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Systematic Review

Invasive physiotherapy techniques in patellar tendinopathy. A Systematic Review

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ABSTRACT

Background: Patellar tendinopathy (PT) is a degenerative condition characterized by pain and functional impairment, primarily affecting physically active individuals. In recent years, non-pharmacological invasive physiotherapy techniques such as percutaneous needle electrolysis (PNE) and dry needling (DN) have increased.

Objective: To evaluate the effectiveness of non-pharmacological invasive physiotherapy techniques in reducing pain and improving functional disability in patients with PT.

Methods: A total of 2,644 studies were identified through an electronic search in July 2024. After applying the selection criteria, four randomized controlled trials were included. These assessed pain and/or functional disability in 254 adults with PT who received invasive physiotherapy treatments.

Results: DN and PNE improved pain and functional disability in patients with PT. However, these improvements are comparable to those achieved through conventional physical therapy (CPT). Only in the case of pain does the addition of DN to CPT appear to offer greater effectiveness than CPT alone.

Discussion: In line with previous reviews, the use of invasive physiotherapy techniques has shown a positive effect on pain intensity and functional functional disability in patients with PT. This benefit may be attributed to the mechanical effect induced by the needle and the biological processes triggered after its application. A relevant finding was the influence of symptom severity in patients with PT, as those with more severe symptoms experienced greater benefits in terms of functional disability. This pattern is consistent with previous studies conducted in other populations. Notably, none of the reviewed studies reported adverse effects, possibly due to using ultrasound guidance during the interventions.

Conclusions: PNE and DN effectively reduce pain intensity when combined with combined with eccentric exercises (EE) or CPT in individuals with PT. PNE and DN do not enhance the effectiveness of EE and CPT in improving functional disability. Future studies should examine the effect of invasive techniques as stand-alone treatments.

Other information: PROSPERO (CRD42024608225).

Keywords: Patellar tendinopathy; Invasive physiotherapy techniques; Dry needling; Percutaneous needle electrolysis; Pain; Functional disability.

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1. Introduction

Patellar tendinopathy (PT) is a degenerative condition primarily characterized by localized pain at the inferior pole of the patella[1]. This pain typically manifests immediately upon mechanical loading and diminishes rapidly once the load is removed[2]. The pain experienced by individuals with chronic tendinopathy, commonly long-standing conditions, may also be influenced by processes involving the central nervous system, potentially affecting pain regulation and contributing to its persistence[3]. Despite numerous investigations, the exact etiology of PT remains unclear. However, several risk factors have been identified, including body mass index, leg length discrepancies, foot arch height, muscle strength, and genetic predispositions[4,5]. The prevailing theory suggests that PT results from physical activity overload, where repetitive or sustained impact disrupts natural tendon repair processes, ultimately leading to pathological changes[6,7].

PT predominantly affects people who perform repetitive activities, particularly athletes who play sports requiring jumping or rapid direction changes. Among non-elite athletes, the prevalence is 19.9%, compared with 16.7% in elite athletes[8]. In contrast, the prevalence in the general population is significantly lower (0.1%), which is attributed to less tendon loading during daily activities[8,9]. The social impact of PT is substantial, causing pain and functional limitations that can restrict daily activities and significantly impair the careers of professional athletes[10,11].

Diagnostic criteria for PT include tendon thickening, localized pain, and crepitus in the patellar tendon. The pain usually worsens during repetitive knee flexion activities or provocative maneuvers such as eccentric single-leg squats[12,13]. Imaging modalities such as ultrasound (US) and magnetic resonance imaging (MRI) are critical to visualize the tendon structure, confirm the diagnosis, and exclude other differential conditions with overlapping symptoms[10,12,13].

Treatment of PT usually consists of tailoring interventions to the stage of tendinopathy. Key components include exercise therapy, patient education about the pathology, and load management[3,14,15]. This primary treatment is sometimes complemented with invasive therapies, such as platelet-rich plasma injections, hyaluronic acid, or corticosteroids, but the evidence supporting their effectiveness is limited[16]. Recently, non-medication invasive physiotherapy techniques, such as percutaneous needle electrolysis (PNE) and dry needling (DN), have developed a powerful trend in both clinical use and study of these techniques in different pathologies, including tendinopathy[17,18]. These methods offer several advantages, such as ease of application and avoidance of substance injections, making them more feasible in daily clinical practice.

Numerous systematic reviews and meta-analyses have evaluated the efficacy of invasive therapies in treating PT. However, these reviews include interventions with medication or biological substances, such as platelet-rich plasma or autologous blood[19-25]. To date, no systematic review has focused exclusively on the effectiveness of non-pharmacological invasive physiotherapy techniques in PT. This constitutes an important gap in the current evidence base, as these techniques are increasingly used in clinical settings due to their minimally invasive nature and favorable safety profile. Moreover, existing reviews often fail to distinguish between invasive procedures that include substance injection and those that do not[19,20], making it difficult to isolate the specific effects of techniques like PNE or DN. Therefore, this systematic review seeks

to address these limitations by evaluating the effectiveness of non-pharmacological invasive physiotherapy techniques in improving pain and functional disability among individuals with PT, a prevalent condition in our society, especially among non-elite athletes[24].

2. Methods

2.1 Study design

This systematic review was carried out following the guidelines of the Preferred Reporting Items for Systematic Reviews (PRISMA) protocol[26] and has been registered with the PROSPERO international registry for prospective systematic reviews (reference number: CRD42024608225).

