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Efficacy of percutaneous electrolysis for the treatment of tendinopathies: A systematic review and meta-analysis

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Abstract

Objective: To evaluate the efficacy of percutaneous electrolysis for the treatment of patients with tendinopathies.

Data sources: A systematic search of publications was conducted in Pubmed, Cinahl, Medline, Scopus and Web of Science.

Methods: The Oxford 2011 Levels of Evidence and the Jadad scale were used to assess the quality of studies. The mean and standard deviation were obtained for each study group and used to calculate the effect size. The DerSimonian and Laird method was used to develop a random-effects model.

Results: Of the 14 articles, four applied percutaneous electrolysis to the knee, three to the shoulder, three to the elbow, two to the hip and two to the ankle and foot. A meta-analysis on intensity of pain (evaluated with algometer and the Visual Analogue Scale) was performed on studies comparing percutaneous electrolysis with a control group, indicating that the groups treated with percutaneous electrolysis had better results ($p = 0.01$). Although percutaneous electrolysis did not overcome the analgesic effect achieved by corticosteroid injections.

Conclusions: The percutaneous electrolysis is effective for the treatment of tendinopathies. The combination of this technique with eccentric training has proven to be one of the most effective treatments to date for improving pain.

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Introduction

Tendinopathy refers to injuries affecting the tendon or paratendon that are aggravated by mechanical loading.[1] Thus, it could be defined as a chronic degeneration of the tendon that causes pain and partial tendon ruptures.[2] Its prevalence varies greatly depending on the population studied and the anatomical region affected. Even so, the most frequent tendinopathies are Achilles tendinopathy, patellar tendinopathy, epicondylitis and rotator cuff tendinopathy.[3,4,5] In turn, their high prevalence has an impact on healthcare systems due to the economic cost they entail.[2]

The first treatment option for tendinopathies is a conservative approach using medications and physiotherapy. As pharmacological treatment, non-steroidal anti-inflammatory medications are indicated to reduce pain, although these medications may interfere with tendon healing processes causing malignant effects on the tendon such as reduced tensile strength.[6] Corticosteroid injections are also a widespread intervention to relieve pain and improve function quickly and inexpensively (although it may result in tendon rupture).[7] On the other hand, physiotherapeutic methods include the application of ultrasound, laser, transcutaneous electrical nerve stimulation, deep transverse massage, eccentric training, extracorporeal shock waves and percutaneous electrolysis.[8–10]

The percutaneous electrolysis is a minimally invasive electrotherapy technique that involves the application of galvanic current through an echo-guided acupuncture needle. It combines mechanical and electrical stimulation to provoke a controlled microtrauma in the affected structures.[11] This provokes a local inflammatory response to achieve an increase in cellular activity and tissue repair.[12] Percutaneous Intratissue Electrolysis (EPI®) and Therapeutic Percutaneous Electrolysis (EPTE®) are the trade names for the best-known percutaneous electrolysis modalities. The main difference between them is that EPI® applies high intensities for short periods of time (3–5 s); while EPTE® applies lower intensities for longer periods of time (72–90 s).[13]

Various studies have demonstrated the efficacy of percutaneous electrolysis in different pathologies such as temporomandibular myofascial pain syndrome,[14] acute whiplash syndrome[15] and mammary fistulas[16] but there is still no consensus on its application in tendinopathies. For all these reasons, it was considered necessary to carry out this systematic review with the aim of evaluating out the efficacy of percutaneous electrolysis for the treatment of patients with tendinopathies.

Methods

This study was prospectively registered on PROSPERO (ID: CRD42021230005) and followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) in Exercise, Rehabilitation, Sport medicine and Sports Science reporting guidelines and the recommendations from the Cochrane Collaboration.[17,18] The PICO question was then chosen as follows: P—population: patients with tendinopathy; I—intervention: percutaneous electrolysis; C—control: conventional physiotherapy techniques; O—outcome: intensity of patient pain, range of motion and ultrasound imaging of the tendon; S—study designs: experimental studies.

A systematic search of publications was conducted in between 30 October and 6 November 2022 in the following databases: Pubmed, Cinahl, Medline, Scopus and Web of Science. The search strategy included different combinations with the following Medical Subject Headings (MeSH)

terms: *Tendinopathy*, *Electrolysis*, *Percutaneous electrolysis* and *Intratissue percutaneous electrolysis*. The search strategy according to the focused PICOS question is presented in Table 1.

