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PERCUTANEOUS ELECTROLYSIS IN THE TREATMENT OF TENDINOPATHY – A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Percutaneous electrolysis (PNE/EPI) is a minimally invasive technique used in the management of tendinopathies. The mechanism of action of this compound is based on the induction of a localised electrochemical reaction, which in turn triggers a controlled inflammatory response. This inflammatory response serves to promote the resorption of degenerated tissue and to stimulate collagen regeneration. In recent years, this method has gained increasing popularity as an alternative or adjunct to conventional conservative therapies, such as eccentric exercise, extracorporeal shockwave therapy (ESWT), or platelet-rich plasma (PRP) injections. A mounting body of clinical evidence, encompassing randomised controlled trials, has emerged to support the efficacy of this approach in alleviating pain and enhancing function in patients afflicted with chronic tendinopathy..

Objective: This systematic review aims to evaluate the existing evidence regarding the effectiveness and clinical relevance of percutaneous electrolysis in the treatment of tendinopathy.

Materials and Methods: The article is based on scientific literature sourced from PubMed and Google Scholar.

Results: PNE demonstrates beneficial effects on pathologically altered tendons. The majority of studies report pain reduction and functional improvement in patients. The combination of PNE with other therapeutic modalities shows a synergistic effect. Nevertheless, further comparative analyses and meta-analyses are required to definitively establish the superiority of PNE over other treatment approaches.

Conclusions: PNE may serve as a core component in the treatment of tendinopathy. However, standardization of treatment parameters—such as current intensity and therapeutic protocols—is necessary to ensure consistency and reproducibility of outcomes.

KEYWORDS

Percutaneous Electrolysis, Tendinopathy, Lateral Epicondylitis, Extracorporeal Shockwave Therapy, PNE, EPI

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Introduction

Definition and Terminology

Current expert consensus recommends the use of the term *tendinopathy* to describe persistent tendon pain and dysfunction associated with mechanical loading, replacing the traditional and often misleading terms *tendinitis* (inflammation) and *tendinosis* (degeneration). This terminology was formalized in the consensus of the International Scientific Tendinopathy Symposium (ICON 2019), which states: "*tendinopathy is the preferred term for persistent tendon pain and loss of function related to mechanical loading*."The use of a unified and standardized terminology aims to enhance the consistency of clinical research and facilitates the comparison of outcomes across therapeutic interventions[1].

Epidemiology and Common Etiological Factors

Tendinopathies represent a prevalent cause of musculoskeletal pain in both the general and athletic populations, imposing a substantial social and economic burden due to absenteeism and reduced physical performance. They most commonly affect tendons subjected to high mechanical demands in the context of dynamic energy storage and release, such as the Achilles tendon, patellar tendon, rotator cuff, and lateral epicondyle of the elbow.

The etiology of tendinopathy includes both extrinsic and intrinsic factors. Extrinsic factors encompass excessive or improperly programmed mechanical loading (e.g., abrupt increases in training volume or intensity, poor movement technique, occupational strain), whereas intrinsic factors include age, anatomical variations, metabolic disorders such as diabetes and dyslipidemia, specific medications (e.g., fluoroquinolones), and genetic predisposition.

Numerous studies have demonstrated that metabolic diseases (e.g., hyperlipidemia, diabetes mellitus) significantly increase the risk of developing tendinopathy and negatively impact the healing process[2,3,4].

1. Pathophysiology – Molecular and Tissue Mechanisms

The pathophysiology of tendinopathy is multifactorial and involves the interplay between mechanotransduction, extracellular matrix (ECM) remodeling, cellular responses, and inflammatory/degenerative components. Current perspectives conceptualize tendinopathy as a dynamic process encompassing both degenerative and adaptive/regenerative elements, rather than a simple "inflammatory versus degenerative" dichotomy.

Key mechanisms of pathogenesis include:

1. **Mechanical Overload and Structural Alterations:**
2. Chronic or repetitive loading leads to microtrauma in collagen fibers, disrupted fiber organization (e.g., increased collagen disorganization, decreased density of type I collagen, and increased presence of type III collagen), and overall tendon thickening[5,6].
3. **ECM Remodeling and Protease Activity:**
4. An imbalance between synthesis and degradation of the extracellular matrix—particularly involving matrix metalloproteinases (MMPs)—contributes to pathological tendon remodeling. These changes are closely linked to cellular inflammatory and reparative responses[7].

