Twitch-Obtaining Intramuscular Stimulation: Observations in the Management of Radiculopathic Chronic Low Back Pain

Jennifer Chu

ABSTRACT. Objectives: To display the effect of twitch-obtaining intramuscular stimulation [TOIMS] in chronic lower back pain management and to identify characteristics of patients who respond best to TOIMS.

Methods: Retrospective analysis included 32 consecutive patients who failed conventional treatment for low back and/or lower extremity pain. All patients referred for TOIMS received such treatment. Analysis included TOIMS patients treated between January, 1992 through June, 1995. Treatments occurred weekly or every two weeks. The controls were patients with similar symptoms referred for electrodiagnosis and received only standard treatment [StdRx, not including TOIMS] for lower back pain management. Assessment of outcomes occurred at a mean of 30.9 ± 10.8 months. The main outcome measures studied were pain reduction and return to work.

Results: Patients who received TOIMS had significantly longer symptom duration, and there were more patients with fibromyalgia, spinal stenosis, and failed lumbar surgeries. At follow-up, 60.7% of the

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TOIMS patients indicated a perception that TOIMS therapy was very effective for pain control whereas only 10% of the StdRx patients felt that way about conventional care. The two groups exhibited no differences in their pain levels or numbers of working patients at follow-up. However, the TOIMS group had an increase in the number of patients who expressed lower pain levels and in those patients who could return to work from the pre-treatment assessment. This pattern did not occur in the StdRx patients. Twitch obtaining intramuscular stimulation was more effective in those without evidence of spinal stenosis.

Conclusions: Twitch obtaining intramuscular stimulation seems promising in the management of partial radiculopathy related chronic low back pain. With the present manual mode of TOIMS, it is unlikely to benefit those with evidence for bony spinal abnormalities such as stenosis. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: getinfo@haworthpressinc.com <Website: http://www.haworthpressinc.com>]*

KEYWORDS. Twitch-obtaining intramuscular stimulation, low back pain, fibromyalgia, lumbosacral radiculopathy

INTRODUCTION

A hypothesis proposed by Gunn for myofascial pain syndrome and fibromyalgia includes radiculopathy induced muscle fiber shortening from denervation related spasm or contracture (1). This is a mechanism not commonly known or accepted and not cited in prior literature concerning these two conditions (2-4). The hypothesis maintains that shortening of muscle fibers can cause mechanical effects that lead to a large variety of pain syndromes. The proposed mechanism is an unrelenting pull by the contracted muscles on nerves, blood vessels, tendons, the bones onto which the muscles attach or the joints over which they cross (5).

It was proposed that the muscle fiber shortening could be released by pin stimulation of the tender motor points in a muscle band and/or bands (1,6). Gunn described this method as intramuscular stimulation. The method involves "pecking" and "twirling" movements of an intramuscularly inserted pin at tender motor points. The theory is that these movements cause the muscle shortening to initially intensify and then relax leading to relief of muscle pain (1).

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intramuscular stimulation [TOIMS] involves elicitation of twitch responses from specific points in the muscles. These points in the muscles have characteristics of myofascial trigger points [TrPs] (2,3). The twitch point identification, similar to that of TrP identification, includes palpation for the presence of muscle bands, knots, nodules or cord-like intramuscular swellings (2-4). The most tender point along these areas gives the most reliable yield of twitches. The twitch points [TrPs] are believed to be regions of abnormally excitable motor endplate zones [motor points] in muscles, identifiable by electromyography (7-13). The precise placement of the treatment pin at the TrP objectively elicits twitch responses on pin insertion and oscillation.

The purpose of this retrospective study is to determine whether 1. TOIMS has promise for controlling chronic myofascial pain syndrome and fibromyalgic pain secondary to lumbosacral radiculopathies. 2. TOIMS has potential for identifying the characteristics of patients who can benefit most from this treatment.

