The Immediate Effects of Lidocaine Iontophoresis on Trigger-Point Pain

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Objective: To assess the efficacy of lidocaine iontophoresis on myofascial trigger-point pain. Setting: University athletic training facility. Design: Randomized, double-blind, placebo-controlled, repeated-measures. Subjects: Twenty-three subjects with sensitive trigger points over the trapezius. Intervention: Placebo iontophoresis treatment without current or lidocaine, control treatment using distilled water and normal current dose, medicated treatment using 1% lidocaine and normal current dose. Main Outcome Measure: Trigger-point pressure threshold assessed with an algometer. Results: ANOVA revealed a significant difference among treatments ($F_{2,40} = 7.38, P < .01$). Post hoc comparisons revealed a significant difference in pressure threshold between the lidocaine treatment and the control ($P = .01$) and placebo ($P = .001$) treatments. Effect sizes of .28 and .39, respectively, were found for these comparisons. Conclusions: Although the data revealed significant differences between treatments, the small effect sizes and magnitude of the pressure-sensitivity deviation scores suggest that iontophoresis with 1% lidocaine is ineffective in treating trigger points. Key Words: myofascial pain syndrome, pain threshold, sensory threshold


Treating chronic pain in the active population is an increasingly common challenge faced by athletic trainers and physical therapists. One of the most common causes of chronic pain is myofascial pain syndrome (MFPS). MFPS is characterized by the presence of hyperirritable bands of taut skeletal-muscle fibers that are palpable and firm. Within these taut fibers are highly localized and painful points called trigger points. Myofascial trigger points (MTPs) are tender to deep palpation and often elicit referred pain. In addition to trigger points, MFPS is often associated with limited motion and a sense of weakness in the affected muscle.

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Long-term relief of myofascial pain can be achieved through proper posture, ergonomics, and exercise. Immediate relief of sensitive MTPs, however, is needed to facilitate exercise and return patients to activities of daily living. Therefore, we often use modalities, in combination with other forms of rehabilitative therapy, to inactivate or reduce the sensitivity of MTPs.

A variety of conventional modalities have been recommended for the initial treatment of MTPs, including transcutaneous electrical nerve stimulation to elicit pain relief and a muscle contraction, cold and stretch, ultrasound, and trigger-point massage. There is limited research, however, to support the effects of these modalities on MTP sensitivity and treatment outcomes.

One treatment shown to be an immediate and effective method of short-term MTP relief is direct injection of a local anesthetic into the MTP. Hong reported significant improvements in trigger-point sensitivity immediately after injections of 0.5% lidocaine. Injections, however, often produce painful side effects such as postinjection soreness, as well as a dull aching sensation around the point of injection. Tissue damage can also occur from localized high concentrations of medication. In addition, patients are sometimes apprehensive about being injected. Furthermore, most athletic trainers and sport therapists are not trained to administer injections, therefore excluding this technique from their treatment options.

A common, less invasive alternative for introducing medication into tissue is iontophoresis. Iontophoresis involves the use of low-intensity electrical current to drive the ionized medication through the skin. Typically, a local anesthetic in an ionized solution is applied to an active electrode pad placed directly over the painful trigger point. To drive the ions into the tissue, an electrical stimulator then delivers a continuous direct current, of the same charge as the ionized solution, to the medicated pad. This current is measured in milliamperes (mA), with treatment amplitudes ranging from 3 to 5 mA, durations ranging from 10 to 20 minutes, and the overall dosage described in milliamperes multiplied by minutes (mA · min).

Iontophoresis has been gaining popularity in the treatment of myofascial pain. Relative to injections, iontophoresis is painless, sterile, and non-invasive. The side effects are relatively mild, usually involving increased skin temperature and redness and mild irritation. When compared with oral nonsteroidal pain medications, iontophoresis is not associated with adverse effects on the gastrointestinal tract. Furthermore, although certain iontophoretically delivered drugs require a physician’s prescription, iontophoresis can be applied by athletic trainers and sport therapists.

