

The Application and Effectiveness of Electroacupuncture in the Pain Management of Temporomandibular Disorders

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ABSTRACT

Objective: This manuscript explores the application and effectiveness of electroacupuncture in the pain management of temporomandibular disorders.

Summary: Temporomandibular disorders (**TMDs**) refer to a group of related pathologies involving the temporomandibular joints, muscles of mastication, and/or associated structures. TMDs are characterized by symptoms such as pain and decreased maximal mouth opening (**MMO**). Currently, the standard treatment modality for TMDs is nonsurgical management based on the results of longstanding clinical research studies. However, many alternative approaches to the treatment of TMDs have arisen, primarily due to the frequency of cases that are refractory to traditional nonsurgical intervention. Acupuncture, had its origins in Eastern medicine; however, it is now widely practiced throughout the world, mainly for the purpose of pain management. In many clinical studies, acupuncture has been proven an effective form of pain management, particularly pain of musculoskeletal origin, including TMDs. Within the last decade, there

has been a substantial increase in the number of research studies addressing the efficacy of electroacupuncture techniques in the treatment of persistent tissue injury, nerve injury, pain associated with cancer, and visceral pain. These studies indicate that electroacupuncture not only reduces both the sensory and affective components of inflammatory pain but also inhibits neuropathic pain. The mechanism by which electroacupuncture blocks pain results from the activation or inhibition of a variety of bioactive chemicals throughout the peripheral, spinal, and supraspinal pathways. This article begins with a brief description of the signs and symptoms of TMDs and proceeds to a summary of diagnostic criteria. We then present an analysis of the various treatment approaches in the scientific literature. Finally, we summarize current research that establishes electroacupuncture as an effective treatment for pain associated with TMDs.

DEFINITION AND SYMPTOMS OF TEMPOROMANDIBULAR DISORDERS (TMDs)

TMDs are a group of various pathologies, which include a number of clinical conditions involving the muscles of mastication, the temporomandibular joint (**TMJ**), and/or associated orofacial structures. TMDs affect approximately 5% to 12% of the population, and TMDs, as a group, are the second most common musculoskeletal condition resulting in pain and disability, chronic lower back pain being the most common. TMDs are a major cause of nondental pain in the orofacial region.

Patients may report pain over preauricular area, face, or temples, and may be accompanied limited range of mouth opening. Some may even complain of difficulty speaking or chewing, sounds emanating from the temporomandibular joint, or a sudden change in their bite coincident with the onset of pain [1]. Myogenous forms of TMDs are far more common than arthrogenous forms. In the majority of cases, the pain originates from the muscles of mastication rather than from the TMJ. However, the condition may be exacerbated by the development of jaw dysfunction resulting from the use of the affected masticatory muscles. Clinicians might consider a diagnosis other than a TMD when patient's pain is not influenced by jaw movement [2].

CLASSIFICATION OF TMDs

TMDs can be grouped into two broad categories: (1) myogenous TMDs, primarily involving the muscles that control jaw function and (2) arthrogenous TMDs, that directly involving the bones, ligaments, and cartilage of the temporomandibular joint.

Myogenous TMDs (Muscle-Related TMDs)

Among all the TMDs, those of myogenous origin account for the majority. Myogenous TMDs are characterized by pain and dysfunction that arise from pathologic, dysfunctional processes in the masticatory muscles. Myogenous TMDs can be further sub typed into myofascial pain, myositis, muscle spasm, and muscle contracture and may have varying underlying etiologies [3].

Arthrogenous TMDs (Joint-Related TMDs)

The basic pathologies of arthrogenous TMDs leading to TMJ malfunctions involve inflammation and degeneration in arthritic disorders and structural minor defects in growth disorders. Most of the cases have pain and internal derangements. There are three subgroups under this category: 1) Arthritic disorders, characterized mainly by pain and leading to internal derangements in late stage, 2) Growth disorders, characterized by facial deformity, and 3) Non-arthritic disorders, mainly characterized by mechanical derangement [4].