2.2 Eligibility criteria

The eligibility of studies was determined using the PRISMA checklist and the PICOS framework (P-Participants; I-Interventions; C-Comparators; O-Outcome; S-Study design). Studies were included based on the following criteria: 1) Studies involving adult populations (>18 years old) diagnosed with PT; 2) Studies in which patients underwent invasive physiotherapy interventions without medicament or any substance injection either alone or in combination with other therapies such as physical exercise and education programs; 3) Comparisons with any non-surgical treatment (e.g., education program, physical exercise, other physical therapy techniques (including invasive ones), etc.); 4) Studies reporting outcomes related to pain and/or functional disability; 5) Only randomized controlled trials (RCTs) published in peer-reviewed journals and written in English or Spanish. Exclusion criteria included: 1) Studies involving participants with other knee pathologies (e.g., fractures, sprains, degenerative joint processes, meniscal injuries, etc.); 2) Studies including surgical techniques or pharmacological treatments (e.g., corticosteroids, PRP, autologous blood).

2.3 Data Sources and Search Strategy

An electronic search for RCTs was conducted and ended on 1 July 2024. The PubMed, Cochrane, PEDro, BVS, Science Direct, Web of Science, and Scopus databases were evaluated and consulted to identify studies. Regarding the search terms, four categories were defined: the first related to patellar tendinopathy ("patella*", "patela*", "Tendinopathy", "tendin*", "tendon*", "jumper's knee", "ligament"); the second related to invasive physiotherapy techniques ("dry needling", "acupuncture", "electrolysis", "Electroacupuncture", "needl*", "electr*", "acupuncture", "invasive*", "percutaneous", "physical therap*", "physiotherapy"); the third related to pain ("pain*", "Myalgia", "nociception", "Pain Measurement", "pain threshold", "pain perception", "chronic pain", "acute pain", "analgesia", "pain management", "musculoskeletal pain", "Neuralgia", "analgesia", "ache*", "suffer*", "nocicept*", "discomfort", "tenderness", "soreness"); and the fourth related to functional disability (Physical Functional Performance", "functional status", "disability", "capacity", "ability", "function*", "performance", "limitation*", "activity"). Once these terms were established, they were entered into the search engine of the different databases and combined with the Boolean operators "AND" and "OR". Two independent researchers (DA, GO) reviewed the titles and abstracts of the publications identified through the search strategy and assessed

the full texts for potential inclusion. Any disagreements between the two researchers were resolved through discussion and consultation with a third reviewer (AC).

2.4 Study Selection

Two reviewers (DA, GO) reviewed each report to decide if the studies met the inclusion criteria. They worked independently to avoid bias, followed the same methodology after agreeing on how to perform the search equations, and then compared their results.

Initially, all records were gathered from the seven databases, and duplicate publications were eliminated using Mendeley (version 1.19.8). An initial screening of the articles was conducted, selecting those that appeared to meet the inclusion criteria based on the information provided in the title and abstract. In the second phase, the articles that passed the initial screening were reviewed in full text, and those that met all the inclusion criteria were chosen. The selected studies were then compared, and in case of disagreement, a third researcher (AC) was consulted to achieve consensus.

2.5 Data extraction process

The same two reviewers (DA and GO) independently performed the study selection and data extraction. Any disagreements were discussed, and a third reviewer (AC) was consulted when necessary. During the data extraction process, the following information was collected from each study: authors and year of publication, sample characteristics (such as sample size, gender, age, and baseline pain and functionality values), inclusion criteria, intervention, comparator/control group, primary outcomes and evaluation time points (pain and/or functional disability), key results, and adverse effects. In case of missing or unclear data in the included studies, the corresponding authors were contacted via email. If no response was received after two attempts, the available data were analyzed as reported in the original article.

2.6 Assessment of methodological quality/risk of bias

The PEDro scale was used to assess the methodological quality of the included studies. The two reviewers worked independently (DA, GO), and the results were compared. The intervention of a third reviewer was not required. The PEDro scale, explicitly developed for RCTs, comprises 11 items, scoring 1 if the article meets the criteria and 0 if it does not. Item 1 confirms whether the eligibility criteria have been established (external validity), items 2–9 assess the study design (internal validity), and items 10 and 11 evaluate the interpretability of the results. The maximum score is 10 points, as the first item is not considered in the final score. In interpreting the score, the articles that scored at least 6 out of 10 were considered to be of “high quality," while the studies between 4 and 5 were considered to be of “moderate quality.” The articles with less than 4 points were supposed to be of “low quality”[27,28].

On the other hand, regarding the risk of bias in the included studies, the two reviewers worked independently (DA, GO), and the results were subsequently compared without involving a third reviewer. As these were RCTs, the Cochrane Risk of Bias 2.0 (RoB2) tool was used[29]. The risk of bias was assessed based on ‘allocation to intervention’ for all five domains: 1) randomization

process, 2) deviations from planned interventions, 3) missing outcome data, 4) outcome measurement, and 5) selection of reported outcome. The overall risk of bias was assessed as either "low risk", "some concern", or "high risk" of bias for each outcome.

3. Results

3.1. Study selection

After implementing the previously described strategies, a total of 2,644 studies were identified across seven databases (PubMed: 420, Cochrane: 108, PEDro: 89, BVS: 477, Web of Science: 616, Science Direct: 347, Scopus: 587). Following the removal of duplicate studies, 2,576 articles remained for title and abstract screening. Of these, 50 studies progressed to the next stage and underwent full-text analysis, where 46 were excluded for not meeting the inclusion criteria. Consequently, four articles were included in our systematic review[30–33]. The Flow Diagram (Figure 1) provides a detailed overview of the search and selection process, including the reasons for exclusion, in adherence to PRISMA criteria.

