Application of Acupuncture in Temporomandibular Joint Disorders

Abstract
The treatment of temporomandibular joint disorder (TMD) usually begins with conservative remedies such as medication, heat compression, patient education, and occlusal bite plates, among others. Normally, a combination of methods is needed to relieve patient symptoms because of the complexity of the disorder and its specific etiology for each patient. Because acupuncture has been proven to possess pain-reducing and anti-inflammatory effects, in this report, we reviewed the effectiveness of acupuncture in relieving the symptoms of TMD. The mechanism of acupuncture is very different between traditional and modern medicine, with the evidence showing that the analgesic effect of acupuncture comes from its ability to elevate the pain threshold, release neurotransmitters in local regions, and modulate pathways in the central nervous system. Within the limits of our review, the local acupoints around the TMJ, such as ST-6, ST-7, SI-18, GV-20, GB-20, BL-10, and distant point LI-4 can be suggested for treating TMD. With 30-minute treatment sessions occurring once a week for 6 weeks, evidence showed that the effectiveness of acupuncture in minimizing patient discomfort is comparable to the effectiveness of other treatment options.

Keywords: acupuncture, temporomandibular joint disorder

Introduction
Temporomandibular joint disorder (TMD) is a condition that dentists frequently encounter. The condition often causes musculoskeletal problems, including pain and disability (just second to chronic low back pain), and it is the most common cause of facial pain. Signs and symptoms of TMD vary, but as epidemiological studies have shown, there is a high prevalence of certain conditions, such as pain and tenderness in the temporomandibular joints (TMJ) and masticatory muscles, sounds in the joints during function, and limitations or other disturbances in jaw movement. Approximately two-thirds of patients suffering from TMD seek medical help; nevertheless, approximately 15% of them develop chronic pain. TMD includes a number of related diagnoses for temporomandibular joints, masticatory muscles, and associated structures. The classification provided by the American Academy of Orofacial Pain (AAOP) divides
Review Article based on self-reports or clinical diagnoses suggest a positive association between bruxism and TMD pain, some potential bias cannot be ruled out at the diagnostic level. Studies that were designed specifically to diagnose bruxism have shown less association between bruxism and TMD.

Because of the complex nature of this disorder, there is no gold standard for treating TMD. Approaches generally include a combination of methods and designs based on the specific etiology for each patient. Acupuncture originated in China thousands of years ago and has long been used by Chinese people to treat various diseases. Over the last few decades, it has been increasingly applied in western medicine to combine acupuncture with conventional treatments. In 2002, the World Health Organization reported chronic myofascial pain to have a good reaction to acupuncture treatment. This treatment method is characterized by comparatively low side effects. Therefore, acupuncture has been introduced as a treatment for TMD due to its function in pain reduction as well as its anti-inflammatory and neurohormonal effects.

In this review, we describe the mechanism of acupuncture based on various theories—from traditional Chinese medicine to modern western medicine, including studies on the molecular level. To introduce acupuncture as part of the treatment of TMD, we reviewed articles so as to understand the effectiveness of acupuncture and how it should be executed in treatments.

The Role of Acupuncture in Temporomandibular Joint Disorders

Mechanism of acupuncture

Acupuncture developed in China thousands of years ago. In the book Huangdi Neijing (黃帝內經), which is now considered by archeologists to be the most ancient literary record of acupuncture to date. The use of sharp stones and herbs to cure pain and disease is described to have existed since the Stone Age.

