractic & Manual Therapies* 29 (September 2021): 40. https://doi.org/10.1186/s12998-021-00396-z.

Summary Analgesic Effects

The Science of Electric Needle Stimulation (ENS): Clinical Dosage & Mechanisms

Electric Needle Stimulation (ENS) provides superior analgesic effects compared to manual needling by triggering complex endogenous mechanisms.

The 3 Critical Dosage Parameters

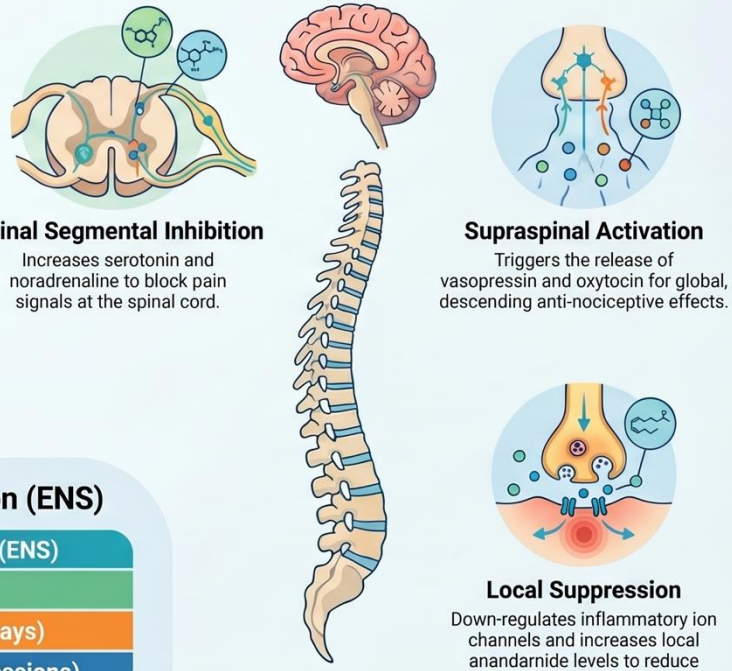


Intensity: Strong and Noxious
Higher intensity activates A-delta and C-fibers for broader, more potent pain suppression.

Duration: 15 to 30 Minutes
Extended stimulation produces longer-lasting analgesia and increases pressure pain thresholds globally.

Placement: Segmental Targeting
Placing needles within the symptomatic spinal segment provides the most robust pain relief.

How ENS Inhibits Pain



Spinal Segmental Inhibition
Increases serotonin and noradrenaline to block pain signals at the spinal cord.

Supraspinal Activation
Triggers the release of vasopressin and oxytocin for global, descending anti-nociceptive effects.

Local Suppression
Down-regulates inflammatory ion channels and increases local anandarnide levels to reduce sensitivity.

Comparison: Manual Needling vs. Electric Needle Stimulation (ENS)

	Manual Needling	Electric Needle Stimulation (ENS)
Analgesic Effect	Standard	Superior/Enhanced
Global Inhibition	Limited	Potent (Descending Pathways)
Duration of Effect	Minutes	Up to 1 Year (with repeated sessions)

NotebookLM

Even OA Pain!

Periosteal Simulation

ORIGINAL ARTICLE

OPEN

Periosteal Electrical Dry Needling as an Adjunct to Exercise and Manual Therapy for Knee Osteoarthritis

A Multicenter Randomized Clinical Trial

James Dunning, DPT, MSc, FAAOMPT,†*
Raymond Butts, DPT, MSc, PhD,†‡ Ian Young, DSc, PT, Dip Osteopractic,†§
Firas Mourad, PT, OMT, Dip Osteopractic,‖*
Victoria Galante, DPT, FAAOMPT,¶ Paul Bliton, DPT, FAAOMPT,#
*Michelle Tanner, DPT, FAAOMPT,***
*and César Fernández-de-las-Peñas, DMSc, PT, PhD**

- 18 outpatient clinics, 10 states, 2 years of data collection, 18 PTs
  - 6 hour training session with lead investigator
- 8-10 treatment sessions, 1-2 times per week, over 6 weeks
  - 242 patients (split even intervention and control)
- Manual therapy = PROM and stretching
- Exercise = stationary bike, ROM, strength
- DN group = EDN 9 point protocol for 20-30 min

