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The effectiveness of superficial versus deep dry needling or acupuncture for reducing pain and disability in individuals with spine-related painful conditions: a systematic review with meta-analysis

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ABSTRACT

Objective: The purpose of this systematic review was to evaluate the effects of deep versus superficial dry needling or acupuncture on pain and disability for spine-related painful conditions. A secondary purpose was to account for the differences of needling location in relation to the painful area.

Methods: This PROSPERO (#CRD42018106237) registered review found 691 titles through a multi-database search. Following a comprehensive search, 12 manuscripts were included in the systematic review and 10 in the meta-analysis. Standardized mean differences (SMD) with 95% confidence intervals were calculated for pain and disability.

Results: The included studies demonstrated an unclear to high risk of bias recommending a cautious interpretation of the results. A consistent effect supporting deep needling over superficial with an SMD of 0.585 [0.335, 0.835], $p < 0.001$ from 10 articles for pain but a non-significant effect of 0.197 [−0.066, 0.461], $p = 0.14$ from 2 studies for disability. A temporal examination was similar for effects on pain with an SMD of 0.450 [0.104, 0.796] immediately, 0.711 [0.375, 1.048] short-term (1 to 11 weeks), and 0.470 [0.135, 0.805] for time-points ≥12 weeks. Regionally, there was a greater effect needling the area of pain locally (SMD = 0.754) compared to remotely (SMD = 0.501).

Discussion: Statistically significant between-group differences were observed favoring deep needling over superficial. Both superficial and deep needling resulted in clinically meaningful changes in pain scores over time. However, differences between groups may not be clinically meaningful. More high-quality trials are needed to better estimate the effect size of deep versus superficial needling while controlling for location and depth of the lesion.

Level of evidence: 1a

KEYWORDS
Deep; superficial; dry needling; acupuncture; pain

Introduction

Dry needling and acupuncture are commonly used interventions for the management of spine-related painful disorders. Pain conditions can manifest as myofascial pain syndrome (MPS), which is diagnosed based by identifying myofascial trigger points (MTrP) [1]. A MTrP is a local foci within skeletal muscle fibers that cause local or referred pain [2]. A broader understanding of the myofascial pain phenomenon, however, includes non-muscular contributors to MPS involving both peripheral and central nervous system pain mechanisms [3,4]. Non-muscular contributors to peripheral hyperalgesia are comprised of local ischemia [5], biochemical inflammatory mediators [6,7], and neurogenic inflammation [4], leading to activation of primary sensory nerve endings. Persistent activation of these nerve endings can create neuroplastic changes in the dorsal horn of the spinal cord leading to central sensitization [8]. Understanding peripheral and central nervous system mechanisms involved with MPS may be helpful in recognizing the mechanisms of various applications needling for pain relief. Mechanisms related to the depth of needle penetration for various treatment models impacts the physiological dosage and subsequent effects on pain [3,4,9,10].

Dry needling and acupuncture are two distinguishable treatment paradigms that involve puncturing of the skin using a filiform needle. The application of dry needling targets trigger points or sensitized nerve endings of symptomatic soft tissue while acupuncture targets acupoints or 'Ashi' (tender points) based on Traditional Chinese Medicine principles. Several dry needling models have been developed including a radiculopathy model [11], myofascial trigger point (MTrP) model [2], a neurological model [12], and superficial dry needling model [9].

Superficial dry needling [9] involves inserting a needle at a depth up to 10 mm or into the subcutaneous tissue and may be combined with manipulation of the needle while in situ. Benefits of needling superficially include

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ease of administering, less risk of significant tissue trauma, reduced risk of nerve or visceral injury, and patient comfort [9]. Deep needle penetration involves inserting a needle through the skin, beyond subcutaneous tissue, and into muscular or other connective tissue structures and can be combined with needle manipulation. The majority of dry needling studies involve deep needling into MTrP for pain relief [13]. Deep needle penetration has not consistently demonstrated superior results compared to superficial needle insertion [14–16]. Acupuncture can also be applied using deep or superficial needle insertion for pain management related to painful orthopedic conditions [17]. Several randomized controlled trials have compared the depth of needle penetration using dry needling [14–16] or acupuncture [18–25] on pain reduction for spine-related painful conditions with inconsistent results.

The purpose of this systematic review with meta-analysis (MA) was to evaluate the effects of deep versus superficial dry needling or acupuncture on pain and disability for spine-related painful conditions. Differences in needling performed local, local and remote (mixed), and remote to the painful area were also evaluated.

Methods

Protocol and registration

This study was registered prospectively on 22 August 2018, with the International Prospective Register of Systematic Reviews (PROSPERO# CRD42018106237). Registration occurred prior to data extraction in accordance with PROSPERO guidelines. PROSPERO is an international database of registered systematic reviews.

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were used during the methods completion and writing phases of this systematic review [26]. A systematic electronic database search was completed using PubMed, CINAHL, Scopus, and the Cochrane Central register of controlled trials from the date of their inception to the date of search completion. The original search strategy was optimized for PubMed with the consultation of a health sciences librarian and subsequently translated to meet the searching requirements for the remaining databases. The search strategies incorporated MeSH terms and text words relating to spine-related pain and dry needling or acupuncture. Search results were filtered to include randomized controlled trials or clinical trials and human subjects in the English language. Results were not restricted based on publication date. All database searches were completed on 8/7/2018. The full PubMed search strategy is located in **Appendix 1**.