DIAGNOSTIC CRITERIA FOR TMDS

The dual-axis Diagnostic Criteria for TMDs (**DC/TMD**) is the most current diagnostic tool with evidence power for clinicians or researchers to use when assessing patients. The DC/TMD provides simple, clear, reliable, and valid operational definitions relating to history, physical examination, imaging procedures, as well as biobehavioral assessment of pain-related behavior and psychosocial functioning. Schiffman et al developed the modified diagnostic protocol following panel discussions among clinical and basic science pain experts.

This modified version includes the use of more comprehensive instruments, facilitating shorter and simpler screening methods for Axis I and Axis II diagnoses. Optimal evaluation and diagnosis will facilitate communication regarding consultations, referrals, and the prognosis of each individual patient [5].

EVALUATION OF TREATMENT RESPONSE

1. The parameters listed below assist the clinician in evaluating the treatment response of TMD symptoms:
2. The Visual Analog Scale of spontaneous pain or the pain under pressure on the associated masticatory muscles.
3. The extent of major mouth opening.
4. The frequency of jaw clicks.
5. Associated patient questionnaire regarding quality of life, mood (depression or anxiety), quality of sleep, and ability to carry out activities of daily life, social behavior and working performance.

CONVENTIONAL TREATMENT OF TMDS

Various treatment modalities have been used in clinical practice and have been described in previous studies. Occlusal splints are the most common dental treatment for TMDs. Pharmacologic agents prescribed by dentists or physicians include tricyclic antidepressants, muscle relaxants, and other medications. For chronic pain, adjunctive treatment choices include muscle exercise and stretches, trigger point injections, transcutaneous electrical nerve stimulation, biofeedback, posture correction, and addressing other possible aggravating factors [6-8].

As mentioned previously, nonsurgical management is recommended based on the results of current clinical studies [9]. The goal for the treatment of TMDs focuses on reducing or eliminating pain, restoring normal jaw function, and reducing the associated mental and physical stress.

Psychosocial evaluations and cognitive and behavioral therapies are advised for patients with chronic pain and those who present with related anxiety, depression or other systemic symptoms. The roles of electrophysical modalities and surgery in the management of TMDs have not been fully elucidated [10]. Initial conservative therapy is based on 3 general approaches: patient education, pharmacologic therapy, and physical therapy. However, patients with chronic TMDs usually need a multidisciplinary approach involving a team of therapists, including a dentist, psychologist, physical therapist, and even a chronic pain physician [11].

APPLICATION OF ACUPUNCTURE/ELECTROACUPUNCTURE FOR PAIN MANAGEMENT

Patients suffering from TMDs may consider acupuncture as an alternative treatment modality, particularly if they have had a poor response to previous treatments. Proponents of acupuncture cite the convenience, safety, and minimally invasive nature of the procedure.

CLINICAL STUDIES EVALUATING THE TREATMENT EFFECTS OF ACUPUNCTURE/ ELECTROACUPUNCTURE

Since 2007, three million American adults have been recipients of acupuncture treatments [12]. Chronic pain was the most common reason for seeking acupuncture treatment. A systematic review published by Ezzo et al in 2000 concluded that there was limited evidence to prove that acupuncture was more effective than no treatment for chronic pain; and evidence that acupuncture was more effective than placebo, sham acupuncture, or standard care was inconclusive [13]. However, more recent studies were conducted utilizing improved methods and designs, including a larger patient population. In 2012, a systematic review of these studies utilized individual patient data meta-analyses from 29 eligible randomized control trials (**RCTs**), with a total of 17,922 patients analyzed [14]. Four clinical conditions associated with chronic pain were observed, including back and neck pain, osteoarthritis, chronic headache, and shoulder pain. Significant differences between true and sham acupuncture procedures indicated that true acupuncture was a more effective treatment for chronic pain than was placebo, and it was therefore concluded that it was reasonable for a clinician to refer such patients for acupuncture. Many RCTs revealed that electroacupuncture inhibits the progression from acute to chronic pain in osteoarthritis of the knee, and it relieves the pain of chronic low back pain, neck pain, chronic prostatitis, and chronic pelvic pain syndrome in men and women [15-17].