It is, however, uncertain whether iontophoresis is an effective treatment option for oversensitive MTPs. Therefore, the purpose of this study was to assess the effects of iontophoresis on myofascial trigger-point pain.
Methods

Design

We used a randomized, repeated-measures, placebo-controlled, double-blind design. All subjects underwent a placebo iontophoresis treatment without current or lidocaine, a control treatment using distilled water and a normal current dosage, and a medicated treatment using a 1% lidocaine solution and a normal current dosage. The dependent variable was trigger-point sensitivity measured through algometry. We measured pretreatment and posttreatment sensitivity for each condition. The order of the 3 iontophoresis treatments was randomly assigned using a balanced Latin square.

Subjects

Twenty-three subjects, 10 men and 13 women (height = 166.8 ± 10.1 cm, mass = 73.2 ± 14.6 kg, age = 23 ± 2.6 years), with active or sensitive trigger points over the upper trapezius muscle volunteered as subjects. Active trigger points were initially self-reported and then later confirmed through instrumented testing. Subjects were recruited from the student population via announcements made during classes. Based on preliminary data, our sample size was determined through a power analysis (power = .80) to detect a difference of at least 1 SD between pretreatment and posttreatment sensitivity levels. Subjects who had previously had iontophoresis treatments, adverse reactions to electrical modalities, trigger-point injections, allergic reactions to lidocaine, allergic reactions to topically applied anesthetics, or adverse reactions to other injected medications were excluded from the study. In addition, we excluded subjects who were receiving ongoing treatment for MFPS. Furthermore, we asked subjects to report whether they were under medical care for any existing condition during the study that would affect their participation. Subjects provided informed consent in accordance with the university’s institutional review board policy.

Based on the questionnaire, subjects who met the inclusion criteria were asked to schedule a preliminary screening session to determine their trigger-point sensitivity threshold. During this preliminary session, we tested 1 sensitive trigger point in the upper trapezius to determine each subject’s pressure threshold (trigger-point sensitivity/activity). Because of the maximum range of the pressure-threshold meter (10 kg), any subject exhibiting a threshold of 7.1 kg/cm² or greater was excluded. Therefore, we could potentially detect a minimum of at least a 3-kg/cm² improvement in pressure threshold. Subjects displaying a trigger-point pressure threshold below 7.1 kg were identified as eligible participants and were scheduled for the 3 testing session.
Instruments

The instruments used for this study included the pressure-threshold meter (Model PTH, Pain Diagnostics and Treatment, Inc, Great Neck, NY), the Iontophor-II™ iontophoresis generator (Model 6111PM/DX, Dynatronics Corp, Salt Lake City, Utah), the DynaPak™ electrodes (Model 6580M-D, Dynatronics Corp), and a 1% lidocaine HCL (10 mg/ml) solution (NDC0074-4276-02, Abbott Laboratories, Philadelphia, Pa).

The pressure-threshold meter is used to quantify pressure sensitivity over tender, hypersensitive areas. Specifically, it is used to diagnose and locate trigger points, as well as quantify changes in pressure reported as painful. In separate studies by Fischer, Reeves et al, Delaney and McKee, and Nussbaum and Downs, the pressure-threshold meter was reported to be highly reliable between and within experimenters when measuring trigger-point sensitivity. Nussbaum reported excellent same-day intratester reliability (ICC²,1 = .93–.98) and excellent day-to-day intratester reliability (ICC²,1 = .88–.90). Furthermore, the pressure-threshold meter has been used as an assessment tool in pertinent research evaluating the effectiveness of trigger-point therapy.

The pressure-threshold meter is a small handheld device consisting of a small rubber plunger (1 cm²) attached to the end of a force gauge (10-kg range, 0.1-kg division). The pressure threshold is the minimum pressure that induces discomfort. Using the rubber plunger, the evaluator applies gradual pressure directly over the sensitive trigger point until the patient states that the pressure is uncomfortable. We used the pressure-threshold meter to determine the sensitivity of myofascial trigger points in the trapezius muscle.

We used the commercially available Iontophor-II, Model 6111PM/DX, for our iontophoresis treatments. The drug was delivered through the DynaPak electrodes. The electrodes included a medicated delivery (active) electrode and a dispersive (inactive) electrode. For the medicated treatment, we injected 1 ml of ionized lidocaine HCL into the active electrode. Lidocaine, which has a positive polarity, is commonly used as a local anesthetic in the treatment of trigger points and is available in concentrations of 1% to 5%. We used a 1% solution of lidocaine HCL because of the potential of the ions to clog as they attempt to pass through the pores of the skin. The iontophoresis treatments were overseen by a physician affiliated with the university and were administered by a certified athletic trainer.