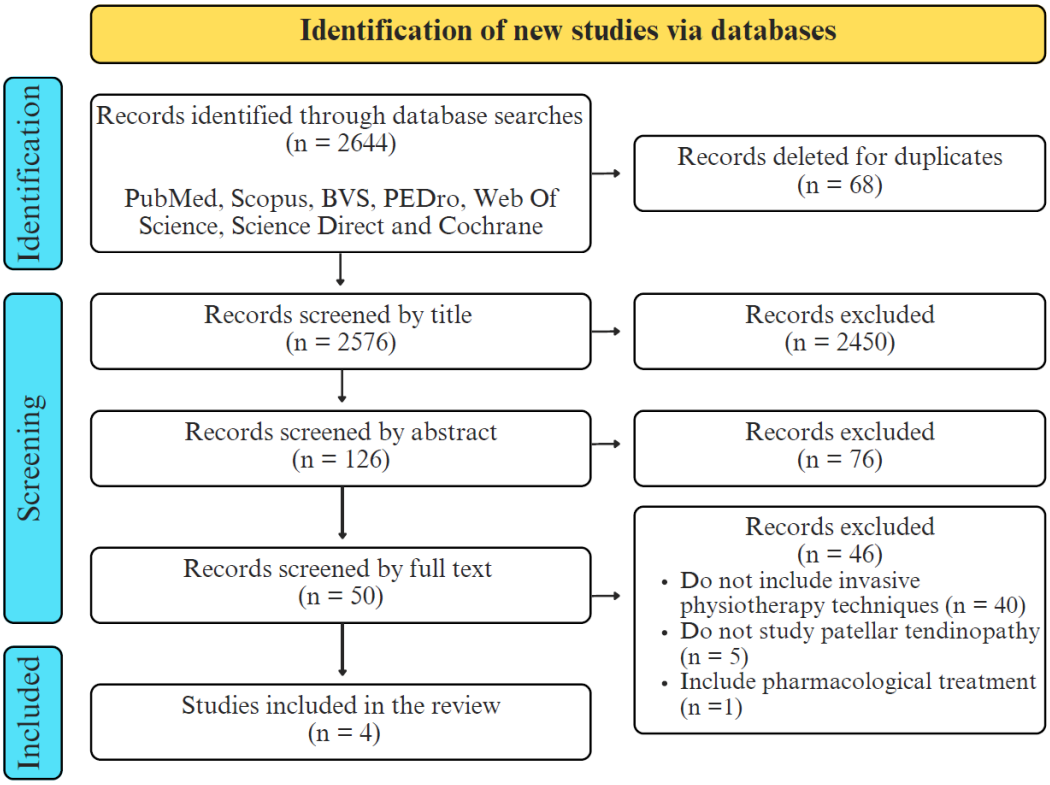

Figure 1. Flow Diagram.

3.2. Study characteristics

The data extracted from the four articles are presented in Tables 1 and 2, arranged alphabetically by the first author's last name. All four included trials were published in English between 2016 and 2022.

3.2.1. Sample characteristics

A total of 254 participants diagnosed with PT were included. The sample size of the selected studies ranged from 48 to a maximum of 94 participants. The total sample of the review comprised 77.1% men (n = 196) and 22.8% women (n = 58). The male sample had a higher proportion in three of the four included studies[31–33]. The mean age of the sample was 30.54 ± 4.98 years. All the evaluated studies share two key criteria: pain localized at the inferior pole of the patella or its insertion and tenderness upon palpation at the patellar tendon insertion[30–33]. Two studies by Lopez-Royo et al.[32,33] included a score of less than 80 on the Victorian Institute of Sport Assessment Patella Questionnaire (VISA-P) as a criterion. At the same time, another[30] used a score of ≥ 3 on the Visual Analogue Scale (VAS) during activities such as climbing/lowering stairs or performing decline squats. In all trials, participants presented symptoms for over one month[30–33] and two studies[32,33] for more than 3 months. Patients were physically active before injury or played sports regularly in all studies[30–33], while one[33] required a minimum frequency of sports practice of at least 3 times per week.

3.2.2. Intervention and follow-up

Regarding the interventions, three of four trials included in this review combined eccentric exercises (EE) with different invasive physiotherapy techniques: PNE[30–32] and DN[30,31]. While one of the studies combined Conventional Physical Therapy (CPT) -which includes stretching, cycling on a stationary bike with minimal resistance, pain-free partial weight-bearing squats, moist heat packs, pulsed ultrasound, and deep transverse friction massage of the patellar tendon- with DN[33]. In respect of comparators, three studies combined EE with sham needling[30,31] or electrotherapy[32], while the remaining study used CPT[33].

The follow-up ranged from four weeks[30] to a maximum of 22 weeks[32,33] with a mean of 3 assessment points. There were six follow-up losses. One study registered four losses (two participants from each group) due to non-adherence to the treatment program[31]. Another study reported two losses, one due to an unknown reason and the other due to a fear of needles[30].

3.2.3. Outcomes

Pain and functional disability were assessed in all four included trials[30–33]. Pain was evaluated using two distinct tools: the VAS in two trials[30,33], and the VISA-P questionnaire in the remaining two studies[31,33]. On the one hand, the VAS is a unidimensional measure of pain intensity typically presented as a 100-mm horizontal line with anchor terms such as “no pain” at one end and “worst possible pain” at the other[34]. On the other hand, the VISA-P is a widely used, condition-specific, patient-reported questionnaire designed to assess the clinical impact of PT through eight items, six of which address pain, while the remaining two assess sports participa-

tion. VISA-P scores range from 0 to 100, where 100 indicates an asymptomatic individual and 0 reflects complete functional impairment[35].

Functional disability was assessed in all four studies with the VISA-P Questionnaire[35]. In addition, one study incorporated the Lysholm Knee Scale and the Knee injury and Osteoarthritis Outcome Score (KOOS)[30]. The Lysholm Knee Scale assesses knee function, especially in cases of ligamentous injuries, across eight parameters, including pain, stability, and activity levels. Scores range from 0 to 100, with higher scores signifying superior knee function[36]. The KOOS is a patient-reported outcome measure that examines the impact of knee injuries and osteoarthritis through five subscales: pain, symptoms, activities of daily living, sports/recreation, and knee-related quality of life[37]. Each subscale is scored from 0 to 100, with higher scores reflecting better knee health.

