DAVID M. KIETRYS, PT, PhD, OCS[1] • **KERSTIN M. PALOMBARO,** PT, PhD, CAPS[2] • **ERICA AZZARETTO,** PT, DPT[3]
RICHARD HUBLER, PT, DPT[4] • **BRET SCHALLER,** PT, DPT[5] • **J. MATHEW SCHLUSSEL,** DPT • **MARY TUCKER,** PT, DPT[6]

Effectiveness of Dry Needling for Upper-Quarter Myofascial Pain: A Systematic Review and Meta-analysis

STUDY DESIGN: Systematic review and meta-analysis.

BACKGROUND: Myofascial pain syndrome (MPS) is associated with hyperalgesic zones in muscle called myofascial trigger points. When palpated, active myofascial trigger points cause local or referred symptoms, including pain. Dry needling involves inserting an acupuncture-like needle into a myofascial trigger point, with the goal of reducing pain and restoring range of motion.

OBJECTIVE: To explore the evidence regarding the effectiveness of dry needling to reduce pain in patients with MPS of the upper quarter.

METHODS: An electronic literature search was performed using the key word *dry needling*. Articles identified with the search were screened for the following inclusion criteria: human subjects, randomized controlled trial (RCT), dry needling intervention group, and MPS involving the upper quarter. The RCTs that met these criteria were assessed and scored for internal validity using the MacDermid Quality Checklist. Four separate meta-analyses were performed: (1) dry needling compared to sham or control immediately after treatment, (2) dry needling compared to sham or control at 4 weeks, (3) dry needling compared to other treatments immediately after treatment, and (4) dry needling compared to other treatments at 4 weeks.

RESULTS: The initial search yielded 246 articles. Twelve RCTs were ultimately selected. The methodological quality scores ranged from 23 to 40 points, with a mean of 34 points (scale range, 0-48; best possible score, 48). The findings of 3 studies that compared dry needling to sham or placebo treatment provided evidence that dry needling can immediately decrease pain in patients with upper-quarter MPS, with an overall effect favoring dry needling. The findings of 2 studies that compared dry needling to sham or placebo treatment provided evidence that dry needling can decrease pain after 4 weeks in patients with upper-quarter MPS, although a wide confidence interval for the overall effect limits the impact of the effect. Findings of studies that compared dry needling to other treatments were highly heterogeneous, most likely due to variance in the comparison treatments. There was evidence from 2 studies that lidocaine injection may be more effective in reducing pain than dry needling at 4 weeks.

CONCLUSION: Based on the best current available evidence (grade A), we recommend dry needling, compared to sham or placebo, for decreasing pain immediately after treatment and at 4 weeks in patients with upper-quarter MPS. Due to the small number of high-quality RCTs published to date, additional well-designed studies are needed to support this recommendation.

LEVEL OF EVIDENCE: Therapy, level 1a–.
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KEY WORDS: *dry needling, myofascial pain syndrome, randomized controlled trial*

Myofascial pain syndrome (MPS) is a common condition associated with myofascial trigger points (MTrPs).[27] MTrPs are a common source of pain in patients presenting to primary care or pain clinics.[13,25,37] MTrPs are localized areas of taut, band-like hardness in muscle that typically contain hyperalgesic zones.[19,32,36,42] MTrPs may develop anywhere in the body in response to sudden injury, muscle overload, or repetitive microtrauma.[36,42] Chronic upper-quarter pain, tension-type headaches, and orofacial pain have all been commonly associated with MPS.[25] Poor posture, as well as certain physical and social conditions, can activate MTrPs.[44]

When compressed, MTrPs can cause local and/or referred tenderness and pain, aggravation of existing pain, motor dysfunction, and/or autonomic phe-

[1]School of Health Related Professions, Rutgers, The State University of New Jersey, Stratford, NJ. [2]Institute of Physical Therapy Education, Widener University, Chester, PA. [3]NovaCare Rehabilitation, Philadelphia, PA. [4]NovaCare Rehabilitation, Sewell, NJ. [5]Comber Physical Therapy, Williamsburg, VA. [6]SportsCare of America, Bridgewater, NJ. The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Dr David Kietrys, 40 East Laurel Road, UEC Suite 2105, Stratford, NJ 08084. E-mail: kietrydm@shrp.rutgers.edu

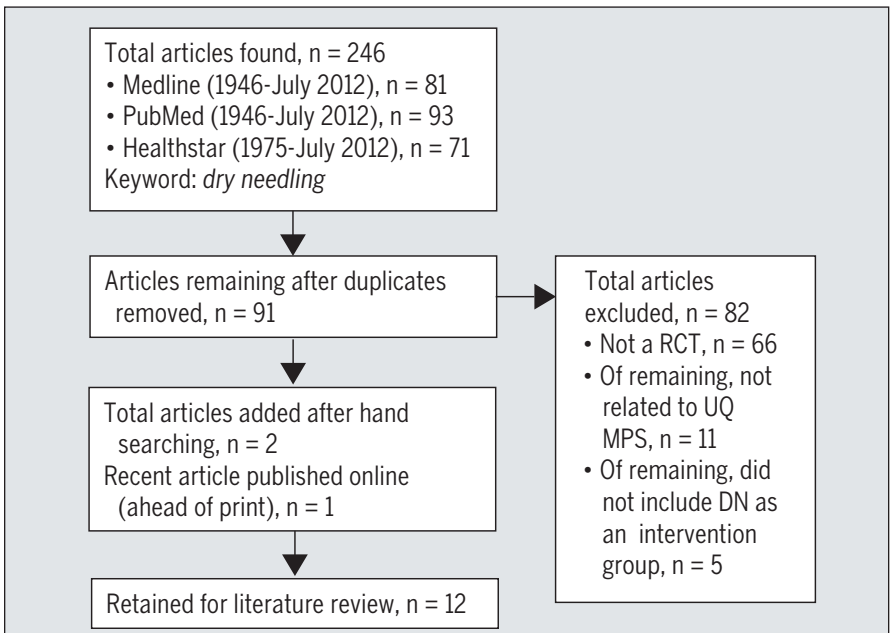


FIGURE 1. Flow diagram of search strategy and results. Abbreviations: DN, dry needling; MPS, myofascial pain syndrome; RCT, randomized controlled trial; UQ, upper quarter.

nomena.[8,19,36,41] MTrPs can contribute to impaired range of motion and increased sensitivity to stretch.[13,16,18,33,36,42] Active MTrPs can cause spontaneous pain, whereas latent MTrPs elicit symptoms when compressed.[13,16,18,20,33,36,42] Palpating an MTrP or inserting a needle into an MTrP may elicit a localized twitch response, defined as a brisk contraction of muscle fibers in or around the MTrP.[13,16,18,33,36,42] Localized twitch responses are more easily elicited when sensitive loci within an MTrP are identified and targeted.[16-19]

Dry Needling

Trigger-point dry needling is a procedure in which an acupuncture-like needle is inserted into the skin and muscle in the location of an MTrP.[11] Needles are removed once the trigger point is inactivated. Dry needling is typically followed by stretching exercises.[14] The actual mechanism of effect of dry needling is still being debated. The localized twitch response that often occurs may interrupt motor end-plate noise, eliciting an analgesic effect.[10] Eliciting a localized twitch response and stretching exercises relax the actin-myosin bonds in the tight bands.[4] Some studies have suggested that pain relief and range-of-motion restoration are greater when a localized twitch response is elicited during dry needling.[16,18,19] It has been suggested that the gate control theory of pain may play a role.[14] Dry needling causes stimulation of alpha-delta nerve fibers, thus activating the enkephalinergic inhibitory dorsal horn interneurons and causing opioid-mediated pain suppression.[2] Dry needling may correct levels of several chemicals in the affected muscles, including bradykinin, calcitonin gene-related peptide, and substance P.[10] Needling of MTrPs is also theorized to disrupt reverberatory central nervous system circuits.[30]

A previously published systematic review of 7 studies of acupuncture/dry needling for the management of MTrPs in various body regions (including the upper quarter, low back, and lower extremity) found limited evidence in 1 study that dry needling had an overall effect compared to standardized care.[41] Meta-analysis of 4 studies comparing dry needling to a sham (placebo) treatment did not show statistical significance between interventions but noted that, overall, the results suggested a positive treatment effect of dry needling for MTrP pain.

The purpose of this systematic review and meta-analysis was to determine the immediate and longer-term effectiveness in pain reduction of dry needling, specifically in patients with upper-quarter MPS, and to make a recommendation for clinical practice based on the best available evidence.

METHODS

The studies included in this systematic review and meta-analysis had human subjects, were randomized controlled trials (had a control or comparison group), had a dry-needling intervention group, included participants with upper-quarter myofascial symptoms, and were in the English language. An electronic search of the term *dry needling* was performed on the following databases: OvidSP MEDLINE (1946-2012), HealthSTAR, and PubMed. Search results are illustrated in **FIGURE 1**. After removal of duplicates, articles that were not randomized controlled trials were excluded. Next, articles that did not involve subjects with upper-quarter myofascial pain and articles that did not include dry needling as an intervention group were excluded.