After removing duplicates, two reviewers (LA-O and RL-R) independently screened articles for eligibility. In case of disagreement, A third reviewer (MPM-S) finally decided whether the study should be included or not. For the selection of results, the inclusion criteria established that: (a) the articles must have been published in the last ten years (from 2012 to the present); (b) the intervention should include percutaneous electrolysis; and (c) the sample was to be made up exclusively of patients with tendinopathy. On the other hand, studies were excluded from this review if they had a non-experimental methodology (reviews, meta-analyses, editorials, …) and their full text was not available.

After screening the data, extracting, obtaining and screening the titles and abstracts for inclusion criteria, the selected abstracts were obtained in full texts. Titles and abstracts lacking sufficient information regarding inclusion criteria were also obtained as full texts. Full text articles were selected in case of compliance with inclusion criteria by the two reviewers using a data extraction form. The two reviewers mentioned independently extracted data from included studies using a customized data extraction table in Microsoft Excel. In case of disagreement, both reviewers debated until an agreement was reached.

The data extracted from the included articles for further analysis were demographic information (title, authors, journal and year), characteristics of the sample (age, inclusion and exclusion criteria, and number of participants), study-specific parameters (study type, duration of the intervention, interventions applied), percutaneous electrolysis application parameters (frequency, application time, intensity and location of electrodes) and results obtained (variables analyzed, instruments used and time of follow-up). Tables were used to describe both the studies' characteristics and the

Table 1. Search strategy according to the focused question (PICO).

Database	Search equation	Results identified	Results selected
PubMed	(tendinopathy[MeSH Terms]) AND (electrolysis[MeSH Terms])	12	1
	(tendinopathy[MeSH Terms]) AND (percutaneous electrolysis[MeSH Terms])	9	0
	(tendinopathy[MeSH Terms]) AND (intratissue percutaneous electrolysis[MeSH Terms])	4	0
Scopus	TITLE-ABS-KEY(electrolysis) AND TITLE-ABS-KEY(tendinopathy)	27	0
	TITLE-ABS-KEY(percutaneous electrolysis) AND TITLE-ABS-KEY(tendinopathy)	21	0
	TITLE-ABS-KEY(intratissue percutaneous electrolysis) AND TITLE-ABS-KEY(tendinopathy) ("tendinopathy" [Mesh])	7	0
Cinahl	(MH "tendinopathy") AND (MH "electrolysis")	2	2
	(MH "tendinopathy") AND (MH "percutaneous electrolysis")	0	0
	(MH "tendinopathy" AND (MH "intratissue percutaneous electrolysis")	0	0
Web of Science	TS = (tendinopathy) AND TS = (electrolysis)	23	0
	TS = (tendinopathy) AND TS = (percutaneous electrolysis)	21	0
	TS = (tendinopathy) AND TS = (intratissue percutaneous electrolysis)	5	0
Medline	(MH "tendinopathy") AND (MH "electrolysis")	8	0
	(MH "tendinopathy") AND (MH "percutaneous electrolysis")	0	0
	(MH "tendinopathy") AND (MH "intratissue percutaneous electrolysis")	0	0

[a]RD: Randomization (1 point if randomization is mentioned; 2 points if the method of randomization is appropriate).
[b]BD: Blinding (1 point if blinding is mentioned; 2 points if the method of blinding is appropriate).
[c]WD: Withdrawals (1 point if the number and reasons in each group are stated).

extracted data. When possible, the results were gathered based on type of intervention applied. The Oxford 2011 Levels of Evidence was used to assess the quality of studies. Risk of bias assessment for the non-randomized studies was assessed with the Newcastle–Ottawa scale and for the randomized was assessed with the Jadad scale.

Statistical Analysis

Treatment effects were defined as standardized mean difference and their 95% confidence intervals. The mean and standard deviation were obtained for each study group and the result of interest was used to calculate the effect size. The DerSimonian and Laird method was used to develop a random-effects model, assuming heterogeneity across studies. The magnitude of the effect size of the intervention was assessed using Cohen's method (0.2 < standardized mean difference > 0.5 indicates a small effect; 0.5 < standardized mean difference > 0.8 indicates a moderate effect; and standardized mean difference > 0.8 indicates a high effect). Forest plot was used to graphically represent effect sizes and 95% confidence intervals. Statistical significance was set at $p < 0.05$.