MATERIALS AND METHODS

Twitch-obtaining intramuscular stimulation is an approved clinical procedure for use in patient care at the author's institution. Patients treated with TOIMS were those referred by their primary physicians due to failure of conventional treatments for chronic lower back and/or lower extremity pain. Sequential randomization of patients to a treatment group was not done. All patients referred for treatment received TOIMS. All patients received detailed explanations of the treatment prior to its start but written consent was not obtained. Retrospective analysis included the TOIMS patients treated between the January 1992 through June 1995. This is to allow sufficient numbers of patients for analysis as determined statistically [N = 17] and to allow for drop-outs. The controls were patients referred to the author by their physicians, solely for electrodiagnostic studies as an aid to the diagnosis of lower back and/or lower extremities pain. The patients examined between the period of 1993-1994 allowed a minimum duration of two years at the time of follow-up in February 1997. The referring physicians managed and provided standard treatment [StdRx] to these patients. The author had no further involvement with these patients after the initial contact for electrodiagnostic studies. The retrospective analysis was reasonably objective for both groups since the follow-up occurred two or more years after the intervention and the outcome assessor was a nurse blinded to intervention group, whether it was TOIMS or electromyogram [EMG].

At the time of their initial entry into the study, all patients had a physical examination to include goniometric measurements obtained in degrees for cervical spine flexion and extension; shoulder abduction, flexion, and extension; lumbosacral spine flexion and extension; and the supine straight leg raising test bilaterally. Other measurements also included the distance between the heel and the floor in centimeters while the patient stood on the toes of one supporting limb.

Muscle tenderness assessment included notation of patient's expressed pain level on pressing very strongly [estimated 4 kg pressure], the blunt end of a Paper Mate ball point pen [about 0.6 cm^2 surface area] into muscle motor points. The pressure application was sufficient to leave a deep indentation of the blunt end of the pen on the skin overlying the muscle. The palpation of muscle motor points occurred at regions of the muscles identified by the presence of a muscle band, knots, nodules or cord-like intramuscular swellings (2,3,13). The patients also received instructions to grade the pain as mild, medium or severe. Motor point palpation included the representative muscles of the L2-S1 and the C2-C8 myotomes. Examination of tender points [TeP] included points as described by the American College of Rheumatology (14) allowed recording of the number of TePs. Palpation for firm swelling of muscles was performed for the cervical, thoracic, and lumbosacral paraspinal muscles.

The EMG studies for all patients included examination of the these muscles: sartorius [L2], adductor longus [L3], vastus medialis and lateralis [L4], tensor fascia latae [L5], gluteus medius [L5], gluteus maximus [S1], and the paraspinal muscles at L2-S1. Some of these patients also had EMG studies of the upper extremities and cervical paraspinal muscles.

Examination of each muscle was at two skin insertion sites. The muscle examination was in different directions and at different depths for electrical activity at rest and minimal and maximal contraction. Study of the motor unit action potentials [MUAPs] was by the method of triggering and delaying the MUAP activity at a sweep speed of 5 ms/division. The filter used was 20 Hz-10 kHz. Twenty MUAPs were semi-quantitatively analyzed. Determination of MUAP morphology included measurement of amplitude, duration, number of phases, and percentage of polyphasia when the MUAPs had the sharpest rise time. Assessment of the duration occurred at a standard gain of 200 μV to 250 μV/division. Equipment used for EMG was the TD 20 EMG machine [Oxford Medical Instruments, Pleasantville, New York] and disposable Oxford Instruments monopolar MG 37 needles.

A diagnosis of chronic radiculopathy occurred when there was an increase in the percentage [>10%] of long duration triphasic potentials [>20 ms] with large amplitude [>4 mV] (15). The potentials had to be present in a myotomal pattern including the paraspinal muscles.

Twitch-obtaining intramuscular stimulation treatments were applied to include the T10 through S1 paraspinal muscles and the proximal muscles of the L3 through S1 myotomes bilaterally. The treatments occurred on a weekly or bi-weekly basis. Many of the patients also received treatment with TOIMS to the symptomatic proximal muscles of the C3 through C7 myotomes. Included also were the contralateral muscles of the most involved cervical myotomes. Treatments required the use of monopolar EMG electrodes MG 37 or MG 50.

The follow-up done in February, 1997 consisted of a questionnaire approved by the Institutional Review Board with inquiries directed towards: 1. most effective treatment received by the patient. The options available were: medication [oral or injected into muscles or nerves], physical treatments [such as exercises, chiropractor, acupuncture], surgical treatments, TOIMS [pain relief very effective, moderately effective, mildly effective or not effective], or others; 2. the current average pain level on a visual analog scale; 3. current medications used [narcotics or otherwise]; 4. current utilization of other health care professionals; 5. current work status; 6. comments. Follow-up occurred only by mail and no further contacts were attempted. A clinic nurse, not involved with the treatments supplied the questionnaire to the five patients still in treatment. The author was not directly involved in the follow-up procedures.