Inclusion criteria

Studies were included if they were a randomized controlled trial directly comparing deep to superficial dry needling or acupuncture for the treatment of spine-related painful conditions. Studies were included if the sham, placebo, or comparison intervention in the trial was described as a superficial technique [27]. However, studies investigating the effects of either dry needling or acupuncture post-surgically were not included. Superficial needling was defined as a needling technique inserted at a depth of <10 mm and/or specified in the study methods as superficial. Deep needling was defined as a needling technique inserted at a depth of >10 mm and/or described as deep needle insertion in the study methods. Additionally, all included studies were required to include a measure of pain and/or disability. We operationally defined follow-up time frames as immediate or weeks post initial treatment session.

Study selection

All electronic database results were exported into a common location and duplicate titles were subsequently removed. Two authors independently screened titles for inclusion. In situations when authors disagreed, a decision was made by discussion between the screening authors with subsequent consensus agreement. The abstracts of articles selected based on the title were subsequently screened by two different authors. Disagreements were again settled through discussion between the two authors. Two authors then screened full-text manuscripts independently with disagreements again being settled by discussion until a consensus was reached. Reliability between authors during each step of study identification was calculated using an unweighted Cohen's Kappa [28].

Risk of bias

Two authors independently performed a risk of bias assessment on all included studies using the Cochrane Risk of Bias tool [29]. When the two authors disagreed, an agreement was reached through discussion. This tool assesses bias using seven items covering six different bias domains for each included study. The bias domains and items are: selection bias (random sequence generation and allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other biases (other sources of bias). Each domain is assigned a judgment regarding the risk of bias within the included study for that domain using the labels of 'low risk' of bias, 'high risk' of bias, or 'unclear' risk of bias. A summary assessment of each article was formulated using the recommendations as presented by Higgins

[29]. In order for an included article to be assessed as 'low risk of bias', all key domains were required to be assessed as low risk of bias. If all key domains were determined to be low or unclear risk of bias, the article was determined to have an unclear risk of bias. If one or more key domain within the study was assessed as 'high risk of bias', the included study was then determined to have a high risk of bias.

Data extraction

One author extracted data from all included studies and subsequently input data into a standardized data extraction form. A second author checked all extracted data for accuracy. Data extracted from each study included information related to population, intervention, comparison, outcome, setting, and study design.

Quantitative synthesis

Meta-analyses were performed, when able, to quantitatively synthesize outcome results using the software program, Comprehensive Meta-Analysis 3 (Biostat, Inc. Englewood, NJ.). Standardized Mean Differences (SMD) with 95% confidence intervals (CIs) were calculated for both domains of pain and disability. The I^2 statistic was used to determine the percentage of variance among studies that is due to heterogeneity as opposed to chance. The I^2 values were interpreted as follows: 25% = Low heterogeneity, 50% = Medium, and 75% = High heterogeneity [30]. The random effects model was chosen as a conservative measure to account for heterogeneity among included studies. Calculated SMD were interpreted using Cohen's interpretation of effect size with an effect size of 0.2 being small, 0.5 being moderate, and 0.8 being large [31].

Results

The electronic database search yielded a total of 691 articles after duplicates were removed. After the title screen, a total of 175 abstracts were reviewed for inclusion and 30 full-text articles were reviewed resulting in 12 full-text articles being included in this systematic review. PRISMA flow diagram (Figure 1) illustrates the review process from the initial search to the final manuscript review and subsequent inclusion. Following a full-text manuscript review, 10 manuscripts were found to be appropriate for inclusion in the MA [14,16,18–25]. The absolute agreement for inclusion based on title review was 98.0%, abstract review was 89.7%, and full-text was 93.3%. Chance-corrected agreement for each step was $\kappa = 0.95$ for title review, $\kappa = 0.52$ for abstract review, and $\kappa = 0.87$ for full-text.

Study characteristics

We included 6 studies investigating the effects of acupuncture targeting acupoints [18,19,22,23,25,32], four studies targeting trigger/tender points [14–16,21], and three studies targeting both acupoints plus trigger/tender points [20,21,24]. There were two studies where the type of point targeted varied between groups [20,21]. One study [21] involved targeting both acupoints and tender points in one group and two groups where trigger points only were targeted. Another study [20] involved deep needling of tender points plus local and remote acupoints and remote needling only being performed in the superficial group. Each of the 12 studies addressed the effectiveness of dry needling or acupuncture on musculoskeletal complaints with an emphasis on chronic spinal conditions. Two studies reported outcome data in a way that would not allow inclusion in the MA [15,32]. Ten studies included in this MA covered 426 subjects in the deep needling group and 339 in the superficial group. With multiple time points available for some studies, a total of 2603 comparisons were included in the overall pain analysis. Study characteristics of all 12 trials can be found in Table 1.

Outcome measures

The purpose of the systematic review was to determine the difference between superficial and deep needling on the clinical outcomes of pain and disability. All 12 manuscripts used a pain scale as a main outcome comprised of VAS in 7 studies [16,20–22,24,25,32], NPRS in two studies [14,23], McGill Pain Scales in two studies [18,19], or a 0–4 pain sensitivity scale [15]. Only 2 articles reported disability in a way that would allow inclusion in the MA [20,21]

Superficial needling

There was heterogeneity in the application of superficial needling techniques. Two studies did not specify the depth of needle penetration but stated it was superficial [20] or inserted at a shallower depth than the group receiving deep insertion [23]. Seven studies defined superficial between 2–5 mm [16,18,19,21,22,25,32], two studies inserted to subcutaneous tissues [14,15], and one study inserted ≤1 cm [24].