3. **The Role of Inflammation and Inflammatory Mediators:**
4. Although earlier theories downplayed the involvement of classical inflammation, current evidence demonstrates that pro-inflammatory cytokines (e.g., IL-1β, IL-6, TNF-α), immune cells, and neuropeptides participate in both the initiation and maintenance of tendinopathic changes, as well as in pain modulation. In many cases, neovascularization and neurogenic alterations—such as increased vascularization and ingrowth of nociceptive nerve fibers—are observed and have been shown to correlate with pain symptoms[8].
5. **Cellular Changes and Mechanotransduction:**
6. Tendon cells (tenocytes) respond to mechanical dysregulation by altering their phenotype, proliferating, expressing inflammatory markers, and producing altered extracellular matrix. These processes play a pivotal role in the transition from normal healing to chronic pathology. Recent molecular studies have identified specific signaling pathways and transcription factors involved in the overload response and ECM regulation[9].
7. **Systemic Factors as Modulators of Risk and Disease Course:**
8. Metabolic and hormonal imbalances (e.g., steroid dysregulation), dyslipidemia, and age-related changes affect the tendon microenvironment, impairing regeneration and promoting chronic pathological remodeling[10].

In light of the above mechanisms, tendinopathy should be conceptualized as a multifactorial disorder—resulting from aberrant mechanical loading within the specific biological context of the host—rather than merely a localized "overuse" injury of the tendon.

2. Clinical Presentation and Diagnosis (Brief Overview)

Clinically, tendinopathy presents as localized pain at the tendon or its insertion site, exacerbated by specific loading activities (e.g., jumping, tiptoe standing, throwing), functional limitation, and occasionally local swelling.

Diagnosis is primarily based on clinical examination. Imaging techniques such as ultrasound and MRI are valuable for confirming structural abnormalities (e.g., hypoechogenicity, tendon thickening, neovascularization), although the correlation between imaging findings and clinical symptoms is often limited. Structural abnormalities may also be present in asymptomatic individuals.

The ICON consensus emphasizes the need for integrating clinical assessment with imaging and functional evaluation in both research and clinical practice[1,6].

3. Treatment Strategies – Review of Evidence and Clinical Practice

Management of tendinopathy is guided by evidence of varying levels of certainty. A multimodal approach—typically involving load management, therapeutic exercise, and optional adjunct interventions—is widely adopted in clinical practice.

1. **Load Management and Therapeutic Exercise**
2. Exercise aimed at restoring the tendon's load tolerance is the cornerstone of treatment. The most robust evidence supports eccentric training programs and heavy slow resistance (HSR) training—both approaches have been shown to reduce symptoms and improve function across various tendinopathies, including Achilles tendinopathy and patellar tendinopathy.
3. Rehabilitation should be individualized, progressive, and closely monitored, with consideration for pain thresholds and functional tolerance. Systematic reviews and meta-analyses consistently support exercise as the first-line therapeutic modality, although the optimal parameters (e.g., volume, intensity, tempo) remain the subject of ongoing investigation[11],[12].
4. **Physical and External Modalities (ESWT, Laser Therapy, Therapeutic Ultrasound)**
5. Extracorporeal shockwave therapy (ESWT) has moderate evidence of efficacy, particularly when combined with exercise, and is often utilized in cases of rehabilitation failure.
6. Other modalities—such as low-level laser therapy and therapeutic ultrasound—show variable evidence quality and are not consistently recommended as standard treatments[13],[14].
7. **Injection-Based and Biologic Interventions (PRP, Corticosteroids, Others)**

- **Corticosteroids:** These provide short-term pain relief, particularly in enthesopathies such as lateral epicondylitis. However, they lack long-term benefit and may have deleterious effects on tendon structure.
- **Platelet-Rich Plasma (PRP):** The evidence is heterogeneous. Some meta-analyses indicate potential benefit in patients resistant to conservative therapies, but outcomes vary significantly depending on protocol and study quality[15],[16].

4. Minimally Invasive Techniques

Techniques such as dry needling, disrupting injections, or percutaneous needle procedures (e.g., percutaneous electrolysis, barbotage, tenotomy) are employed to induce controlled microtrauma or stimulate tissue remodeling. While these interventions have shown promising results in certain anatomical regions, their overall effectiveness remains under investigation. High-quality randomized controlled trials (RCTs) are still needed to establish their clinical utility definitively[17].

5. Surgery

Surgical intervention is considered a last resort, indicated only when conservative and minimally invasive treatments fail and when symptoms significantly impair function. Surgical procedures typically aim to debride degenerative tissue, restore tendon structure, or perform tendon reconstruction. Treatment decisions should be individualized based on clinical presentation and patient expectations[18].