Comparison of the average pain level obtained on each patient at the beginning of the study with that obtained at the end of the study allowed assessment of the change in average pain level. A physician pain rating scale utilized the average pain levels expressed weekly by each patient. An excellent pain rating included patients whose pain levels were stabilized at 0-1 level, good pain rating = 2-4, medium rating = 5-6, and a poor rating = 7-10, where 0 and 10 represent the lowest and highest pain levels, respectively. The same rating was used for the average pain level reported by the patient at follow-up.

To better understand the outcome measures for TOIMS, there was a division of the patients into three groups depending on the survey results for the pain reducing effects of TOIMS [variable #1 of the questionnaire]. These three groups were 1. lower group-very effective [LG-VE], 2. lower group-mild/medium or no pain relief effects [LG-M/NE] and 3. lower group-no follow-up [LG-NF].

Statistical Analysis: A Chi-square testing and logistic regression testing determined significance in group differences between the groups of patients. Pearson product moment correlation testing allowed correlation analysis. Bonferoni correction assured that significance for multiple measures between groups did not occur by chance. Significance was set at [$P \leq 0.01$]. The software used was Statistica [Statsoft Inc., Tulsa, OK].

RESULTS

Study Population

There were 32 patients who received TOIMS treatment during the analysis period. There was a success rate of 87.5% for follow-up. The follow-up period for 23 patients who discontinued TOIMS and for five still in treatment, was 30.9 ± 10.8 months and 39.0 ± 15.1 months respectively. The follow-up success was only 30% for 100 consecutive control patients [StdRx] and the follow-up period was 33.8 ± 4.1 months. However, the StdRx patients who could be followed were comparable in numbers of patients, age, sex, and number of TePs elicited. Although not significant statistically, there was a trend for patients older than 65 years to be in the TOIMS group.

Both groups showed EMG abnormalities compatible with recent ongoing re-innervation changes and chronic stable re-innervation changes in multiple myotomal levels from L2 to S1 root supply. Both groups showed the most involved roots to be at the L5 and S1 levels. However, there were no significant differences in EMG abnormalities between the two groups. This is in terms of increased percentage of normal duration, normal amplitude polyphasic MUAPs suggesting ongoing re-innervation. No differences were noted for the long-duration triphasic MUAPs compatible with chronic re-innervation [$P < 0.01$].

Twitch-Obtaining Intramuscular Stimulation and the Standard Treatment Group Comparison

As shown in Table 1 TOIMS patients had significantly longer duration of symptoms, and higher percentage of patients with: 1. complaints of diffuse body pain, 2. stenosis at L5-S1 level, and 3. failed lumbar surgeries. No significant differences were noted between the two groups with respect to age, sex or the number of TePs.

As shown in Table 2, no differences seen between the two groups for the percentages of patients who indicated low levels of pain [good pain rating] at start of the study or at follow-up. At the start of the study, numerically only half as many patients in the TOIMS group could work full-time even though the difference was not significant. By the time of follow-up significantly more of the TOIMS patients had changed their pain question answer to low pain levels [good pain rating] and had changed their response regarding their ability to work full-time.

TABLE 1. The Clinical Characteristics of the Twitch-Obtaining Intramuscular Stimulation Patients and Standard Treatment Patients

	TOIMS [N = 32]	StdRx [N = 30]
Age [years]	45.4 ± 15.1	40.7 ± 13.3
Age ≥ 65 [%]	28.1	6.7
Female sex [%]	50.0	63.3
Tender points [#]	14.8 ± 2.4	13.4 ± 1.9
Diffuse body pain symptoms [%]	93.8	40.0
Pain duration [months]	43.1 ± 40.8*	12.5 ± 14.8

TOIMS: Twitch-obtaining intramuscular stimulation
StdRx: Standard treatment
*Significant difference between TOIMS and StdRx groups at $P \le 0.01$

TABLE 2. Comparisons of Outcome Measures at the Start of the Study and at Follow-Up

	TOIMS		StdRx	
	Start	Follow-Up	Start	Follow-Up
Good pain rating [%]	9.4	46.4	30.0	30.0
Full time work status [%]	18.8	35.7	36.7	33.3
MRI stenosis at L5-S1 level [%]	50.0*	N/A	6.7	N/A
Procedure performed [%]				
Nerve blocks	21.8	0	23.3	0
Laminectomy	18.8*	0	0	0
Discontinued treatment with health care professionals [%]	0	28.9	0	33.3
Treatments with definite pain relief				
TOIMS	0	60.5	N/A	N/A
Others	0	0	N/A	10.0