The mechanisms of pathophysiology in Chinese medicine are quite different from those of Western medicine. Acupoints can be located almost everywhere on the human body, as was discovered in prehistoric times, when people realized that diseases could be cured after certain points on the body were accidentally burnt or punched. The acupoint is the exit point of qi (氣) on the skin surface of the hu-

Table 1. Diagnostic Category from AAOP

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<th>Temporomandibular joint disorders</th>
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<td>Ankylosis</td>
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<td>Fracture</td>
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<td>Congenital or developmental disorder</td>
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the diagnoses into two categories, based on anatomical structure: "masticatory muscle disorder" and "temporomandibular joint (TMJ) disorders" (Table 1).1

Under most circumstances, the treatment of TMD-related pain, especially pain originating primarily from the muscle, begins with conservative, noninvasive methods. Conservative treatments often include medication, patient education, dietary modifications, and occlusal splints and/or occlusal therapy. When comparing the management of TMD using a stabilization splint worn at night and no treatment, short-term improvements can normally be expected from the splint treatment. However, comparisons of stabilization splint treatment with placebo treatment (via a non-occluding palatal splint) have been in-conclusive. There is thus a lack of evidence to either support or invalidate the treatment of TMD with occlusal splints and occlusal adjustments. In short-term follow-up studies, stabilization appliances were equally effective compared to other treatments such as physical therapy (e.g., acupuncture, TENS) and behavioral management. However, long-term effects are still limited.5

The etiology of TMD is complex and undetermined. Both central and peripheral mechanisms have been proposed. Systemic factors often have psychological origins, for example, mental stress, anxiety, and depression, and some systemic conditions such as rheumatoid arthritis are also often noted in TMD patients. Local factors should also be considered, such as trauma of the mandible and masticatory system, prolonged mouth opening, habits involving heightened or persistent pressure on the chewing system (e.g., gum chewing or betel-nut chewing). Although many investigations
man body. When disease occurs in the internal organs, bad qi can travel through the meridians of the diseased organs and present on the corresponding acupoints as focal soreness. These sore acupoints can then be used as a diagnostic tool to locate the source of the disease.

The acupoint is also the entrance for introducing elements from the outside environment into the body because it is the opening of meridians on the skin surface. For example, the entrance of cold and bad qi from some acupoints can lead to headaches and perhaps symptoms of the common cold.

The view of traditional Chinese medicine

According to the earliest description in Lingshu Jing (靈樞經), which is a part of "Huangdi Neijing" (黃帝內経), a thin needle inserted into the Meridians regulates qi. In Su Wen (素問), which is another part of "Huangdi Neijing", the ability of acupuncture to balance yin (陰) and yang (陽) of the human body by engaging the meridians with needles is described. When too much yin has taken over yang, we bring more yang to the patient to balance the flow of qi by manipulating the acupuncture needle in a certain way. When too much qi jammed in one meridian or acupoint and causes disease, the excess qi can be led out by acupuncture needles to balance yin and yang.7

Lingshu Jing also stressed that if one cannot feel the qi while inserting the needle into the acupoint, the practitioner must keep trying until qi is reached (刺之而氣不至，無問其數). Biao You Fu (標幽賦) and Dou Han Qing (竇漢卿) (1295) described the feeling of locating qi as that of a fish taking a bite from a hook during the act of fishing, and when people fail to reach qi, it is like hanging in a deep and large room. (氣之至也，如魚吞鉤餌之沉浮；氣至未至也，如聞處幽堂之深邃). In modern Chinese medicine, it has been described and emphasized as "de qi (得氣)". From the patients’ point of view, the sensation of the needle puncturing the skin and reaching the acupoint does not feel like the pain of being punctured by a needle, but rather like soreness, dullness, and heaviness. Some patients say that it feels like a weak electric shock, which can sometimes travels with the meridian and spread to areas away from the inserted needle.