Characteristics of Percutaneous Electrolysis (Percutaneous Needle Electrolysis — PNE / Intratissue Percutaneous Electrolysis — EPI)

Percutaneous electrolysis (PNE/EPI) is an invasive physiotherapeutic technique involving the application of a controlled galvanic (direct) current via a fine needle inserted directly into the affected tendon tissue, typically under ultrasound guidance or anatomical palpation. The goal of this procedure is to elicit a local tissue response—characterized by inflammation, microdisruption, and stimulation of extracellular matrix (ECM) remodeling—which hypothetically accelerates tendon healing, improves mechanical properties, and alleviates pain.

The intervention is performed using a specialized device that delivers galvanic current through a single fine stainless steel needle. Treatment parameters—including current intensity, duration of application, number of impulses, and number of sessions—vary depending on the protocol and the device manufacturer. In clinical practice, PNE is frequently combined with eccentric or heavy slow resistance (HSR) exercise programs and other rehabilitative modalities[19],[20].

Proposed Mechanism of Action – Molecular and Tissue-Level Perspective

Experimental studies and systematic reviews suggest several interrelated mechanisms that may explain the observed clinical effects of PNE:

1. **Induction of Controlled Inflammation and Local Cytotoxicity:**
2. Galvanic current flow induces electrochemical reactions at the needle tip (localized electrolysis), leading to activation of inflammatory pathways and partial destruction of pathological tissue. This triggers a reparative and remodeling phase. Experimental reviews categorize the biological effects of PNE into an initial *pro-inflammatory* phase followed by a *regenerative* phase involving ECM modulation[19,21].
3. **ECM Remodeling and Modulation of Proteolytic Enzymes:**
4. In vitro and in vivo studies suggest that PNE influences the expression and activity of matrix remodeling enzymes (e.g., matrix metalloproteinases – MMPs), as well as the type I/type III collagen ratio. These effects are theorized to promote restoration of organized collagen fiber architecture[22].
5. **Effects on Vascularization and Neural Components:**
6. Histological and imaging studies have reported changes in neovascularization and modulation of angiogenic factors such as vascular endothelial growth factor (VEGF), which may correlate with pain perception and tissue repair. Additionally, neurophysiological effects—such as modulation of nociceptive thresholds—are also hypothesized[23].
7. **Synergistic Effect with Load-Based Exercise:**
8. Clinical practice and observational studies most commonly apply PNE as an adjunct to eccentric or HSR exercise programs. The proposed mechanism suggests that PNE facilitates tissue remodeling by disrupting pathological tissue constraints and initiating a transient inflammatory phase, after which mechanical loading via exercise guides proper tendon adaptation and structural reorganization[20].

Technique and Treatment Parameters – Practical Considerations

- **Imaging:** Most protocols recommend ultrasound-guided needle placement for precision and safety. Some earlier protocols used palpation-based localization.
- **Electrical Parameters:** The literature presents a wide range of **current intensities** and **application durations** (e.g., milliampere vs. microampere levels, impulses lasting several seconds, repetitive applications). There is currently **no consensus** on the "optimal" dosing regimen.
- **Treatment Protocols:** Typically involve 1–6 sessions spaced over several weeks. PNE is most often **combined with exercise programs** throughout the rehabilitation period.
- **Safety:** Clinical reports indicate a low incidence of serious adverse events. Common post-procedure complaints include transient pain and local skin reactions. However, long-term safety data and standardized adverse event reporting in larger trials are lacking[20,24].

Clinical Evidence and Systematic Reviews on the Effectiveness of PNE/EPI

Recent systematic reviews and meta-analyses have evaluated the effectiveness of percutaneous electrolysis (PE/PNE/EPI) in the treatment of tendinopathies. Key findings include:

- A recent meta-analysis reported a statistically significant reduction in pain in PNE-treated groups compared to controls, with a pooled SMD of approximately −0.97 (95% CI −1.26 to −0.68). Heterogeneity was moderate to high across studies. The quality of evidence was generally rated as low to moderate, due to methodological limitations and protocol heterogeneity. Some subgroups demonstrated sustained benefits across short-, medium-, and long-term follow-ups, although overall certainty remains limited[25].
- Narrative and systematic reviews suggest that PNE combined with exercise programs (especially eccentric loading) appears to be more effective than exercise alone in reducing pain and improving function in several tendon regions (e.g., lateral epicondyle, supraspinatus tendon, Achilles tendon, patellar tendon). However, many included studies were small-scale and varied significantly in PNE parameters and accompanying protocols[26].