Procedures

During testing, each subject was seated in a chair, assumed a resting position by leaning forward onto a padded table, and supported his or her head with a pillow and their forearms. This was the optimal position for exposing and relaxing the trapezius muscles.

Once the subject achieved a comfortable position, we located the trig-
trigger point. One examiner palpated the upper trapezius muscle until a taut band of muscle fiber was felt. Using the tip of the index finger, the examiner palpated (massaged) across the tight fibers until the subject identified the tenderest spot. The tender spot was designated as a trigger point and marked with a nonpermanent marker.¹⁶

Once the trigger point had been identified, we measured trigger-point sensitivity by placing the tip of the pressure-threshold meter directly over the marked trigger point. The dial faced away from the examiner. The examiner then applied pressure at a rate of approximately 1 kg/s until the subject indicated that the pressure on the trigger point became painful¹⁴,¹⁶ by saying “pain.” At this time, the examiner released the pressure and a second examiner read the measurement and recorded the pressure value. This procedure was repeated twice for a total of 3 trials, with the mean of the 3 values representing the subject’s pressure threshold.¹⁸ The trigger-point examiner was blinded to both the treatment and the pressure readings. This procedure was repeated to determine the pretreatment and posttreatment pressure threshold for each of the 3 testing sessions.

Before each treatment, the surface area of the marked trigger point was cleansed with isopropyl alcohol. For the medicated treatment, 1 ml of 1.0% lidocaine HCL solution and 1 ml of the buffering solution (0.9% saline and 0.5% potassium phosphate, Meditrode Return Electrode Solution) were mixed and applied to the active (medicated) electrode via a hypodermic syringe. The buffering solution, provided with the DynaPak electrodes, is used to prevent potentially dangerous changes in pH at the skin by reducing the collection of negatively charged hydroxide ions. The lidocaine electrode was placed directly over the marked area where the sensitive myofascial trigger point was located. The dispersive electrode was applied to the skin 6 in from the active electrode. Depending on patient tolerance, we applied a current intensity ranging from 2 to 4 mA and followed the manufacturer’s application guidelines. To reduce the risk of burns¹¹ and protect the identity of the placebo and control conditions, each treatment lasted 2 minutes. Therefore, the maximum treatment dosage did not exceed the maximum recommended dosage of 80 mA · min.¹⁰

For the control treatment, the same treatment-dosage (mA · min) guideline was followed, except we substituted 1.0 ml of distilled water for the lidocaine. For the placebo treatment, we followed the same procedure as the control, except no current was delivered to the electrodes.

If a subject reported any sensation other than tingling, we stopped the treatment, disconnected and removed the electrodes, and inspected the skin. If the skin displayed signs of blistering, we discontinued the session and removed the subject from the study. If the skin appeared normal, we continued the treatment at a lower current dosage. Two subjects experienced mild blistering and were therefore removed from the study, leaving 21 subject responses for analysis.
Statistical Analysis

To estimate the reliability of the pressure-threshold testing, we analyzed the 3 trials of the precontrol condition. We calculated an interclass correlation coefficient (ICC\textsubscript{3,1}) to determine intratester reliability and the standard error of measurement (SEM) to determine the precision of measurement. The changes in pressure threshold (change scores) for each of the testing conditions were calculated by subtracting the mean of each subject’s pretest scores from the mean of the posttest scores. An ANOVA of the change scores was performed to identify significant differences between the treatment conditions, and post hoc pairwise comparisons were performed to identify sources of significant between-treatment variance. We calculated effect size by dividing the difference between change scores by the mean square within.\textsuperscript{19} In addition, we performed a Pearson product-moment correlation to assess the relationship between the treatment dose and the change in trigger-point sensitivity after lidocaine treatment. The level of significance was set at .05 for all analyses.

