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Research Article

Inhibitory Effect of Dry Needling on the Spontaneous Electrical Activity Recorded from Myofascial Trigger Spots of Rabbit Skeletal Muscle

ABSTRACT

Chen JT, Chung KC, Hou CR, Kuan CR, Chen SM, Hong CZ: Inhibitory effect of dry needling on the spontaneous electrical activity recorded from myofascial trigger spots of rabbit skeletal muscle. *Am J Phys Med Rehabil* 2000;80:729–735.

Objective: Dry needling of myofascial trigger points can relieve myofascial pain if local twitch responses are elicited during needling. Spontaneous electrical activity (SEA) recorded from an active locus in a myofascial trigger point region has been used to assess the myofascial trigger point sensitivity. This study was to investigate the effect of dry needling on SEA.

Design: Nine adult New Zealand rabbits were studied. Dry needling with rapid insertion into multiple sites within the myofascial trigger spot region was performed to the biceps femoris muscle to elicit sufficient local twitch responses. Very slow needle insertion with minimal local twitch response elicitation was conducted to the other biceps femoris muscle for the control study. SEA was recorded from 15 different active loci of the myofascial trigger spot before and immediately after treatment for both sides. The raw data of 1-sec SEA were rectified and integrated to calculate the average integrated value of SEA.

Results: Seven of nine rabbits demonstrated significantly lower normalized average integrated value of SEA in the treatment side compared with the control side ($P < 0.05$). The results of two-way analysis of variance show that the mean of the normalized average integrated value of SEA in the treatment group (0.565 ± 0.113) is significantly ($P < 0.05$) lower than that of the control (0.983 ± 0.121).

Conclusions: Dry needling of the myofascial trigger spot is effective in diminishing SEA if local twitch responses are elicited. The local twitch response elicitation, other than trauma effects of needling, seems to be the primary inhibitory factor on SEA during dry needling.

Key Words: Myofascial Trigger Points, Myofascial Pain Syndrome, Needle Injection, Abnormal Endplate Potentials, Local Twitch Response

Myofascial trigger points (MTrP) are characteristic of myofascial pain syndrome, the most common muscle pain disorder in clinical practice.[1,2] MTrP is a hyperirritable spot in a palpable taut band that is firmer in consistency than the adjacent muscle fibers.[3,4] When an MTrP is mechanically stimulated through snapping or needling, local twitch responses (LTRs), brisk contraction of the taut band (but not the surrounding normal muscle fibers), can be elicited.[4–9] Clinically, MTrP injection has often been used as an effective and valuable procedure to inactivate an active MTrP and subsequently relieve the pain and tightness of the muscle involved in myofascial pain syndrome. During MTrP injection, as soon as the needle penetrates to a sensitive site, an LTR usually can be elicited, especially for rapid needling.[6,7,10] Dry needling of the MTrP has been reported to be as effective as local anesthetic injection.[6,7,10–12] Effective outcomes of MTrP injection or dry needling have been associated with the elicited LTRs.[6,7,10] On the contrary, little clinical effectiveness has resulted from minimal LTR elicitation. Studies in both human and animal experiments have suggested that immediately after an effective injection or dry needling, LTRs would be suppressed and no more LTRs could be elicited by further needling.[6] It seems that LTR is closely related to the activity (or pain intensity) of an MTrP.

Research studies have been conducted to develop an animal model for addressing the issue of MTrP in humans.[13–17] In the rabbit model we used, taut bands were palpable in the skeletal muscles. A hyperirritable spot in the taut band could also be identified. When the rabbit was awake, compression of this spot usually caused responses in the animal as if it suffered pain or discomfort. This sensitive spot was defined as a myofascial trigger spot (MTrS), similar to human MTrP in many aspects. Rabbit LTRs, similar to human LTRs, can be elicited when a mechanical stimulation is applied to the MTrS region. It has been reported that the LTR is mediated by means of a spinal reflex in both humans[8] and rabbits.[13,14] However, the exact mechanism of LTR is still unclear. It is also unknown why it is important to elicit LTRs during MTrP injection to obtain a better treatment effect.