TOIMS: Twitch-obtaining intramuscular stimulation
StdRx: Standard treatment
MRI = Magnetic resonance imaging
*Significant difference between TOIMS and StdRx groups at P ≤ 0.01

Lower Group-Very Effective Patients and Lower Group-Mild-Moderate Effective/Not Effective Patients Comparison

When the TOIMS group was divided into three groups on the basis of the effectiveness of TOIMS for providing pain relief [see Tables 3 and 4], the lower group-very effective [LG-VE] group showed significantly: 1. greater number of treatment sessions [$P \leq 0.005$], and 2. more patients who had treatments directed toward the cervical myotomes also [$P < 0.005$]. Otherwise there were no differences between the two groups for all parameters studied.

Correlation Matrices

When correlation analysis was applied to all TOIMS patients, age showed a negative correlation with the number of twitches obtained during treatment [$R = 0.4$, $P \leq 0.005$]. The number of treatment sessions

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TABLE 3. The Clinical Characteristics of the Twitch-Obtaining Intramuscular Stimulation Patients Grouped According to Perceived Pain Relief Effects with Twitch-Obtaining Intramuscular Stimulation

	LG-VE [N = 17]	LG-M/NE [N = 11]	LG-NF [N = 4]
Age [years]	44.4 ± 16.1	56.5 ± 54.9	37.5 ± 9.4
Age ≥ 65 [%]	17.6	54.5	0
Female sex [%]	52.9	45.5	50.0
Diffuse body pain symptoms [%]	90.9	100.0	100.0
Tender points [#]	14.4 ± 2.3	15.3 ± 2.2	15.0 ± 3.5
Pain duration [months]	33.1 ± 27.3	55.8 ± 4.9	43.5 ± 49.3
Number of TOIMS treatments	36.5 ± 27.7*	7.3 ± 3.8	14.3 ± 9.5
Cervical and Lumbosacral myotomal TOIMS [%]	88.2*	27.3	50.0
Procedures performed before TOIMS [%]			
Nerve blocks	23.5	27.3	0
Laminectomy [failed]	29.4	9.1	0

LG-VE: lower group-very effective
LG-M/NE: Lower group-mild/medium/not effective
LG-NF: Lower group-no follow-up
TOIMS: Twitch-obtaining intramuscular stimulation
Significant difference between LG-VE and LG-M/NE at * = [P ≤ 0.01]

correlated with the reduction in the pain level [$R = 0.4$, $P < 0.0001$]. There was also a direct correlation with the number of treatment sessions with the increase in straight leg raising testing bilaterally [$P < 0.001$]. There was an increased ability to lift the heel of the supporting limb off the floor while standing only on this limb [$R = 0.3$, $P = 0.01$]. There was a negative correlation between the pain level and the number of obtainable twitches [$R = -0.3$, $P = 0.01$]. There was a correlation between the pain rating graded by the author during the study and the patient satisfaction with TOIMS method at follow-up [$R = 0.4$, $P < 0.001$].

DISCUSSION

The hypothesis proposed by Gunn (1) can be summarized as follows: It assumes that spondylotic attrition can lead to denervation and

TABLE 4. Comparisons of Outcome Measures at the Start of the Study and at Follow-Up for Twitch-Obtaining Intramuscular Stimulation Patients Grouped According to Perceived Pain Relief Effects with Twitch-Obtaining Intramuscular Stimulation

	LG-VE [N = 17]		LG-M/NE [N = 11]		LG-NF [N = 4]	
	Start	Follow-Up	Start	Follow-Up	Start	Follow-Up
Good pain rating [%]	5.9	64.7*	0	18.2	50.0	N/A
Pain scale reduction at treatment termination [#]		2.5 ± 2.0*		−0.5 ± 2.6		−0.1 ± 1.5
Full time work status [%]	17.6	47.1	27.3	18.2	0	N/A
Discontinued treatment with health care professionals [%]		35.7		14.3		N/A

