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Invasive Needling Therapy for Myofascial Pain Syndrome

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by

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Abstract

Myofascial pain syndrome (MPS) is one of the most common musculoskeletal conditions characterized by tight bands of fascia and muscle fibers known as myofascial trigger points (MTrP). Empirical evidence suggests that deactivation of MTrP's is best accomplished with invasive needling therapy such as dry needling, trigger point injections, and Botulinum toxin-A (BTX-A) injections. The objective of this systemic review is to compare the effectiveness of various needling therapies on pain intensity and determine if ultrasound guidance and obtaining a local twitch response (LTR) improves clinical outcomes.

A comprehensive search of five databases including PubMed, Science Direct, Google Scholar, Cochran, and CINHAL was completed. *Keywords* included myofascial pain syndrome, trigger point, trigger point injections, dry needling, local anesthetic, botulinum toxin-A, local twitch response, and ultrasonography

Fifteen studies were included in this systemic review with inconsistent results. All three therapies were shown to be effective for decreasing pain intensity associated with MPS. Research suggests that dry needling and local anesthetics have similar short-term efficacy and are best indicated for treating regions of the shoulder and cervical muscles. Analgesic effects of BTX-A are delayed but may be longer-lasting, especially when treating regions of highly active muscles. Ultrasound guidance improves clinical outcomes by reducing localization errors and adverse events. Obtaining an LTR is inconsistently correlated with short-term pain relief but is not dependent upon it.

Invasive Needling Therapy for Myofascial Pain Syndrome

Introduction

Myofascial pain syndrome (MPS) can be an acute or chronic localized musculoskeletal condition characterized by tight bands of fascia and muscle fibers that elicit referred pain in a predictable pattern when exacerbated by palpation. These tight bands are known as myofascial trigger points (MTrPs), and are associated with debilitating pain, weakness, decreased range of motion, and in some cases may lead to depression and disability. MPS commonly occurs as a result of traumatic musculoskeletal injury, overuse, poor posture, or underlying disease. Although the exact pathophysiology has not been determined, several theories point toward a multifactorial mechanism. Mechanisms include damaged and dysfunctional motor end plates that cause excessive acetylcholine release which binds to receptors to facilitate an influx of sodium resulting in spontaneous depolarization. The damaged sarcoplasmic reticulum causes calcium to be released in excess, initiating cross bridge cycling. Adenosine triphosphate (ATP) is depleted in an unsuccessful attempt to pump calcium back into the sarcoplasmic reticulum for termination of the crossbridge cycle. These muscle fibers remain contracted and compress surrounding capillaries leading to tissue hypoxia, and subsequent release of biochemicals that activate and sensitize nociceptors. Recurrent activation of nociceptors can cause reinforcement in the central nervous system resulting in hypersensitive pain which is more commonly seen with chronic cases of MPS (Bernstein & Shah, 2017).

The diagnosis is made clinically, based on Travell and Simons criteria which involves (a) point tenderness within a taut band of muscle, (b) local twitch response or jump sign upon palpation, (c) exacerbation of pain upon firm pressure, (d) exacerbation of pain with active or passive stretching (Bernstein & Shah, 2017). Treatment of MPS requires deactivation of MTrPs

which can be achieved through invasive or noninvasive therapeutic techniques. This study will focus on invasive therapies comparing dry and wet needling.

Dry needling involves insertion of a hypodermic needle into the MTrP to mechanically disrupt and deactivate the muscle contracture. Trigger point injections are performed in a similar method as dry needling but include an injection of medication, most commonly a local anesthetic such as lidocaine. More recently, botulinum toxin-A has been used as an alternative to local anesthetics for trigger point injections. Other injectates, such as ozone, have been used experimentally.

Statement of Problem

The prevalence of myofascial pain syndrome is unknown due to underdiagnosis but is estimated to account for nearly 30% of general clinic visits for musculoskeletal pain (Ahmed et al., 2019). Untreated acute MPS can result in a process of peripheral and central sensitization. It is important to recognize this condition and initiate treatment before sensitization occurs, resulting in chronic pain and hypersensitivity. Myofascial pain is associated with more frequent clinic and emergency room visits and can lead to misuse of opioids and muscle relaxants which offer minimal therapeutic benefit to patients with MPS. Currently, there are no standardized protocols for treating MPS and there is limited evidence surrounding the efficacy of most recommended therapies (Roldan, Osuagwu, Cardenas-Turanzas, & Huh, 2019). The purpose of this study is to compare the efficacy of various needling therapies on pain intensity and determine if ultrasound guidance and obtaining a local twitch response (LTR) further improves clinical outcomes.

Research Questions

Do trigger point injections provide more pain relief than dry needling in patients with myofascial pain syndrome?

What pharmaceutical agents are most effective for trigger point injections?

Does ultrasound guidance influence the efficacy of trigger point injections when compared to a blind approach?

What is the clinical significance of the local twitch response during dry needling and trigger point injections?

Research Methods

A systemic literature review was performed using the following databases: PubMed, Science Direct, Google Scholar, Cochran, and CINHAL. *Keywords* and MeSH terms used for the search included myofascial pain syndrome, trigger point, trigger point injections, dry needling, local anesthetic, botulinum toxin-A, local twitch response, and ultrasonography. Emphasis was placed on randomized controlled studies. All research was limited to human studies. Clinical trials were all published within the last ten years except for one case-controlled comparison study from 2004. Data was collected from fifteen published articles including six randomized control trials, one controlled observational study, two systemic reviews with meta-analysis, two systemic reviews, one narrative review, one retrospective cohort analysis, one preliminary pilot study, and one quasi-experimental study.

Literature Review

Historically, trigger point injections have been thought to be the most effective treatment method for deactivating MTrPs, and therefore have been adopted as first-line invasive therapy for treating patients with MPS (Nouged et al., 2019). Pharmacologic injectates discussed in the

literature included local anesthetics, corticosteroids, normal saline, botulinum toxin A (BTX-A), and ozone. New research has been done on BTX-A as an alternative injectate for certain cases of MPS (Abboud, Hassin-Baer, Joachim, Givol, & Yahalom, 2017). Based on the suspected pathophysiology of MTrP formation, using a pharmacological injectate should theoretically be more effective in treating pain associated with MPS. However, according to Roldan et al. (2019) the effects of trigger point injections are partly due to manipulation of the needle itself. This proposal has resulted in dry needling becoming increasingly popular for treating patients with MPS, but its clinical efficacy has not yet been well established (Espejo-Antúnez et al, 2017). Themes found within the literature included effectiveness of trigger point injections using local anesthetics, BTX-A injections, and dry needling. Comparison studies of each of these therapies were evaluated with mixed results. The local twitch response, or involuntary muscle fasciculation, is often considered to be an objective sign of MTrP deactivation with invasive needling therapy (Rha, et al., 2011). This typically requires accurate needle insertion directly into the center of the MTrP, which can be difficult to localize with manual palpation. Ultrasound guidance has been suggested to reduce localization errors and improve clinical outcomes in patients treated with trigger point injections (Kang et al., 2019).