Electrophysiologic studies showed that spontaneous electrical activity (SEA) can be recorded from multiple active loci in an MTrP region in humans[18,19] or in an MTrS region in rabbits.[15,17] SEA consists of continuous, noise-like action potentials (5–50 μV, occasionally up to 80 μV) accompanied by intermittent, large-amplitude spikes (100–600 μV, biphasic, initially negative). This electrical activity would disappear if the recording needle electrode was advanced or withdrawn as little as 1 mm. The control needle electrode in nearby muscle fibers of the taut band showed no SEA. Previous studies have indicated that SEA can be recorded more frequently in an MTrS region than in a control site of rabbit skeletal muscles, and similar findings have also been demonstrated in human skeletal muscles.[17]

Simons has indicated that an SEA is an abnormal endplate potential caused by excessive leakage of acetylcholine (ACh).[4] The spikes in SEA are propagated single-fiber muscle action potentials originating in the immediate vicinity of the endplate zone. The excessive ACh release depolarizes the postjunctional membrane, which may cause additional Ca^{2+} release to aggravate the taut band formation through the mechanism of energy crisis.[4]

It has been demonstrated that the magnitude of SEA is significantly increased by laboratory stressors in both healthy subjects[20] and patients with tension headaches[21] or chronic myofascial pain syndrome.[19] Furthermore, the magnitude of SEA is closely related to the pain intensity in patients with chronic and recurrent muscle pain associated with MTrPs.[18,19] However, the interrelation of SEA, LTR, and MTrP injection is still unknown.

Our hypothesis is that dry needling of MTrP is useful in diminishing SEA, leading to effective pain relief of myofascial pain syndrome patients. The aim of this study was to apply electrophysiologic signal analysis in quantitatively characterizing the change of SEA for dry needling on MTrS, using a rabbit model.

METHODS

Animal Preparation. Nine adult New Zealand rabbits with body weights ranging from 8 to 10 pounds were studied. All procedures used in this study were approved by the Institutional Animal Care and Use Committee of the National Cheng-Kung University. Each animal was anesthetized with an intramuscular injection of ketamine 0.05 mg/kg of body weight prior to intravenous injections of thiopentone sodium (0.01 g/ml). Bilateral biceps femoris muscles were separated from the underlying semimembranosus muscles after the skin of the lateral thigh was incised.

Identification of MTrS. The biceps femoris muscle was palpated by gently rubbing (rolling) it between the fingers to find taut bands. A taut band feels like a clearly delineated "rope" of muscle fibers roughly 2–3 mm or more in diameter. Snapping palpation testing was applied on the band for LTRs elicited. The MTrS of rabbit skeletal muscle was determined from the location along the band with the most vigorous LTRs in the snapping palpation testing.

Electrophysiologic Recordings of SEA. For SEA recording in an MTrS region, a monopolar electromyographic needle electrode was initially

inserted into a taut band region and connected to channel 1 of a 4-channel Viking EMG System (Nicolet Biomedical Inc., Madison, WI). The control needle electrode was inserted into the nearby normal muscle fibers and connected to channel 2. The reference electrode common to both channels 1 and 2 and the ground electrode were attached to the adjacent subcutaneous tissue. The sensitivity of recording was set at 0.02 mV per division, and the sweeping speed of the screen was set at 10 msec per division.

Search for SEA. The active recording needle was advanced gently and slowly along the muscle fibers in the MTrS region. Each advance was of a short distance (for only about 1 mm) because of the minute size of an active locus. Fifteen sets of SEA were recorded from different active loci within the MTrS region (2×2 cm) of biceps femoris muscle before and immediately after rapid dry needling for treatment and very slow needle inserting for control.

Dry Needling to Elicit LTRs. In dry needling treatment, repetitive and rapid needle inserting into multiple sites in the MTrS region was applied to elicit sufficient LTRs. LTRs, which are generally both palpable (feeling of muscle twitch) and visible, are recognized by firm finger palpation over the MTrS region. The numbers of LTR elicited during dry needling were recorded for comparison. Control study was conducted on the other side by very slow needle insertion along the muscle fibers in the MTrS region for minimal LTR elicitation.