LG-VE: Lower group-very effective
LG-M/NE: Lower group-mild/medium/not effective
LG-NF: Lower group-no follow-up
TOIMS: Twitch-obtaining intramuscular stimulation
Significant difference between LG-VE and LG-M/NE at * = [P ≤ 0.01]

hyper-irritability of the spinal nerve roots. The spondylosis-induced partial denervation is multiradicular and bilateral (7-9,15,16). The effects of partial denervation, when present, will occur in multifocal areas of the muscle since the distribution of the muscle fibers belonging to one motor unit may occur to over 100 fascicles in a muscle (17). The denervated end plates on denervated muscle fibers develop denervation supersensitivity allowing slow depolarization from circulating acetylcholine (18,19). This leads to electromechanical coupling with resultant shortening of muscle fibers. When the muscle fiber shortening is irreversible, contracture occurs. Muscle fiber shortening which occurs with functional denervation due to neuropraxia can be reversed when the neuropraxia is relieved (20). These denervation features can explain the presence of "dysfunctional end-plates," described for the pathophysiology of TrPs by Travell and Simons (2,3,21). The shortened muscle fibers create a constant tugging effect to various structures causing a variety of pain syndromes. These structures could include spinal nerve roots, intramuscular nerves, blood vessels, nociceptors, and tendons, joints and bones to which the muscles attach or crossover (1).

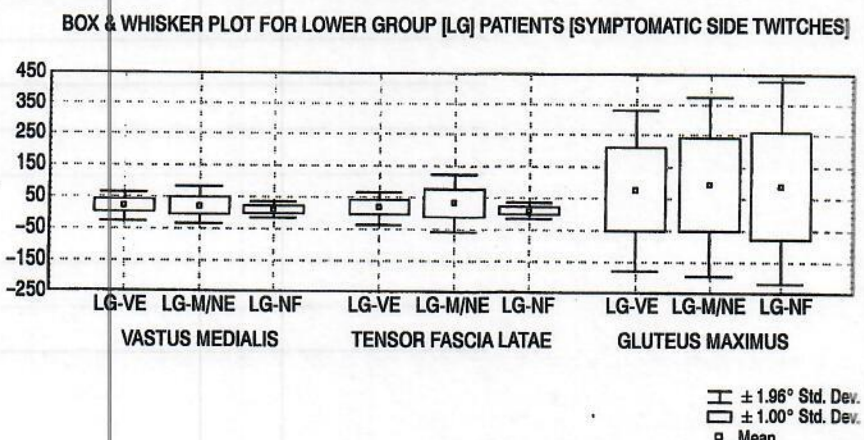
Reduced levels of adenosine triphosphate noted in the TrPs of regional myofascial pain syndrome and fibromyalgia suggest that these syndromes have the same basic underlying defects (22). However, others have implied that these two conditions have basic etiological differences with a neurochemical basis attributed for fibromyalgia (23-25). The present study seems to support Gunn's theory that spondylotic radiculopathy is a possible explanation of the pain in both conditions. There is evidence of membrane instability at TrPs (26-28) especially with partial radiculopathies (8,9). Even if axonal regeneration and remyelination could occur after nerve damage, the nerve fiber would only be as functional as its most severely affected internode (29). Also, the nerves that have been injured are easily susceptible to re-injury (30). Although not proven, this could be one of the possible explanations why patients with fibromyalgia do not show a significant improvement in symptoms over the long-term follow-up of five years (31,32). In this study, continuing treatments for those workers with injured nerve roots controlled their pain and maintained their ability to work. Most of the TOIMS patients had fibromyalgia. Only the LG-VE had many treatment sessions that included the cervical and lumbosacral myotomes. Generalized pain reduction attained by patients in this group may be the reason why LG-VE group concluded that TOIMS gave satisfactory pain relief. The patients who had StdRx also elicited multiple TePs compatible with fibromyalgia, but only a low percentage complained initially of diffuse body pain at time of electrodiagnosis. Therefore, if these StdRx patients with fibromyalgia received only regional treatments to the low back, unsatisfactory pain reduction may occur.

This study and in the study of patients with cervical nerve root irritation treated with TOIMS [Chu, J, 1999, unpublished], age had an inverse correlation on the number of twitches. This implied that aging muscle fibers have been subjected longer to the influences of chronic partial denervation. These muscle fibers become less resilient or more fibrotic losing the ability to respond well by twitching when stimulated mechanically. Any pathology, especially concomitant peripheral neuropathy, which impairs conduction to and from the spinal cord would also reduce the ability of the muscles to twitch with mechanical stimulation (33,34).