Our initial search produced a systematic review and meta-analysis regarding dry needling and acupuncture in the management of MTrP pain.[41] A hand search of that review produced 2 articles that met our inclusion criteria that were not previously identified with our electronic search. All other key references,[1,4,9,15,17,20-23,26,43] as well as 1 other systematic review[8] on the topic, were hand searched but did not yield any additional articles. One article[39] published online (ahead of print) in November 2012 was added to the review.

Retained articles were scored independently for internal validity using the evaluation guidelines for rating the quality of an intervention study (the Mac-

Dermid Quality Checklist).[28] This tool assesses 7 domains of internal validity (study question, study design, subjects, intervention, outcome, analysis, and recommendations) and has been used in other published reviews.[3,24] The MacDermid Quality Checklist consists of 24 items, each scored from 0 to 2, with a highest possible score of 48 points.[28] In this review, each article was scored by at least 3 different evaluators. Any differences in scores or ratings were discussed by the reviewers until they reached a consensus score. If the reviewers could not reach a consensus score to within 1 point, an additional reviewer was used to adjudicate the score. If a consensus could still not be reached, the lower score was assigned. In addition, the studies reviewed were assigned a level-of-evidence rating as described by Sackett et al.[34] All authors (except K.M.P.) participated in extraction of relevant data related to MacDermid Quality Checklist scoring.

Two of the authors (D.M.K. and K.M.P.) worked as a team to extract relevant data related to meta-analyses. Meta-analyses were performed with MetaAnalyst Version Beta 3.13 (Tufts Medical Center, Boston, MA), with a continuous-variable random-effects model. Four separate meta-analyses were performed, with pain on a visual analog scale (VAS) as the outcome measure: (1) dry needling compared to sham or control, immediate effects; (2) dry needling compared to sham or control at 4 weeks; (3) dry needling compared to other treatments, immediate effects; and (4) dry needling compared to other treatments at approximately 4 weeks. All studies that compared dry needling to other treatments provided data at 4 weeks, with the exception of the study by DiLorenzo et al,[9] which measured outcomes at 21 days. These data were used in the comparisons at approximately 4 weeks. Outcomes at times other than immediately after and approximately 4 weeks after treatment were not considered in this review, due to variability across studies in other times to outcomes. The VAS pain scores reported by Itoh et al[23] were measured on a 100-point scale (mm), and were converted to a 10-point scale (cm) before entering the data for the meta-analysis.

The data from Chu[4] were not reported such that they could be included in the meta-analysis, thus the study was excluded from meta-analysis. In the meta-analysis of dry needling compared to other treatments (immediate effects), 2 different data sets from the study by Hong[17] were entered separately, because the data were not reported such that they could be combined. In a meta-analysis, Kamanli et al[26] and Itoh et al[23] both assessed the effects of dry needling in comparison to 2 different treatments at 4 weeks. The data for each of these other treatments were entered separately; therefore, these 2 studies are each represented twice in the meta-analysis of dry needling compared to other treatments at approximately 4 weeks.

We used 2 points on a 0-to-10 VAS as a conservative cutoff value for clinical meaningfulness of change in pain for between-group comparisons. Various studies have reported a range of minimal clinically important difference values for numeric or visual analog pain scales for patients with upper-quarter pathologies, including 1 point for patients with chronic musculoskeletal pain,[35] 1.3 points for neck pain,[5] 1.7 points for chronic pain,[12] 2.17 points for shoulder pain,[31] and 3.0 points for patients with neck/upper extremity/lower extremity pain.[38]

RESULTS

Twelve studies that met our inclusion criteria[1,4,9,15,17,20-23,26,39,43] are listed in chronological order in **TABLES 1** through **6**. Inclusion and exclusion criteria for participants in the reviewed studies are described in **TABLE 1**. In all studies, subjects had symptoms attributed to upper-quarter MPS, typically involving the neck or shoulder region. Etiology of pain was not consistent across studies. For example, DiLorenzo et al[9] included subjects with shoulder pain following cerebrovascular accident, whereas other studies included chronic neck, shoulder, or trapezius myofascial pain, often of ambiguous origin.[1,4,15,17,20-23,26,39,43] Exclusion criteria varied across studies but generally included alternative musculoskeletal diagnoses and contraindications for needling.

TABLE 2 presents the participants' age range and duration of symptoms where these data were provided by the authors. In general, participants were adults, and in 4 studies[9,15,20,23] they were primarily adults over 60 years of age. Duration of symptoms varied among studies; participants in 8 of the studies had chronic symptoms ranging from 3 months[23] to 63 months[39] in duration. One study[9] included participants whose shoulder symptoms started following a stroke. The study by Ilbuldu et al[21] included only female participants, whereas all other studies appear to have included individuals of both genders.

Intervention groups (independent variables), outcome measurements (dependent variables), and times to outcomes are summarized in **TABLE 3**. Six of the studies used a true control (placebo or sham) group.[4,21-23,39,43] One study used the contralateral side of the participants as the control.[20] Eight studies utilized a variety of comparison groups (groups that received interventions other than dry needling to MTrPs). Comparison groups included lidocaine injection,[1,17,26] botulinum toxin injection,[26] laser,[21] nonlocalized acupuncture,[22,23] and standard rehabilitation (external support, positioning, exercise) for hemiparetic shoulder pain.[9] The comparison group in the study by Ga et al[15] received a treatment (intramuscular stimulation) that, technically, is a dry-needling technique, with subtle differences in technique between the authors' operational definitions of dry needling and intramuscular stimulation. Times to outcomes ranged from immediate[4,17,20,22,43] to 6 months,[21] with 4 studies[17,20,22,43] reporting only immediate effects.

TABLE 4 describes the key findings, MacDermid Quality Checklist scores, and

TABLE 1 Inclusion and Exclusion Criteria by Study

Study	Inclusion Criteria	Exclusion Criteria
Hong[17]	• MPS (tender spots in palpable taut bands, typical pattern of referred pain, LTR with snapping palpation of MTrP, restricted ROM of CS for lateral bending to opposite side) • At least 1 active MTrP in upper trapezius	• MTrP injection in prior 6 mo • CS or shoulder surgery in prior year • Narcotic medication in prior month • Fibromyalgia • CS radiculopathy or myelopathy • Severe disc or skeletal lesion • Hyperesthesia in shoulder or CS • Cognitive deficit • Inadequate cooperation
Chu[4]	• Neck or UE pain • Referred for electrodiagnostic studies	• Evidence of peripheral neuropathy (via nerve conduction study)
Irnich et al[22]	• Chronic pain of greater than 2 mo in duration • Limited ROM in CS • Diagnosis of cervical MPS (pain and limited ROM associated with MTrPs) or "irritation syndrome" (diffuse intense pain and irritated soft tissues with prolonged aggravation after motion and pressure)	• CS radicular syndrome, segmental instability, fracture, or surgery • Contraindications to acupuncture • Drug treatment, physical therapy, or manual treatment in prior 4 wk
Ilbuldu et al[21]	• MTrP in upper trapezius • Diagnosis of MPS (local pain, pain and sensory changes referred from MTrP, palpable taut band, extreme sensitivity in 1 point in band, limited ROM)	• Tumor • Infectious disease • Stage 3 or 4 osteoarthritis • Pregnancy • Scoliosis • Bleeding diathesis • Chronic obstructive lung disease
DiLorenzo et al[9]	• Patients 4 to 8 wk post-CVA who had undergone at least 3 wk of physical therapy • Shoulder pain (at least 6/10 on VAS) on affected side	• Pain due to CVA affecting spinothalamic pathways in brain stem with sensory deficit • Primary depression • Hemiparesis due to neurosurgical procedure • Cerebral tumor • Head injury • Congenital cerebral palsy • Worsening or pre-existing internal derangement of shoulder ligaments or tendons • Adhesive capsulitis • Peripheral neuropathy • Complex regional pain syndrome • Shoulder fractures • Neglect syndrome • Decline participation
Kamanli et al[26]	• At least 1 MTrP on CS, back, or shoulder muscles with disease of at least 6 mo in duration	• Treatment in prior 8 wk • MTrP injection within prior 2 mo • Cardiovascular or respiratory disease • Allergies • CS or shoulder surgery in prior year • Fibromyalgia • CS radiculopathy or myelopathy with severe disc or skeletal lesions • Uncooperative • Use of medications that prevent neuromuscular transmission • Motor neuron or neuromuscular junction disease • Pregnancy

Table continues on page 624.

level-of-evidence ratings. Scores for each of the 24 items on the MacDermid Quality Checklist are provided in **TABLE 5**. The criteria and description of the scoring system for this tool have been previously published.[3] Levels of evidence[34] ranged from 2b[4] to 1b.[1,9,15,17,20-23,26,39,43] Internal validity scores (MacDermid Quality Checklist) ranged from 23[4] to 40,[39] with a mean of 34. The articles with the strongest internal validity, as evidenced by relatively higher scores on the MacDermid Quality Checklist, were those by Tekin et al,[39] Ga et al,[15] and Irnich et al.[22] The studies with the weakest internal validity were those