Deep needling

The individual trials also demonstrated heterogeneity of deep needling techniques. Three studies did not specify depth but stated them to be deep or pragmatically applied [14,15,20]. The other nine studies ranged

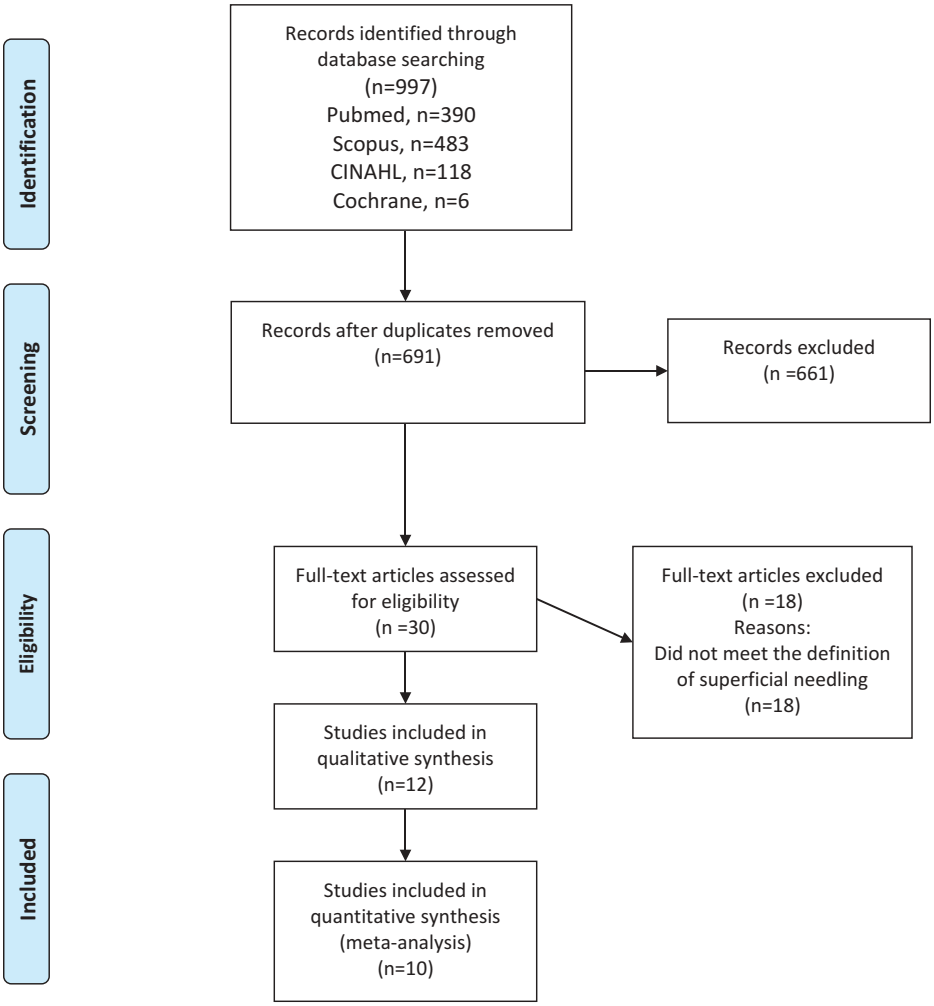

Figure 1. PRISMA Flow diagram of search strategy and results.

from as low as 13 mm to as deep as 10 cm and are as follows: 13 mm eliciting needling sensation [23], 15 mm [19], 20 mm [21,25], 10–30 mm [22], 25 mm [18], 25–40 mm [32], 50 mm [16], and 1–10 cm [24].

Risk of bias

The results of the Cochrane Risk of Bias assessment for each included study can be found in Table 2. Two raters demonstrated an absolute agreement of 92.9% and a linear weighted kappa of 0.894. Nine studies had an unclear risk of bias with four studies demonstrated unclear risk in one domain [16,21,23,25], and three studies having an unclear risk in two domains [20,22,24]. Three studies had a high risk of bias in one [32], two [15], or three domains [18]. High risk of bias mostly fell under the areas of performance or detection bias for lack of blinding. Overall, the aggregate data are likely categorized as unclear risk of bias.

Global effect of needling depth on pain and disability

All 12 studies included 13 groups examined the impact of needling depth on pain. Three studies [14,18,24]individually found significant differences favoring deep needling at all time points. Six groups across five studies [15,21–23,32] reported no significant differences. Four studies [16,19,20,25] reported mixed results depending on the individual time point. Ten [14,16,18–25] of the 12 studies included in the MA suggested a statistically significant effect of needling depth on pain reduction (Figure 2(a)). Overall the standard mean difference (SMD) was moderate at 0.585 [0.335, 0.835], $p < 0.001$. Within and between groups differences for pain were calculated at available time frames and presented in Table 3.

Only two studies involving three groups reported on disability in a way that could be included in the MA [20,21], with one study [21] having two different active treatment groups (Figure 3). There was no overall effect of needling depth on disability with a small SMD of 0.197 [–0.066, 0.461], $p = 0.14$.