The model described by Higgins and Green[19] was used to calculate the mean and standard deviation between pre- and post-treatment data for all studies included in the meta-analysis. Statistical heterogeneity was assessed using Crohan's Q test and quantified using the I^2 index.[20] A subgroup analysis was performed according to the treatment analyzed (electrotherapy or electrotherapy and kinesitherapy). All analyses were performed with Review Manager 5.3 (The Cochrane Collaboration, 2014).

Results

Study Selection and Characteristics

Out of 139 search results, 77 studies were considered eligible for inclusion after removing duplicates. Among the 77 papers screened, 56 were excluded after abstract and title screening. After the first reading of all candidate full texts, Kappa score of reviewers 1 and 2 was 0.94, indicating a very high agreement. Of the 21 full-text articles assessed for eligibility, 14 were finally included in the synthesis, as depicted by the PRISMA flowchart in Figure 1. All the data necessary for analysis were obtained from all the studies analysed.

Of the 14 articles, four applied percutaneous electrolysis to the knee,[21–24] three to the shoulder,[25–27] three to the elbow,[28–30] two to the hip[31,32] and two to the ankle and foot.[33,34] The methodological characteristics of the investigations are shown in Table 2 and a summary of the findings of each can be found in Supplementary Table 1.

Regarding the experimental designs of the investigations analyzed, six studies were randomized controlled trials[21,24–26,29,31] and the remaining studies were quasi-experimental studies: five with a single experimental group,[22,23,28,30,32] two with two experimental groups[27,34] and one with three experimental groups[33] (only two of them with random assignment of participants[27,33]).

The methodological quality of the studies was four or five points on the JADAD scale in 71.4%[21,24,26,27,29] of the randomized controlled trials. At the same time, as can be seen in Table 3, 85.7%[22,23,28,30,33,34] of the non-randomized trials scored at most three points.

Shoulder Applications

The investigations that applied percutaneous electrolysis in this region did so by combining EPTE® combined with eccentric training[25] or with eccentric training and manual therapy[26] for the treatment of subacromial pain syndrome. Another study compared the effects of the same eccentric training program combined with EPTE® or dry needling of supraspinatus myofascial trigger points in patients with supraspinatus tendinopathy.[27] Details of the exercise program applied are given in Supplementary Table 2. The manual therapy intervention consisted of passive mobilizations of the glenohumeral, acromioclavicular, sternoclavicular and scapulothoracic joints and associated soft tissues.[26] The percutaneous electrolysis application was statistically superior