MECHANISMS OF ELECTROACUPUNCTURE ON PAIN

As mentioned previously, within the last decade there has been a substantial increase in the number of preclinical research studies addressing the efficacy of electroacupuncture techniques

in the treatment of persistent tissue injury, nerve injury, pain associated with cancer, and visceral pain. These studies showed that electroacupuncture reduced both sensory and affective inflammatory pain and inhibited neuropathic pain in animal models. Zhang et al. (2014) reviewed the current theories and recent research conducted in animal models [18]. The study suggested that the mechanism of action of electroacupuncture in alleviating pain was the result of activation or inhibition of a variety of bioactive chemicals through peripheral, spinal, and supraspinal pathways. More specifically, it was found that endogenous opioids desensitize peripheral nociceptors and reduce pro-inflammatory cytokines peripherally and in the spinal cord. Serotonin and norepinephrine decrease phosphorylation of the GluN1 subunit of the N-methyl-D-aspartate (NMDA) receptor in the spinal cord.

Electroacupuncture could also be an adjunctive therapy to conventional treatment. It was shown to provide an augmented analgesic effect when combined with low-dose analgesics, thus achieving optimal pain management while minimizing the dosage and the side effects of pharmaceuticals. The parameter profile survey in the study disclosed that 10 Hz electroacupuncture produced alleviation of inflammatory pain for a better response than did 100 Hz; 2-10 Hz inhibited allodynia and hyperalgesia caused by nerve injury more potently than did electroacupuncture at 100 Hz.

The mechanisms by which electroacupuncture is thought to inhibit pain are shown in figure 1 [18].

ACUPUNCTURE/ELECTROACUPUNCTURE IN PAIN MANAGEMENT OF TMDS

Acupuncture

According to the most recent studies, the treatment effect of acupuncture in pain management of TMDs was superior, but the sample size of trials was quite small. One systematic review included RCTs of patients treated with actual acupuncture compared to sham acupuncture; the data included in this review was extracted from 13 electronic databases compiled through July 2010 [19]. Their conclusions provided limited evidence for acupuncture as a symptomatic treatment of TMDs. However, a review article by Sharad Vaidya et al presented evidence for a positive attitude toward the use of acupuncture for treating chronic head and face pain [20]. Comparing the results of clinical trials, the authors proposed that the effect of acupuncture is comparable to that of stomatognathic treatments for TMJ pain and dysfunction. Another meta-analysis of RCTs suggested that acupuncture was a reasonable adjunctive treatment for producing a short-term analgesic effect in patients with painful TMD symptoms [21]. Trials involving trigger point acupuncture have demonstrated effective responses to treatment [22]. The current scientific studies support acupuncture as an effective therapy for TMD symptoms, but larger, well-designed clinical trials are warranted in the future to better address the efficacy of acupuncture in relieving TMD pain.