Superficial versus deep needling: immediate effect for pain

Five [14–16,22,23] of the 12 studies reported the immediate effects for pain. Two studies [14,16] independently reported significant between-group differences

Table 1. Study Characteristics.

Author (Year)	Design	N	Diagnosis	Group	Points Targeted	Outcome Measure(s)	Outcome Duration	Treatment Sessions	Pain	Disability
Brinkhaus B. (2006)	Randomized controlled, multicenter trial	298	Chronic low back pain (14.7 ± 11.0 y and 13.6 ± 10.5 y)	1. Deep (pragmatic): Mixed local and remote 2. Superficial: remote 3. Waiting list, no needling (8 weeks)	Deep: Acupoints, ear points, trigger points Superficial: Nonacupoints	Pain Questionnaire including VAS, Pain Disability Index, Back Function, emotional aspects of pain, SF-36, Depression scale, global assessment of treatment	8, 26, 52 weeks	12 sessions, 30 minutes each, over 8 weeks.	8 weeks: *In favor of deep 26 weeks: No difference 52 weeks: No difference	No difference
Calamita (2018)	Cross-sectional, randomized, single-blind sham-controlled, crossover trial	30	Non-specific neck Pain (≥ 3 months)	Remote 1. Deep (13 mm needles to elicit mild shock) 2. Superficial (13 mm needles shallower insertion with no sensation)	Deep: Acupoints Superficial: Nonacupoints	EMG of upper trapezius, 11-point NRS for pain	Immediate	2 sessions: 1 sham, 1 experimental. 30 minutes each session.	No difference at any time point	NA
Ceccherelli, F. (2002)	Double-blind randomized controlled study	42	Chronic lumbosacral myofascial pain (≥ 3 months)	Mixed local and remote 1. Deep (1.5 cm) 2. Superficial (2 mm)	Acupoints	McGill Pain Questionnaire	6, 12 weeks	8 sessions, 20 minutes each, over 6 weeks	6 weeks: No difference 12 weeks: *In favor of deep	NA
Ceccherelli, F. (2001)	Randomized controlled study	44	Shoulder myofascial pain (≥ 3 months)	Mixed local and remote 1. Deep (25 mm) 2. Superficial (4 mm)	Acupoints	McGill Pain Questionnaire	5, 9, 17 weeks	10 sessions over 5 weeks, for 20 minutes, each.	*In favor of deep at all time points	NA
Goddard, G. (2002)	Double-blinded randomized controlled trial	18	Myofascial pain of the jaw (≥ 12 weeks)	Mixed local and remote 1. Deep (10–30 mm) 2. Superficial (2–4 mm)	Deep: Acupoints Superficial: Nonacupoints	100 mm VAS	Immediate	1 session, 30 minutes	No difference	NA
Itoh, K. (2004)	Double blinded, randomized, controlled clinical trial	27	Chronic low back pain (≥ 6 months)	Mixed between groups 1. Standard acupuncture (20 mm), mixed and local 2. Deep (20 mm), local 3. Superficial (3 mm), local	Standard acupuncture: Acupoints and tender points Deep: Trigger points Superficial: Trigger points	10 cm VAS, Roland Morris Questionnaire	Pain: 1, 2, 3, 4,7, 8, 9, 10, 13 weeks (12 weeks after treatment begins) Disability: 1, 4, 7, 10, 13 weeks (12 weeks after treatment begins)	6 sessions, 30 minute each, over 10 weeks	No difference at any time point	No difference
Liang, Z. (2011)	Two-arm, single-blinded, randomized controlled design	178	Chronic neck pain (Experimental: Pain <5 months 37 and pain > 5 months 51 Control: Pain < 5 months 34 and Pain >5 months 56	Local 1. Deep (20 mm) 2. Superficial (3 mm)	Deep: Acupoints Superficial: 1 cm lateral to the acupoints	NPQ, 10 cm VAS, SF-36	3, 7, 15 weeks	9 sessions, 20 minutes each, over 3 weeks	*In favor of deep at 3 and 7 weeks after treatment. No difference at week 15.	NA

(*Continued*)

Table 1. (Continued).