TABLE 1 Inclusion and Exclusion Criteria by Study (continued)

Study	Inclusion Criteria	Exclusion Criteria
Ga et al[15]	• Chronic MPS of upper trapezius based on physical examination and interview	• MTrP injection, intramuscular stimulation, or DN in prior 6 mo • CS or shoulder surgery in prior year • Narcotic medication in prior month • Fibromyalgia • CS radiculopathy or myelopathy • Severe cardiovascular or respiratory disease • Cognitive deficit • Difficulty with communication • Inadequate cooperation
Hsieh et al[20]	• Bilateral shoulder pain with active MTrPs in the infraspinatus • No significant differences in clinical presentation between 2 sides	• Treatment other than oral medication in past 3 mo • Contraindication for DN, such as local infection, serious medical problems, recent multiple trauma, or pregnancy with threatened abortion • Condition that might interfere with pain/pain threshold assessment • CS or UE surgery
Itoh et al[23]	• Neck pain for 6 mo or longer with no radiation • Normal CS nerve function • Aged 45 y and older	• Major trauma or systemic disease • Other conflicting or ongoing treatments, except medication with uniform dosage for 1 mo or longer
Ay et al[1]	• Clinical diagnosis of MPS (regional pain, taut band[s], referred trigger point pain and sensory change, extreme sensitivity in taut band, decreased ROM) • At least 1 active trigger point in upper trapezius • Symptom duration for at least 1 mo	• Fibromyalgia • Systemic disease • Cervical disc lesion • History of MTrP injection • Physical treatment in past 6 mo • Pregnancy • Neck or shoulder surgery • Drug allergies • Abnormal lab results
Tsai et al[43]	• Unilateral shoulder pain caused by digital compression of MTrP in the upper trapezius (MTrP diagnosed as tenderness and pain reproduction with palpation of a tight band)	• Contraindication for DN, such as local infection or trauma • Anticoagulant medication • Pregnancy with threatened abortion • Problem that might interfere with pain/pain threshold assessment • Cognitive deficit • Needling treatment in past
Tekin et al[39]	• MPS (local spontaneous pain, referred pain or sensory changes from MTrP, palpable taut band, localized tenderness, reduced ROM) • At least 1 active MTrP • Symptom duration at least 6 mo	• Physical therapy or local injection within prior 3 mo • Fibromyalgia • Pregnancy • Cervical nerve root irritation • Abnormal lab results • Thoracic outlet syndrome • Upper-limb entrapment syndromes

Abbreviations: CS, cervical spine; CVA, cerebrovascular accident; DN, dry needling; LTR, localized twitch response; MPS, myofascial pain syndrome; MTrP, myofascial trigger point; ROM, range of motion; UE, upper extremity; VAS, visual analog scale.

by Hsieh et al,[20] Chu,[4] and Hong.[17] As indicated in **TABLE 4**, all studies reported significant decreases in pain in the groups receiving dry needling. In many cases, comparison groups also realized an improvement in pain.

Meta-analysis: Dry Needling Compared to Sham or Control, Immediate Effects

Four studies compared dry needling to sham or control and assessed immediate effects on pain (**FIGURE 3**).[20,22,39,43] The overall effect size (standardized mean difference) of 1.06 (95% confidence interval [CI]: 0.05, 2.06) suggests a large effect[7] favoring dry needling over sham or control. Heterogeneity was high (I^2 = 86.3%). Three of the 4 studies entered into this meta-analysis favored dry needling.

The study with the largest treatment effect[20] used the same subject's uninvolved side as the control, and reported a raw between-group effect size of 4.0 VAS points, which is clinically meaningful. The other 2 studies that favored dry needling[39,43] had large treatment effects (0.88 and 0.75, respectively), but their raw between-group effect sizes (1.4 and 1.2 VAS points, respectively) were of questionable clinical meaningfulness.

TABLE 2 Participant Characteristics by Study

Study	Sample Size, n	Age, y*	Duration of Symptoms*
Hong[17†]	58	41.7 ± 14.4‡	7.6 ± 4.7 mo‡
		42.1 ± 10.2‡	9.1 ± 4.2 mo‡
		42.2 ± 12.2§	10.2 ± 5.6 mo§
		39.9 ± 9.6§	11.7 ± 6.7 mo§
Chu[4‖]	164	44.2 ± 14.0‡	10.9 ± 12.2 mo‡
		40.1 ± 11.5‡	13.9 ± 17.6 mo‡
		40.5 ± 13.7¶	11.3 ± 13.3 mo¶
		40.9 ± 12.8¶	17.1 ± 20.4 mo¶
Irnich et al[22]	36	51.9	36.7 mo
Ilbuldu et al[21]	60	35.3 ± 9.2‡	38.5 ± 31.9 mo‡
		33.9 ± 10.4§	32.9 ± 28.6 mo§
		32.3 ± 6.9¶	36.5 ± 33.6 mo¶
DiLorenzo et al[9]	101	69.6 ± 6.2‡	3.53 wk
		67.4 ± 9.1§	
Kamanli et al[26]	29	37.2 ± 8.1‡	32.5 ± 22.0 mo‡
		37.3 ± 9.8§	49.2 ± 35.0 mo§
		38.3 ± 5.3§	50.7 ± 19.9 mo§
Ga et al[15]	40	79.2 ± 6.8‡	…
		76.3 ± 8.6§	…
Hsieh et al[20]	14	60.2 ± 13.2	…
Itoh et al[23]	40	62.3 ± 10.1‡	2.9 ± 2.7 y‡
		62.3 ± 11.0§	3.2 ± 3.1 y§
		65.0 ± 10.5§	3.3 ± 3.9 y§
		65.0 ± 10.5¶	2.3 ± 1.5 y¶
Ay et al[1]	80	38.1 ± 9.8‡	34.3 ± 40.9 mo‡
		37.2 ± 10.1§	30.6 ± 37.2 mo§
Tsai et al[43]	35	46.4 ± 12.2‡	7.5 ± 3.9 mo‡
		41.5 ± 10.4¶	6.8 ± 4.5 mo¶
Tekin et al[39]	39	42.9 ± 10.9‡	63.5 ± 50.7 mo‡
		42.0 ± 12.0§	57.9 ± 48.3 mo§

**Values are mean ± SD where those data were provided by the authors.*
†Reported age and duration of symptoms based on occurrence of a localized twitch response; the subgroup that experienced a localized twitch response is listed first.
‡Dry-needling group.
§Comparison group(s).
‖Reported age and duration of symptoms based on pain relief outcome; subgroup experiencing pain relief listed first.
¶Control (placebo or sham) group.

Meta-analysis: Dry Needling Compared to Sham or Control at 4 Weeks

Three studies compared the effects of dry needling to sham or control on pain at 4 weeks (**FIGURE 4**).[21,23,39] The overall effect size (standardized mean difference) of 1.07 (95% CI: −0.21, 2.35) suggests a large effect favoring dry needling over sham treatment or control; however, the 95% CI crosses the line of no difference, suggesting that caution should be used when making conclusions based on overall effect size. Heterogeneity was high (I^2 = 84.2%). Two of the 3 studies[23,39] in this meta-analysis favored dry needling over the sham or control at 4 weeks, and both had large effect sizes (1.95 and 1.55, respectively). Both had raw between-group effect sizes at 4 weeks that were clinically meaningful (3.6 and 3.1 VAS points, respectively). The most recent study[39] had the highest internal validity score of any study in this review.

Meta-analysis: Dry Needling Compared to Other Treatments, Immediate Effects

Two studies compared dry needling to other treatments and assessed immediate effects on pain (**FIGURE 5**).[17,22] Hong[17] used lidocaine injection (with or without localized twitch response), whereas Irnich et al[22] used nonlocalized acupuncture as the other treatment. Hong[17] reported results separately for subjects who had a localized twitch response and those who did not, and these data were entered separately into the meta-analysis because the results could not be combined. The overall effect size (standardized mean difference) of −0.64 (95% CI: −1.21, −0.06) suggests a moderate effect[7] favoring other treatment over dry needling. Heterogeneity was high (I^2 = 90%). Although both studies entered into this meta-analysis favored other treatment, the raw between-group effect sizes (0.58-1.69 VAS points for Hong[17] and 1.01 VAS points for Irnich et al[22]) were of questionable clinical meaningfulness.