Effectiveness of Trigger Point Injections

Local Anesthetics. Nouged et al. (2019) conducted a comprehensive systemic review and meta-analysis of 15 randomized control trials to determine the effectiveness of local anesthetic trigger point injections in treating pain associated with MPS in regions of the head, neck, and shoulders. The number of participants in each study ranged from 20-129 patients with a diagnosis of MPS based on Travell and Simons criteria. Effectiveness was measured by various

pain scales over a period of one to eight weeks. Secondary outcomes included depression scales, pain pressure thresholds, and range of motion.

Six studies that used dry needling as a placebo (a needle connected to a syringe without a physical injection) had improved pain scores at one to four weeks follow-up in the treatment arm that received an injection of local anesthesia (DM = -1.586; 95% CI = -2.926, -0.245; p = 0.20). When evaluating only double blinded studies, the comparison of pain scores between the two arms was similar without statistical significance (95% CI = -4.458, 1.502; p = 0.331). When studies with a high risk of bias were removed from the statistical analysis, there was no evidence that local anesthetics were more effective than placebo needling (p = 0.952). Three double blinded studies that compared local anesthetic injection to placebo injection using normal saline found that visual analog scale (VAS) pain reports were significantly improved in the local anesthetic treatment arm at two to eight weeks follow-up (DM = -0.767; 95% CI = -0.324, -0.210; p = 0.007). Secondary outcomes indicated improved depression scales in three studies (all using different scales) at two to four weeks with local anesthetics, but the results were not statistically significant when compared to placebo (SMD = -0.239; 95% CI = -0.898, 0.419; p = 0.476). There was virtually no difference between treatment and placebo when evaluating pain pressure thresholds or improved range of motion, although both treatment arms reported improvement of these secondary parameters. Interestingly, non-blinded studies showed more significant improvements in patient pain scales when local anesthetics were used, which may indicate a positive psychological effect.

Small sample size was a common limitation of all fifteen studies included. Heterogeneity in the design of the studies, including blinded vs. non-blinded studies, various local anesthetics used, differing controls, various pain scales, and different follow-up periods make it difficult to

determine the true overall effectiveness of local anesthetics. Risk of bias was vetted in the final data analysis, but there were few studies within the review that had a low risk of bias according to Cochrane guidelines.

Local Anesthetics + Corticosteroids. The effectiveness of local anesthetics plus corticosteroid (conventional active drug mixture or CADM) for trigger point injections was evaluated by Roldan et al. (2019) in a randomized, double-blind, controlled trial. Normal saline injection was used as a control. Patient pain reports via standard numeric pain scale from 0-10 was assessed longitudinally prior to injection, immediately after, and again at a two-week follow-up period. The final data was collected from 48 patients (Normal saline group $n = 23$; CADM group $n = 25$).

Both groups had statistically similar pain intensity upon arrival in the emergency room. Results immediately after trigger point injection showed a mean pain reduction of 5.68 (SD = 2.54; $p < 0.001$) in the CADM group, and a mean pain reduction of 5.48 (SD = 2.92; $p < 0.00$) in the normal saline group. Patients were discharged with basic exercises for muscle rehabilitation at home, however there was no reliable means of assessing patient compliance. Results at the two-week follow-up revealed a reduction in mean pain scores of 3.09 (SD = 2.48; $p < 0.001$) in the CADM group and a similar reduction in mean pain scores of 3.05 (SD = 4.55; $p = 0.01$) in the normal saline group. These results indicate that significant analgesia was provided by both groups when compared to baseline, however, there is no statistical evidence that CADM trigger point injections were more effective than the normal saline placebo.

The biggest limitation of this study includes the contaminant use of alternative therapies along with trigger point injections. Analgesics were used in all but 10 subjects prior to treatment,

and patients were sent home with basic rehab exercises. This makes it difficult to determine if pain improvement was mostly due to treatment, or alternative therapies.

Botulinum Toxin A. A Cochrane systemic review of randomized control trials was conducted by Soares, Andriolo, Atallah, and Silva (2014) to determine the therapeutic effectiveness of BTX-A for treating MPS of various muscles. The final report included four trials that met the inclusion criteria, with low risk of bias, and high quality. All four trials were randomized, double-blinded, and placebo controlled.

The largest trial in the review included 145 subjects with MPS of the shoulder or cervical muscles and utilized normal saline as placebo. The primary clinical outcome was patient reported pain intensity on a scale of 0-3 over the course of 12 weeks. Results indicated significant improvement in pain reports with BTX-A, as well as decreased duration of daily pain.

Another longitudinal study in this review included 28 subjects with bilateral MPS of the low back muscles. The trial was designed to reduce inter-subjective variability by having each patient serve as their own control. BTX-A injections were done on each patient unilaterally with a placebo injection of bupivacaine or normal saline used randomly on the contralateral side. Results indicated that BTX-A was effective for improving patient pain reports, but there was no statistical superiority when compared with either placebo. Interestingly, they found VAS scores consistently trended downward at each follow-up period (15, 30, and 90-days) on the side injected with BTX-A, which was not demonstrated contralaterally with placebo.

The last two studies reviewed in Soares et al. (2014) evaluated patient pain scores after BTX-A injection over the course of one and two months and found no statistically significant pain improvement when compared to the normal saline placebo group.

A major limitation of this systemic review is the small sample sizes of each study. The differences of the individual study designs including follow-up periods, and patient pain reporting scales also creates more discrepancy. All factors which may lead to increased variance of results.

In a different study, Abboud et al., (2017) theorized that patients with localized MPS respond better to BTX-A trigger point injections compared to those with referred MPS. Localized myofascial pain is characterized as MTrPs that, when aggravated by palpation, pain remains within the solitary muscle group. Referred myofascial pain spreads beyond the affected muscle group with palpation. Referred MPS is often chronic and occurs due to the phenomenon of central sensitization. There is evidence from prior studies that patients with central sensitization do not respond as well to trigger point injections. This theory may be the reason that past trials have produced mixed results with BTX-A injections.