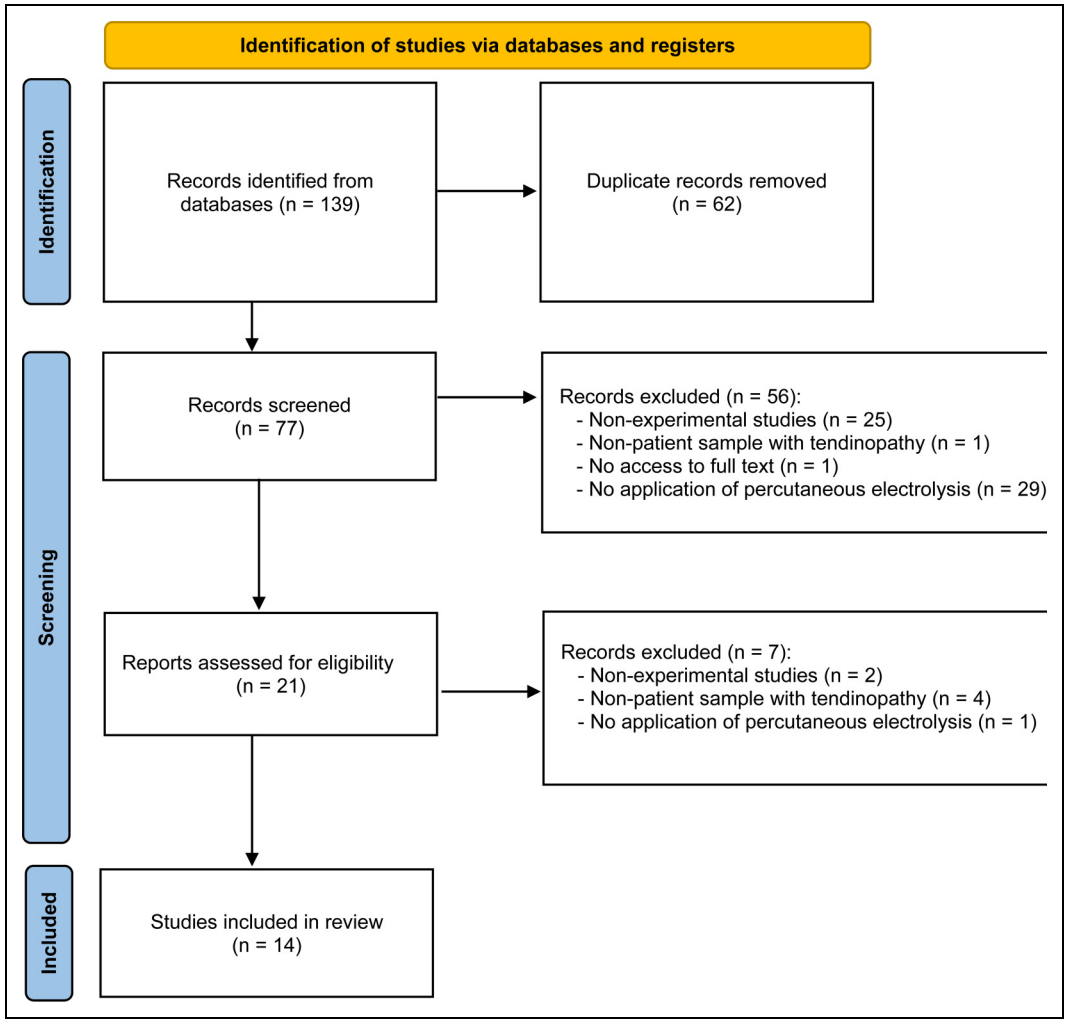

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram.

to control group interventions in improving pain intensity,[25–27] disability,[25,26] supraspinatus pressure pain thresholds[27] and range of motion in flexion, extension, abduction and both rotations.[27] All of them showed that these results remained one week,[25] six months[26] and one year[27] after the intervention. However, range of motion in flexion was similar to that achieved with eccentric training and dry needling at the last reassessment.[27] Furthermore, although percutaneous electrolysis also improved in the PPT of the zygapophyseal joints of C5–C6, deltoid and second metacarpal, it did so similarly to manual therapy techniques.[26]

Elbow Applications

The elbow applications were aimed at evaluating the cost-effectiveness of EPI®,[28] comparing the effects of EPTE® and dry needling[29] and evaluating the combination of ultrasound-guided Percutaneous Needle Electrolysis and stretching of the epicondylar musculature[30] in patients with

Table 2. Methodological characteristics of the studies analyzed.

Authors	Design	Sample size	Intervention: Experimental group	Intervention: Control group	Time of intervention (number of sessions)	*E*	IT	*I*
Abat et al.[23]	QES	34	EPI® + ET	—	12 weeks (6 of EPI® and 24 of ET)	Patellar tendon	*	3 mA
Abat et al.[22]	QES	33	EPI® + ET	—	4-5 weeks (4-5 of EPI® and 8–10 of ET)	Patellar tendon	*	3 mA
Abat et al.[21]	RCT	60	USGET + ET	Ultrasound + Interferential current + ET	8 weeks (4 of USGET and 24 of conventional electrotherapy)	Patellar Tendon	*	2 mA
Arias-Buría et al.[25]	RCT	36	EPTE® + ET	ET	4 weeks (4 of EPTE® and 56 of ET)	Supraspinatus tendon	72 s	350 μA
de Miguel et al.[26]	RCT	48	EPTE® + Manual therapy + ET	Manual therapy + ET	5 weeks (5 of EPTE® and manual therapy; 70 of ET)	Supraspinatus tendon	90 s	350 μA
De-la-Cruz-Torres et al.[33]	QES	30	Group 1: ET Group 2: PNE Group 3: PNE + ET	—	2–4 weeks (2 of PNE and 16 of ET)	Soleus myoten-dinous junction	3 s	2.5 mA
Iborra-Marcos et al.[34]	QES	64	Group 1: EPI® Group 2: Corticoste-roid injection	—	5 weeks (5 EPI® and 2-3 inyections)	Proximal insertion of plantar fascia	5 s	3 mA
López-Royo et al.[24]	RCT	48	Group 1: PNE + ET Group 2: dry needling + ET	Sham needling + ET	8 weeks (16 of PNE and 112 of ET)	Patellar Tendon	3 s	3 mA
Moreno et al.[32]	QES	30	EPI®	—	4 weeks (2–6 of EPI®)	Rectus abdominis distal insertion	4 s	3 mA
Moreno et al.[31]	RCT	22	EPI® + ET	ET	Depended on the patients' symptoms (2 sessions/week of EPI®)	Proximal tendon of the adductor longus	5 s	3 mA
Muñoz et al.[28]	QES	36	EPI® + ET + stretching	—	6 weeks (6 of EPI® 84 of stretching)	Epicondylar insertional tendon	3 s	4–6 mA
Rodríguez-Huguet et al.[27]	RCT	36	Group 1: EPTE® + ET Group 2: dry needling + ET	—	4 weeks (4 of EPTE® and dry needling; 28 of ET)	Supraspinatus tendon	72 s	350 μA