Signal Processing. Data collection and analysis were done with a PC-586 computer and DaqBook 100 (12 bits, 16 channels, maximum sampling rate of 100 kHz) analog-to-digital converter (IOtech Inc., Cleveland, OH). The SEA signal was sampled at 20 kHz then detrended and filtered out with a 60-Hz notch filter by use of MATLAB 5.0 software (MathWorks, Inc., Natick, MA). The raw data of 1-sec SEA were rectified and integrated to calculate the average integrated value for each SEA recording (AIV-SEA) (Fig. 1). The signal of spikes was included because the spikes are considered to represent a more active SEA because they are usually found in an active MTrP rather than a latent one.[18]

Data Analysis. The AIV-SEA was used as an index of the intensity of SEA and dependent variable for statistical analysis using SPSS/PC package (SPSS Inc., Chicago, IL).[15] The AIV-SEA parameter was initially tested for heterogeneity between and within rabbits and groups to validate its feasibility in the quantitative measurement of SEA. In each group, the mean of AIV-SEA after needle injection was normalized with the data before injection. For each individual rabbit, *t* test was used to compare the normalized AIV-SEA between treatment and control sides. Lumped data from all nine rabbits were further analyzed with two-way analysis of variance for statistical significance between treatment and control groups. A significance level of 0.05 was selected for this study.

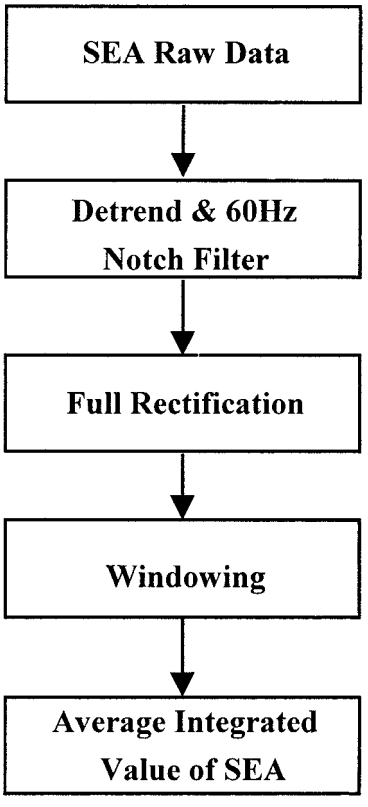

Figure 1: Electrophysiologic signal processing of the spontaneous electrical activity (*SEA*).

RESULTS

Figure 2 shows a typical example of the SEA recordings from an MTrS region of a rabbit before and immediately after dry needling of MTrS. The magnitude of raw SEA data are obviously suppressed after dry needling. All the data of AIV-SEA recorded from 15 different loci within the MTrS region in both treatment and control sides of nine rabbits have exhibited a normal distribution pattern consistently. In the treatment group, the numbers of LTR elicited during rapid dry needling on nine rabbits are ranged from 22 to 37 times with mean and standard deviation at 30.2 ± 4.7 (median and mode equal to 30), whereas in the control group, the numbers of LTRs elicited during very slow needle insertion are ranged from 6 to 10 times, with mean and standard deviation at 8.4 ± 1.4 (median and mode equal to eight). The results of the *t* test demonstrate that the numbers of LTRs of the dry needling group are significantly larger than those of the control group. The means of normalized AIV-SEA in the treatment group are lower than those in the control group for all nine rabbits; the results of the *t* test on treatment effect comparison indicate that seven out of nine rabbits have a significantly lower normalized AIV-SEA on the treatment side than on the control side ($P < 0.05$) (Fig. 3). In the two-way analysis of variance of treatment and rabbit factors, the statistical results with means and standard deviations (Table 1) show that the normalized AIV-SEA in the