Abboud et al. (2017) retrospectively analyzed the charts of 25 patients (localized MPS n = 13; referred MPS n = 12) treated with BTX-A trigger point injections for MPS of the temporal mandibular region. All patients were treated with a similar protocol that included manual palpation to locate the MTrP, an injection of 100 MU BTX-A diluted in 1 mL normal saline, and clenching exercises immediately following the injection to facilitate endocytosis. Over a period of four months pain levels were documented as *significant improvement*, *moderate improvement*, *no improvement*, or *worse*. Analgesic use and subsequent patient request to continue with BTX-A therapy were considered as secondary clinical outcomes.

At the one-month follow-up, 8/13 (61.5%) patients with localized MPS reported significant improvement, while only 4/12 (33.3%) with referred MPS reported similar results ($p = 0.237$). At the two-month follow-up, 9/13 (69.2%) patients with localized MPS reported

significant improvement, while only 2/12 (16.7%) with referred MPS reported similar results ($p = 0.015$). At three-months follow-up, 36% of patients did not return for continued treatment, but interestingly, all patients with *significant improvement*, returned for their four-month follow-up appointment. For patients with localized MPS, 7/10 (70%) requested to continue with treatment at this time, while only 3/6 (50%) with referring MPS chose to continue treatment ($p = 0.51$). Throughout the four months, 10/13 (76.9%) patients with localized MPS reported using less analgesics, while only 3/12 (25%) with referring MPS reported similar results ($p = 0.017$). The average duration of analgesia from the BTX-A injections was 3.21 months, with most patients reporting a return to their baseline pain at the four-month follow-up. These results indicate that after one month, BTX-A trigger point injections were more effective in patients with localized MPS. Secondary outcomes showed that patients with localized MPS were more compliant with follow-up, chose to continue with therapy, and reported less analgesic use for their myofascial pain.

Although this analysis was limited by its small sample size and retrospective design, it gives important insight into treating patients with localized vs. referred MPS.

Ozone. The use of ozone is an emerging pharmacologic agent that has shown positive results in treating several musculoskeletal disorders. In a single-blinded randomized control trial conducted by Raeissadat, Rayegani, Sadeghi, and Dehgolan (2018), 22 patients with MPS received trigger point injections using 8 mL of O2/ozone as an injectate. Results showed statistically significant improvement in VAS pain scores pain pressure thresholds, and disability indexes. These results are promising, but there are few studies in the literature and none with large enough sample sizes to determine true clinical efficacy.

Effectiveness of Dry Needling

Espejo-Antúnez et al. (2017) conducted a systemic review of randomized control trials in accordance to Cochrane guidelines to determine the clinical effectiveness of dry needling in patients with MPS. A total of 761 subjects were included across 15 studies with individual sample sizes ranging from 12-94 patients. Placebos included: no intervention, sham needling (placebo needling with a blunt tip), and pharmacologic therapy including lidocaine trigger point injections. Various scales for pain reporting were utilized to determine efficacy.

Most of the 11 studies that compared dry needling to placebo needling, or no intervention reported statistically significant improvement in pain intensity. Of the four studies that compared dry needling with pharmacologic interventions, two had statistically similar clinical outcomes while the other two had conflicting results. The most significant effects were seen when dry needling was performed in areas of the neck and shoulder. Overall, these results suggest that dry needling is an effective option for short term pain relief of MPS, however it may not have a superior benefit to pharmacologic injections. This systemic review found that dry needling was more effective for increasing pain pressure thresholds, quality of life, and range of motion. Analgesic use, disability, and sleep quality were not significantly affected with dry needling.

To determine the efficacy of different techniques used for dry needling, Espejo-Antúnez et al. (2017) compiled information from all 15 of these studies. This included location of needle insertion, depth, number of repeat insertions, and rotation or fanning techniques. However, there was very limited information within the literature on techniques used and they could not make any recommendations.

In a another double-blinded, randomized, control trial, Tekin et al. (2012) evaluated the clinical efficacy of dry needling when compared to sham needling with a blunt needle utilizing

identical treatment protocols. The trial was composed of 39 subjects randomly divided into two groups: dry needling (n = 22), and sham needling (n = 17). All patients had MPS diagnosed by Travell and Simons criteria with at least one active trigger point and symptoms for greater than six months. Patients were treated for a total of six sessions over four consecutive weeks and had no further treatment with exercise or physical therapy. The only analgesic medication allowed was an acetaminophen equivalent. A separate physician in charge of follow-up assessment of VAS pain scales, quality of life assessment, and analgesic use, was blinded to which treatment group patients were assigned to in order to prevent bias. The dry needling group was further assessed for a local twitch response (LTR) during treatment to determine its clinical significance in correlation to pain relief.

Results showed improvement of VAS scores in the sham group at the first week assessment, but scores did not continue to improve at the end of four weeks. The dry needling group had significant improvement in VAS scores on both assessments at one and four weeks. When VAS scores were compared between the two groups the dry needling scores were significantly lower ($p < 0.001$). Quality of life, assessed using the short-form-36 health survey, indicated improvement in all categories in the dry needling group. Patients in this group also reported a decrease in analgesic use. There were no statistical differences identified in the sham group. For patients in the dry needling group that had identifiable LTRs, VAS scores were further improved during follow-up compared to those without an identifiable LTR.

This study is limited by its small sample size which may lead to increased statistical variance of outcomes.

Comparison of Needling Therapies

Local Anesthetic vs. Botulinum Toxin-A. Ahmed et al. (2019) compared the clinical effectiveness of local anesthetic and BTX-A trigger point injections in this systemic review with meta-analysis. They evaluated 33 randomized and controlled trials—18 studies focused on local anesthetics, 16 focused on BTX-A, and one discussed both. The review focused on patient pain reporting in a longitudinal fashion with follow-up periods ranging from 0-24 weeks.

The results of the individual studies that compared local anesthetics and BTX-A trigger point injections to placebo found both treatments to be clinically effective for improving patient pain reports, although not all reports were significant. Within the research, 8/18 (44%) of studies had statistically significant improvement in VAS pain scores using local anesthetic trigger point injections. Only 4/16 (25%) studies had statistically significant improvement in VAS pain scores using BTX-A injections. The meta-analysis results favored local anesthetic injections for improvement of patient pain reports at specific follow-up times: at one to two weeks (SMD = -0.96; 95% CI = -1.80, -0.13; $p < 0.05$), at three to four weeks (SMD = -0.01; 95% CI = -1.76, -0.27; $p < 0.05$), and at 16 weeks (SMD = -1.33; 95% CI = -2.11, -0.55; $p < 0.001$). BTX-A injections showed moderate effective pain improvement at specific follow-up times: at 18 weeks (SMD = -0.59; 95% CI = -1.51, 0.34; $p > 0.05$) and at 24 weeks (SMD = -0.33; 95% CI = -0.96, 0.31; $p > 0.05$). Interestingly, it was found that BTX-A injections were more effective in trials that were limited to temporomandibular muscles (SMD = -0.19) unlike those that were limited to the cervical or shoulder muscles (SMD = 0.01). A possible explanation of these results may be that BTX-A requires energy from muscular activity to facilitate toxin migration into motor endplates. The temporomandibular muscles are some of the most active muscles in the human body which helps to facilitate this process of endocytosis.