Dunning J, Butts R, Young I, et al. Periosteal Electrical Dry Needling as an Adjunct to Exercise and Manual Therapy for Knee Osteoarthritis: A Multi-Center Randomized Clinical Trial. *The Clinical Journal of Pain*. May 2018:1.
doi:10.1097/AJP.0000000000000634

RCT OA Knee

- At least 3 needles were tapped to the bone
- 4 channels of estim across the joint
  - 2 Hz 250 pulse width
  - Biphasic, continuous waveform

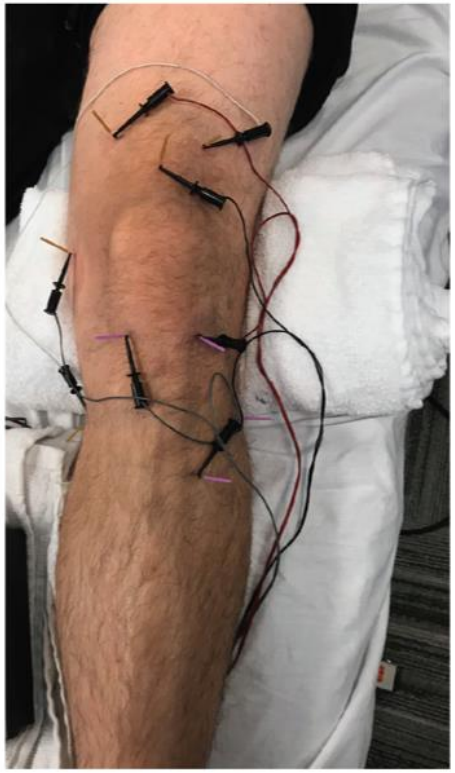


FIGURE 1. Standardized 9-point protocol of periosteal electrical dry needling for knee osteoarthritis.

Dunning J, Butts R, Young I, et al. Periosteal Electrical Dry Needling as an Adjunct to Exercise and Manual Therapy for Knee Osteoarthritis: A Multi-Center Randomized Clinical Trial. *The Clinical Journal of Pain*. May 2018:1. doi:10.1097/AJP.0000000000000634