Author (Year)	Design	N	Diagnosis	Group	Points Targeted	Outcome Measure(s)	Outcome Duration	Treatment Sessions	Pain	Disability
Molsberger, A. (2002)	Prospective, randomized controlled trial	186	Chronic low back pain (≥ 6 weeks)	Mixed local and remote 1. No needling 2. Deep (1–10 cm) 3. Superficial (< 1 cm)	Deep: Acupoints and tender points Superficial: Nonacupoints of lumbar spine and 5 needles along either side of the back	100 mm VAS, Schobers sign, finger to ground distance	4, 16 weeks	12 sessions, 30 mintes each, over 4 weeks.	*In favor of deep at all time points	NA
Sarrafzadeh, J. (2018)	Randomized quasi-experimental double-blinded trial	50	Myofascial pain syndrome of upper trapezius (≥ 3 months)	Local 1. Deep (up to 50 mm) 2. Superficial (5 mm)	Trigger points	Muscle thickness under US and 10 cm VAS	Immediate, 1, 2 weeks	3 sessions, time frame not specified, 5 + minutes	*In favor of deep	NA
Sedighi, A. (2017)	Randomized clinical trial	30	Cervicogenic headache (Superficial: 34.2 and deep: 37.3 m)	Local 1. Deep (into trigger points) 2. Superficial (subcutaneous)	Trigger points	Headache index, muscle tenderness,0–4 pain intensity, cervical range of motion, FRI	Immediate and 1 week	1 session, 15 minutes	No difference at any time point	NA
Sun, M-Y. (2010)	Randomized control trial	34	Chronic neck mypascial pain syndrome (>1 month)	Mixed local and remote 1. Deep (25–40 mm) 2. Superficial (2 mm)	Acupoints	SF-36, ROM, motion related pain using VAS, and SF-MPQ	7, 15 weeks	6 sessions, 20 minutes each, over 3 weeks	No difference at any time point	NA
Tsai, C-T. (2010)	Randomized controlled trial	35	Myofascial pain syndrome of upper trapezius (Sham: 6.8 Experimental:7.5)	Remote 1. Deep needling into the trigger point 2. Superficial (subcutaneous) over trigger point	Trigger points	0–10 NRS, PPT, Cervical ROM	Immediate	1 session, 2 minutes	*In favor of deep needling	NA

Abbreviations: ROM, range of motion; VAS, Verbal analogue Scale; NRS, numeric rating scale; MPS, myofascial pain syndrome; SF-36, short-form 36; SF-MPQ, short-form McGill pain questionnaire; NPQ, neurophysiology of pain questionnaire; FRI, functional rating index; PPT, pain pressure threshold; mm, millimeter; US, Ultrasound

Table 2. Risk of bias of included studies.

	Risk of Bias Domain						
	1	2	3	4	5	6	7
Brinkhaus, 2006	Low	Unclear	Low	Unclear	Low	Low	Low
Calamita, 2018	Low	Unclear	Low	Low	Low	Low	Low
Ceccherelli, 2002	Low	Unclear	Low	Low	Unclear	Low	Low
Ceccherelli, 2001	Unclear	Unclear	High	High	High	Low	Unclear
Goddard, 2002	Low	Unclear	Low	Low	Unclear	Low	Low
Itoh, 2004	Low	Unclear	Low	Low	Low	Low	Unclear
Liang, 2011	Low	Low	Low	Unclear	Low	Low	Low
Molsberger, 2002	Low	Unclear	Low	Low	Low	Low	Low
Sarrafzadeh, 2018	Low	Unclear	Low	Low	Low	Low	Low
Sedighi, 2017	Unclear	High	Unclear	Unclear	Unclear	High	Unclear
Sun, 2010	Low	Unclear	High	Low	Low	Low	Low
Tsai, 2009	Low	Unclear	Low	Unclear	Low	Low	Low

1) Random sequence generation, 2) Allocation concealment, 3) Performance bias, 4) Detection bias, 5) Attrition bias, 6) Reporting bias, 7) Other bias.

in favor of deep needling. Three [15,22,23] studies independently reported no between-group differences between deep and superficial needle insertion. Four [14,16,22,23] of those five studies were included in the MA and resulted in a small SMD of 0.450 [0.104, 0.796], $p < 0.011$ (Figure 2(b)).

Superficial versus deep needling: one to <12 weeks effects for pain

Nine [15,16,18–21,24,25,32] of the 12 studies reported the effects for pain from 1 to <12 weeks. Five studies independently demonstrated a statistically significant difference favoring deep needling [16,18,20,24,25] Three studies independently reported nonsignificant differences [15,19,32]. One study [21] reported the local dry needling group had statistically significant effects and the standard acupuncture involving mixed local and remote was non-significant. Of the nine studies [15,16,18–21,24,25,32] reporting short-term effects, seven studies [16,18–21,24,25] involving eight groups included in the MA reported results for time durations between 1 and 11 weeks, and there was a moderate SMD of 0.711[0.375, 1.048], $p < 0.001$ [14,16,18–25] (Figure 2(c)).

Superficial versus deep needling: ≥12 week effects for pain

Seven [18–21,24,25,32] of the 12 studies reported the long-term effects for pain from ≥12 weeks. Three studies [18,19,24] independently demonstrated a statistically significant difference favoring deep needling. Four studies involving five groups reported non-significant differences [20,21,25,32]. Six [18–21,24,25] of 10 studies involving 7 groups included in the MA provided data for time durations ≥12 weeks (Figure 2(d)). There was a small SMD of 0.470 [0.135, 0.805], $p = 0.006$.

Secondary analysis by needling location

Sub-analysis for the treatment effect of needling depth on pain when the study compared treatments local to the painful anatomical area from three studies [16,21,25] demonstrated a moderate, and statistically significant SMD of 0.754 [0.027, 1.480], $p = 0.042$ (Figure 4(a)). When the studies compared depth of needle insertion mixed local and remote, the effect from six studies [18–22,24] was moderate and significant for pain SMD of 0.555 [0.224, 0.886], $p = 0.001$ (Figure 4(b)). Two studies [14,23] compared the needling depth - remote to the painful area and the effect was moderate but not significant for pain SMD of 0.501 [−0.300, 1.302], $p = 0.22$, reported in (Figure 4(c)). Analysis of mixed local and remote treatment for two studies [20,21] on disability was small and not significant SMD of 0.197 [−0.077, 0.472], $p = 0.16$ (Figure 5). Itoh et al [21] provided the only local treatment group, therefore, it could not be included in the MA.