The intramuscular exercise obtained from muscle contraction and immediate relaxation associated with the evoked twitches at the treated TrPs may reduce stiffness of muscle and improve circulation (12,35,36). Post isometric relaxation and high voltage galvanic stimulations are commonly used to treat muscle pain (37-39). The exercise effects from these techniques differ from that obtained through the twitches in TOIMS. The focal muscle exercise and stretch effects from the twitches occur from various depths and circumscribed regions within the muscle. The twitches associated with TOIMS have an advantage in mobilizing deep tissues not possible with StdRx. The stretch effects from the twitches will also excite the muscle spindles since the latter has been associated with the TrPs (27). Since spinal pathways are associated with the twitch response (33,34), normalization of spinal pathways may also play a role in the therapeutic effects.

The clinical trend showed that excessive numbers of twitches with every treatment is a poor prognostic indicator for response to TOIMS [see Figure 1]. It is possible that this was not shown statistically due to the presence of large standard deviations in the muscles analyzed and the small numbers of patients involved. The gluteus maximus showed the largest number of twitches and the largest standard deviation. This muscle received more treatment points due its mass and its perceived influence on low back pain through its attachment into the sacrum

FIGURE 1. Twitch response distribution in the vastus medialis, tensor fascia latae and gluteus maximus muscles of the patients who received TOIMS.



LG-VE: Lower group-very effective
LG-M/NE: Lower group-mild/medium/not effective
LG-NF: Lower group-no follow-up

(40). Similar numbers of twitches recorded from the muscles in the symptomatic and asymptomatic side relate to the presence of bilateral multi-level radiculopathy. Twitch force measurements may help better elucidate the differences in findings between symptomatic and asymptomatic sides.

Follow-Up and Outcome Assessment

The long-term follow-up of patients who received TOIMS suggest that TOIMS can be promising in the management of chronic pain reduction and stabilization. Patients who benefited significantly from this treatment had the following characteristics: 1. fewer MRI abnormalities such as lumbar stenosis, 2. received treatments to both the cervical and lumbosacral myotomes, 3. the involved muscles twitched readily but not excessively, and 4. received continued treatments to stabilize the pain and maintain their functional ability. The physician time spent with the patient and the effort intensiveness of the procedure are considerations that may have influenced the patients' opinion regarding the pain relieving effects of TOIMS. However, these factors may be inconsequential, since at follow-up there was an objective increase not only in the number of TOIMS patients who can work but also in those who had maintained lower pain levels.

The problems associated with TOIMS include treatment pain due to needle flexion during skin and muscle penetration. Also, when the pin is oscillated during treatment, the trajectory for the active twitch point is lost when the pin encounters different tissue resiliencies. The manipulation of the pin inside the muscle to regain the twitch point is another source of pain. Post-treatment pain can occur for 1-2 days in patients who had significant muscle tightness that predisposes the tissue to trauma. The force of the twitch pulling the pin into adjacent unexcitable muscle tissue also causes inadvertent transient tissue trauma. The painful nature of manually performed TOIMS and needle phobia may have played a significant role why the patients in the LG-NF group did not return the questionnaire. Similarly, the StdRx patients who did not respond to follow-up are assumed to have had treatment failures to conventional methods.

The advantages are that TOIMS is ideal for repeated use in patients with chronic pain. The twitch induced muscle movements prevent the same TrP from being repeatedly treated. The pin used does not have a beveled edge as in hypodermic needles used in TrP injections and therefore minimizes tissue trauma. Injection methods are not feasible for long-term repeated use in chronic pain patients. Also, as spinal reflexes are involved in the elicitation of the mechanically evoked twitch, injection of local anesthetics would counteract the effects needed from TOIMS.

Twitch-obtaining intramuscular stimulation is tedious and time-consuming. There is accumulative physical trauma to the physician from the repetitive nature of the work involved with manually oscillating the pin at numerous twitch points in many muscles. The problem becomes compounded when many patients need this type of treatment.

The observations noted in this study have limitations since this is a retrospective study. The intensity and quality of treatments or physician time involvement in the StdRx group is unknown. The nature of the referral to the author decided which group the patient would be in and a sequential randomization was not involved. Therefore, the results of this study are only suggestive. There may be value in repeating the study with a randomized controlled design after TOIMS method has been further refined. Improvement of the treatment method for both patient and physician related factors is reasonable and medically appropriate. An automated TOIMS system is currently under development (41).

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