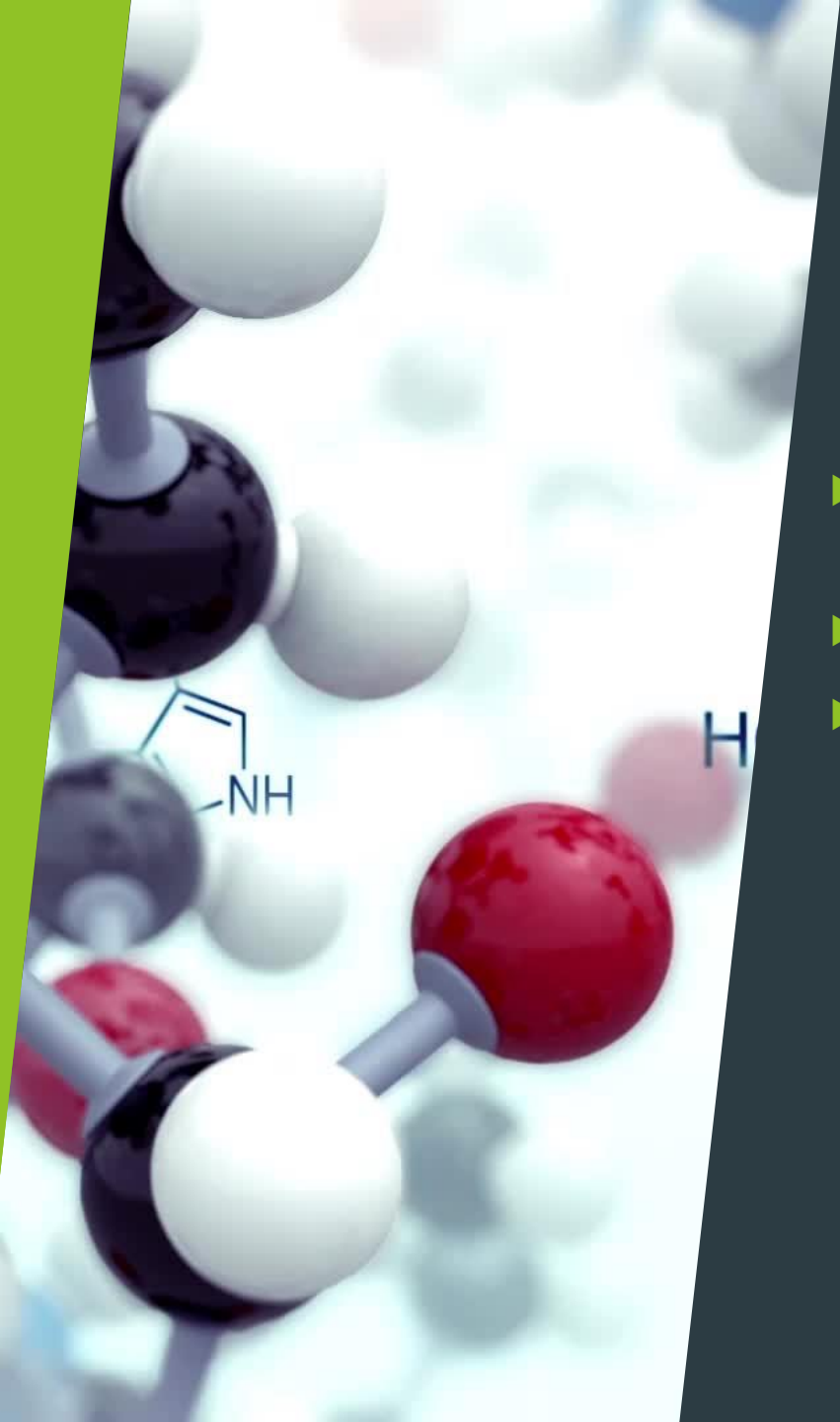
RCT OA Knee

- Results:
  - EDN group had significant improvements in WOMAC at 6 weeks and 3 months
  - Patients in EDN group were 1.7 times more likely to stop taking pain medication at 3 months than MT and Exercise groups.
  - The inclusion of electrical dry needling into a MT and exercise program was more effective for improving pain, function, and related-disability than the application of MT and exercise alone in individuals with painful knee OA.

Dunning J, Butts R, Young I, et al. Periosteal Electrical Dry Needling as an Adjunct to Exercise and Manual Therapy for Knee Osteoarthritis: A Multi-Center Randomized Clinical Trial. *The Clinical Journal of Pain*. May 2018:1. doi:10.1097/AJP.0000000000000634

EDN for Muscle Activation

- Needles bypass skin impedance
- Standard NMES settings (12–25 Hz lower limb)
- Effective for atrophy and facial paralysis



Preclinical Muscle Preservation

- Prevents muscle weight loss
- Counters IGF-1 decline
- Increases protein synthesis and myogenesis

Clinical Motor Function Evidence

- Improves strength recovery
- Benefits Peripheral Nerve Healing
- Induces motor cortex neuroplasticity

EDN for Muscle Activation

- Muscle activation exercise in early retraining of movement
- The combination of NMES with loading exercises will induce neuroplasticity in muscle
- 2 Hz or as low as possible for 20 min, has been shown to aid in decreasing pain and improving function at the shoulder
  - VAS score and Quick Dash score improvement

Saylor-Pavkovich, Estee, and Cert Dn. *STRENGTH EXERCISES COMBINED WITH DRY NEEDLING WITH ELECTRICAL STIMULATION IMPROVE PAIN AND FUNCTION IN PATIENTS WITH CHRONIC ROTATOR CUFF TENDINOPATHY: A RETROSPECTIVE CASE SERIES*. n.d., 14.

EDN for Muscle Activation

- Evaluated the efficacy of EA (NMES) on the recovery of lower extremity muscle strength, specifically, during the early post-TKA period (Xu et al., 2020)
  - Low Hz and a pulse width of 1 ms, gradually increased until it reached an intolerable intensity.
  - Ten 30-min sessions over 2 weeks (5 sessions per week).
  - Results indicated:
    - Significant increased Biodex 4 isokinetic muscle strength velocity at 60°/s
    - Significant increases in 4 min Walk test
    - Decreased VAS scores

Xu, Hui, Bingxin Kang, Yulin Li, et al. "Using Electroacupuncture to Recover Muscle Strength in Patients with Knee Osteoarthritis after Total Knee Arthroplasty: A Study Protocol for a Double-Blinded, Randomized, and Placebo-Controlled Trial." *Trials* 21 (August 2020): 705. https://doi.org/10.1186/s13063-020-04601-x.