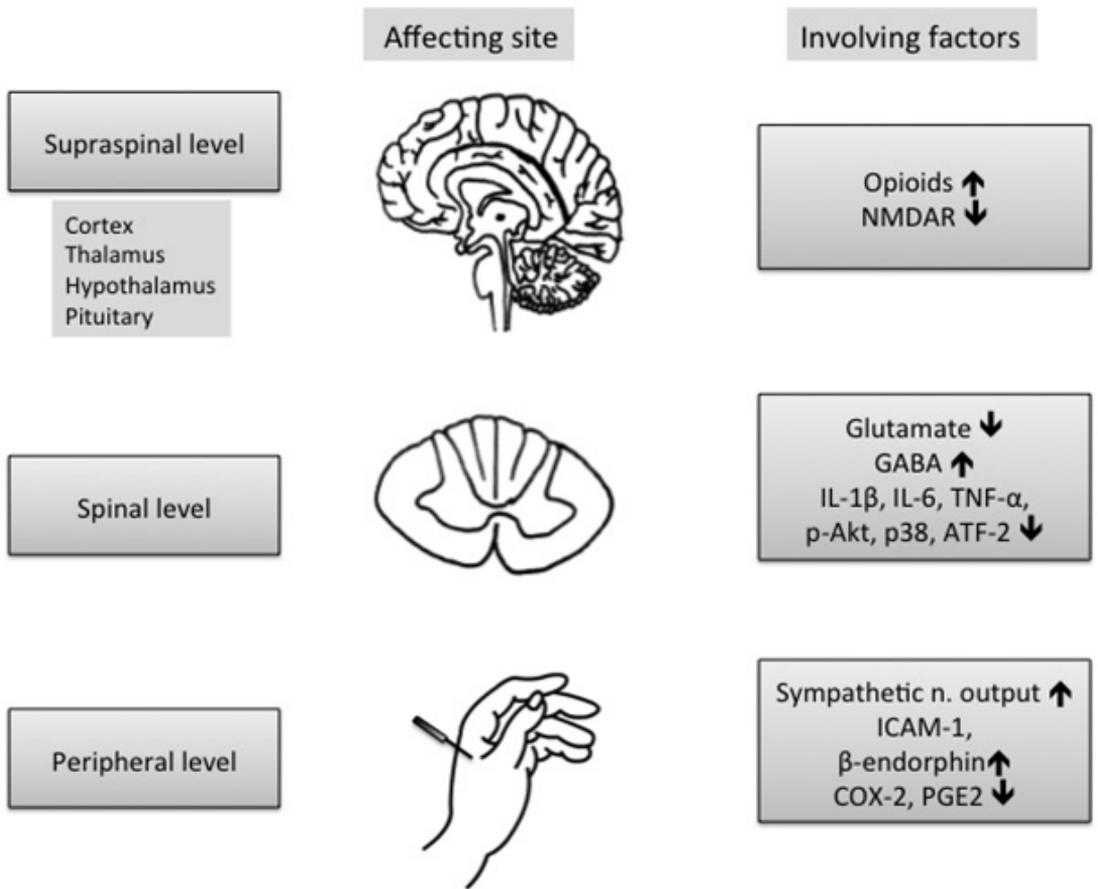


Figure 1: Proposed mechanisms for the inhibition of pain by electroacupuncture. The three levels of nervous system involvement, as well as the biochemical and molecular mechanisms, are listed in boxes [18].

Symbols ↑ and ↓ respectively represent increasing and decreasing of the biochemical or molecular mediators.

The abbreviation are as follows: ATF-2, activating transcription factor-2; COX-2, cyclooxygenase-2; GABA, γ -aminobutyric acid; ICAM-1, intracellular adhesion molecule-1; IL-6, interleukin-6; IL-1 β , interleukin-1beta; NMDAR, N-methyl-D-aspartate receptor; p-Akt, phosphorylated Akt; PGE2, prostaglandin E2; p38, p38 MAP kinase; TNF- α , tumor necrosis factor- α .

Electroacupuncture

A literature search for clinical studies addressing the use of electroacupuncture to treat TMDs yielded nine publications from Chinese practitioners with all positive treating effect in TMD

symptoms. The acupoints, frequency (**Hz**) of electric stimulation, the duration of stimulation, frequency of treatment, and the number of treatment sessions were listed in Table 1. Studies that provided an incomplete description of above-mentioned parameters or were inconsistent with respect to treatment were excluded from our analysis [23-26]. In one study of electroacupuncture performed in TMD subjects over a four-year period, 403 outpatients suffering from TMJ pain and dysfunction syndrome were treated with electroacupuncture under following parameters: continuous waves, 2-20 Hz, 20 minutes for each treatment, 8-10 treatments as one treatment course [25]. Their results indicated that electroacupuncture demonstrated analgesic efficacy in the treatment of patients with TMD. The research team emphasized the need for an evaluation of the underlying pathology, and they suggested the use of surface electromyography (**EMG**) as the fundamental device to study the related muscular imbalance.

EMG has been used to perform electrical stimulation at acupoints on the temporalis muscle of TMD patients in order to assess whether electrical stimulation of the acupoint may improve the rhythmic activity of the associated muscles [27].

The study showed that the surface electrical current applied to facial skin acupoints might excite or inhibit the anterior temporalis muscle via reflex pathways. Though EMG and electroacupuncture are not identical modalities, the concept of electrical stimulation and acupoint selection may be considered in the acupuncturists' treatment regimen for TMDs.