Findings from RCTs and Controlled Clinical Trials – Clinical Examples

- **Supraspinatus Tendinopathy (Shoulder):** A single-blinded RCT comparing PNE to trigger point dry needling showed significantly greater improvement in pain, range of motion, and pain thresholds in the PNE group in both short- and medium-term outcomes when used in combination with an exercise program[27].
- **Lateral Epicondylalgia:** An RCT found that PNE combined with eccentric exercise resulted in greater reductions in pain (NPRS/VAS) and improvements in pain threshold and functional scores compared to alternative interventions (e.g., dry needling), at 1- and 3-month follow-ups[28].

- **Achilles, Patellar, and Other Tendon Sites:** Several prospective series and controlled trials suggest beneficial effects of PNE in pain reduction and functional recovery, particularly when combined with eccentric loading. However, RCTs for some anatomical regions remain scarce, and many studies are of low methodological quality[24,29].
- Comparative Effectiveness of PNE Versus Other Treatments
- **PNE vs. Dry Needling (DN/TDN):** Available RCTs and meta-analyses suggest that PNE may be slightly more effective than dry needling in reducing pain and improving function in the short- to medium-term. However, clinical effect sizes are often modest and protocol-dependent[28,30].
- **PNE vs. PRP:** Direct comparisons of PNE with platelet-rich plasma are limited. PRP has shown potential superiority over corticosteroids in medium-term outcomes in some meta-analyses, though findings are mixed when compared with placebo or other interventions. In clinical practice, PNE is often viewed as a minimally invasive, lower-cost alternative to biologic injections, but well-powered head-to-head RCTs are lacking[31,32].
- **PNE vs. ESWT:** Extracorporeal shockwave therapy (ESWT) has supportive evidence in selected tendinopathies (e.g., plantar fasciitis, patellar tendinopathy), but with variable strength depending on location and protocol. Direct comparisons with PNE are limited, and both are typically used as second-line interventions, with treatment choice influenced by availability, cost, and clinician experience[33,34].
- **PNE vs. Corticosteroid Injections:** Corticosteroids offer rapid short-term pain relief, especially in enthesopathies, but their effectiveness wanes over time, and concerns persist about adverse structural effects on tendons. PNE offers gradual but potentially longer-lasting improvement, with some studies suggesting superior outcomes in the medium to long term. However, strong direct comparisons are still lacking[35,36].

Clinical Outcomes – Summary of Effectiveness Criteria

- **Pain:** Most systematic reviews and meta-analyses show a statistically significant pain reduction after PNE compared to control or alternative therapies, particularly in short- and medium-term. Reported effect sizes range from moderate to large (SMD ≈ -0.8 to -1.3), though tempered by study quality and heterogeneity[37,20].
- **Function:** Improvements in tendon-specific functional scales have been demonstrated, especially when PNE is used as an adjunct to exercise. Not all studies report sustained long-term functional gains[28].
- **Imaging (Ultrasound):** Evidence regarding structural tendon changes post-PNE (e.g., echogenicity, thickness, neovascularization) is limited and inconsistent, and structural changes do not always correlate with clinical improvement[38].
- **Safety:** PNE appears to have an acceptable short-term safety profile, with few serious adverse events reported. However, long-term safety data are lacking, and adverse event reporting is inconsistent[20].

Limitations of the Evidence and Research Gaps

- **Protocol heterogeneity:** There is considerable variation in electrical parameters, number of sessions, technique (ultrasound-guided vs. palpatory), and exercise protocols, making comparisons and synthesis of data challenging[37].
- **Methodological quality:** Many studies are small-scale, often lack adequate blinding, and present a risk of bias (e.g., lack of operator blinding, incomplete data reporting)[26].
- **Lack of head-to-head comparisons:** There are relatively few high-quality RCTs directly comparing PNE with other commonly used interventions such as PRP, ESWT, or corticosteroid injections, and those that exist often lack statistical power[20].
- **Biological mechanisms:** Despite preliminary experimental findings, translational research linking molecular marker changes to clinical outcomes in humans remains insufficient[19,22].

Summary

Percutaneous needle electrolysis (PNE/EPI) represents a promising, minimally invasive intervention, primarily used as an adjunct to exercise therapy in the management of tendinopathies. Current meta-analyses and RCTs suggest a beneficial effect on pain reduction and functional improvement, especially when PNE is combined with eccentric or heavy slow resistance (HSR) exercise programs.

However, the quality of evidence is limited by significant protocol heterogeneity, small sample sizes, and methodological biases. Moreover, direct comparisons with other treatment modalities (PRP, ESWT, corticosteroids) are few and inconclusive.

There is a pressing need for: well-designed, multicenter RCTs using standardized PNE parameters (clearly defined dosing protocols and treatment regimens); adequate blinding and robust adverse event reporting, Long-term follow-up data, and translational studies that correlate molecular markers of ECM remodeling with clinical outcomes[19],[25],[31].

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