(Continued)

Table 2. (Continued)

Authors	Design	Sample size	Intervention: Experimental group	Intervention: Control group	Time of intervention (number of sessions)	E	IT	I
Rodríguez-Huguet et al.[29]	RCT	32	EPTE® + ET	Dry needling + ET	4 weeks (4 of EPTE® and dry needling; 56 of ET)	Insertional tendon of epicondylar muscles	72 s	350 µA
Valera-Garrido et al.[30]	QES	32	PNE + ET + stretching	—	6 weeks (4–6 of PNE and 84 of ET and stretching)	Tendon of the extensor carpi radialis brevis and extensor digitorum communis	3 s	4–6 µA

E: Electrode; IT: Impulse time; I: Intensity; LE: Level of evidence; QES: Quasi-Experimental study; RCT: Randomized controlled trial; ET: eccentric training; USGET: Ultrasound-guided Galvanic Electrolysis Technique; PNE: Percutaneous Needle Electrolysis; —: not applicable.

epicondylalgia. In all three investigations, the same ES protocol was applied to all participants (Supplementary Table 2). Only Valera-Garrido et al.[30] specified that the application was performed on the deep surface of the common extensor and short radial extensor tendons of the carpus. The results obtained showed significant improvements in pain intensity,[28–30] pressure pain threshold,[28–30] Cozen and Thompson tests,[28,30] disability[28,30] and tendon hypogeneicity and hypervascularity.[30] Percutaneous electrolysis showed no difference in the improvement of elbow extension range of motion and pronation–supination range of motion or quality of life compared to dry needling.[29] However, clinical success after three months was 100% in the EPTE® group and 75% in the dry needling group.[29]

Hip Applications

The two studies that evaluated percutaneous electrolysis in the hip region were aimed at treating groin pain related to distal insertion of the rectus abdominis[32] or adductor longus enthesopathy.[31] One of them consisted of a randomized controlled clinical trial in which the authors combined EPI® with an active physiotherapy program (Supplementary Table 2).[31] The other was a quasi-experimental study in which the authors applied percutaneous electrolysis in isolation.[32] Both interventions achieved significant improvements in pain intensity and function.[31,32] Although the improvement in functionality was equivalent to that achieved with the active physiotherapy program alone.[31] In addition, percutaneous electrolysis did not improve strength versus endurance.[32]

Knee Applications

The interventions in this region were aimed at treating patellar tendinopathy through the combination of EPI® and a program of eccentric training[22,23] and, in two cases, to compare the combination of eccentric training with ultrasound-guided galvanic electrolysis technique or conventional electrotherapy[21] and the combination of eccentric training with percutaneous electrolysis or with dry

Table 3. Oxford 2011 Levels of Evidence, Newcastle-Ottawa Scale scores for the non-randomized studies and JADAD Scale scores for the randomized trials.