The clinical differences between local anesthetics and BTX-A could be due to the pharmacological effects and location of the trigger point injection in relation to the MTrP. Local anesthetics cause inhibition of both afferent and efferent neurons, whereas BTX-A only affects the afferent neurons. Because of its mechanism of action, if BTX-A were to be injected into the motor endplate instead of directly into the MTrP, Ahmed et al. believes that clinical outcomes may improve due to a higher concentration of neuromuscular junctions at the motor endplates.

The meta-analysis was limited by a high rate of heterogenicity among the control groups, and type of local anesthetics used. Several of the studies also included adjunctive therapy making it unclear if clinical effects were solely due to trigger point injections.

Local Anesthetic vs. Botulinum Toxin-A vs. Dry Needling. In a prospective, single-blinded trial, Kamanli et al. (2004) enrolled 29 patients with MPS to compare the efficacy of common needling therapies. Patients were randomly divided into three treatment groups: lidocaine injections (n = 10), dry needling (n = 10), and BTX-A injections (n = 9) with a total of 87 MTrPs identified and treated. All three therapies were performed in a similar fashion using a modified technique suggested by Travell and Simons. A dose of 1 mL equal mixture of lidocaine and normal saline, or 10-20 IU of BTX-A was injected directly into the palpated MTrP, following 8-10 needling's to deactivate the trigger point. Compression and passive stretching immediately followed treatment and patients were given instructions for daily home exercises and correction of poor postural habits.

Clinical outcomes were assessed at baseline and again at one month. Parameters included, range of motion, pain pressure threshold measurements, pain score measurements (scored 0-3 based on manual pressure applied to the MTrP), subjective VAS pain scores, fatigue measured by VAS, and disability measured by the Nottingham Health Profile. A psychiatrist,

blinded to which treatment the patient received to prevent bias, evaluated for pain-related anxiety and depression. Results at the one-month follow-up showed that each treatment group had significant improvement in subjective pain, fatigue, disability, pain pressure thresholds, and range of motion. When outcomes were compared amongst the three treatment groups, they found that pain pressure thresholds were significantly higher in the group that received lidocaine injections compared to dry needling ($p < 0.016$) but similar results were seen in the group treated with BTX-A injections. Pain score measurements were most significant in the lidocaine group ($p < 0.016$). VAS scores for subjective pain, fatigue, and disability had statistically significant and similar improvement in both the lidocaine and BTX-A groups. Notable improvement in depression and anxiety was only noted in the BTX-A group. Although all groups had positive clinical outcomes, comparisons of evaluation criteria suggested that lidocaine injections were most effective in terms of pain pressure thresholds, and subjective VAS pain scores.

The limitations of this study include a small sample size and unknown patient compliance with home exercise and correction of postural habits. These limitations may lead to increased variance of results. There was also a lack of long-term follow-up which is significant when evaluating effectiveness of BTX-A.

Local Anesthetic vs. Ozone vs. Dry needling. To compare the efficacy of invasive needling therapies for patients with MPS of the trapezius muscles, Raeissadat et al. (2018) conducted a single-blinded, randomized, control trial. They assessed clinical outcomes including VAS pain scores, pain pressure thresholds, neck range of motion, and subjective disability indexes of 62 patients treated with dry needling ($n = 20$), lidocaine injections ($n = 20$), and ozone injections (n=22). Protocols for trigger point injections were similar and included identification of MTrPs via palpation and subsequent injection of 8 mL oxygen/ozone, or 2 mL of lidocaine.

Dry needling was performed with a fanning technique that included multiple needle insertions. All three treatment groups were given instructions for lifestyle modification, an exercise regimen, and told to avoid muscle overuse. Compliance was evaluated on a weekly basis via phone call.

Results at four weeks showed improvement of VAS pain scores (MD = -3.6 ± 1.4; p = 0.001), pain pressure thresholds (MD = 7.2 ± 5.1; p = 0.001), and disability indexes (MD = -9.9 ± 8.7; p = 0.001) in all three groups. Cervical range of motion only improved in the lidocaine group, but results were statistically insignificant. When all three groups were compared by variance analysis, there was statistically significant improvement in VAS pain scores (p = 0.02), pain pressure thresholds (p = 0.01), and disability indexes (p = 0.04) that favored ozone and lidocaine injections (ozone had minimally higher scores). The dry needling group had the least significant results out of the three treatment arms. They did note a transient increase in pain immediately post-procedure that occurred in one subject treated with ozone and one subject treated with dry needling.

The current study was limited by small sample size and a lack of long-term follow-up.

Local Anesthetic Trigger Point Injections vs. Dry Needling. Ay, Evcik, and Tur (2009) conducted a prospective, randomized, control trial to compare trigger point injections with local anesthetic to dry needling in patients with MPS of the trapezius muscles. They enrolled 80 patients and randomly divided them into two treatment groups: local anesthetic injection (*n* = 40), and dry needling (*n* = 40). Both groups were treated by an experienced physician that utilized a fanning technique with multiple needle insertions as recommended by Travell and Simons. All patients were given a 12-week home exercise regimen and were not allowed to use analgesics prior to follow-up.

Patient VAS pain scores, cervical range of motion, and depression scales (Beck depression inventory) were reassessed at four- and 12-week intervals. Results indicated that VAS scores in both groups significantly decreased at the four- and 12-week follow-up ($p < 0.001$) with no significant difference between the two groups ($p = 0.053$ at 4-weeks; $p = 0.215$ at 12-weeks). Both groups showed improvement in cervical range of motion and depression scores with no significant differences. The authors concluded that trigger point injections with local anesthetic and dry needling were equally effective for treating MPS of the trapezius.

The biggest limitation of this study is the small sample size which led to a low power analysis in all assessment parameters (6%-55%). There was no mention of patient blinding in the study design which increases the risk of patient bias during assessment.