BASIC RESEARCH www.jasn.org

Low-Frequency Electrical Stimulation Attenuates Muscle Atrophy in CKD—A Potential Treatment Strategy

Li Hu,*† Janet D. Klein,* Faten Hassounah,* Hui Cai,*‡ Cong Zhang,* Ping Xu,† and Xiaonan H. Wang*

*Renal Division, Department of Medicine, Emory University, Atlanta, Georgia; †Acumox and Tuina Research Section, College of Acumox and Tuina, Shanghai University of Traditional Chinese Medicine, Shanghai, China; and ‡Section of Nephrology, Atlanta Veterans Administration Medical Center, Decatur, Georgia

- Low-Frequency ES- (LFES) may act as an exercise surrogate for Chronic Kidney Disease CKD patients unable to tolerate traditional exercise
- Suggests needling w/electrical stimulation can improve:
  - Muscle protein synthesis
  - Regeneration
  - Functional performance
- LFES improved muscle mass, strength, protein metabolism, and regeneration in CKD muscle wasting via local IGF-1 upregulation and macrophage-mediated repair signaling.

Review

NEURAL REGENERATION RESEARCH
www.nrronline.org

Basic mechanisms of peripheral nerve injury and treatment via electrical stimulation

https://doi.org/10.4103/1673-5374.335823
Date of submission: April 11, 2021

Xiao-Lei Chu[1, 2, #], Xi-Zi Song[1, #], Qi Li[1, 2], Yu-Ru Li[3], Feng He[4, *], Xiao-Song Gu[1, *], Dong Ming[1, 4]

- Preclinical strong support; selected clinical RCTs/ trials show improved sensory/motor recovery and reduced pain
- Practical points:
  - Common paradigm = Low Hz (2-20 Hz) ES (30 min-1 h) to proximal nerve
  - ES acts across the nervous-system axis (cell body → injury site → end organ)
  - Produces reduced apoptosis/inflammation, boost pro-regenerative signaling (BDNF/cAMP/CREB), accelerate accurate axon regeneration, and mitigate muscle atrophy and neuropathic pain

Chu, Xiao-Lei, et al. "Basic Mechanisms of Peripheral Nerve Injury and Treatment via Electrical Stimulation." *Neural Regeneration Research* 17, no. 10 (2022): 2185-93. https://doi.org/10.4103/1673-5374.335823.

Reducing Tone & Spasticity

- Reduced Tone
- Effective for stroke and MS spasticity
- Optimal: <20 Hz for 30+ minutes
- Reduces velocity-dependent reflex torque

- This systematic review summarizes existing studies on dry needling for spasticity and range of motion (ROM) and discusses its potential for use as an occupational therapy intervention.
- Optimal: <20 Hz for 30+ minutes
- This systematic review suggests that dry needling is an effective physical agent modality to decrease spasticity and increase ROM, both of which are potentially beneficial to functional outcomes.



Irish Journal of Medical Science (1971 -)
https://doi.org/10.1007/s11845-025-04261-3

ORIGINAL ARTICLE

Therapeutic impact of electrical stimulation versus intramuscular electrical stimulation via dry needling on tibialis anterior muscle on reducing spasticity in stroke survivors: a randomized controlled trial

Ranim Al Amin[1] · Rami L. Abbas[1] · Ahmed S. Ali[2,3] · Ibtissam M. Saab[1] · Salma AlKhatib[4] · Ahmed M. El Melhat[1,5]

Received: 26 September 2025 / Accepted: 17 December 2025
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- Sixty stroke survivors were randomly assigned to either the surface ES or IMES groups. Each intervention (100 Hz)* was applied for 30 min.
- Surface ES and IMES effectively reduce post-stroke spasticity, with IMES showing additional neurophysiological benefits in the Gastrocnemius muscle.
- Both techniques are viable for immediate spasticity reduction, though further research is needed to explore long-term effects and underlying mechanisms.