Discussion

The purpose of this systematic review with MA was to evaluate the effectiveness of deep versus superficial dry needling or acupuncture on pain and disability for spine-related painful conditions. The results indicate that deep needle insertion performed during either dry needling or acupuncture provides greater pain relief than superficial needling, but no differences were detected for disability measures. Even considering the lower bound estimates of the 95% confidence intervals, effect sizes were between small and moderate in favor of deep dry needling for pain reduction. There was a small and insignificant effect between groups for disability measures, however; only two studies [20,21] that met our inclusion criteria reported disability data that could be included for the MA.

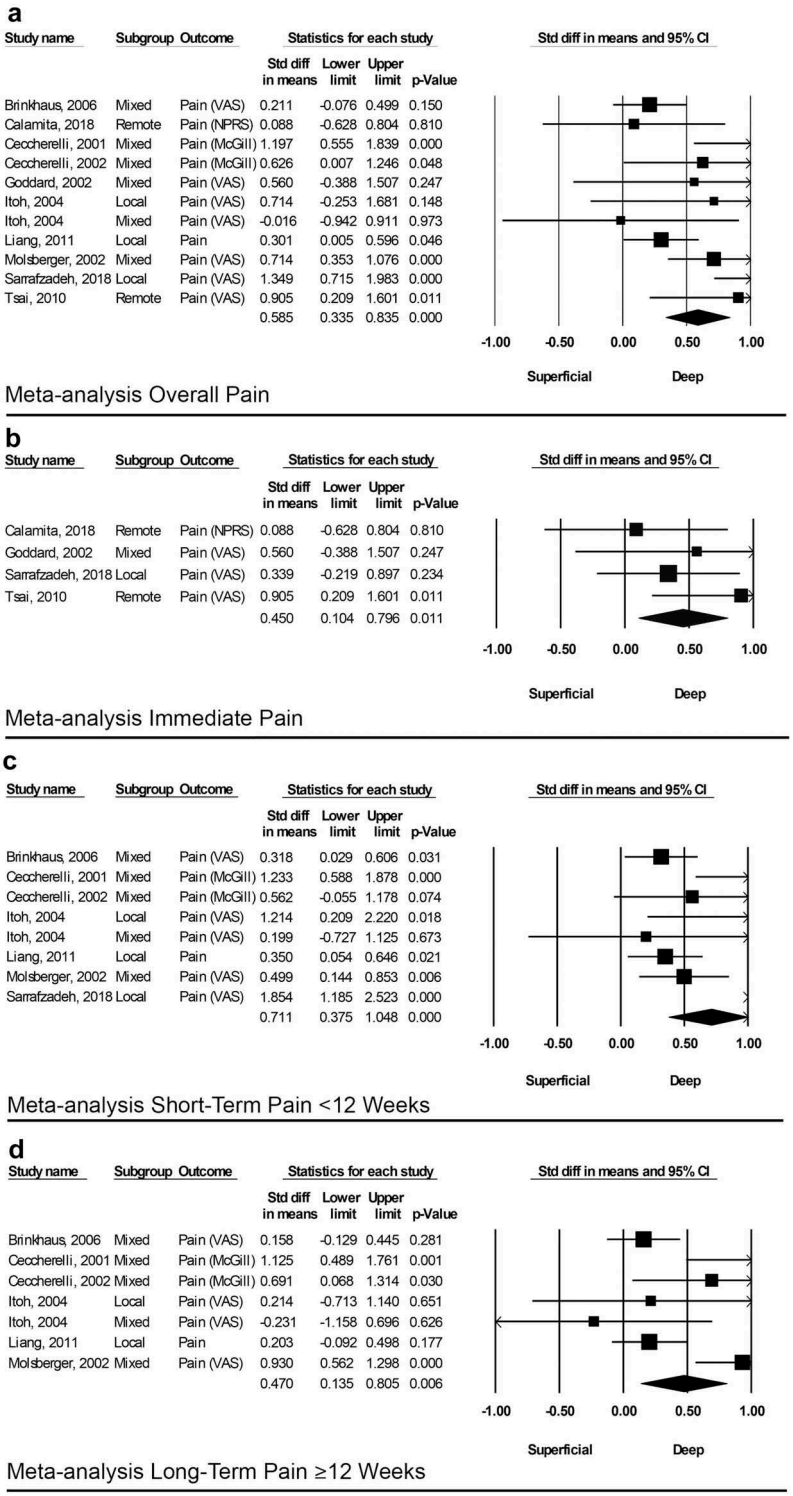

Figure 2. Forest plots illustrating the treatment effects of deep versus superficial needle insertion on overall pain (2a), immediately (2b), <12 weeks (2c), and >12 weeks (2d). Treatment effects ranged from small to moderate. Within the plots, squares represent estimates of treatment effect with larger squares representing larger sample sizes. Diamond represents pooled treatment effect, horizontal lines represent 95% confidence intervals, and vertical line at 0 represents no difference.

Percent change scores for pain were determined for both groups at time points immediately following treatment [14–16,22,23], 1 to 11 weeks [14–16,18–21,24,25,32], and ≥12 weeks [18–21,24,25,32] and are reported in Table 3. Clinically meaningful changes existed for both superficial and deep needling. The between-group differences were statistically meaningful, however, the difference in pain change scores between superficial and deep needling did not meet the clinically meaningful threshold of 30% [33].