In a different randomized control trial, Asku (2019) compared the effects of trigger point injections and dry needling in patients with temporomandibular MPS. A total of 63 patients were randomly divided into three therapeutic groups: group one ($n = 21$) followed exercise and protective therapy only. Group two ($n = 20$) included dry needling, exercise, and protective therapies. Group three ($n = 22$) included trigger point injections with local anesthetics, exercise, and protective therapies. Exercise and protective therapy served as the clinical control for each group. MTrPs were found by manual palpation and 1 mL of prilocaine was injected in group three. Dry needling was performed with a winding technique while the needle remained within the MTrP for 20 minutes in group two. Patient VAS pain scores were assessed longitudinally at 10 days, and one month after treatment.

The results of Asku's trial showed that patient pain reporting was greatly improved in all three groups without a significant median difference in VAS scores (variation between all three groups $p = 0.557$). At the 10-day follow-up the highest pain improvement occurred in the dry

needling group (group 2). The most significant improvement of temporomandibular pain with palpation, occurred in the trigger point injection group (group 3) at the one-month follow-up period.

There was no mention in the study if patients in groups two and three were blinded to the treatment they received which increases the risk of patient bias for pain reporting. Another limitation included poor patient compliance with exercise and protective therapy. The sample size was small, but consistent with other trials included within this study.

Ultrasound Guidance

Advancements in ultrasound technology have allowed for more accurate detection of MTrPs using shearwave elastography. When ultrasound is used for guidance during trigger point injections, it has been shown to increase accuracy of needle placement directly into the center of the MTrP according to Kang et al. (2019). They conducted a preliminary pilot study to determine if clinical outcomes were improved with the use of ultrasound guided trigger point injections when compared to a blind technique in patients with MPS of the trapezius muscles. A total of 41 patients were enrolled and randomly divided into two groups: trigger point injections using ultrasound guidance (trial $n = 21$), and trigger point injections using a blind approach (control $n = 20$). Shearwave elastography ultrasound was used to determine muscle stiffness of the MTrP with a range set between 0-200 kPA in both groups prior to injection. The same protocols were followed for both groups using an equal mixture of lidocaine and normal saline and utilizing injection techniques suggested by Travell and Simons. For the trial group a region of interest set at 1.4 cm x 1.4 cm and served as a target for the trigger point injection. Patients were instructed to perform daily stretching exercises at home but were not allowed to take analgesics or receive physical therapy through the evaluation period.

Patient VAS pain scores, manual muscle testing, range of motion, and disability indexes were assessed at baseline, and again at two- and four-week follow-up. Results at the four-week follow-up showed that visual analog pain scores, neck disability, and shoulder disability indexes were all improved significantly ($p = 0.003$, $p = 0.012$, $p = 0.018$, respectively) in the trial group that utilized ultrasound guidance, when compared to the blind approach used in the control group. Manual muscle testing, and range of motion were not improved enough to make a statistical difference between the two groups. These results conclude that ultrasound guidance can help to improve clinical outcomes of trigger point injections, likely due to increased accuracy of needle placement.

This was a preliminary pilot study which limits the its ability to provide conclusive results. There have not been any further large-scale quantitative studies published to this date. Further limitations include a small sample size, and a rural setting in a secondary medical institution which could increase the risk of inherent subject selection bias.

Local Twitch Response

There is debate about the clinical significance of eliciting an LTR, so Hakim, Takamjani, Sarrafzadeh, Ezzati, and Bagheri (2019) conducted a quasi-experimental study to determine the analgesic effects of dry needling with and without elicitation of the LTR. A total of 26 patients met the study's inclusion criteria of active trigger points in the upper trapezius muscle. Patients were randomly divided into two protocol groups: dry needling with elicitation of LTR, and dry needling with *de qi* sensation (feeling of heaviness, tinging, or warmth). A pistoning technique with multiple needle insertions in a fan shape, was used to elicit an LTR in the first group. The second groups protocol involved needle insertion into the MTrP without manipulation until a *de qi* sensation was achieved. Therapy was performed in three sessions at three-day intervals.

After four weeks, patient VAS pain scores, range of motion (left and right lateral flexion), pain pressure thresholds, and neck disability index (NDI) scores were assessed and compared between both groups. Results favored the group without elicitation of LTR in all parameters except NDI scores. VAS pain scores were improved (MD = 7.23 ± 7.447; p = 0.03), along with pain pressure thresholds (MD = -15.769 ± 7.602; p = 0.049), and ROM evaluated via right and left lateral neck flexion (MD = -15.23 ± 2.622; p = 0.000 and MD = -8.385 ± 2.931; p = 0.009, respectively). Results may be attributed to the multiple needle reinsertions (7.4 ± 3.9) that were necessary to elicit maximum LTR's, causing muscle fiber and neuronal axon damage. Muscle soreness for 24-48 hours is commonly reported in the literature when using a maximal LTR technique.

A limitation of the study was the small sample size; however, the effect size was calculated to be 0.83 which is large enough to determine significance of the results. Even though this study was a quasi-experiment, subjects were still randomized into the two treatment arms so there is less threat to the internal validity.

In a different study, Perreault, Dunning, and Butts (2017) compiled a narrative style review to determine the clinical significance of eliciting the LTR in both dry and wet needling in relation to analgesia and disability. They critically evaluated six studies from the literature with patient sample sizes ranging between 29 to 103 and follow-up periods ranging from immediately following the procedure to four weeks after.

Results from two of their studies found that decreased pain intensity was associated with elicitation of the LTR secondary to trigger point injection and dry needling. One study found an insignificant correlation with the degree of pain relief and elicitation of the LTR, while the remaining three studies found no correlation at all.

Limitations of the narrative review includes heterogenicity of the different types of trials used and the relatively short-term follow-up periods for evaluation. There are very few quality studies available that attempt to directly correlate the LTR with improved clinical outcomes of needling therapy.

In another case controlled observational study Rha et al. (2011) warns that studies concluding that an LTR during needling therapy as unnecessary, may be inaccurate if they did not accurately detect an LTR in deeper muscles. The goal of Rha et al.'s study was to accurately identify the LTR utilizing ultrasound to better determine clinical significance of needling therapy.

The authors recruited 41 patients with MPS of the upper trapezius (superficial muscles) and 62 patients with MPS of the lower back muscles (deep muscles). Two experienced clinicians performed therapy using identical techniques. Multiple needle insertions, but no more than 10, were made to elicit several LTR's. Next, an injection of lidocaine was given to decrease post-procedure soreness. One clinician evaluated for LTR's using ultrasound and the other evaluated through visualization only. Out of 1,004 needle insertions in the deep muscles 155 LTR's were detected by visualization, and 196 were detected only by ultrasound. Out of the 548 needle insertions in the superficial muscles all LTR's were detected by both methods.