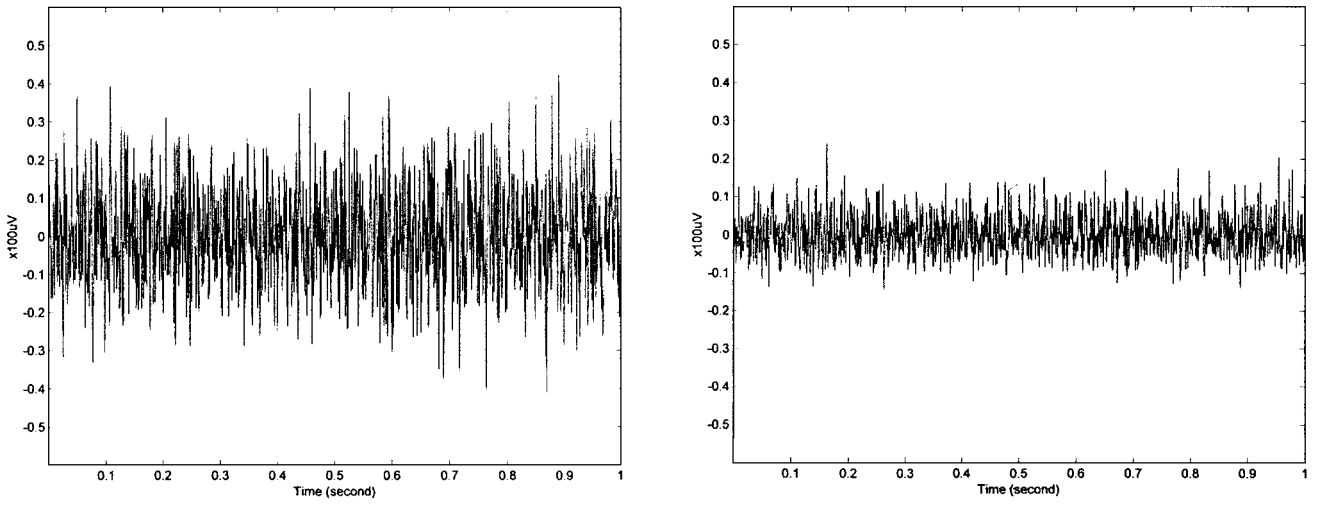

Figure 2: Electromyographic recording of spontaneous electrical activity from the active locus of the myofascial trigger spot in the biceps femoris muscle of a rabbit before (*left*) and immediately after dry needling (*right*).

treatment group (0.565 ± 0.114) is significantly lower than that of the control group (0.983 ± 0.121; $P < 0.05$).

DISCUSSION

Electrophysiologic studies of the motor endplate have shown that there is intermittent quantal release of ACh from the nerve terminals, resulting in the appearance of discrete miniature endplate potentials (MEPPs).[22] There is evidence that the discharges caused by spontaneous local excitation of individual motor nerve endings or small, specialized membrane areas that are concerned with the release of ACh.[23] Jones and coworkers drew attention to the presence of two types of spontaneous electromyographic activity in normal muscles at rest.[24] They described two components that are similar to SEA pattern. The first is characterized by high-frequency negative monophasic deflections of low amplitudes (5–20 μV). The second component consists of a variable number of biphasic spike potentials (100–500 μV). Similar potentials have been observed in the rat, guinea pig, cat, dog, rabbit, and monkey.[24–27] In humans, these potentials may be observed in 5–10% of routine insertions of the needle into normal muscle and can be observed more frequently in the region of the motor point.[24] Buchthal and coworkers[26] originally suggested that the first type of activity, also known as endplate noise, corresponds to extracellularly recorded MEPPs emanating from endplates located adjacent to the needle electrode. The second type of activity, referred to as endplate spikes, corresponds to single muscle fiber action potentials postsynaptically activated by suprathreshold endplate noise. Wiederholt examined rabbit endplate noise with histologic, electrophysiologic, and pharmacologic means. He concluded that potentials in endplate noise are MEPPs.[27] The issue of whether the endplate noise (SEA) arises from normal or abnormal endplates is critical and questions conventional belief. Normal endplate potentials are occasional, discrete, short, and negative monophasic potentials. Endplate noise is the result of a 100- to 1000-fold increase in the rate of release of ACh.