Deep needle penetration may be more effective than superficial at reducing pain due to enhanced blood flow and tissue oxygenation [5,34], altering the neuro-inflammatory environment [4,7] in deeper

Table 3. Within and between group differences for pain by percent change scores.

Study	Group	Immediate Effect (%)	Between Group Differences	1–11 week effect (%)	Between Group Differences	≥12 week effect (%)	Between Group Differences
Brinkhaus, B. (2006)	D			45.4%	11.0%	39.2%	2.0%
	S			34.4%		36.8%	
Calamita, S-A-P. (2017)	D	44.5%	7.7%				
	S	36.7%					
Ceccherelli, F. (2002)	D			89.3%	40.8%	87.4%	36.9%
	S			48.5%		50.5%	
Ceccherelli, F. (2001)	D			43.4%	19.4%	73.7%	35.8%
	S			24.1%		38.0%	
Goddard, G. (2002)	D	44.7%	15.7%				
	S	29.0%					
Itoh, K. (2004)	D			64.8%	38.4%	32.3%	8.7%
	D			32.5%	32.3%	11.3%	12.4%
	S			26.4%		23.6%	
Liang, Z. (2010)	D			45.5%	9.0%	45.7%	3.8%
	S			36.4%		41.9%	
Molsberger, A. (2002)	D			61.8%	18.0%		
	S			43.8%			
Sarrafzadeh, J. (2018)	D	27.7%	3.4%	78.7%	40.2%		
	S	24.2%		38.5%			
Sedighi, A. (2017)	D	33.4%	7.9%	68.4%	9.2%		
	S	25.5%		59.2%			
Sun, M-Y. (2010)	D			40.0%	0.0%	20%	20%
	S			40.0%		40%	
Tsai, C-T. (2010)	D	28.8%	17.7%				
	S	11.1%					
Pooled			10.4%		21.8%		17.0%

Note: D = Deep; S = Superficial

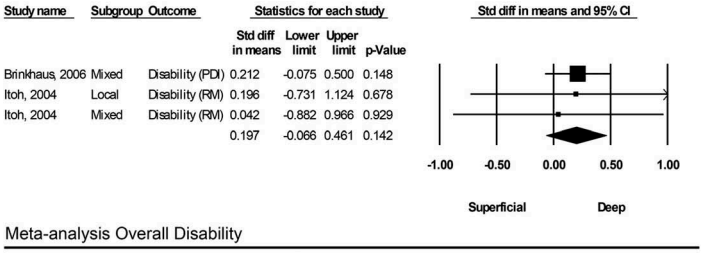

Figure 3. Forest plots illustrating the effect of deep versus superficial needle insertion on overall disability. Small treatment effects were observed. Within the plots, squares represent estimates of treatment effect with larger squares representing larger sample sizes. Diamond represents pooled treatment effect, horizontal lines represent 95% confidence intervals, and vertical line at 0 represents no difference.

tissue structures. Superficial needling stimulates primary sensory afferents, attenuating an endogenous opioid response, and restructuring subcutaneous fibrous connect tissue [3,35]. The neurophysiological response achieved with superficial needling may not improve microcirculation and reducing inflammation in deeper structures. Additionally, the type and degree of needle manipulation [13,36–38] effects the overall therapeutic dosage and subsequent pain inhibitory response during needling practice.

The sub-analysis demonstrated deep and superficial dry needling or acupuncture applied local and a combination of local and remote produced moderate and statistically significant effects on pain. But remotely applied, it did not. Our results differed from another systematic review [39] sub-analysis that reported no between-group differences between local and remote acupuncture for chronic musculoskeletal pain. Both reviews, however, investigated the importance of needle insertion site related to the painful area as the sub-analysis. Therefore, search terms, strategies, and inclusion criteria likely altered studies included leading to mixed results.

Limitations

Risk of bias was evaluated using Cochrane Risk of Bias Assessment [29] with all studies being classified as either unclear [14,16,19–25] or high risk of bias [15,18,32]. There was heterogeneity across studies for application of either deep or superficial needling. The difference in depth between superficial and deep for some studies were minimal [23], unclear [20,23], or described as targeting specific tissue and not described metrically [14,15]. Application of needling varied between groups in some studies regarding factors that could impact the therapeutic dosage [16,20,21,24,25,32]. Time needles are left in situ [40], eliciting specific sensations [41], presence of a local twitch response [42,43], or the use of needle manipulation techniques including pistoning (fast in/out technique or