Given its clinical relevance, this systematic review also examined adverse effects. One study[31] included PNE and reported no adverse effects during the procedure. However, the remaining studies[30,32,33], which used DN and PNE, did not provide data on adverse effects.

Table 1. Characteristics of included studies.

Authors and year	Sample Characteristics	Inclusion criteria	Intervention	Comparator	Main Outcomes and Follow-up	Main Results	Adverse Effects
Abat et al., 2016[31]	N = 64 (51 men; 13 women) Age (years): CG (30.9±5.9); IG (31.2±6.5) Gender (Male/Female): CG (27/5); IG: (24/8) BMI (kg/m2): CG (23.3±2.1); IG (23.6±2.4) Physical Activity (days/week): CG (3.8±1); IG (4.3±1.4) Baseline Functional Disability (VISA-P): CG-1 (52.5±18.8); CG-2 (69.1±9.1); IG-1 (51.4±17.9); IG-2 (66.3±13.1) Symptoms duration (months): CG (29.5±31.5); IG (28.8±32.4) Tendon thickening (Yes/No): CG (32/0); IG (32/0)	Clinical and US diagnosis of unilateral insertional patellar tendinopathy. Age: 20 - 60 years. Symptoms > 1 month. Athletically active prior to injury.	PNE + EE (N = 30)	Electrotherapy + EE (N = 30)	Functional Disability (VISA-P): Baseline and 2 months	Functional Disability: There were SSD for CG-1 and IG-1 in intra-groups VISA-P values between baseline and 2 months. There were no SSD for CG-2 and IG-2 in intra-groups VISA-P values between baseline and 2 months.	No adverse events were found in either group during the study.
López-Royo et al., 2024[32]	N = 48 (42 men; 6 women) Age (years) DN: (35.5±7.7); PNE: (33.5±7.8); CG: (35.2±6.1) Gender (Male/Female): DN: (13/3); PNE: (14/2); CG: (15/1) BMI (kg/m2): DN: (23.9±2.5); PNE: (25.7±3.9); CG: (24.7±2.4) Sports practice (hours/week): DN: (5.1±1.4); PNE: (4.4±1.1); CG: (5.2±1.2) Baseline Functional Disability (VISA-P): DN: (57.1±14.1); PNE: (48.8±14.5); CG: (56.2±10.5)	Anterior knee pain located in the inferior pole of the patella >3 months Age: 18 - 45 years Palpation tenderness of the superior insertion of the patellar tendon Score less than 80 on the VISA-P questionnaire.	PNE + EE (N= 16) DN + EE (N= 16)	Sham needling + EE (N=16)	Functional Disability (VISA-P): Baseline, 10 and 22 weeks.	Functional Disability: SSD were found between the pre-test and follow-up evaluations in all three groups for the VISA-P ($p < 0.001$), but no differences were found between the groups of treatment.	Adverse effects were not reported.
López-Royo et al., 2021[33]	N = 48 (42 men; 6 women) Age (years): PNE: (31.1 ± 7.33); DN: (33.2 ± 7.97); CG: (32.7 ± 6.1) Gender (Male/Female): DN: (13/3); PNE: (14/2); CG: (15/1) BMI (kg/m2): PNE: (90.3 ± 15.74); DN: (84.4 ± 10.37); CG: (88.1 ± 9.61) Physical Activity (times/week): PNE: (4.4 ± 1.15); DN: (5.2 ± 1.42); CG: (5.3 ± 1.24) Baseline Functional Disability (VISA-P): PNE: (48.9 ± 14.56); DN: (57.2 ± 14.14); CG: (55.5 ± 10.44) Baseline pain (VAS): PNE: (4.5 ± 1.85); DN: (3.8 ± 1.98); CG: (4.3 ± 2.11) Symptoms duration (months): PNE: (16.9 ± 10.3); DN: (19 ± 28.4); CG: (18.4 ± 16.3) Tendon thickness (cm): PNE: (0.59 ± 0.141); DN: (0.67 ± 0.15); CG: (0.66 ± 0.172)	Anterior knee pain located on the inferior pole of the patella for at least 3 months while practicing sport. Age: 18 - 45 years. Practicing any kind of sports at least 3 times a week. Score less than 80 on the VISA-P questionnaire.	PNE + EE (N= 16) DN + EE (N= 16)	Sham needling + EE (N =16)	Functional Disability (VISA-P), and Pain intensity (VAS): Baseline, 10 and 22 weeks	Functional Disability: There were no SSD for the VISA-P score among the 3 groups. However, a significant effect was found in all groups at both the 10- and 22-week follow-up evaluations. Pain intensity: There were no SSD between groups for the mean VAS score. Regarding within-group differences, the PNE group showed SSD at the 10-week follow-up, while all groups demonstrated SSD at 22 weeks. Similarly, no SSD were found between groups for the maximum VAS score. However, within-group differences revealed SSD in all groups at both 10 and 22 weeks.	Adverse effects were not reported.
Sharif et al., 2022[30]	N = 94 (61 men; 33 women) Age (years): CG (21.62 ± 1.82) ; IG (20.50 ± 2.42) Gender (Male/Female): CG (29/18); IG (32/15) BMI (kg/m2): CG (26.76 ± 4.20); IG (23.73 ± 3.81) Baseline Functional Disability (VISA-P): CG (40.70 ± 6.61); IG (43.10 ± 7.08) Baseline pain (VAS): CG (8.00 ± 0.64); IG (8.20 ± 0.75) Symptoms duration (months): CG (22.8 ± 15.9); IG (31.5 ± 31.3) Tendon thickness (mm): CG (7.6 ± 0.13); IG (7.5 ± 0.23)	Diagnosed patellar tendinopathy. Age: 18–45 years. Symptoms > 1 month. Pain intensity ≥ 3 on the VAS while ascending or descending stairs. Severe pain in a declined single-leg squat.	DN + CPT (N = 47)	CPT (N = 47)	Functional Disability (VISA-P / Lyshol knee sacle / KOOS scale), and Pain intensity (VAS): Baseline, 1, 2 and 4 weeks	Functional Disability: VISA-P, Lysholm, and KOOS values increased significantly (P-value ≤ 0.05) over time in both groups. However, this effect was significantly stronger in IG compared with CG. Pain intensity: There were SSD (P-value ≤ 0.05) for the VAS score in favour of IG compared to CG at all time points after intervention.	Adverse effects were not reported.