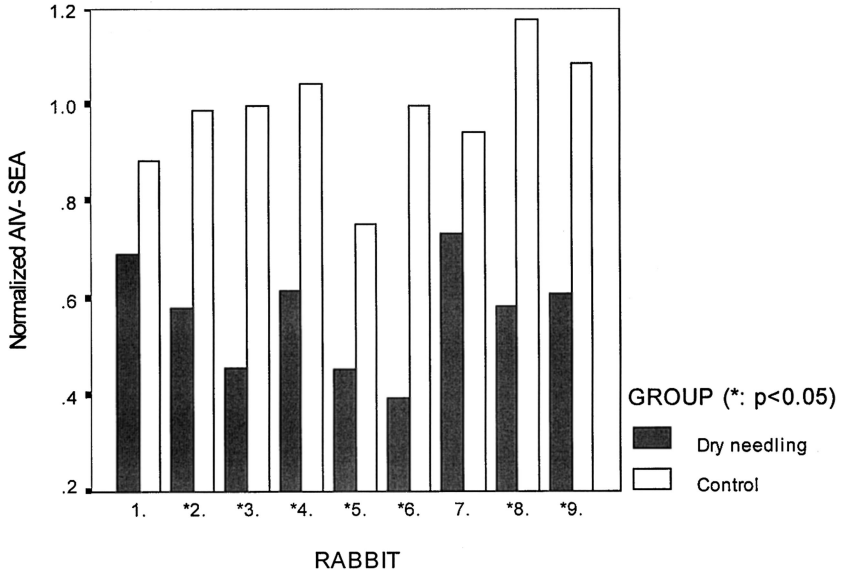

Figure 3: Means of the normalized averaged integrated value (*AIV*) of spontaneous electrical activity (*SEA*) in 15 different loci in the treatment and the control sides.

TABLE 1
Mean and SD of normalized average integrated value of spontaneous electrical activity in two-way analysis of variance

Rabbit	Dry Needling Side (μV)	Control Side (μV)
1	0.688 ± 0.274	0.883 ± 0.607
2	0.577 ± 0.105[a]	0.987 ± 0.365
3	0.452 ± 0.217[a]	0.995 ± 0.303
4	0.614 ± 0.255[a]	1.040 ± 0.325
5	0.449 ± 0.141[a]	0.751 ± 0.354
6	0.390 ± 0.180[a]	0.995 ± 0.445
7	0.730 ± 0.446	0.940 ± 0.375
8	0.581 ± 0.369[a]	1.177 ± 0.557
9	0.606 ± 0.273[a]	1.084 ± 0.479
Mean ± SD	0.565 ± 0.114[a]	0.983 ± 0.121

[a] Significant differences ($P < 0.05$) between dry needling and control sides.

A newborn baby may have very little, if any, activated loci in the skeletal muscle.[4] As the motor system becomes more and more active during the growing period, the muscles or other surrounding tissues are vulnerable to stressful life events and abnormal muscle stress. As a consequence, spontaneous local excitation of individual motor nerve endings increases with age. Originally, those scattered activated loci are not painful, but later on, some of them may accumulate in a certain region and form a latent MTrP. Further mechanical stress or other aggravating factors may cause a latent MTrP to become active. Latent MTrPs, which often cause tenderness and motor dysfunction (stiffness and restricted range of motion), are far more common than the active MTrPs that cause spontaneous pain. Reports of the prevalence of latent MTrPs in healthy young individuals are available and indicate a high prevalence.[28,29] Similarly, we could search the SEA signal easily from the motor point area (latent MTrP) of biceps femoris muscles of adult New Zealand rabbits, although variations in SEA magnitude and accumulation were found.[15,17]

In this study, dry needling to an MTrS region could effectively suppress SEA if LTRs were elicited. Is there a possibility that the insertion of a needle at the endplate region, especially rapidly, may lead to greater endplate discharges and thereby reduce immediately available ACh stores such that the SEA is reduced? It is also possible that sufficient mechanical activation of endplates by needle stimulation causes muscle fibers to discharge and thus to elicit LTR. It has been demonstrated that LTRs in humans and animals are associated with a transient burst of EMG activity.[8,9,13,14] The electromyographic activity of LTRs almost disappeared after Lidocaine block or transection of the innervating muscle nerve. This activity disappeared temporarily after spinal cord transection during the spinal shock period but was almost completely recovered after the spinal shock stage. It was proposed that LTRs are mediated through the nervous system and integrated at the spinal cord level.[8,13,14] Hong and Simons, based on recent studies in humans and animals, have proposed the multiple loci concept and postulated that there are multiple MTrP loci in an MTrP region.[3] An MTrP locus consists of a sensitive locus (the site from which an LTR can be elicited by needle stimulation) and an active locus (the site from which SEA can be recorded). The sensitive locus may be sensitized nociceptive nerve fibers in the immediate vicinity of an active locus with dysfunctional motor endplates.[3,16] The mechanical stimulation of an MTrP could activate the sensitive locus. When these potentials are propagated by means of afferents to the spinal cord, they reflexly cause corresponding motoneurons to fire and thus produce an LTR. However, the underlying mechanism for the effectiveness of MTrP injection resulted from LTR elicitation is still unclear.