The patients were then further divided into LTR-positive and LTR-negative groups to compare VAS pain scores immediately after treatment. Pain scores were significantly lower in the LTR-positive group ($p < 0.001$) of both the superficial and deep muscles.

A major limitation of this study was the short-term follow-up period. Patients were only followed immediately after therapy and long-term effects are not known. MPS was diagnosed based on a modified Travell and Simons criteria which leads to questioning the validity of the initial diagnosis of MPS.

Discussion

Do Trigger Point Injections Provide more Pain Relief than Dry Needling in Patients with MPS?

Dry needling has increased in popularity since the scientific proposal that analgesic effects of trigger point injections stem more from needle manipulation of myofascial tissue than the pharmacological injectate used (Tekin et al., 2012). Needle insertion alone within the MTrP causes mechanotransduction of sensory and motor nerves, improves local blood flow and oxygenation, increases endorphins, and decreases sensitizing biochemicals (Perreault et al., 2017).

Most studies in the literature review agreed that dry needling is an effective form of therapy for relieving pain associated with MPS. Several of these comparison studies found similar analgesic efficacy based on patient pain reports with dry needling when compared to trigger point injections at follow-up times ranging from one to 12 weeks (Aksu, 2019; Ay et al., 2009; Espejo-Antúnez et al., 2017; Nouged et al., 2019). Improvement was most significant when dry needling was performed in areas of the neck and shoulder (Espejo-Antúnez et al., 2017). Studies that refuted these results found that although dry needling improved baseline VAS pain scores and pain pressure thresholds, therapy was not as effective as trigger point injections using lidocaine, BTX-A, or ozone at one month (Kamanli et al., 2004; Raeissadat et al., 2018). Larger longitudinal comparison studies are needed to further determine the long-term efficacy of dry needling. Interestingly, Nouged et al. (2019) found that subjective pain scales were further improved when patients were enrolled in non-blinded trials, suggesting that a pharmacological injectate such as local anesthetics, may have a positive psychological effect on some patients.

What Pharmaceutical Agents are most Effective for Trigger Point Injections?

Several different injectates are discussed in the literature including local anesthetics, corticosteroids, botulinum toxin A (BTX-A), and ozone. Each injectate has a different pharmacologic action, and studies suggest that each may have their own indication.

Local anesthetics have been studied extensively and have long been considered first-line pharmacologic choice for trigger point injections. Commonly used anesthetics include amides such as lidocaine or bupivacaine because of their decreased risk of anaphylactic reaction (Crisculolo, 2001). The pharmacologic effects of local anesthetics are derived from blockade of sodium channels, which prevents action potentials in the sympathetic nerves, and results in an interruption of the pain pathway via afferent neurons to the central nervous system (CNS) (Nouged et al., 2019). Local anesthetics also influence the efferent neurons that carry impulses from the CNS to the periphery in response to sensory input. This mechanism suggests that local anesthetic trigger point injections may be more beneficial for patients with chronic MPS that have experienced the phenomenon of central sensitization (Ahmed et al., 2019). However, the research to support this theory is lacking. The meta-analysis by Nouged et al. (2019) found that local anesthetic trigger point injections were an effective treatment for relieving short-term (1-4 weeks) pain associated with MPS, but controlled trials showed insignificant superiority to invasive placebo needling. Interestingly though, extended follow-up periods (2-8 weeks) showed more significant analgesic effects over saline placebo injections. These results suggest that analgesia is partly influenced by mechanical stimulation of the needle, as well as the pharmacologic injectate. When lidocaine was compared to BTX-A, all assessment parameters were similar. However, a statistically significant improvement in pain scores occurred with the group that received lidocaine trigger point injections at one-month follow-up (Kamanli et al.,

2004), indicating that lidocaine had better short-term analgesic effects. A commonly adopted protocol involves mixing equal parts anesthetic with normal saline, palpating for a MTrP within the taut band of muscle and injecting the mixture directly into the MTrP (Crisculolo, 2001).

The addition of corticosteroids to local anesthetic trigger point injections is quite controversial. This combination is considered a conventional active drug mix (CADM). The pharmacological effect of adding a corticosteroid is to decrease inflammation that may be associated with some cases of MPS (Crisculo, 2001). The reported benefit is mixed and may be outweighed by the risk of adverse effects including skin thinning, striae, muscle atrophy, hormone imbalance, and decreased bone density associated with intramuscular steroid injection (Roldan et al., 2019). This double-blind, controlled, study by Roldan et al. found that although effective, there was no statistical benefit to CADM trigger point injections when compared to a normal saline placebo at short-term follow-up (0-2 weeks).

BTX-A has recently become an accepted pharmacologic alternative for trigger point injections when traditional invasive therapies have failed to produce adequate pain relief from MPS. Ahmed et al. (2019) explains that pharmacologic effects are produced by toxin-mediated inhibition of acetylcholine release at the motor end plates resulting in temporary inhibition of muscle contraction. For this process to occur, the toxin must migrate from the injection site to the motor neurons via endocytosis, which requires adequate energy. If migration to the motor neurons is unsuccessful, therapeutic effects may be negligible. This mechanism is likely why BTX-A injections have shown to be more effective in patients with MPS of the temporomandibular muscles, because these muscles are constantly being used, creating enough energy to facilitate endocytosis (Ahmed et al., 2019). Another retrospective study that supports this information showed statistically significant improvement in pain levels over one to four

months, with decreased analgesic use in patients that received BTX-A injections in the temporomandibular region (Abboud et al., 2017). Other studies that included patients with myofascial pain of the cervical, trapezius, and lumbar regions, report mixed results with BTX-A injections, which could be due to ineffective endocytosis in these less active muscles (Ahmed et al., 2019; Kamanli et al., 2005; Soars et al., 2014). Abboud et al. (2017) found that patients had improved outcomes and requested to continue therapy when MPS was localized rather than referred. Patients with localized MPS are less likely to have sensitization, and the results suggest that patients with central sensitization do not respond well to BTX-A. The Cochrane systematic review of controlled trials conducted by Soares et al. (2014) found that BTX-A injections significantly improved pain scores and duration of daily pain at long term follow-up of 12 weeks. They also found that pain scores slowly trended downward when pain was assessed longitudinally, indicating that the onset of analgesic effects is delayed and cumulative with repeat injections. Ahmed et al., (2019) agreed that there was clinically moderate pain improvement at long-term follow-up (18 and 24 weeks). When BTX-A and lidocaine trigger point injections were compared at one month, there was similar improvement in pain pressure thresholds, but subjective pain scores favored lidocaine trigger point injections (Kamanli et al., 2004). A typical dose recommendation is 10-20 IU for BTX-A injections. Although trigger point injections should be directed into the center of the MTrP, Ahmed et al. suggests there may be a therapeutic benefit to directing BTX-A injections toward the motor endplate instead, which is typically located 10 mm proximally. Theoretically this technique would decrease the energy requirement for endocytosis and may be more effective in less active muscles.