Data are presented as Mean ± Standard deviation. BMI: body mass index; CG: Control Group; CG-1: participants in control group with VISA-P< 90 in final evaluation; CG-2: participants in control group with VISA-P>90 in final evaluation; CPT: Conventional Physical Therapy; DN: dry needling; EE: Eccentric Exercices; IG: Intervention Group; IG-1: participants in intervention group with VISA-P< 90; IG-2: participants in intervention group with VISA-P>90; KOOS: knee injury and osteoarthritis outcome score; PNE: Percutaneous Needle Electrolysis; SSD: statistically significant differences (p-value <0.05); VAS: visual analogue scale; VISA-P: Victorian Institute of Sport Assessment-Patella.

Table 2. Description of the interventions

Authors and year	Interventions	Description of the intervention	Parameters of application	Duration
Abat et al., 2016[31]	**CG**: EE + Standard electrotherapy **IG**: EE + PNE	**EE**: Slow single-leg squat on an incline of 25°. Standard electrotherapy: Each session saw Ultrasound on the patellar tendon, Laser CO2 with a fan shaped cannon over the surface of the patellar tendon, and Interferential Currents. **PNE**: Patient supine with the knee flexed to 20° after the area had been disinfected with isopropanol. The procedure was performed with ultrasound guided puncturing in the superficial paratendon, deep paratendon and the intratendonous area at the inferior pole of the patella in its deepest portion.	**EE**: 3 sets of 15 repetitions with a 3-min rest between sets. Exercise was conducted without an external load for 15 min. Standard Electrotherapy: Ultrasound: pulsed (1:5) for 2 milliseconds at a frequency of 100 Hz and an intensity of 0.5 W/cm2 for 10 min. Laser CO2: energy of 15 joules at a potency of 10 watts for 2 min. Interferential Currents: tetrapolar application at a frequency of 80–100 Hz for 15 min. **PNE**: In each of the mentioned locations, 3 punctures (without removing the needle from the skin). with an intensity of 2 milliamps until the injured area was completely debrided. The galvanic electrolytic current was applied with a sterile 0.25x25 mm stainless steel acupuncture needle.	**CG**: EE and Standard Electrotherapy was conducted 3 days a week over 8 weeks. **IG**: EE was conducted 3 days a week over 8 weeks. PNE was applied every 2 weeks.
López-Royo et al., 2024[32]	**CG**: EE + Sham DN **IG-1**: DN +EE **IG-2**: PNE + EE	**EE**: Single-leg squat on a decline board. The physiotherapist explained how to do the exercises to all participants to ensure they knew how to do them at home. The patients were informed that exercise was allowed to reach 5 in a numerical pain rating scale. **DN, PNE and Sham DN**: Participants were placed in a supine position with a pillow under the knee (approximately 20 degrees of knee flexion). The area was cleaned with an antiseptic solution (70% propan-2-ola), and a US probe cover was used during the intervention.	**EE**: 3 sets of 15 single-leg squat repetitions twice a day, increasing the speed if participants did not have pain. **DN, PNE and Sham DN**: 0.25×25 mm. needles were used. Each session sonsisted of 3 needle insertions lasting 3 seconds each. In the PNE intervention an intensity of 3 mA galvanic current was used during the 3 seconds that the procedure lasted. In the Sam DN intervention the needle was placed in a specific holder and was manipulated during the intervention to simulate a real treatment.	**EE**: twice a day over 8 weeks. **DN, PNE and Sham DN**: 4 sessions distributed every 2 weeks over 8 weeks of treatment.
López-Royo et al., 2021[33]	**CG**: EE + Sham DN **IG-1**: DN +EE **IG-2**: PNE + EE	**EE**: Single-leg squat on a decline board. The physiotherapist explained how to do the exercises to all participants to ensure they knew how to do them at home. The patients were informed that exercise was allowed to reach 5 in a numerical pain rating scale. **DN, PNE and Sham DN**: Participants were placed in a supine position with a pillow under the knee (approximately 20 degrees of knee flexion). The area was cleaned with an antiseptic solution (70% propan-2-ola), and a US probe cover was used during the intervention.	**EE**: 3 sets of 15 single-leg squat repetitions twice a day, increasing the speed if participants did not have pain. **DN, PNE and Sham DN**: 0.25×25 mm. needles were used. Each session sonsisted of 3 needle insertions lasting 3 seconds each. In the PNE intervention an intensity of 3 mA galvanic current was used during the 3 seconds that the procedure lasted. In the Sam DN intervention the needle was placed in a specific holder and was manipulated during the intervention to simulate a real treatment.	**EE**: twice a day over 8 weeks. **DN, PNE and Sham DN**: 4 sessions distributed every 2 weeks over 8 weeks of treatment.
Sharif et al., 2022[30]	**CG**: CPT **IG**: DN + CPT	**CPT**: Static stretching of legs musculature before and after the exercise session. Cycling on a stationary bicycle with minimum resistance. Pain-free partial weight-bearing squats with knee at 60º-70º Moist heat pack, pulsed ultrasound and deep transverse friction massage of the patellar tendon. **DN**: The treatment area of the knee and ultrasound probe was disinfected with an antiseptic solution (70% isopropyl alcohol) to prevent infections. Patients were positionated in supine lying or sitting with 20° of knee flexion and pillow was placed under the knee for patient's comfort. Specific (0.25 × 25 mm) stainless steel DN needles were used for reaching the appropriate involved areas with focal degenerative tendon changes. Non-steroidal anti-inflammatory drugs were permitted if patients had unbearable pain and there was no schedule of outcome assessment in the next 48 h.	**CPT**: Week 1: Stretching for 30 seconds 3-4 times a day. Around the world eccentric lowering leg raises (4 way). 5-10 min of transverse friction massage 1-2 times a day. No jumping or running, can ride a bike or do pool work. Week 2: Same stretching procedure. Around the world eccentric lowering leg raises (4 way) increasing weight, and progress to upright decline board squats. 5-10 min of transverse friction massage 1-2 times a day. Initiate jumping squats in short range. Week 3: Same stretching procedure. Upright squats on decline board double leg to single leg. Transverse friction massage as required. Cycle, aquatic exercises. Week 4: Same stretching procedure. Jumping squats with single leg, upright squats on decline board, jumping squats with one leg on with maximal resistance. Transverse friction massage as required. Initiate sports-specific training with gradual return to sporting events. **DN**: The total number of needle insertions can be varied from 20 to 30 passes, depending on the area of tendon degeneration under ultrasound guidance.	**CPT and DN**: 2 sessions per week during 4 weeks (total of 8 sessions).