	Newcastle-Ottawa Scale scores										
Authors	Adequate definition	Representative cases	Selection controls	Definition controls	Comparability (important factor)	Comparability (additional factor)	Exposure ascertained	Same method ascertained	Non-response rate	Total score	Level of Evidence
Abat et al.[23]	Yes	No	No	No	No	No	Yes	No	Yes	3	IV
Abat et al.[22]	Yes	No	No	No	No	No	Yes	No	Yes	3	IV
De-la-Cruz-Torres et al.[33]	Yes	No	No	No	No	No	Yes	No	Yes	3	III
Iborra-Marcos et al.[34]	Yes	No	No	No	No	No	Yes	No	Yes	3	III
Moreno et al.[32]	Yes	No	No	No	No	No	Yes	No	No	2	IV
Muñoz et al.[28]	Yes	No	No	No	No	No	Yes	No	Yes	3	IV
Valera-Garrido et al.[30]	Yes	No	No	No	No	No	Yes	No	Yes	3	IV

	JADAD Scale scores				
	Randomization[a]	Blinding[b]	Withdrawals[c]	Total score	
Abat et al.[21]	2	1	1	4	1
Arias-Buría et al.[25]	2	1	0	3	1
de Miguel et al.[26]	2	2	1	5	1
López-Royo et al.[24]	1	2	1	4	1
Moreno et al.[31]	2	0	1	3	1
Rodríguez-Huguet et al.[27]	2	2	0	4	1
Rodríguez-Huguet et al.[29]	2	2	0	4	1

[a]RD: Randomization (1 point if randomization is mentioned; 2 points if the method of randomization is appropriate).
[b]BD: Blinding (1 point if blinding is mentioned; 2 points if the method of blinding is appropriate).
[c]WD: Withdrawals (1 point if the number and reasons in each group are stated).

needling.[24] The conventional electrotherapy intervention consisted of the application of ultrasound Endomed 982 (Enraf Nonius, The Netherlands) pulsed (1: 5) 2 ms on the patellar tendon at 100 Hz and an intensity of 0.5 W/cm^2 for 10 minutes; CO_2 laser (Asa Medical Laser, Italy) applied with a fan-shaped gun on the patellar tendon surface depositing 15 J of energy at 10 W power for 2 minutes; and interferential currents (Endomed 982, Enraf Nonius, The Netherlands) by tetrapolar application at 80–100 Hz for 15 minutes (the authors do not describe the location of the electrodes).[21] Each session of dry needling intervention consisted of three needle insertions lasting 3 seconds each.[24] The results revealed significant improvements in pain,[24] functionality,[21–24] quality of life,[24] patient satisfaction[22] and sports level (according to the Tegner score)[22] with the percutaneous electrolysis. These results, moreover, were maintained up to 2[22,23] and 10 years after the intervention.[22] However, in one of the studies, no significant improvement in sports level (assessed by the same method) was found.[23] And in another, the thickness of the patellar tendon remained unchanged.[24] The application of percutaneous electrolysis resulted in similar improvements in function as dry needling and isolated eccentric training.[24] However, eccentric training (neither alone nor combined with dry needling) failed to improve participants' quality of life and tendon thickness. In terms of pain intensity, eccentric training (both alone and in combination with percutaneous electrolysis) resulted in similar improvements but its combination with dry needling (although similar in magnitude) was achieved 12 weeks later.[24]

Ankle and Foot Applications

The interventions in this region aimed to compare the effects of percutaneous electrolysis combined with an eccentric training program for the treatment of soleus tendon[33] and to compare the effects of EPI® and corticosteroid infiltration for the treatment of plantar fasciosis.[34] Corticosteroids were administered weekly for 2 weeks and a third dose was provided in patients who required it based on their symptomatology.[34] The results showed significant improvements in pain intensity[33,34] and disability[34] in the groups treated with percutaneous electrolysis, but less than that achieved with the administration of corticosteroids.[34] In addition, percutaneous electrolysis showed similar results to the eccentric training program (Supplementary Table 2) and corticosteroids in improving dorsiflexion range of motion,[33] fatigue,[33] structure thickness[34] and health status and symptom severity (assessed with the Dance Functional Outcome Survery).[33] The improvements achieved were maintained even 1 year after the intervention.[34]

Meta-Analysis Results

Despite the methodological variability of the studies, a meta-analysis on intensity of pain (evaluated with algometer and the Visual Analogue Scale) was performed on studies comparing percutaneous electrolysis with a control group.[24–27,29,31] As not all studies analyzed these outcomes, some did not participate in the meta-analysis.[21–23,28,30,32–34]

The standardized mean difference was −0.50 (95% CI −0.89 to −0.12), indicating that the groups treated with percutaneous electrolysis had better results in terms of pain when compared to the control group ($p = 0.01$). The studies showed a moderate level of heterogeneity ($I^2 = 54\%$) (Figure 2).