The emerging use of ozone for musculoskeletal disorders deserves some attention. Analgesic effects are derived from improved tissue oxygenation, inhibition of inflammatory

mediators, and inhibition of phosphodiesterase A2. Only one study discussed its use for MPS specifically and compared its efficacy to lidocaine injection with statistically similar, but improved results in pain scores, pain pressure thresholds, and disability indexes at one month (Raeissadat et al., 2018). More controlled clinical trials are necessary to further explore the use of ozone for MPS.

Does Ultrasound Guidance Improve Clinical Efficacy of Trigger Point Injections when Compared to a Blind approach?

Most studies agree that for invasive needling therapy to effectively deactivate MTrPs, the needle should be directed into the center of the MTrP. This can be difficult when using a blind technique that relies on palpation to guide needle placement. Shearwave elastography is a type of ultrasound that can measure the elasticity of muscles and grade its level of stiffness. This technology can help to identify MTrPs, and guide needle insertion in real-time to prevent localization errors (Kang et al., 2019). Using ultrasound may be most beneficial for patients with MPS of deep muscles such as the low back, where MTrPs are more difficult to palpate (Rha et al., 2011). Kang et al. (2019) showed that pain and disability scores were significantly improved in patients with MPS of the trapezius that received trigger point injections under ultrasound guidance. Several authors agreed that ultrasound guidance for trigger point injections should be considered in order to maximize patient outcomes (Ahmed et al., 2019; Kang et al., 2019; Rha et al., 2011). Additional benefits of utilizing ultrasound guidance include decreased risk of pneumothorax, vascular infiltration, and nerve block (Rha et al., 2011).

What is the Clinical Significance of the Local Twitch Response during Dry Needling and Trigger Point Injections?

The local twitch response (LTR) occurs upon needle stimulation of sensitized loci within the MTrP that causes depletion of acetylcholine and subsequently suppresses motor endplate hyperactivity. This is thought to be an objective measure of MTrP deactivation and successful therapy (Perreault et al., 2017). Maximum LTR is best obtained with a pistoning technique that involves multiple rapid needle insertions in and out of the MTrP in a fan shaped pattern. Reports of post-procedural soreness for up to 72 hours, are common after needling therapy using this technique (Hakim et al., 2019; Perreault et al., 2017). Empirical evidence suggests obtaining maximum LTR's is necessary to deplete excess acetylcholine and facilitate calcium reuptake in order to normalize motor endplate activity for long-term pain relief. However, the multiple needle insertions necessary to exhaust the LTR may result in increased discomfort, local hemorrhage, tissue fibrosis, and adhesions (Hakim et al., 2019). The evidence available to support the LTR is mixed. The narrative review by Perreault et al. (2017) concluded that elicitation of LTR's during dry needling or trigger point injections was poorly correlated to improved clinical outcomes in the short-term. However, Rha et al. (2011) warns that studies may be inaccurate if an LTR was obtained but not properly identified, which is common in deeper muscles. They used ultrasound to identify LTR's that were visually missed and observed that patients in the positive-LTR group had significantly improved pain scores immediately after trigger point injections using a pistoning technique. This study did not follow-up on patient pain reports, but in the study by Tekin et al. (2012), patients with identifiable LTR's had further improved pain reports at four weeks after dry needling therapy than those without. In other literature, the quasi-experimental study found that patients treated with an alternative dry

needling technique that did not require eliciting an LTR had better clinical outcomes regarding pain scores, pain pressure thresholds, and ROM at four weeks (Hakim et al., 2019). Needling techniques that do not require an LTR include acupuncture with *de qi* sensation, and dry needling with manipulation of the needle in a twisting motion. Needle insertion without LTR has still been shown to cause vasodilation and increase local circulation at the MTrP. These mechanisms result in a wash out of sensitizing biochemicals and delivery of natural opioids, creating an analgesic and anti-inflammatory effect (Perreault et al., 2017).

Limitations

This systemic review was limited by several factors. A major limitation was the relatively small sample sizes of the included studies which was consistent throughout the comprehensive database search. Sample sizes of randomized control trials available within the literature ranged between 12-145 patients. Another consistent limitation was the heterogenicity of pain scales used, follow-up times, techniques, and various study designs, which may increase statistical variance. Some studies used contaminant therapies or analgesics making it difficult to know the true therapeutic benefit of needling therapies alone. Some studies used a modified version of Travell and Simons criteria for diagnosis of MPS, which questions the validity of the original diagnosis. Only one randomized control study directly compared the efficacy of all three treatment groups. Lastly, patient pain reports are inherently subjective; with each patient having a different level of pain tolerance, it is difficult to determine the true impact that invasive needling therapies have on pain intensity.

Application to Clinical Practice

Myofascial pain syndrome is a common musculoskeletal disorder encountered in primary care. Unfortunately, standard clinical guidelines for treatment are still uncertain due to a lack of larger controlled trials. First-line therapy should always be conservative, but effective treatment for most patients typically requires a multidisciplinary approach. Invasive needling can be a great addition to the treatment plan for patients with MPS, but without a standard treatment protocol, it is difficult for the primary care provider to know what needling therapy should be implemented. It is imperative for providers to obtain a thorough history and physical and have a good understanding of the pharmacologic and mechanical effects of various needling therapies in order to make an informed clinical decision.

My research suggests that an individualized approach is best for effective pain relief from MPS. With controlled trials having such mixed results, we are still unable to determine if trigger point injections have any superiority over dry needling, however, it appears that both therapies have significant short-term improvement on pain intensity. Both therapies have shown to be clinically effective for patients suffering from MPS of the upper trapezius and cervical paraspinal muscles. Local anesthetics have a more immediate and significant pain relief when compared to BTX-A. However, repeat trigger point injections with BTX-A may provide more long-term pain relief in patients with localized MPS in active muscles. With promising results that were insignificantly superior to local anesthetics and dry needling, ozone should be further studied in patients with MPS. Caution should be used with corticosteroids due to increased risks of adverse effects but may still be beneficial when the cause of MPS is directly due to an inflammatory process. Ultrasound guidance improves the safety of trigger point injections, and should always be considered for improving clinical outcomes, especially in deeper muscles where palpation of

the MTrP is difficult. There is some discrepancy surrounding the clinical significance of the local twitch response. Although there is some correlation with LTR and short-term pain relief, there is little evidence that it is necessary for effective treatment and should not be relied upon. A maximum LTR approach with a pistoning technique should be performed with caution due to risk of post-procedure soreness and muscle damage.