CG: Control Group; CPT: Conventional Physical Therapy; DN: Dry Needling; EE: Eccentric Exercices, IG: Intervention Group; PNE: Percutaneous Needle Electrolysis.

3.3. Assessment of methodological quality/risk of bias

The included studies scored 7[31], 8[30,32], and 9[33] points on the PEDro scale, indicating high methodological quality (Table 3). A common limitation across all studies was the inability to meet item 6 of the PEDro scale, which refers to the blinding of therapists administering the intervention. This limitation is inherently unavoidable due to the nature of invasive physiotherapy techniques. Additionally, two studies[30,31] did not blind the participants (item 5), while two studies[31, 32] did not perform an intention-to-treat analysis (item 9).

Table 3. Assessment of methodological quality by the PEDro scale.

Authors and year	1	2	3	4	5	6	7	8	9	10	11	Total	Quality
Abat et al., 2016[31]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	7	High
López-Royo et al., 2024[32]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	8	High
López-Royo et al., 2021[33]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	9	High
Sharif et al., 2022[30]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	8	High

NO: the study does not present the criterion studied; YES: the study presents the criterion studied; 1: Eligibility criteria were specified (this item is not taken into account for the final score); 2: Subjects were randomly allocated to groups; 3: Allocation was concealed; 4: The groups were similar at baseline regarding the most important prognostic indicators; 5: There was blinding of all subjects; 6: There was blinding of all therapists who administered the therapy; 7: There was blinding of all assessors who measured at least one key outcome; 8: Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9: All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"; 10: The results of between-group statistical comparisons are reported for at least one key outcome; 11: The study provides both point measures and measures of variability for at least one key outcome.

The risk of bias was assessed using the RoB2 tool, which yielded an overall judgment of "some concerns" for all included studies. Problems related to the randomization process were identified in domain 1 in all studies. In addition, all but Lopez-Royo et al.[33] showed concerns in domain 2, related to deviations from the intended interventions. In contrast, domains 3 and 4, which assess the lack of data on outcomes and outcome measurement, respectively, consistently showed a "low risk" of bias (Figure 2).

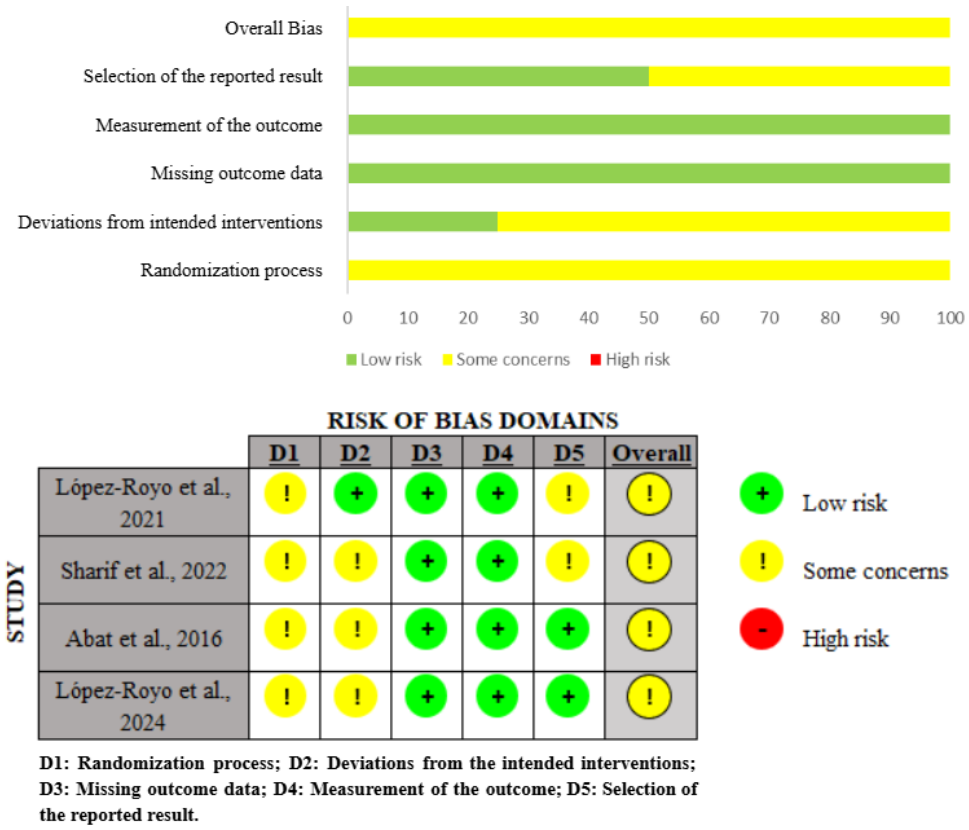

Figure 2. Rob2 risk of bias plots.