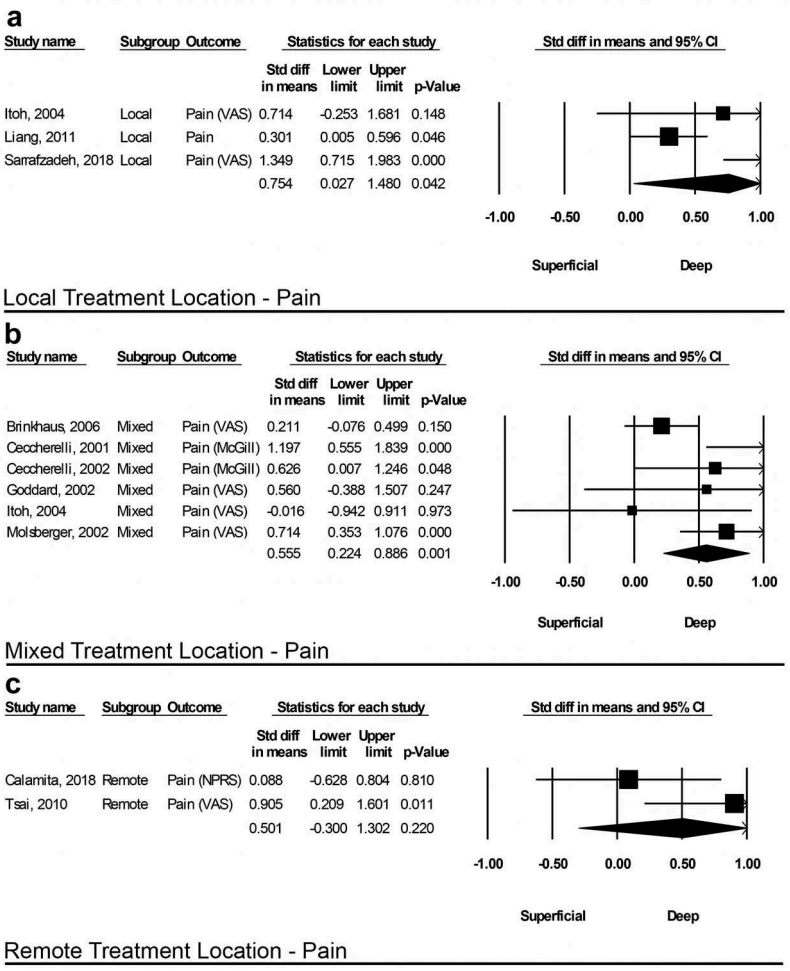

Figure 4. Forest plots illustrating the treatment effects of needling depth on pain when inserted local (4a), mixed local and remote (4b) or remote only (4c). Moderate treatment effects were observed for local and mixed with small effects observed for remote only. Within the plots, squares represent estimates of treatment effect with larger squares representing larger sample sizes. Diamond represents pooled treatment effect, horizontal lines represent 95% confidence intervals, and vertical line at 0 represents no difference.

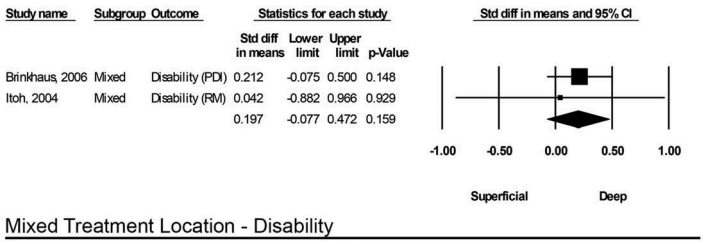

Figure 5. Forest plots illustrating the treatment effects on disability for mixed local and remote to the painful area. Small treatment effects were observed. Within the plots, squares represent estimates of treatment effect with larger squares representing larger sample sizes. Diamond represents pooled treatment effect, horizontal lines represent 95% confidence intervals, and vertical line at 0 represents no difference.

sparrow pecking) [13,41,44] or needle rotations [36], have all been shown to impact the degree of pain relief from dry needling and acupuncture. There was also variability in the number of sessions between studies.

Five studies referenced the superficial technique as a placebo [25], control [23], or sham [14,22,32]. It is unknown what information was provided or withheld from study participants, which could influence the outcomes or blinding measures [45]. One study met our inclusion criteria having a true control group [20] and one study included needling with a combination of other treatments [24]. Our results indicate that superficial needling reduces pain; however, the magnitude of its effect is difficult to ascertain from this review due to the lack of true control groups. Two studies directly comparing superficial needling to control [46] or placebo [47] reported significant between-group effects favoring superficial needling.

Limitations to the sub-analysis

No demarcation boundary has been accepted in the literature for defining local versus remote needling sites. The judgment of local and remote needling for this review was based on whether needles were inserted in the anatomical area of pain (local) or a remote body area. Three studies needled local to the area of pain [15,16,25], five studies included both local and remote needling [18,19,22,24,32], two studies needled only remotely [14,23], and two were mixed between groups [20,21]. The selection of sites needled varied across studies for similar pain conditions since both dry needling and acupuncture studies were included. Variability existed across studies whether clinicians targeted acupoints or non-acupoints [18–20,22,23,25,32], trigger/tender points [14–16,21], or mixed between acupoints plus trigger/tender points [20,21,24]. Variability also existed between studies involving acupuncture where local needling points could have involved either tender ('Ashi points') or prescriptive non-tender acupoints. Needling tender points may result in greater pain relief than non-painful areas [39].

Conclusion

Our results suggest both deep and superficial dry needling or acupuncture produce meaningful changes in pain associated with spinal-related painful conditions, but deep needle penetration may be more effective. Needling local to painful area may reduce pain more than remote needling. These results should be interpreted with caution as all studies were classified as either unclear or high risk of bias and significant heterogeneity existed across studies. Standardization of superficial versus deep needling is needed for future controlled trials to limit the variability of tissue penetration appropriate for the anatomical area. More robust, high-quality studies are necessary to determine the effect of needling depth in dry needling and acupuncture trials on pain and disability.

Disclosure statement

No potential conflict of interest was reported by the authors.

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