Irish Journal of Medical Science (1971 -)
https://doi.org/10.1007/s11845-025-04261-3

ORIGINAL ARTICLE

Therapeutic impact of electrical stimulation versus intramuscular electrical stimulation via dry needling on tibialis anterior muscle on reducing spasticity in stroke survivors: a randomized controlled trial

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New evidence!

- This study evaluated and compared the immediate effects of surface ES and IMES on spasticity in stroke survivors, focusing on the tibialis anterior muscle and its effects on the Gastrocnemius and Soleus muscles
- Surface ES and IMES effectively reduce post-stroke spasticity
  - IMES showing additional neurophysiological benefits in the Gastrocnemius muscle
  - The IMES group uniquely reduced H-reflex amplitude

Mechanotransduction



Needle mechanically couples to connective tissue



EDN provides rhythmic mechanical stress



Activates collagen repair signaling

Tissue Repair Evidence

- Improves collagen fiber organization
- Modulates IL-1ß, IL-6, TNF-α
- Enhances tendon biomechanical strength

Tu, Shi-Wei, Jun Kawanokuchi, Ken Takagi, et al. “Fibroblasts as Key Cellular Targets in Acupuncture Therapy: A Mechanistic Perspective.” *Frontiers in Bioengineering and Biotechnology* 13 (October 2025): 1662525. https://doi.org/10.3389/fbioe.2025.1662525.

- Key points: EDN needle manipulation deforms/entangles collagen fibers and fascia, transmits shear/elastic waves to fibroblasts
- Induces:
  - Fibroblast cytoskeletal remodeling and activation
  - Triggers release of ATP/adenosine, cytokines, growth factors, ECM components (collagen, hyaluronan) and extracellular vesicles
  - Engages immune cells (mast cells, macrophages) and nerves to produce analgesic, anti-inflammatory and tissue-repair effects
- Mechanobiochemical effects on fibroblasts offer a plausible pathway by which EDN improves tissue healing, scar remodeling, and reduce stiffness/adhesions

Even Scars

Case Study: Scar Pain

- This case report describes the successful management of a patient with post-scar neuralgia using dry needling, when all other treatment options were not producing pain relief.
- It is suggested that dry needling can be considered as an effective treatment option.

Das, Gautam, and Khaja J. Khan. "Dry Needling a Novel Treatment Option for Post-Scar Neuralgia: A Case Report." *Journal on Recent Advances in Pain* 5, no. 1 (2019): 29–31. https://doi.org/10.5005/jp-journals-10046-0127.