Meta-analysis: Dry Needling Compared to Other Treatments at Approximately 4 Weeks

Six studies compared the effects of dry needling to other forms of treatment on pain at 4 weeks (**FIGURE 6**).[1,9,15,21,23,26] Two of the studies included 2 other treatment groups, and the results from each of these treatments were entered separately into the meta-analysis, such that 8 data sets were entered. The overall effect size (standardized mean difference) of −0.07 (95% CI: −1.39, 1.26) suggests a small overall effect favoring other treatment, with the 95% CI crossing the line of no difference. Heterogeneity was high (I^2 = 95%). Two of the studies[9,23] entered into this meta-analysis favored dry needling over other treatment at 4 weeks, and both had large[7] effect sizes (2.26

TABLE 3 Summary of Intervention Groups and Outcome Measures by Study*

Study	Intervention Group	Outcome Measure	Time to Outcomes
Hong[17]	• DN • Lidocaine injection • Both groups received spray and stretch technique and "home program"	• Pain (0-10 numeric pain rating scale) • Pressure pain threshold (algometry) • CS ROM (lateral bending) (goniometry)	Immediate
Chu[4]	• DN • Control: DN to random points	• Pain (VAS) • Pain relief duration • Number of MTrPs • CS ROM (goniometry and tape measure) • Shoulder ROM (goniometry)	Immediate, 2 wk
Irnich et al[22]	• DN • Acupuncture (nonlocalized; needles inserted at distant points) • Sham laser acupuncture	• Pain with motion (VAS) • CS ROM (custom device) • Change of general complaints (−5 to +5 scale)	Immediate (15-30 min)
Ilbuldu et al[21]	• DN (once per wk for 4 wk) • Laser (12 times over 4 wk) • Sham laser (12 times over 4 wk) • All groups did stretching exercises	• Pain (VAS) (at rest and with activity) • Pressure pain threshold and pain tolerance (algometry) • Analgesic use • CS ROM (goniometry) • Nottingham Health Profile	1 mo, 6 mo
DiLorenzo et al[9]	• DN (4 times, every 5-7 d) • Rehabilitation (external support, positioning, exercise)	• Pain (VAS) • Rivermead Mobility Index	9, 15, and 21 d
Kamanli et al[26]	• DN • Lidocaine injection • Botulinum toxin injection	• Pain score (0-3 numeric pain rating on palpation) • Pressure pain threshold (algometry) • Pain (VAS) • Fatigue (VAS) • Work disability (VAS) • CS ROM (goniometry) • Nottingham Health Profile • Hamilton Anxiety Scale and Hamilton Depression Inventory	1 mo
Ga et al[15]	• DN • IMS (modified DN technique) of MTrPs and C3-5 multifidi • Both groups treated once per wk over 3 wk	• Pain (VAS; Wong-Baker FACES scale) • Pressure pain threshold (pain rating on palpation) • Geriatric Depression Scale (short form) • CS ROM (goniometry)	Prior to treatment on 4 dates over 4 wk, Geriatric Depression Scale (short form) at wk 0 and wk 4
Hsieh et al[20]	• DN • Control: contralateral side of same subjects	• Shoulder internal rotation ROM (goniometry) • Pain (VAS) • Pressure pain threshold (algometry)	Immediate
Itoh et al[23]	• DN • DN on nontender points • Traditional acupuncture • Sham acupuncture • All groups treated 6 times over 7 wk	• Pain (VAS) • Neck Disability Index	Weekly over 12 wk
Ay et al[1]	• DN • Lidocaine injection • Both groups did stretching exercises	• Pain (VAS) • CS ROM (goniometry) • Beck Depression Inventory	4 wk, 12 wk
Tsai et al[43]	• DN (of extensor carpi radialis MTrP) • Sham needling	• Pain (0-10 numeric scale) • Pressure pain threshold (algometry) • CS ROM (goniometry)	Immediate
Tekin et al[39]	• DN • Sham needling	• Pain (VAS) • Quality of life (SF-36)	After first session (immediate), 4 wk

Abbreviations: CS, cervical spine; DN, dry needling; IMS, intramuscular stimulation; MTrP, myofascial trigger point; ROM, range of motion; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; VAS, visual analog scale.
**Unless otherwise noted, DN and injections were performed at MTrP sites and were done at 1 session.*

TABLE 4 Summary of Key Findings, Quality Scores, and Level of Evidence by Study

Study	Key Findings	Quality/Level of Evidence*
Hong[17]	• Decreased pain immediately and at 2 wk in both groups (when an LTR was elicited), and immediately in lidocaine injection group even if no LTR was elicited ($P<.05$). Between groups, greater decrease in pain in lidocaine injection group at 2 wk ($P<.05$) • Improved pressure pain threshold immediately and at 2 wk in both groups (when an LTR was elicited) ($P<.05$) • Improved CS ROM immediately and at 2 wk in lidocaine injection group (when an LTR was elicited) and in DN group immediately (when an LTR was elicited) ($P<.05$)	30/1b
Chu[4]	• Greater percentage of subjects with pain relief in DN group compared to control (treatment of distal-site DN) group ($P<.0001$) • Decreased number of tender MTrPs in DN group compared to control (treatment of distal-site DN) group immediately after treatment	23/2b
Irnich et al[22]	• Decreased pain in nonlocalized acupuncture group ($P<.001$) • Improved CS ROM in DN group ($P<.05$) and nonlocalized acupuncture group ($P<.05$) • Improvement in rating of general complaints in nonlocalized acupuncture group compared to DN group or sham laser group	39/1b
Ilbuldu et al[21]	• Improved CS flexion in DN group compared to laser group at 1 mo • Improved CS extension and lateral flexion in laser group compared to DN group ($P<.001$ for both) or sham laser group ($P<.001$, $P<.01$, respectively) at 1 mo • Decreased pain in laser group at rest ($P<.05$) and with activity ($P<.001$) compared to DN group or sham laser group at 1 mo • Improved pressure pain threshold in laser group compared to DN group or sham laser group ($P<.001$ for both) at 1 mo • Improved health profile scores in laser group compared to DN group or sham laser group ($P<.05$ for both) at 1 mo	36/1b
DiLorenzo et al[9]	• Decreased shoulder pain in both DN and rehabilitation groups on day 9, 15, and 21 • Greater decrease in pain in DN group compared to rehabilitation group at day 9 and 21	35/1b
Kamanli et al[26]	• Improved pain score (all groups) ($P<.05$) • Improved pressure pain threshold (all groups) ($P<.05$); greater decrease in lidocaine injection group ($P<.016$) • Improved fatigue and work disability in lidocaine injection and botulinum injection groups ($P<.05$) • Improved CS ROM (all groups) ($P<.05$) • Improved health profile score in lidocaine injection and botulinum toxin groups ($P<.05$) • Improved anxiety and depression scale scores in botulinum toxin group ($P<.05$)	37/1b
Ga et al[15]	• Decreased pain (both groups) at 28 d ($P<.001$) • Improved pressure pain threshold (both groups) at 28 d ($P<.001$) • Improved depression scale score at 28 d in IMS group ($P = .024$) • Improved CS ROM (both groups, except extension in DN group) at 28 d ($P<.012$)	39/1b
Hsieh et al[20]	• Improved shoulder ROM compared to untreated side ($P<.01$) • Decreased pain compared to untreated side ($P<.001$) • Improved pressure pain threshold compared to untreated side ($P<.01$)	26/1b
Itoh et al[23]	• Decreased pain in DN group at 3 wk and subsequent intervals compared to pretreatment ($P<.05$) • Less pain in DN group compared to other groups at wk 9-12 ($P<.01$) • Improved NDI score in DN group at wk 3-12 ($P<.01$) • Improved NDI in DN compared to other groups at wk 9 and 12 ($P<.01$)	35/1b
Ay et al[1]	• Decreased pain (both groups) at 4 wk and 12 wk ($P<.001$) • Improved CS ROM (both groups) at 4 wk and 12 wk ($P<.05$) • Improved depression scale scores (both groups) at 4 wk and 12 wk ($P<.001$) • No significant differences between groups	34/1b
Tsai et al[43]	• Decreased pain in DN group ($P<.05$) compared to sham needling • Improved pressure pain threshold in DN group ($P<.05$) compared to sham needling • Improved CS ROM sidebending in DN group ($P<.05$) compared to sham needling	37/1b
Tekin et al[39]	• Decreased pain in DN group compared to sham needling after first treatment (immediate) ($P = .034$) and at 4 wk ($P<.001$) • Improved QoL scores at 4 wk in DN group • Less medication use (paracetamol) in DN group at 4 wk ($P<.01$)	40/1b

Abbreviations: CS, cervical spine; DN, dry needling (directed to MTrP); IMS, intramuscular stimulation; LTR, localized twitch response; MTrP, myofascial trigger point; NDI, Neck Disability Index; QoL, quality of life (measured with Turkish version of Medical Outcomes Study 36-Item Short-Form Health Survey); ROM, range of motion.