3.4 Review Results

3.4.1. Pain Intensity

Regarding pain intensity, results varied among the included studies. Sharif et al.[30] reported a significant reduction in pain intensity when DN was combined with CPT. However, Lopez-Royo et al.[33] found no significant difference in mean or maximum pain intensity between the groups receiving invasive physiotherapy techniques (PNE or DN) combined with EE, or sham needling combined with the same EE protocol. Despite the absence of between-group differences, Lopez-Royo et al.[33] observed significant intragroup improvements at 10-week follow-up, but only in the PNE group for mean and maximum pain intensity values. At 22 weeks of follow-up, all groups showed significant improvements in pain intensity, suggesting that both invasive and noninvasive interventions were effective over time.

3.4.2. Functional Disability

None of the included studies demonstrated significant between-group differences in functional disability improvements when comparing invasive physiotherapy techniques with non-invasive interventions. This is attributed to the fact that both approaches produced significant intragroup improvements, but neither demonstrated superiority.

Abat et al.[31] reported significant intragroup increases in VISA-P scores between baseline and 2 months in both the intervention group (EE combined with PNE) and the comparison group

(EE combined with electrotherapy). Notably, these improvements were only significant for participants with baseline VISA-P scores <90. In contrast, no significant differences were observed for participants with baseline VISA-P scores >90. Two studies[32,33] used identical interventions (PNE or DN combined with EE) and comparison protocols (sham needling with EE). Both studies demonstrated significant intragroup improvements in VISA-P scores between pre- and post-treatment assessments in all groups. However, no significant between-group differences were detected, indicating comparable efficacy across all interventions. Additionally, Sharif et al.[30] observed significant increases in VISA-P, Lysholm Knee Scale, and KOOS scores in both the intervention group (DN combined with CPT) and the control group (CPT only). The intervention group showed a more pronounced improvement than the control group, suggesting a possible additive benefit of DN combined with CPT.

4. Discussion

Building upon the key findings observed, namely the significant reductions in pain intensity across both invasive and non-invasive interventions, this discussion aims to contextualize these results within the broader scope of the review's primary objective: to evaluate the effects of invasive physiotherapy techniques, applied alone or in conjunction with other physical therapy interventions, on pain and functional disability in individuals diagnosed with PT. The findings contribute to the existing literature by highlighting the benefits and limitations of these interventions.

4.1 Pain intensity

The results indicate that various treatment approaches can significantly reduce pain intensity in patients with PT, although the efficacy is highly dependent on the type of intervention. CPT and EE are currently the most widely used noninvasive strategies for treating PT. Both CPT and EE independently demonstrated significant reductions in pain intensity, consistent with previous studies[32,38–41]. Their efficacy may be attributed to biomechanical loading and tension mechanisms that promote collagen remodeling, mainly type I collagen, which is key in tendon healing and strengthening[42]. These exercises also stimulate neovascularization, initially increasing blood flow to the tendon and reducing vascularization as symptoms improve, thus relieving pain[43].

However, the combination of CPT or EE with invasive physiotherapy techniques, such as DN[44] or PNE[45–47], appears to produce superior pain reduction. Several mechanisms can explain this enhanced effect. Needle insertion creates mechanical microtrauma in the degenerated tendon, leading to localized hemorrhage that recruits macrophages and fibroblasts, producing collagen and elastic fibers to facilitate tendon regeneration[48]. The poor vascularization of tendons, which often hinders natural repair processes, is partially mitigated by this response. Pain diminishes as tendon regeneration progresses, with PNE offering additional benefits due to its galvanic current, which enhances type I collagen synthesis by local tissue cells[49,50]. Needle interventions can also stimulate the central nervous system, activating endogenous opioids such as endorphins and modulating spinal cord receptors, thereby providing an analgesic effect[51].

These findings align with those of previous systematic reviews, such as Challoumas et al.[21], which also found that combining physical exercise with adjunctive minimally invasive techniques may improve pain compared to exercise alone. However, this review included pharmacological or biological injections, which may confound the isolated effect of physiotherapy-based needling techniques. Our findings refine this perspective by focusing exclusively on non-medication invasive approaches.

4.2 Functional Disability

Regarding functional disability, no significant differences were observed between invasive physiotherapy techniques and noninvasive interventions such as CPT or EE. All these approaches demonstrated comparable efficacy in improving functional disability. Previous research highlights the benefits of EE, particularly when combined with stretching exercises, which appear to enhance therapeutic outcomes both in the short term and up to six months post-intervention[41,52,53].

Interestingly, the findings of Abat et al.[31] revealed that improvements in functional outcomes, as measured by VISA-P scores, were most pronounced in participants with lower baseline scores (<90 points). Participants with higher baseline scores (>90 points) showed minimal improvements. Consistent with this, other studies involving PT but different populations, such as soccer players[54] and young adults with chronic insertional PT[45] receiving PNE, also found that participants with lower baseline VISA-P scores achieved more significant improvements at final assessment than those with higher baseline values. However, both studies reported that individuals with better baseline VISA-P scores required fewer treatment sessions to improve, indicating that the baseline severity of PT may influence both the degree of improvement and the required number of treatment sessions. Similarly, other populations, such as individuals with low back pain, have also shown greater benefit from PT treatments when they had more pronounced symptoms at baseline[55].