General Contraindications



Metal allergies, needle phobia



Systemic blood diseases



Local lesions, cancerous tissue, lymphedema

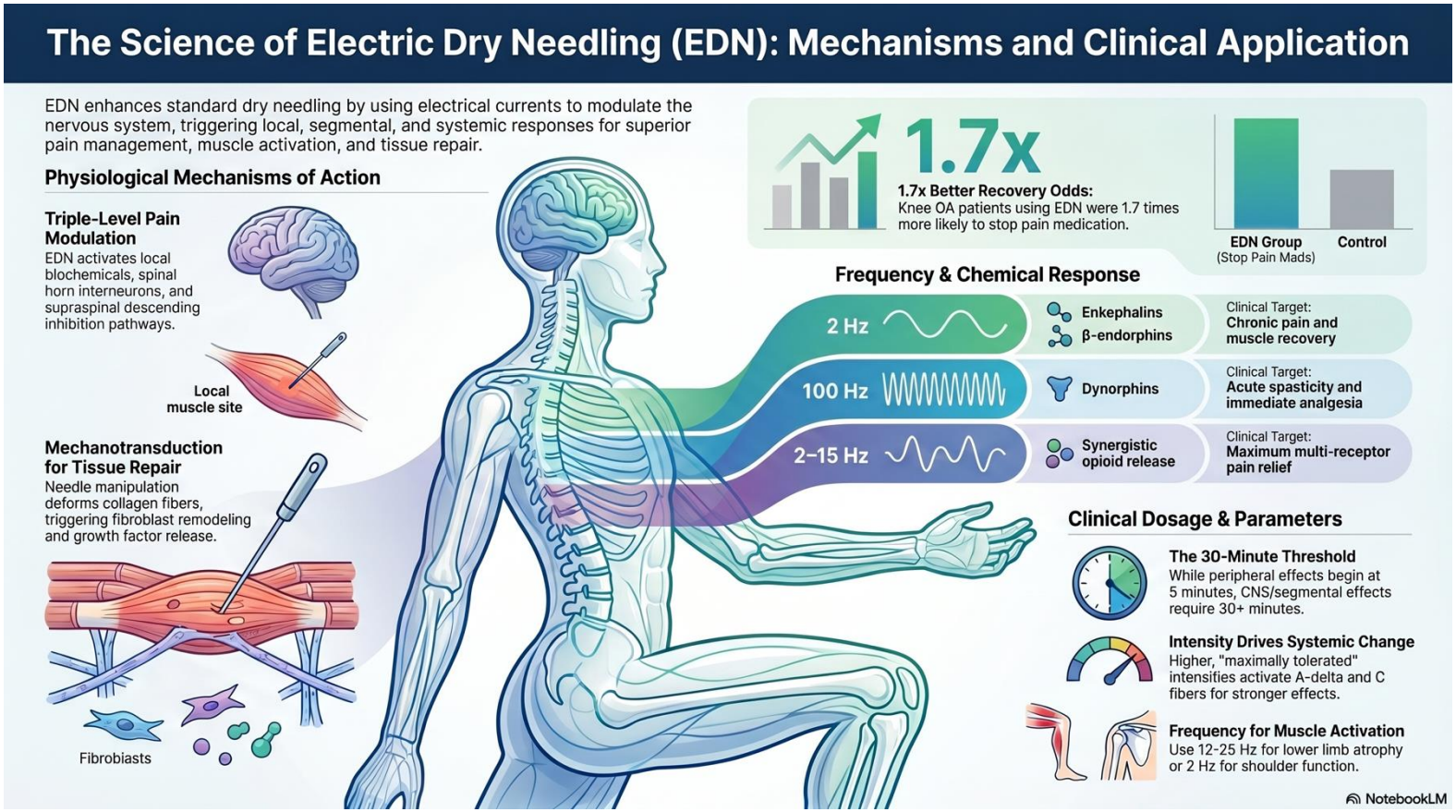
Electrical-Specific Precautions

- Pacemakers, neural stimulators
- No anterior neck or transcranial stimulation
- Precautions: pregnancy, vascular disease, impaired sensation

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Clinical Summary

- Multi-level analgesia: local, spinal, brain
- Dose parameters determine outcomes
- Applications include pain, muscle repair, tone reduction


The Science of Electric Dry Needling (EDN): Mechanisms and Clinical Application
EDN enhances standard dry needling by using electrical currents to modulate the nervous system, triggering local, segmental, and systemic responses for superior pain management, muscle activation, and tissue repair.
Physiological Mechanisms of Action
Triple-Level Pain Modulation
EDN activates local biochemicals, spinal horn interneurons, and supraspinal descending inhibition pathways.
Local muscle site
Mechanotransduction for Tissue Repair
Needle manipulation deforms collagen fibers, triggering fibroblast remodeling and growth factor release.
Fibrobiasts
1.7x
1.7x Better Recovery Odds:
Knee OA patients using EDN were 1.7 times more likely to stop pain medication.
EDN Group (Stop Pain Mads)
Control
Frequency & Chemical Response
2 Hz
Enkephalins
β-endorphins
Clinical Target: Chronic pain and muscle recovery
100 Hz
Dynorphins
Clinical Target: Acute spasticity and immediate analgesia
2–15 Hz
Synergistic opioid release
Clinical Target: Maximum multi-receptor pain relief
Clinical Dosage & Parameters
The 30-Minute Threshold
While peripheral effects begin at 5 minutes, CNS/segmental effects require 30+ minutes.
Intensity Drives Systemic Change
Higher, "maximally tolerated" intensities activate A-delta and C fibers for stronger effects.
Frequency for Muscle Activation
Use 12-25 Hz for lower limb atrophy or 2 Hz for shoulder function.
NotebookLM

Lab Demonstrations

- Analgesic effects
  - NMES VMO
  - OA Periosteal stim
  - Mechanotransduction
  - Pain



Thank You!

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Questions?





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Promo code: CATS50
$150 off any Foundations DN course.
Promo code: CATS150
www.structureandfunction.net

Key References

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- Langevin HM. (2001)