Results

Based on the analysis of the 3 precontrol trials, the assessment of pressure threshold was reliable and precise (ICC\textsubscript{3,1} = .99, SEM = 0.095 kg). Mean change in pressure-threshold scores and standard-error values are found in Figure 1. The treatment dose for the lidocaine treatment ranged from 50 to 70 mA · min (60.26 ± 5.89 mA · min). There was no relationship between the lidocaine treatment dose (mA · min) and the change in pressure-threshold scores (r = –0.11, P = .65). The descriptive statistics for all pretest and posttest conditions are listed in Table 1. The ANOVA revealed

![Figure 1](image-url)  
**Figure 1** Change in pressure-threshold values (mean and standard error) for the 3 treatment conditions.

*Significantly different from the placebo and control treatments.
a significant difference among treatment conditions ($F_{2,40} = 7.38, P < .01$). Post hoc comparisons revealed that there was a significant difference in pressure-threshold sensitivity for the lidocaine treatment compared with the control ($P = .01$) and the placebo ($P = .001$). Small effect sizes of .28 and .39, respectively, were found for these comparisons, however.

**Comments**

We found that the lidocaine iontophoresis treatment increased the pain threshold of sensitive trigger points, when compared with the control and placebo treatments. The magnitude of the changes in pressure threshold, however, raises question with regard to the clinical value of this treatment technique.

The magnitude of improvement in pain threshold we found (0.28 kg/cm$^2$) does not compare favorably with previous trigger-point research.$^{6-8}$ Hong$^8$ reported significant improvements in pain threshold greater than 1 kg/cm$^2$ immediately after both a 0.5% lidocaine injection and a dry-needling technique, when a twitch response was elicited during needle insertion. Esenyel et al$^7$ found significant improvements greater than 1 kg/cm$^2$ for subjects treated with lidocaine injection and for those treated with 10 ultrasound sessions. Jaeger and Reeves$^6$ reported similar success with coolant spray and stretching.

Although it is recommended in the rehabilitation literature,$^{9,20,21}$ the effectiveness of iontophoresis in treating MFPS has not been extensively reported. In a comparative study on MFPS of the shoulder girdle, Delacerda$^{22}$ reported that dexamethasone/lidocaine iontophoresis produced greater pain-free shoulder abduction than did ultrasound and moist heat. There was, however, no inferential analysis of the data, no control group, and no indication of patient work status during the study.$^{22}$ Lark and Gangarosa$^{21}$ presented similar success in the treatment of 5 cases of temporomandibular-joint dysfunction with associated MFPS, although they make reference to only 1 case with identifiable trigger points.

The effectiveness of iontophoresis in treating general musculoskeletal
pathologies has been reported through case studies,\textsuperscript{21,23} as well as clinical research. Based on subjective improvements in pain and function, Harris\textsuperscript{24} reported that 75\% of subjects with conditions such as tendinitis and bursitis were effectively treated with dexamethasone/xylocaine iontophoresis. There was, however, no comparison with control or placebo conditions and no inferential comparison of the data.\textsuperscript{24} Bertolucci\textsuperscript{25} reported similar results for various shoulder pathologies (biceps, supraspinatus, and infraspinatus tendinitis) that did not accompany degenerative changes. Although a control condition was incorporated, 80\% of the control subjects had concomitant degenerative conditions, and between-group differences were not statistically analyzed. Antich et al\textsuperscript{26} reported a 14.5\% increase in isometric quadriceps strength and a 24\% self-reported improvement in knee-extensor-mechanism pain with iontophoresis treatments used in conjunction with a quadriceps-strengthening program. Although the treatment was compared with an ultrasound/ice treatment, no inferential analysis was performed and no control group was used. Furthermore, the authors made no mention of the possible effect the exercise program had on posttreatment isometric strength gains.\textsuperscript{26}