Therefore, improvements in pain and disability appear more pronounced in symptomatic populations, irrespective of the intervention type. Conversely, individuals with relatively good baseline values for pain and functional disability may show less significant improvements, probably due to a "ceiling effect"[56] in which additional measurable gains become difficult to detect in individuals with relatively mild symptoms. The interaction between baseline severity and treatment efficacy underscores the importance of stratifying patients with PT according to symptom severity when assessing therapeutic outcomes. Although invasive physiotherapy techniques did not offer significant advantages over CPT or EE alone, these results suggest that baseline functional levels may influence the improvement observed in treatment efficacy.

Similar trends have been observed in previous systematic reviews. For example, Vander Doelen et al.[25] reported sustained improvements in function with both DN and EE, while Mendonça et al.[57] and Chen et al.[24] noted only modest functional improvements from conservative approaches. Breda et al.[58] demonstrated greater VISA-P gains and return to sport rates using progressive tendon-loading exercises compared to traditional eccentric programs. Our results add nuance to these findings by showing that adding non-medication invasive techniques, such as

DN or PNE, may improve pain. Still, they may not yield superior results in functional disability, particularly in individuals with high baseline function, where a ceiling effect may occur.

4.3 Adverse effects

Adverse effects associated with invasive physiotherapy techniques are well documented in the literature, with post-needling pain being the most prevalent[59,60]. Other adverse effects, such as bruising, localized bleeding, and transient pain during treatment, are infrequent[61], with an estimated rate of one adverse event per 90 interventions. More serious events, such as pneumothorax, have been reported in only two cases out of 229,233 individuals[62].

Of the studies included in this systematic review, only one study[31] reported no adverse effects from the intervention. In contrast, the remaining studies did not provide information on this aspect. It is possible that these studies did not report adverse effects because none occurred, although this cannot be confirmed. It is believed that adverse effects did not happen because all interventions administered, both PNE and DN, were performed under ultrasound guidance—a methodology enhances procedural safety and minimizes the risk of unintended tissue damage by allowing real-time needle visualization[63,64].

4.4 Limitations

This systematic review provides valuable information on the effectiveness of invasive physiotherapy techniques that do not involve the injection of medication. However, several limitations should be kept in mind when interpreting the findings: 1) One of the main difficulties lies in the design of the included studies, which did not allow isolated evaluation of invasive physiotherapy techniques independently of other therapeutic interventions; 2) The limited number of available studies, combined with the significant heterogeneity of the interventions applied, precluded the possibility of performing a meta-analysis; 3) The small number of eligible studies and their relatively limited sample sizes reduce the generalizability and statistical power of the findings; 4) Variability in application protocols further complicated the interpretation of the results, as each study employed different methodologies for administering invasive physiotherapy techniques, making it difficult to draw definitive conclusions about their overall efficacy or to identify optimal treatment protocols; 5) Another important limitation is the absence of true control groups in most studies. Without control groups receiving no intervention or a placebo equivalent, it remains unclear whether invasive physiotherapy techniques are superior to alternative strategies, such as reducing training loads or simply letting the condition progress naturally; 6) There is a notable lack of direct comparisons between invasive physiotherapy techniques and other well-established therapeutic interventions, such as exercise, that is supported by solid evidence. This lack of comparative data limits our understanding of the relative efficacy of invasive physiotherapy techniques and their potential synergistic effects when combined with other approaches; 7) The heterogeneity of participants also poses a challenge. Many studies likely included individuals with varied athletic backgrounds, but most did not provide detailed demographic or clinical specifications. This lack of information precludes a thorough investigation of how factors such as athletic experience or baseline functional status might influence therapeutic outcomes.

Nonetheless, it is essential to highlight that all included studies were conducted by experienced physiotherapists trained in applying invasive physiotherapy techniques. Moreover, all participants completed the assigned interventions with no reported dropouts. This consistency in therapist expertise and participant adherence helps reduce the influence of potential confounding variables and reinforces the internal validity and robustness of the results presented in this systematic review.

4.5 Future Research

Future clinical trials should aim for larger sample sizes and methodological standardization to address current limitations and enable direct comparisons between invasive and non-invasive physiotherapy techniques. It is essential to include long-term follow-up and patient-centered outcomes, such as satisfaction and quality of life, to assess better the sustained impact and clinical relevance of these interventions. Subgroup analyses and standardized intervention protocols are also recommended to reduce clinical heterogeneity. Additionally, future research should include study arms focused exclusively on invasive physiotherapy techniques and comparisons with physical exercise alone, combined treatments, and true control groups to identify the most effective therapeutic approaches. Incorporating economic evaluations and patient preference measures will further support the development of cost-effective, patient-centered strategies.

Moreover, as more high-quality randomized controlled trials become available, systematic reviews should be updated and, when possible, include meta-analyses to synthesize the evidence quantitatively. Meta-regression and other advanced statistical models should also be considered in future studies to identify treatment effect modifiers, provided sufficient data homogeneity exists.

By addressing these gaps, future research will contribute to a more comprehensive and nuanced understanding of the role of invasive physiotherapy techniques in the treatment of PT. This, in turn, will support the development of more precise, effective, and individualized treatment strategies that better meet patients' needs.

5. Conclusions

This systematic review highlights the efficacy of invasive physiotherapy techniques, particularly PNE and DN, in reducing pain intensity when combined with CPT or EE in individuals with PT. However, the absence of significant advantages in functional outcomes suggests the possibility of a “ceiling effect” in less symptomatic populations. Although both invasive and non-invasive interventions demonstrate significant improvements in pain and functional disability without the presence of adverse effects, there is no conclusive evidence to suggest the superiority of one approach over the other. Future studies should seek to isolate the effects of invasive physiotherapy techniques and compare them directly with established interventions such as exercise. Ultimately, these results highlight the importance of tailoring interventions to individual needs while respecting PT treatment's fundamental principles.

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The authors declare no conflicts of interest.

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