**MacDermid Quality Checklist score (range, 0-48), with higher scores reflecting greater internal validity.[28] Level-of-evidence ratings were assigned as described by Sackett et al.[34]*

TABLE 5 MacDermid Quality Checklist Scores for the Individual Items

	Item																							
Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
Hong[17]	2	2	1	2	1	1	1	2	1	2	0	1	2	0	2	1	2	1	1	1	1	1	0	2	30
Chu[4]	1	1	1	2	1	1	1	0	1	1	0	0	2	1	1	1	1	0	2	1	2	0	1	1	23
Irnich et al[22]	2	1	2	2	2	1	1	2	1	2	0	2	2	2	2	2	1	0	2	2	2	2	2	2	39
Ilbuldu et al[21]	2	2	2	2	1	1	1	2	1	2	0	2	1	0	2	2	2	2	2	1	1	2	2	1	36
DiLorenzo et al[9]	2	2	2	2	1	1	1	0	1	2	0	2	2	0	2	2	2	1	2	1	2	1	2	2	35
Kamanli et al[26]	2	2	2	2	1	1	1	0	1	2	0	2	2	1	2	2	2	1	2	2	1	2	2	2	37
Ga et al[15]	2	2	2	2	1	2	1	0	1	2	0	2	2	1	2	2	2	2	2	2	1	2	2	2	39
Hsieh et al[20]	2	0	2	2	0	1	1	0	1	1	0	2	1	0	0	2	1	1	2	1	2	2	0	2	26
Itoh et al[23]	2	2	2	2	1	2	1	2	1	2	0	1	2	0	2	2	1	2	2	1	1	0	2	2	35
Ay et al[1]	2	2	2	2	2	1	1	0	1	2	0	2	2	0	2	1	1	2	2	2	2	2	0	1	34
Tsai et al[43]	2	2	1	2	2	2	1	2	1	2	0	2	2	0	2	2	2	0	2	2	1	2	1	2	37
Tekin et al[39]	2	2	2	2	2	2	1	2	1	2	1	1	2	2	2	2	2	1	2	2	1	1	1	2	40

TABLE 6 Summary of Key Methodological Issues and Outcomes by Study

Study	True Control Group (Sham or Placebo)	Examiner Blinded to Group Allocation	Sample Size Justified by Power Analysis	DN Group: Effectiveness for Pain Reduction (Statistical Significance)	Clinical Meaningfulness of Magnitude of Pain Reduction (MCID) Discussed in Article
Hong[17]	No	No	No	Yes	No
Chu[4]	Yes	?*	No	Yes	No
Irnich et al[22]	Yes	Yes	No	Yes	Yes
Ilbuldu et al[21]	Yes	?*	No	Yes	No
DiLorenzo et al[9]	No	No	No	Yes	No
Kamanli et al[26]	No	?*	No	Yes	No
Ga et al[15]	No	Yes	No	Yes	No
Hsieh et al[20]	No†	?*	No	Yes	No
Itoh et al[23]	Yes	?*	No	Yes	No
Ay et al[1]	No	?*	No	Yes	No
Tsai et al[43]	Yes	Yes	No	Yes	No
Tekin et al[39]	Yes	Yes	Yes	Yes	No

Abbreviations: DN, dry needling; MCID, minimal clinically important difference.
**Authors did not provide adequate information for reviewers to assess whether the examiner was blinded to group allocation.*
†Hsieh et al[20] used the contralateral side of the same subjects as a "control group"; there was not a separate control group of participants.

and 1.48-2.15, respectively). In the study by DiLorenzo et al,[9] in which dry needling was compared to rehabilitation, the raw between-group effect size at approximately 4 weeks approached clinical meaningfulness (1.81 VAS points). The raw between-group effect size between groups at 4 weeks was clinically meaningful (2.73-3.98 VAS points) in the study by Itoh et al,[23] where dry needling was compared to dry needling of nontender points or to acupuncture. In the studies that favored the comparison ("other") treatment, only Kamanli et al[26] reported clinically meaningful raw between-group effect sizes at 4 weeks (2.44 VAS points favoring botulinum toxin injection and 3.17 VAS points favoring lidocaine injection), with corresponding large[7] treatment effect sizes (0.83 and 1.08, respectively). Ay et al[1] also reported a large effect favoring lidocaine injection over dry needling (3.30), but the raw between-group effect size of 1.55 VAS points (at 4 weeks) was of questionable clinical meaningfulness.

Ilbuldu et al[21] reported statistical significance and a moderate[7] effect size (0.71) favoring laser over dry needling at 4 weeks, but meta-analysis results

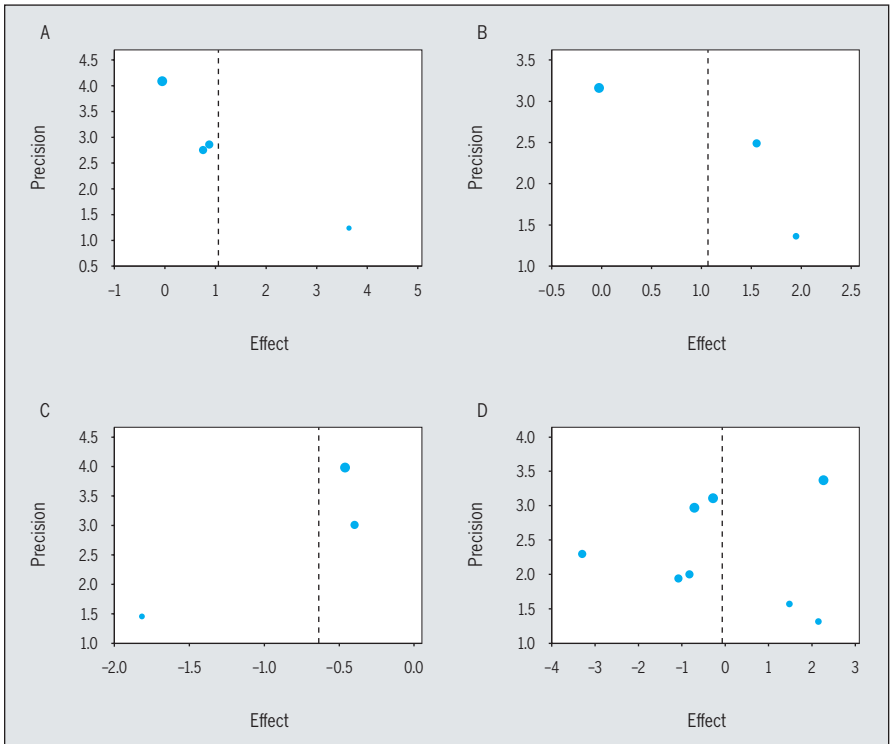


FIGURE 2. Funnel plots for meta-analyses showing (A) dry needling compared to sham or control immediately after treatment, (B) dry needling compared to sham or control at approximately 4 weeks, (C) dry needling compared to other treatment immediately after treatment, (D) dry needling compared to other treatment at approximately 4 weeks. The diameter of the circles represents the standardized mean difference of each study, with larger diameters corresponding to larger standardized mean differences.

showed a wide 95% CI that crossed the line of no difference. The raw between-group effect size at 4 weeks was 1.66 VAS points (favoring laser), which approaches clinical meaningfulness. Ga et al[15] found no difference between dry needling and intramuscular stimulation. However, intramuscular stimulation is very similar to dry needling, and therefore the lack of difference was expected.

Publication Bias

Funnel plots (**FIGURE 2**) were created to determine the risk of publication bias for the 4 separate meta-analyses. The funnel plots for dry needling compared to sham or control for both immediate effects and at 4 weeks, as well as the funnel plot for the immediate effects of dry needling compared to other treatments, were asymmetrical, demonstrating a risk for publication bias. The funnel plot for dry needling compared to other treatments at 4 weeks was symmetrical, demonstrating a lower likelihood for publication bias.

DISCUSSION

Interpretation of the collective body of results of the studies reviewed is complicated due to the variance in comparison groups, control conditions, dosage of intervention, outcomes, outcome measurement tools, times to outcomes, and internal validity (quality) of the studies. The studies that have been published to date were conducive to the 4 meta-analyses described, but the high heterogeneity for all analyses performed requires special consideration.

Dry Needling Compared to Sham or Control, Immediate Effects

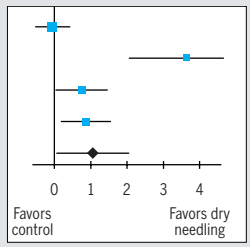
In studies that compared dry needling to sham or control, high heterogeneity of pooled results (I^2 = 86.3%) was likely attributable to the small number of studies, variance across studies in the conditions for the sham or control group, and differences in inclusion criteria. Hsieh et al[20] used the same subject's uninvolved side as the control, Irnich et al[22] used sham laser acupuncture, and Tsai et al[43] and Tekin et al[39] used sham needling. Despite the high heterogeneity, 3 of the 4 studies provided evidence of a large[7] effect of dry needling compared to sham or control. However, such results should be interpreted with caution, as raw between-group differences in pain scores in 2 of these studies were of questionable clinical meaningfulness.[39,43] The data by Chu[4] were not included in the meta-analysis because they could not be extracted in a way conducive to inclusion in the meta-analysis. Chu[4] reported a greater percentage of subjects with pain relief for the dry-needling group compared to the control group (P<.0001). However, the internal validity of that study was the weakest of the 12 studies reviewed, with a score of 23 points on the MacDermid Quality Checklist. Additional high-quality randomized controlled trials are needed to further elucidate the immediate effects on pain of dry needling compared to a sham or placebo.