Discussion

It has previously been identified that percutaneous electrolysis can reduce pain and perceived disability from musculoskeletal pain conditions in the short, medium and long term.[35] The aim of this review was to determine the efficacy of percutaneous electrolysis for the treatment of tendinopathies. After analyzing the results obtained, it could be affirmed that it is an effective application in the treatment of this pathology.

As for pain intensity,[24–34] this decreased with percutaneous electrolysis alone,[32,33] combined with eccentric training[24,25,27–31] or with manual therapy and exercise.[27] However, this variable

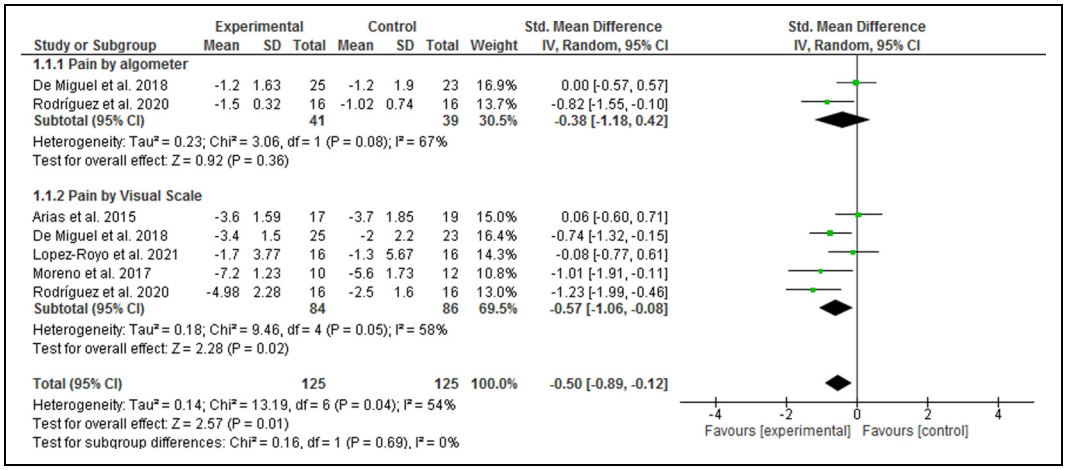

Figure 2. Meta-analysis results for percutaneous electrolysis vs. control group (outcome analyzed: intensity of pain).

improved more with corticosteroid injection than with EPI®.[34] This finding may be due to the anti-inflammatory action of this drug, inhibiting the release of destructive enzymes and reducing the formation of prostaglandins that are mainly responsible for the sensation of pain.[36] It should be noted that the improvements obtained in this variable were produced with only two percutaneous electrolysis sessions in one of the interventions[33] while almost all other studies applied this technique between four and six sessions[25–32,34] (only López-Royo et al. reached 16 sessions[24]). Furthermore, it is important to bear in mind that the intervention that obtained improvements in pain intensity in the longest term applied four EPTE® sessions with a weekly frequency[27] (so it is not possible to confirm that with fewer sessions the analgesic effect can be maintained for periods of more than 1 year).

Functionality improved[21–24,26,31–32] except in one study in which improvements were superior in the group injected with corticosteroids.[34] Again, probably due to the anti-inflammatory action of this compound, which causes mechanical improvements in the joint and pain relief.[36] At the same time, the improvements obtained by De Miguel et al.[26] in this variable could be due to the combination of percutaneous electrolysis with manual therapy and exercises. Treatment based on the latter two techniques has beneficial effects on the perception of functionality in patients with subacromial pain syndrome.[37] Moreover, the application of percutaneous electrolysis alone produced benefits in functionality that were maintained after 6 and 12 months.[32,34] Therefore, it could be affirmed that percutaneous electrolysis alone improves this variable, and the combination with exercises and manual therapy improves this effect.