Other methodological issues with these studies include the lack of reliability data,\textsuperscript{22,24,25} the omission of pretreatment subject status,\textsuperscript{22,24,25} the quantifiability of the assessment measures,\textsuperscript{22,24-26} and the activity level of the subjects while undergoing treatment.\textsuperscript{22,24-26} Smith et al,\textsuperscript{27} Gudeman et al,\textsuperscript{28} and Pellecchia et al\textsuperscript{29} reported success in treating shin pain, plantar fasciitis, and infrapatellar tendinitis, respectively, with iontophoresis as an adjunct to exercise. Their randomized designs included the use of control conditions, inferential comparison of data, quantifiable and reliable measures of impairment, and pretreatment-to-posttreatment changes in pain and function. In a study that assessed muscle pain using methods similar to ours, Hasson et al\textsuperscript{30} reported that, compared with a control and a placebo condition, a single dexamethasone/lidocaine iontophoresis treatment applied 24 hours after exercise significantly reduced delayed-onset muscle soreness (pain intensity $\times$ area). A placebo treatment consisting of only lidocaine, however, did not significantly reduce the increase in delayed-onset muscle soreness.

One concern with the use of iontophoresis for any musculoskeletal injury is the ability of the medicated ions to penetrate deeply enough to reach underlying tissue such as muscle and tendon. Glass et al\textsuperscript{31} found that significant levels of dexamethasone (37.43 $\pm$ 15.62 $\mu$g/g tissue) reached muscle tissue 8.5 mm deep when iontophoresed for 20 minutes at 5 mA. These tissue dexamethasone-concentration levels were considered clinically significant, but the tissue concentrations of the lidocaine that was mixed with the dexamethasone were not reported.

Unlike Glass et al\textsuperscript{31} and other investigators,\textsuperscript{24,27-30} we applied only an anesthetic (lidocaine). Biochemical abnormalities and the proliferation of inflammatory mediators that might exist in some chronic muscle pathologies\textsuperscript{32} have not been confirmed in MTP.\textsuperscript{4,32} The pathophysiology of MTP,
although not fully understood, has been linked to a high concentration of sensory- and motor-nerve endings within the trigger points, as opposed to inflammatory events in the tissue.\textsuperscript{4,33} Therefore, we did not include an anti-inflammatory agent (corticosteroid) in our treatment. In addition, our solution concentration of lidocaine was 1%. Although the amount of solute transferred through iontophoresis might have a direct linear relationship to the concentration of the ion solution,\textsuperscript{13} less transfer might occur from highly concentrated solutions because of a clogging effect in the available pores in the skin.\textsuperscript{34}

We chose to standardize treatment duration as opposed to dose (mA · min). Our protocol allowed subjects to receive the highest tolerable amplitude over a duration that we felt would minimize the potential for burns, as well as protect the identity of the placebo and control trials, because as treatment duration increases, so does the risk of burns.\textsuperscript{11,13,34} Our dosage range of 50–70 mA · min does, however, compare favorably with doses employed in previous iontophoresis research.\textsuperscript{22,24,25,29,30} Furthermore, our results suggest that dose did not affect the magnitude of change in MTP sensitivity. Our literature review lead us to believe that there is no generally accepted treatment dose for lidocaine iontophoresis, nor is there convincing evidence relating dosage with treatment outcomes.

Lidocaine iontophoresis has not been substantiated as an effective treatment for MFPS. Thus, we selected minimally symptomatic subjects rather than provide an unproven intervention to a more symptomatic population or confound the results with concurrent treatments by other providers. Nonetheless, even though our subjects were not actively seeking treatment for MFPS, the pretreatment threshold values we recorded were similar to those reported by Jaeger and Reeves,\textsuperscript{6} Esenyel et al,\textsuperscript{7} and Hong\textsuperscript{8} for patients diagnosed with and undergoing treatment for MFPS. Whereas latent trigger-point threshold values in the upper trapezius range from 4.0 to 4.7 kg/cm\textsuperscript{2},\textsuperscript{17,14,15} our mean pretreatment and posttreatment threshold values were below 3.0 kg/cm\textsuperscript{2}. Fischer\textsuperscript{15} classifies any value below 3 kg/cm\textsuperscript{2} as abnormal or active.

Although analysis of our data revealed a significant difference between the treatments, the small effect sizes and magnitude of the change in pain-threshold scores suggest that iontophoresis with 1% lidocaine is ineffective in the treatment of MTP. Perhaps a higher concentration of lidocaine or repeated treatments would result in greater changes in MTP sensitivity. Further study, however, is clearly warranted before iontophoresis with lidocaine can be recommended for treating patients suffering from MFPS.

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**References**