Other Acupuncture Modalities

Among the various choices of alternative therapeutic procedures, low-level laser therapy (**LLLT**) has recently been proposed as a treatment option for the reduction of pain intensity and improvement of maximal mouth opening (**MMO**) in both acute and chronic TMD patients [28].

Table 1: Acupoints used and treatment details provided by Chinese studies relating to electroacupuncture as a treatment for the pain associated with TMDs.

Coupled acupoints for electroacupuncture	Frequency of electroacupuncture pulses	Duration of treatment	Frequency of treatment	Number of treatment sessions	Number of cases studied	Author (Year)
1. ST7 (I) ST6 (I)	Not stated	30 minutes	Daily	10	100	Lin Jiang-hong et.al (2009)
1. ST7(I) LI4(C) 2. ST6(I) Ashi(I)	50Hz	30 minutes	Daily	10	32	Chen Chuan-yao et.al * (2012)
1. ST7(I) LI4(C) 2. ST6(I) Ashi(I)	50Hz	30 minutes	Daily	10	21	Jia Ning et.al* (2010)
1. ST7 (I) ST6 (I) 2. LI4 (U)	120Hz	25 minutes	Daily	10	32	Jiang Ting-kang et.al (2001)

I= Ipsilateral; C= Contralateral; U= Unilateral.

* Combined with microwave therapy.

One observational study investigated the effect of LLLT on TMD symptoms in patients in whom previous treatments were unsuccessful. As a result, laser acupuncture therapy was found to improve the symptoms of patients with treatment-resistant TMDs [29].

CONCLUSION AND SUGGESTIONS

Though electroacupuncture has been proven to provide significant analgesia in many preclinical and clinical studies, the role of electroacupuncture in the management of TMDs has not been fully established. Despite the many recent studies surveying effect of acupuncture in the treatment of TMD pain, the methodological shortcomings of these previous trials limit the current clinical evidence for acupuncture as an effective therapy. However, the studies proved the safety of acupuncture, with only few occasional side effects, including pain, minimal bleeding, and hematomas [30]. We still view acupuncture as a potential alternative and/or adjunctive means of treating pain and jaw dysfunction that characterize TMDs.

Acupuncture has both local and distant analgesic effects that may be mediated by different mechanisms. Acupuncturists infer the presence of sensation pathways that correspond to meridians. The method to inspire Qi and Blood by needling is different in concept to the dry needle therapy of Western medicine. According to the theory of traditional Chinese medicine (**TCM**), pain results from Blood stasis due to Qi stagnation (a pathological change in which a longstanding or severe stagnation of Qi impedes blood flow) [31,32]. The acupoints for treatment of TMDs were chosen primarily on both hand and foot Yangming meridians, based on the principle of “places where meridian passed, treatments thereby can be reached” and on locations nearby the affected muscles and trigger points. We have mapped the acupoints used in electroacupuncture treatment of TMDs from several published studies, and these are shown in figure 2.

However, the exact mechanisms within the brain that provide electroacupuncture analgesia have been far less studied than peripheral and spinal mechanisms. These mechanisms need to be determined in future studies in order to more fully understand the analgesic effect provided by stimulation of the central nervous system in patients with TMDs.

In conclusion, we suggest electroacupuncture as a potential viable alternative or adjunctive treatment for pain and jaw dysfunction that characterize TMDs. The results of preclinical studies may provide guidelines for future clinical trials or even future clinical use. These guidelines include the choice of acupoints, the frequency (Hz) of electroacupuncture, and the optimal duration and interval of treatments. With the references collected, we suggest electroacupuncture for 20 to 30 minutes per treatment, 4 to 6 acupoints at one time, with daily or every-other-day treatment frequency, for at least ten sessions.

Here we recommend the use of electroacupuncture and offer the acupoints and treatment protocol according to previous studies and clinical experience. However, because much clinical research is still needed, we could not present a strong advice of standard protocol or specific

recommended doses of electroacupuncture for the treatment of pain and joint dysfunction due to TMDs. As future studies in this field are conducted and the results published, it is our hope that electroacupuncture becomes recognized as a highly efficacious, cost-effective treatment modality for the pain associated with TMDs, either alone or as an adjunctive therapy to rational treatments.