Dry Needling Compared to Sham or Control at 4 Weeks

At 4 weeks, 2 studies[23,39] provided evidence of a strong effect of dry needling compared to a sham or control, with clinically meaningful raw between-group effect sizes. Although the overall effect was strong, it was confounded by a wide 95% CI due to the equivocal findings of the study by Ilbuldu et al.[21] It was unclear if the examiners in the Ilbuldu et al[21] study were blinded, and a low number of subjects (n = 40) without a priori power analysis might have contributed to the finding of a lack of difference between groups (type II error). The high heterogeneity for this meta-analysis (84.2%) may, in part, be explained by the small number of stud-

Immediate Effects

Study	Dry Needling n	Dry Needling Mean ± SD*	Control/Sham n	Control/Sham Mean ± SD*	Weight	Treatment Effect, Random†
Irnich et al[22]	33	2.92 ± 2.19	34	2.8 ± 1.94	49.2%	−0.06 (−0.53, 0.42)
Hsieh et al[20]	14	2.8 ± 1.1	14	6.8 ± 1.3	4.5%	3.64 (2.05, 5.22)
Tsai et al[43]	17	5.2 ± 1.6	18	6.4 ± 1.00	22.3%	0.75 (0.04, 1.46)
Tekin et al[39]	22	4.0 ± 1.6	17	5.4 ± 1.6	24.0%	0.88 (0.19, 1.56)
Total	86		83		100%	1.06 (0.05, 2.06)

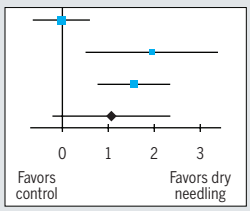


**Values are pain scores immediately posttreatment. Outcome measure was pain rating on a 0-to-10 visual analog scale.*
†Values are standardized mean difference (95% confidence interval). In the plots, the squares represent point estimates of treatment effect; bigger squares indicate larger samples; the diamond represents the pooled treatment effect; the horizontal lines are 95% confidence intervals; and the vertical line represents no difference. Tests for heterogeneity: $\tau^2 = 0.855$, df = 3.0 (P<.001), $I^2 = 86.3\%$.

FIGURE 3. Forest plot for dry needling compared to sham or control.

Approximately 4 Weeks

Study	Dry Needling n	Dry Needling Mean ± SD*	Control/Sham n	Control/Sham Mean ± SD*	Weight	Treatment Effect, Random†
Ilbuldu et al[21]	20	3.71 ± 2.33	20	3.65 ± 2.03	55.4%	−0.03 (−0.65, 0.59)
Itoh et al[23]	8	1.86 ± 1.85	7	5.46 ± 2.0	10.3%	1.95 (0.51, 3.38)
Tekin et al[39]	22	2.2 ± 2.0	17	5.3 ± 1.8	34.3%	1.55 (0.76, 2.34)
Total	50		44		100%	1.07 (−0.21, 2.35)



**Values are pain scores immediately posttreatment. Outcome measure was pain rating on a 0-to-10 visual analog scale.*
†Values are standardized mean difference (95% confidence interval). In the plots, the squares represent point estimates of treatment effect; bigger squares indicate larger samples; the diamond represents the pooled treatment effect; the horizontal lines are 95% confidence intervals; and the vertical line represents no difference. Tests for heterogeneity: $\tau^2 = 1.042$, df = 2.0 (P = .002), $I^2 = 84.2\%$.

FIGURE 4. Forest plot for dry needling compared to sham or control.

ies and the variance in sham or control conditions (eg, Ilbuldu et al[21] used sham laser, Itoh et al[23] used sham acupuncture, and Tekin et al[39] used sham needling). In addition, there were differences in the inclusion criteria of these studies. More high-quality randomized controlled trials are needed to further elucidate the effects of dry needling compared to sham or placebo on pain at 4 weeks and other clinically relevant time points.

Dry Needling Compared to Other Treatments, Immediate Effects

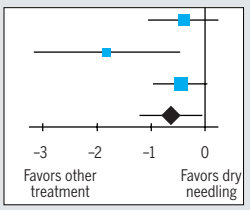
Based on 2 studies,[17,22] dry needling is not superior to lidocaine injection or nonlocal acupuncture to decrease pain immediately after treatment. One study[17] provided evidence that a lidocaine injection had a greater effect on pain, approaching clinical meaningfulness, when the treatments did not induce a localized twitch response. When a localized twitch response was associated with the treatments, the difference between lidocaine injection and dry needling was neither significant nor clinically meaningful. This finding supports the theory that a localized twitch response is an important component of effective dry needling. The high heterogeneity (90%) in this meta-analysis is partly explained by the small number of studies and the variety in comparison treatments: Hong[17] used lidocaine injection and Irnich et al[22] used nonlocal acupuncture. In addition, there were some differences in the subject inclusion criteria between these studies.

Dry Needling Compared to Other Treatments at Approximately 4 Weeks

Based on 6 studies, dry needling is not superior, in general, to the other treatments studied to reduce pain at 4 weeks. However, the overall small[7] effect (−0.07, favoring other treatment) must be viewed with caution because of the high heterogeneity (95%) attributable to the variety of other treatments, dosages of dry needling, and diagnoses of the subjects. Two studies[1,26] provided evidence that a lidocaine injection or botulinum toxin injection had a greater effect than dry needling on reducing pain, with raw be-

Immediate Effects

Study (Comparison Group)	Dry Needling n	Dry Needling Mean ± SD*	Other Treatment n	Other Treatment Mean ± SD*	Weight	Treatment Effect, Random†
Hong[17] (lidocaine with LTR)	15	1.00 ± 1.46	26	0.42 ± 0.49	33.4%	−0.40 (−1.05, 0.26)
Hong[17] (lidocaine without LTR)	8	7.13 ± 0.93	9	5.44 ± 0.83	7.8%	−1.82 (−3.16, 0.47)
Irnich et al[22] (nonlocal acupuncture)	33	2.92 ± 2.19	34	1.91 ± 1.61	58.7%	−0.46 (−0.95, 0.03)
Total	56		69		100%	−0.64 (−1.21, −0.06)

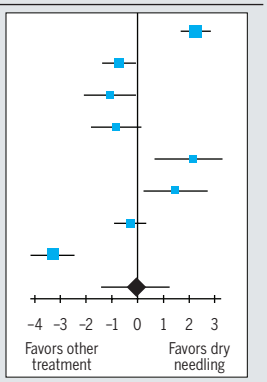


Abbreviation: LTR, localized twitch response.
**Values are pain scores immediately posttreatment. Outcome measure was pain rating on a 0-to-10 visual analog scale.*
†Values are standardized mean difference (95% confidence interval). In the plots, the squares represent point estimates of treatment effect; bigger squares indicate larger samples; the diamond represents the pooled treatment effect; the horizontal lines are 95% confidence intervals; and the vertical line represents no difference. Tests for heterogeneity: $\tau^2 = 1.633$, df = 3.0 (P<.001), $I^2 = 90.0\%$.

FIGURE 5. Forest plot for dry needling compared to other treatments.

Approximately 4 Weeks

Study (Comparison Group)	Dry Needling n	Dry Needling Mean ± SD*	Other Treatment n	Other Treatment Mean ± SD*	Weight	Treatment Effect, Random†
DiLorenzo et al[9] (rehabilitation)	54	3.15 ± 0.8	47	4.96 ± 1.12	24.1%	2.26 (1.68, 2.84)
Ilbuldu et al[21] (laser)	20	3.71 ± 2.33	20	2.05 ± 1.43	18.7%	−0.71 (−1.37, 0.05)
Kamanli et al[26] (lidocaine)	10	5.12 ± 2.94	10	1.95 ± 1.67	8.0%	−1.08 (−2.09, 0.07)
Kamanli et al[26] (botulinum)	10	5.12 ± 2.94	9	2.68 ± 1.04	8.5%	−0.83 (−1.81, 0.15)
Itoh et al[23] (dry needling nontender)	8	1.86 ± 1.85	8	5.84 ± 1.89	3.7%	2.15 (0.66, 3.65)
Itoh et al[23] (acupuncture)	8	1.86 ± 1.85	8	4.59 ± 1.75	5.2%	1.48 (0.23, 2.72)
Ga et al[15] (intramuscular stimulation)	18	3.82 ± 2.47	22	3.11 ± 2.01	20.5%	−0.29 (−0.92, 0.34)
Ay et al[1] (lidocaine)	40	3.82 ± 0.47	40	2.27 ± 0.98	11.2%	−3.30 (−4.15, 2.45)
Total	168		164		100%	−0.07 (−1.39, 1.26)



**Values are pain scores immediately posttreatment. Outcome measure was pain rating on a 0-to-10 visual analog scale.*
†Values are standardized mean difference (95% confidence interval). In the plots, the squares represent point estimates of treatment effect; bigger squares indicate larger samples; the diamond represents the pooled treatment effect; the horizontal lines are 95% confidence intervals; and the vertical line represents no difference. Tests for heterogeneity: $\tau^2 = 3.417$, df = 7.0 (P<.001), $I^2 = 95.0\%$.