This literature review provides primary care providers with the necessary information to make an informed decision about what form of invasive needling therapy is best indicated for the patient with MPS based on clinical presentation. With proper training the provider can confidently perform trigger point injections as an outpatient procedure or refer patients to physical therapy for dry needling. It is important to note that monotherapy is rarely successful, and an interdisciplinary approach should be implemented to maximize treatment.

References

Abboud, W., Hassin-Baer, S., Joachim, M., Givol, N., & Yahalom, R. (2017). Localized myofascial pain responds better than referring myofascial pain to botulinum toxin injections. *International Journal of Oral and Maxillofacial Surgery, 46*(11), 1417-1423. http://dx.doi.org/10.1016/j.ijom.2017.04.020

Ahmed, S., Subramaniam, S., Sidhu, K., Khattab, S., Singh, D., Babineau, J., & Kumbhare, D. (2019). Effect of local anesthetic versus botulinum toxin-a injections for myofascial pain disorders. *The Clinical Journal of Pain, 35*(4), 353-367. http://dx.doi.org/10.1097/ajp.0000000000000681

Aksu, Ö. (2019). Comparison of the efficacy of dry needling and trigger point injections with exercise in temporomandibular myofascial pain treatment. *Turkish Journal of Physical Medicine and Rehabilitation, 65*(3), 228-235. http://dx.doi.org/10.5606/tftrd.2019.1802

Ay, S., Evcik, D., & Tur, B. (2009). Comparison of injection methods in myofascial pain syndrome: A randomized controlled trial. *Clinical Rheumatology, 29*(1), 19-23. https://dx.doi.org/10.1007/s10067-009-1307-8

Bernstein, C., Shah, J., & Weiner, D. (2017). Fibromyalgia and myofascial pain syndromes. In J. Aredo (Ed.), *Hazzard's Geriatric Medicine and Gerontology*. McGraw-Hill. doi:https://accessmedicinemhmedicalcom.ezproxylr.med.und.edu/content.aspx?sectionid=144563489&bookid=1923#144563557

Criscuolo, C. (2001). Interventional approaches to the management of myofascial pain syndrome. *Current Pain and Headache Reports, 5*(5), 407-411. https://dx.doi.org/10.1007/s11916-001-0051-9

Espejo-Antúnez, L., Tejeda, J., Albornoz-Cabello, M., Rodríguez-Mansilla, J., Cruz-Torres, B., Ribeiro, F., & Silva, A. (2017). Dry needling in the management of myofascial trigger points: A systematic review of randomized controlled trials. *Complementary Therapies in Medicine, 33*, 46-57. http://dx.doi.org/10.1016/j.ctim.2017.06.003

Hakim, I., Takamjani, I., Sarrafzadeh, J., Ezzati, K., & Bagheri, R. (2019). The effect of dry needling on the active trigger point of upper trapezius muscle: Eliciting local twitch response on long-term clinical outcomes. *Journal of Back and Musculoskeletal Rehabilitation, 32*(5), 717-724. http://dx.doi.org/10.3233/bmr-181286

Kamanli, A., Kaya, A., Ardicoglu, O., Ozgocmen, S., Zengin, F., & Bayık, Y. (2004). Comparison of lidocaine injection, botulinum toxin injection, and dry needling to trigger points in myofascial pain syndrome. *Rheumatology International, 25*(8), 604-611. http://dx.doi.org/10.1007/s00296-004-0485-6

Kang, J., Kim, J., Park, S., Paek, S., Kim, T., & Kim, D. (2019). Feasibility of Ultrasound-Guided Trigger Point Injection in Patients with Myofascial Pain Syndrome. *Healthcare, 7*(4), 118. http://dx.doi.org/10.3390/healthcare7040118

Nouged, E., Dajani, J., Ku, B., Al-Eryani, K., Padilla, M., & Enciso, R. (2019). Local anesthetic injections for the short-term treatment of head and neck myofascial pain syndrome: A systematic review with meta-analysis. *Journal of Oral & Facial Pain and Headache, 33*(2), 183-198. http://dx.doi.org/10.11607/ofph.2277

Perreault, T., Dunning, J., & Butts, R. (2017). The local twitch response during trigger point dry needling: Is it necessary for successful outcomes? *Journal of Bodywork and Movement Therapies, 21*(4), 940-947. http://dx.doi.org/10.1016/j.jbmt.2017.03.008

Raeissadat, S., Rayegani, S., Sadeghi, F., & Dehgolan, S. (2018). Comparison of ozone and lidocaine injection efficacy vs dry needling in myofascial pain syndrome patients. *Journal of Pain Research, Volume 11*, 1273-1279. http://dx.doi.org/10.2147/jpr.s164629

Rha, D., Shin, J., Kim, Y., Jung, J., Kim, Y., & Lee, S. (2011). Detecting local twitch responses of myofascial trigger points in the lower-back muscles using ultrasonography. *Archives of Physical Medicine and Rehabilitation, 92*(10). http://dx.doi.org/10.1016/j.apmr.2011.05.005

Roldan, C., Osuagwu, U., Cardenas-Turanzas, M., & Huh, B. (2019). A randomized blind controlled non-inferiority trial to compare the effectiveness of trigger point injections performed with normal saline (NS) and conventional active drug mix (CADM) in patients with myofascial pain syndromes. *The American Journal of Emergency Medicine*. http://dx.doi.org/10.1016/j.ajem.2019.158410

Soares, A., Andriolo, R., Atallah, Á., & Silva, E. (2014). Botulinum toxin for myofascial pain syndromes in adults. *Cochrane Database of Systematic Reviews,* (7). http://dx.doi.org/10.1002/14651858.cd007533.pub3

Tekin, L., Akarsu, S., Durmuş, O., Çakar, E., Dinçer, Ü, & Kıralp, M. (2012). The effect of dry needling in the treatment of myofascial pain syndrome: A randomized double-blinded placebo-controlled trial. *Clinical Rheumatology, 32*(3), 309-315. http://dx.doi.org/10.1007/s10067-012-2112-3