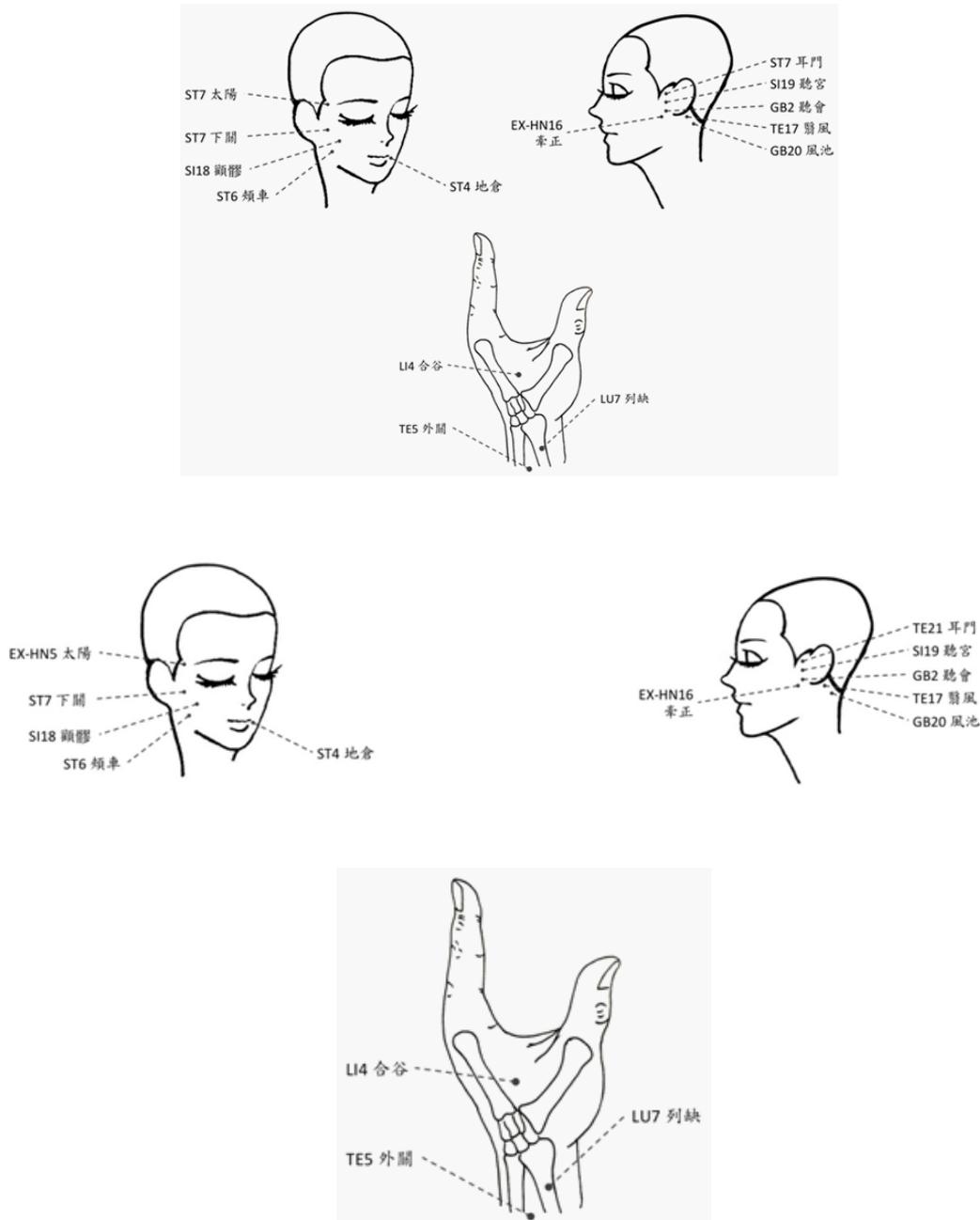


Figure 2: Acupoints applied by electroacupuncture in the treatment of TMD-associated pain, as reported in the literature.

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