FIGURE 6. Forest plot for dry needling compared to other treatments.

tween-group effect sizes that were clinically meaningful. When dry needling was compared to standard rehabilitation in subjects with shoulder pain following a cerebrovascular accident,[9] dry needling was favored (with a strong effect) over rehabilitation, with a raw between-group effect size that approached clinical meaningfulness. In another study of patients with neck pain,[23] dry needling was favored (with a large[7] effect) over dry needling of nontender points or acupuncture, with a raw between-group effect size for pain scores that was clinically meaningful. Despite the high heterogeneity of this meta-analysis, the mixed results, and lack of overall effect, close inspection of the design of individual studies suggests that dry needling may be superior to other treatments, depending on the other treatment and patient diagnoses. However, when dry needling is compared to lidocaine injection in patients with MTrPs in the neck, upper back, or shoulder,[26] lidocaine injection may be superior.

In some cases, combined interventions might have influenced the results regarding the relative contribution of dry needling (or other interventions) to treatment effects. For example, in the studies by Ay et al[1] and Ilbuldu et al,[21] subjects in all groups performed stretching exercises. In these studies, it is possible that the stretching exercises contributed to the treatment effects.

Importance of the Localized Twitch Response in Dry Needling

Many descriptions of dry-needling

techniques emphasize the potential importance of a localized twitch response during treatment. Often, the definition of MPS includes the phenomenon of a localized twitch response in response to stimulation of an MTrP. Of the 12 studies we reviewed, 8 clearly described whether a localized twitch response was desired or elicited upon dry needling of a subject's MTrP.[1,15,17,20,22,23,39,43] In general, provocation of a localized twitch response was described as a necessary component of the dry-needling technique. In a study comparing dry needling with lidocaine injection, Hong[17] noted that a lack of localized twitch response in either group was associated with little change in pain, tenderness, or range of motion. Ga et al[15] compared dry needling with intramuscular stimulation, a variation of dry needling that involves "grasping and winding up" of the muscle (by the needle) and a "stronger stimulation" response. Localized twitch response rates were not different between the groups, with nearly all participants demonstrating localized twitch responses during treatment. Both groups had decreased pain and improved pain pressure threshold at 4 weeks. Further research is needed to clarify whether a localized twitch response is a valid predictor of success or a necessary component of dry-needling treatment in patients with upper-quarter MPS. However, it does appear that provocation of a localized twitch response is common with the dry-needling technique.

Limitations

The limitations of this review include the use of only 1 search term (*dry needling*). However, based on the hand search of references from 2 other systematic reviews,[8,41] it is unlikely that any relevant articles were overlooked. Our methods did not permit us to calculate concordance statistics for data extraction. The authors recognize the value of this information in retrospect but cannot adjust for this aspect of the methodology.

Other tools, such as the PEDro scale,[29] are available to rate the internal validity of randomized controlled trials. The MacDermid Quality Checklist[28] afforded us the opportunity to closely analyze the design and methods of the studies; however, the reliability of the MacDermid Quality Checklist has not been well described in the literature, which may be a limitation. The interpretation of study findings was based on meta-analysis results and consideration of raw difference in pain scores between groups. Any potential instability of the MacDermid Quality Checklist, in terms of reliability, did not have an effect on our conclusions or recommendations. Of great concern was the high heterogeneity in each of the 4 meta-analyses we performed. In general, such high heterogeneity may bring into question whether it is even appropriate to perform a meta-analysis. However, our discussion of likely reasons for this high heterogeneity and our consideration of findings of individual studies provide a rationale to pursue the meta-analyses.

Another limitation of this review is the evidence of publication bias in the asymmetrical funnel plots (**FIGURE 2**) for dry needling compared to sham or control for both immediate effects and at 4 weeks, as well as dry needling compared to other treatments for immediate effects. Publication bias may result from a lower publication rate of negative results, exclusion of publications in foreign languages, or an inability to access work not submitted for publication.[6] The authors did not attempt to locate unpublished research or research in foreign languages examining the impact of dry needling on patients with upper-quarter MPS. However, funnel-plot asymmetry can be influenced by the heterogeneity of studies included in a meta-analysis[40] and can be challenging to interpret when the number of studies included is small.[6] Thus, the asymmetrical funnel plots in this study cannot be interpreted conclusively due to the small number of studies included (range, 3-4) as well as the heterogeneity of those studies (range, 84.2%-90%).

Because most studies of longer-term effects described outcomes at approximately 4 weeks, we chose that time point for meta-analysis. However, 2 studies reported outcomes up to 12 weeks.[1,23] Ay et al[1] found no between-group differences at 12 weeks, whereas Itoh et al[23] reported less pain in the dry needling group at 12 weeks. Although further study of the long-term effects of dry needling is needed, we feel that the time points addressed in this review (immediate and 4 weeks) are of great value, as the goal of dry needling is rapid relief of pain so that patients can be progressed to other forms of therapy, such as exercise and postural correction. Several studies in this review reported statistical superiority of dry needling compared to sham or other outcomes, including pain pressure threshold,[17,43] range of motion,[17,22,43] self-reported disability,[23] and number of tender MTrPs.[4] A limitation of this systematic review was that it did not provide analyses of these secondary variables.

All studies reviewed had methodological limitations, which were extensive in some cases. Key methodological limitations of the studies are summarized in **TABLE 6**. Only 1 study[22] provided a cursory interpretation of pain reduction from the perspective of minimal clinically important difference. The parameters of dry-needling treatment technique varied across studies. The studies by Chu[4] and Ga et al[15] referred to intramuscular stimulation as a consideration in dry needling, with Ga et al[15] actually using intramuscular stimulation as a comparison group. Times to outcomes varied across studies, with 4 reporting only immediate effects.[17,20,22,43] The immediate effects on pain are of interest, but longer-term effects on a comprehensive group of functional and clinically relevant measures should be considered when designing future studies. In general, future studies should be carefully designed to avoid many of the methodological limitations found in the studies published to date.

The external validity of several of the studies is limited due to the age ranges and gender bias of the sample. Four studies[9,15,20,23] focused on an older sample,

while Ilbuldu et al's[21] sample of 18- to 50-year-old adults was composed of female subjects only. Furthermore, there was variance in the causes or diagnoses explaining the upper-quarter myofascial pain in the studies reviewed (as described under the inclusion criteria in **TABLE 1**). For example, the findings of DiLorenzo et al[9] are relevant only for patients with shoulder pain who have suffered a recent stroke.

CONCLUSION

Based on the studies published to date, we recommend (grade A)[34] dry needling, compared to sham or placebo treatment, for immediate reduction of pain in patients with upper-quarter MPS, based on the results of 3 individual randomized controlled trials[20,39,43] included in the meta-analysis of 4 studies and on the overall effect size derived from that meta-analysis. We cautiously recommend (grade A)[34] dry needling, compared to sham or placebo treatment, for reduction of pain at 4 weeks in patients with upper-quarter MPS, based on results of 2 individual randomized controlled trials[23,39] included in a meta-analysis of 3 studies. However, it must be noted that the overall effect of the 3 studies combined is ambiguous due to a large CI of the otherwise strong effect size. Future studies should be critically reviewed to inform the evolution of these recommendations. Additional research with high-quality study design and appropriate choices of comparative treatments will aid in developing more conclusive evidence for dry needling. More evidence is needed to establish efficacy of dry needling compared to other interventions for upper-quarter MPS. However, it appears that injection with lidocaine may be superior to dry needling for pain reduction both immediately after treatment and at 4 weeks. ◉

KEY POINTS

FINDINGS: A large immediate effect of dry needling compared to sham or placebo to decrease pain in individuals with upper-quarter MPS was found in 3 of the 4 studies, with raw between-group effect sizes ranging from 1.2 to 4.9 points on a pain VAS. At 4 weeks, a large effect favoring dry needling was tempered by a large CI, but findings from 2 cohorts showed a large effect favoring dry needling, with clinically meaningful raw between-group effect sizes ranging from 3.1 to 3.6 points on a pain VAS. Several studies have compared dry needling to other treatments, with outcomes varying from no difference to a difference either favoring dry needling or the alternate intervention.

IMPLICATIONS: We recommend (grade A)[34] dry needling for immediate reduction of pain in patients with upper-quarter MPS, and cautiously recommend (grade A)[34] dry needling for reduction of pain at 4 weeks in patients with upper-quarter MPS.

CAUTION: The limited number of studies performed to date, combined with methodological flaws in many of the studies, prompts caution in interpreting the results of the meta-analyses performed here. Variance in study factors, such as control conditions and comparison treatments, contributed to high heterogeneity in the results of the meta-analyses.