In an ongoing study conducted at our laboratory, the change of AIV-SEA after dry needling with time was investigated using seven rabbits. The AIV-SEA were recorded immediately after the treatment procedure and at a half hour, 1 hr, 2 hr, and 4 hr after the treatment procedure. During the 4-hr experimental period, the AIV-SEA recorded from the active locus were constantly suppressed after dry needling of the MTrS. The AIV-SEA did not return to pretreatment levels in the course of the experiment. Therefore, the inhibitory effect of dry needling on SEA seems not to be transient.

One may speculate that the inhibitory effect of dry needling on SEA may be caused by the trauma effects of needling, such as edema or hematoma formation. The control study on the other side of the same rabbit indicated that slow needle insertion into the MTrS region for minimal LTR elicitation has not caused any inhibitory effect on SEA. LTR elicitation is likely to be the key factor attributing to SEA suppression. In our study, we never observed that rapid needle movement caused more edema or ecchymosis to the muscle than the slow needle movement in the control study. This is also true in clinical practice on MTrP injection.[6,7]

Therefore, the trauma effect wound not play any significant role for such changes.

Many researchers have documented the similarity between acupuncture and dry needling in treating MTrP.[6,7,10,12,30,31] According to the theory of acupuncture, it has been emphasized that "Teh-Chi" (gaining spirit) must be attained during acupuncture to provide the therapeutic effect.[31] Teh-Chi has been described in ancient Chinese medical literature as a feeling coming from the needle just like "a fish biting to pull the fishing line." If there is no Teh-Chi response during acupuncture (it feels like "standing in the empty vicinity of a long hall"), little or no therapeutic effect can be found. To a certain extent, acupuncture is probably similar to MTrP injection, and the Teh-Chi effect is probably similar or related to eliciting LTRs. This correlation suggests that MTrP and acupuncture points for pain may represent the same phenomenon and can be explained in terms of the same underlying neural mechanisms. The results of this study are consistent with clinical findings that LTRs must be elicited during MTrP injection to attain the therapeutic effect.

This study provides evidence that SEA can be inhibited by dry needling that elicits LTRs. The application of AIV-SEA as an evaluation index seems to be highly feasible in the quantitative measurement of SEA. However, the distances between the recording electrode and the endplates that profoundly influence MEPP amplitudes were not accurately measured, although we tried to position the needle tip to obtain maximal SEA. Furthermore, the recorded signal may consist of endplate noises and spikes, motor unit potentials, and movement artifacts. Fortunately, those factors influenced both experimental and control studies to the same extent. Further studies to address these issues are needed to confirm our findings and to elucidate the pathogenesis of MTrPs.

CONCLUSIONS

Dry needling of MTrS was proven to diminish the SEA if LTRs were elicited. The LTR elicitation, other than trauma effects of needling, seems to be the primary inhibitory factor on SEA during dry needling.

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Book Review

The Psychobiology of the Hand, Edited by Kevin J. Connolly, Published 1999. Cambridge University Press, Sheffield, United Kingdom $69.95

This was part of a series "Clinics in Developmental Medicine." Although the title was intriguing, the contents did not live up to the promise. For example, the first chapter was written by a hand surgeon but might have been more appropriately done by an anatomist. The tendon of the flexor carpiradialis was omitted from the carpal tunnel and the long finger was called the MIDDLE finger; the human hand has five digits and a thumb and four fingers, so there is a middle digit but no middle finger. The median nerve was said to contain all the roots from the brachialplexus (C5-T1). A chapter devoted to function of the nonhuman hand was excellent, as were the eight chapters covering the developing hand of the infant and child and the last chapter, "Hand Function in a Variety of Neurologic Disorders." A major disadvantage could be the misleading title, which promises much more than the book delivers. A more convincing and relevant title would be simply "The Developing Hand."

Book Rating: ***

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