The pressure pain thresholds increased through the combination of percutaneous electrolysis with eccentric training,[27–30] except in the study by De Miguel et al.[26] in which the improvements obtained were not significant. This finding could be due to the fact that in their intervention they incorporated manual therapy techniques such as passive joint mobilizations directed at the glenohumeral, acromioclavicular, sternoclavicular and scapulothoracic joints, and associated soft tissues that could increase the pressure pain thresholds in patients with musculoskeletal pain immediately after the intervention.[38] In parallel, disability was improved by combining percutaneous electrolysis with eccentric training for 4–6 weeks.[25,28,30] And, also in the same way, in this variable it was identified that the inclusion of manual therapy did not lead to additional improvements.[26] This finding has been previously identified and is due to the fact that the application of manual therapy has greater

effects on pain modulation than on perceived disability.[39] However, on a physiological level, the performance of eccentric training results in increased metabolic activity and increased formation of type I collagen fibers, thus counteracting the failed healing response of tendinopathies.[40]

As for the parameters of percutaneous electrolysis application, these varied greatly among the studies analyzed. The most frequent pattern consisted of the application of four to six percutaneous electrolysis sessions exclusively[32,34] or combined[21–31,33] with other techniques such as: manual therapy,[26] exercise (eccentric training[21–31,33] with isometrics[31] and stretching[28,30]). With the exception of one case that achieved improvements in pain intensity, range of motion, fatigue resistance and health status and symptom severity by applying only two sessions of percutaneous electrolysis.[33] The authors of this study did not perform re-evaluations beyond the end of the intervention, so we do not know whether the improvements were maintained in the medium and long term. As for pulse time and application intensity, these are two parameters that vary fundamentally depending on whether EPI®[21–23,28,30–34] or EPTE®[25–27,29] is applied. The former uses high intensities (2–6 mA) for short periods of time (3–5 s) while the latter uses lower intensities (350 μA) for longer times (72–90 s). It is known that patient tolerance is greater when EPTE® is applied since the intensity is much lower, but the painful sensation after treatment is less with the application of EPI®. At the tissue level, it is possible that the application of percutaneous electrolysis at low intensities and for longer periods of time generates physiological adaptation mechanisms, thus causing a lower inflammatory response and a decrease in tissue proliferation.[13] This great variability in the interventions is due to the lack of standardized protocols for the application of percutaneous electrolysis. In addition, this same reason could be responsible for the recovery times that could be increased after the application of percutaneous electrolysis at low intensities due to the lower inflammatory response that they cause.[13]

The size of the needles used varied in each study. Most authors[21–23,25,26,29–31,33] used needles with a diameter of 0.3 mm and 25–50 mm in length depending on the anatomical area to be treated. However, López-Royo et al.,[24] Moreno et al.[32] and Abat et al.[21] used needles with a diameter of 0.25 mm and 25–30 mm in length. The rest of the studies[27,28,34] did not specify the size of the needles used.

This review has several methodological limitations. The first is the low methodological quality of some of the included studies with small sample sizes and scores below 3 on the JADAD scale. In turn, more than half of the studies were not controlled.[22,23,28,30–34] For this reason, it is suggested that more randomized controlled trials and the analysis of the application of percutaneous electrolysis in isolation should be carried out to determine its specific benefits and compare them with other techniques and their combination. At the same time, the effects of the various parameters of percutaneous electrolysis application should be analyzed and compared. Finally, this research also presents different strengths: this is the systematic review on percutaneous electrolysis in the treatment of tendinopathies that has analyzed the most studies to date.[41–44]

In conclusion, the percutaneous electrolysis is effective for the treatment of tendinopathies showing results both immediately after the interventions analyzed and in those with long-term follow-up. The combination of this technique with eccentric training has proven to be one of the most effective treatments to improve tendinopathy pain to date. However, the scientific evidence on this technique is limited, so experimental studies are needed to provide more information in order to establish specific application protocols for different tendinopathies.

Clinical messages

- Percutaneous electrolysis is effective for the treatment of tendinopathies.
- The improvement in pain intensity is superior to isolated eccentric training.
- To combine of this technique with eccentric training improves functionality and pain.

Author Contributions

LA-O, RL-R, FO-C, MPM-S and LYM conceptualized and designed the study, drafted the initial manuscript, designed the data collection instruments, collected data, carried out the initial analyses and critically reviewed the manuscript for important intellectual content. All authors have read and agreed to the published version of the manuscript.

Declaration of Conflicting Interests

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Supplemental Information

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