REFERENCES

1. Ay S, Evcik D, Tur BS. Comparison of injection methods in myofascial pain syndrome: a randomized controlled trial. *Clin Rheumatol*. 2010;29:19-23. http://dx.doi.org/10.1007/s10067-009-1307-8
2. Baldry PE. *Myofascial Pain and Fibromyalgia Syndromes: A Clinical Guide to Diagnosis and Management*. Edinburgh, UK: Churchill Livingstone; 2001.
3. Brudvig TJ, Kulkarni H, Shah S. The effect of therapeutic exercise and mobilization on patients with shoulder dysfunction: a systematic review with meta-analysis. *J Orthop Sports Phys Ther*. 2011;41:734-748. http://dx.doi.org/10.2519/jospt.2011.3440
4. Chu J. Does EMG (dry needling) reduce myofascial pain symptoms due to cervical nerve root irritation? *Electromyogr Clin Neurophysiol*. 1997;37:259-272.
5. Cleland JA, Childs JD, Whitman JM. Psychometric properties of the Neck Disability Index and numeric pain rating scale in patients with mechanical neck pain. *Arch Phys Med Rehabil*. 2008;89:69-74. http://dx.doi.org/10.1016/j.apmr.2007.08.126
6. Cleophas TJ, Zwinderman AH. Meta-analysis. *Circulation*. 2007;115:2870-2875. http://dx.doi.org/10.1161/CIRCULATIONAHA.105.594960
7. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.
8. Cummings TM, White AR. Needling therapies in the management of myofascial trigger point pain: a systematic review. *Arch Phys Med Rehabil*. 2001;82:986-992. http://dx.doi.org/10.1053/apmr.2001.24023
9. DiLorenzo L, Traballesi M, Morelli D, et al. Hemiparetic shoulder pain syndrome treated with deep dry needling during early rehabilitation: a prospective, open-label, randomized investigation. *J Musculoskelet Pain*. 2004;12:25-34.
10. Dommerholt J. Dry needling in orthopedic physical therapy practice. *Orthop Pract*. 2004;16:15-20.
11. Dommerholt J, del Moral OM, Gröbli C. Trigger point dry needling. *J Man Manip Ther*. 2006;14:E70-E87.
12. Farrar JT, Young JP, Jr., LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain*. 2001;94:149-158.
13. Fricton JR, Kroening R, Haley D, Siegert R. Myofascial pain syndrome of the head and neck: a review of clinical characteristics of 164 patients. *Oral Surg Oral Med Oral Pathol*. 1985;60:615-623.
14. Furlan AD, van Tulder M, Cherkin D, et al. Acupuncture and dry-needling for low back pain: an updated systematic review within the framework of the Cochrane Collaboration. *Spine (Phila Pa 1976)*. 2005;30:944-963.
15. Ga H, Choi JH, Park CH, Yoon HJ. Dry needling of trigger points with and without paraspinal needling in myofascial pain syndromes in elderly patients. *J Altern Complement Med*. 2007;13:617-624. http://dx.doi.org/10.1089/acm.2006.6371
16. Hong CZ. Considerations and recommendations regarding myofascial trigger point injection. *J Musculoskelet Pain*. 1994;2:29-59.
17. Hong CZ. Lidocaine injection versus dry needling to myofascial trigger point. The importance of the local twitch response. *Am J Phys Med Rehabil*. 1994;73:256-263.
18. Hong CZ. Myofascial trigger point injection. *Crit Rev Phys Rehabil Med*. 1993;5:203-217.
19. Hong CZ, Simons DG. Pathophysiologic and electrophysiologic mechanisms of myofascial trigger points. *Arch Phys Med Rehabil*. 1998;79:863-872.
20. Hsieh YL, Kao MJ, Kuan TS, Chen SM, Chen

JT, Hong CZ. Dry needling to a key myofascial trigger point may reduce the irritability of satellite MTrPs. *Am J Phys Med Rehabil*. 2007;86:397-403. http://dx.doi.org/10.1097/PHM.0b013e31804a554d
21. Ilbuldu E, Cakmak A, Disci R, Aydin R. Comparison of laser, dry needling, and placebo laser treatments in myofascial pain syndrome. *Photomed Laser Surg*. 2004;22:306-311. http://dx.doi.org/10.1089/1549541041797878
22. Irnich D, Behrens N, Gleditsch JM, et al. Immediate effects of dry needling and acupuncture at distant points in chronic neck pain: results of a randomized, double-blind, sham-controlled crossover trial. *Pain*. 2002;99:83-89.
23. Itoh K, Katsumi Y, Hirota S, Kitakoji H. Randomised trial of trigger point acupuncture compared with other acupuncture for treatment of chronic neck pain. *Complement Ther Med*. 2007;15:172-179. http://dx.doi.org/10.1016/j.ctim.2006.05.003
24. Iversen MD, Choudhary VR, Patel SC. Therapeutic exercise and manual therapy for persons with lumbar spinal stenosis. *Int J Clin Rheumatol*. 2010;5:425-437. http://dx.doi.org/10.2217/ijr.10.29
25. Kalichman L, Vulfsons S. Dry needling in the management of musculoskeletal pain. *J Am Board Fam Med*. 2010;23:640-646. http://dx.doi.org/10.3122/jabfm.2010.05.090296
26. Kamanli A, Kaya A, Ardicoglu O, Ozgocmen S, Zengin FO, Bayik Y. Comparison of lidocaine injection, botulinum toxin injection, and dry needling to trigger points in myofascial pain syndrome. *Rheumatol Int*. 2005;25:604-611. http://dx.doi.org/10.1007/s00296-004-0485-6
27. Lavelle ED, Lavelle W, Smith HS. Myofascial trigger points. *Med Clin North Am*. 2007;91:229-239. http://dx.doi.org/10.1016/j.mcna.2006.12.004
28. MacDermid JC. An introduction to evidence-based practice for hand therapists. *J Hand Ther*. 2004;17:105-117. http://dx.doi.org/10.1197/j.jht.2004.02.001
29. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther*. 2003;83:713-721.
30. Melzack R. Myofascial trigger points: relation to acupuncture and mechanisms of pain. *Arch Phys Med Rehabil*. 1981;62:114-117.
31. Michener LA, Snyder AR, Leggin BG. Responsiveness of the numeric pain rating scale in patients with shoulder pain and the effect of surgical status. *J Sport Rehabil*. 2011;20:115-128.
32. Perez-Palomares S, Oliván-Blázquez B, Arnal-Burró AM, et al. Contributions of myofascial pain in diagnosis and treatment of shoulder pain. A randomized control trial. *BMC Musculoskelet Disord*. 2009;10:92. http://dx.doi.org/10.1186/1471-2474-10-92
33. Rosen NB. The myofascial pain syndrome. *Phys Med Rehabil Clin N Am*. 1993;4:41-63.
34. Sackett DL, Straus SE, Richardson WS. *Evidence-Based Medicine: How to Practice and Teach EBM*. 2nd ed. Edinburgh, UK: Churchill Livingstone; 2000.
35. Salaffi F, Stancati A, Silvestri CA, Ciapetti A, Grassi W. Minimal clinically important changes in chronic musculoskeletal pain intensity measured on a numerical rating scale. *Eur J Pain*. 2004;8:283-291. http://dx.doi.org/10.1016/j.ejpain.2003.09.004
36. Simons DG, Travell JG, Simons LS. *Travell & Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual Volume 1: Upper Half of Body*. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 1998.
37. Skootsky SA, Jaeger B, Oye RK. Prevalence of myofascial pain in general internal medicine practice. *West J Med*. 1989;151:157-160.
38. Spadoni GF, Stratford PW, Solomon PE, Wishart LR. The evaluation of change in pain intensity: a comparison of the P4 and single-item numeric pain rating scales. *J Orthop Sports Phys Ther*. 2004;34:187-193. http://dx.doi.org/10.2519/jospt.2004.1157
39. Tekin L, Akarsu S, Durmuş O, Çakar E, Dinçer U, Kiralp MZ. The effect of dry needling in the treatment of myofascial pain syndrome: a randomized double-blinded placebo-controlled trial. *Clin Rheumatol*. 2013;32:309-315. http://dx.doi.org/10.1007/s10067-012-2112-3
40. Terrin N, Schmid CH, Lau J, Olkin I. Adjusting for publication bias in the presence of heterogeneity. *Stat Med*. 2003;22:2113-2126. http://dx.doi.org/10.1002/sim.1461
41. Tough EA, White AR, Cummings TM, Richards SH, Campbell JL. Acupuncture and dry needling in the management of myofascial trigger point pain: a systematic review and meta-analysis of randomised controlled trials. *Eur J Pain*. 2009;13:3-10. http://dx.doi.org/10.1016/j.ejpain.2008.02.006
42. Travell JG, Simons DG. *Myofascial Pain and Dysfunction: The Trigger Point Manual Volume 2: The Lower Extremities*. Media, PA: Williams & Wilkins; 1992.
43. Tsai CT, Hsieh LF, Kuan TS, Kao MJ, Chou LW, Hong CZ. Remote effects of dry needling on the irritability of the myofascial trigger point in the upper trapezius muscle. *Am J Phys Med Rehabil*. 2010;89:133-140. http://dx.doi.org/10.1097/PHM.0b013e3181a5b1bc
44. Venâncio RA, Alencar FGP, Jr., Zamperini C. Different substances and dry-needling injections in patients with myofascial pain and headaches. *Cranio*. 2008;26:96-103.