The view of western medicine

Modern researchers have used scientific methods to understand the mechanism behind the analgesic ability of acupuncture. According to classical literature on acupuncture and a study by Hui et al. using fMRI, failure to produce de qi also results in the failure to produce the analgesic effect of acupuncture. As in the case of treating paraplegic patients, whose nerve conductions were interrupted, the practitioners were unable to produce de qi and therefore, acupuncture analgesia. The efficacy of acupuncture analgesia was shown by Chiang et al.13 Acupuncture manipulation at the acupoint hegu (LI-4) gradually increased the pain threshold by 20-40 min after needle insertion, and the pain threshold increased by 100% at 40 min. However, after injection of 2% procaine to the acupoint, the effect of acupuncture analgesia and the local sensation were both inhibited. That same year, a research group of acupuncture anesthesia at Beijing medical college14 modified some of Chiang’s experiment. It was found that blocking the analgesic effect with local anesthesia was successful only when 2% procaine was injected into a deeper layer, such as the muscle or tendon layer, but not subcutaneously, highlighting the importance of nerve innervation in deeper structures of the acupoint. Lin measured the average depth to produce de qi in different acupoints on the backs of 107 patients. Patients were grouped by sex and body type (i.e., obese, regular, and thin). The result shows that although the depth to produce de qi differs case by case, it is located mostly in the muscle layer.15 A further trace into the histology of acupoint using a rat model showed that the distribution of A and C nerve fibers is closely associated with the acupoint.16 Taken together, the acupoint is the A and C nerve innervation at the muscle layer and act as a trigger in the mechanism of acupuncture. The local sensation is the foundation of acupuncture analgesia. Without the afferent signal from the local nerve fiber, there is no analgesic effect.

Regarding the central nervous system (CNS), the pathway of the endogenous descending pain inhibitory system has been thoroughly studied to understand pain.17 The descending inhibitory system consists of various parts of brain regions in the cortical area, thalamus and spinal cord to control pain. The system has been proven by means of opiate analgesia and brain-stimulation-induced analgesia to be closely related to acupuncture analgesia.8
During an acupuncture treatment, stimulation at the acupoint ascends the CNS like a pain signal, but it also activates other brain regions and then the descending inhibitory system to modulate pain.

At the molecular level, a close look at the neurotransmitters shows that the opioid peptides play an important role in regulating acupuncture analgesia. First, Mayer et al. (1977) discovered that naloxone, a specific opioid receptor antagonist, can partially reverse the analgesic effect of acupuncture on electrically stimulated denta-pulp pain in a human model. Using a rat model, Sekido et al. showed that injection of naloxone at the inflammatory site can eliminate the effects of acupuncture treatment, which suggests that the peripheral opioid released by acupuncture stimulation helps modulate pain at the inflammatory site. Using both rat and human models, Han et al. demonstrated that electro-acupuncture (EA) stimulation at a low-frequency (2 Hz) facilitates the secretion of enkephalin, whereas EA at a high frequency (100 Hz) releases dynorphin. Since different frequencies of EA stimulate the secretion of different types of opioid peptides, these molecules work on different zones. EA at 2 Hz sequentially activates the arcuate nucleus of the hypothalamus (beta-endorphinergic neurons), PAG, medulla (enkephalinergic neurons), and the dorsal horn to suppress nociceptive transmission. Hz at 100 Hz activates the par-archiadial nucleus-PAG-medulla-spinal dorsal horn pathway through the release of dy-norphin. Comparing the efficacy of the two frequencies in a spinal nerve constriction model using neuropathic rats showed that 2 Hz EA stimulation for 30 min sup-pressed cold hypersensitivity for more than 24 h, whereas 100 Hz EA stimulation showed no effect. Although most reports showed better therapeutic effects for the lower fre-quency stimulation, some reports indicate 100 Hz EA stimulation to be more effective for relieving muscle spasms induced by spinal trauma.

The effect of acupuncture in treating temporomandibular joint disorders

Noiman et al. recruited 39 patients suffering from facial pain, of which 4 patients had trigeminal neuralgia (TN), 35 had TMD of a non-osseous source. Seventeen were diagnosed as having chronic conditions and 22 as having acute conditions (< 3 months). Local acupoints in the TMJ region and masticatory muscles, regional points around the head and neck, and distal points on the upper and lower limbs were chosen for therapy. Thirty-two (82%) of the 39 patients who received acupuncture treatment reported at least a 30% reduction in visual analogue score (VAS). Of these 32 patients, 28 (71.7%) reported more than 80% pain alleviation, whereas the other 4 patients reported partial pain alleviation (30-80%), and none presented any side effects. In the 32 patients who considered acupuncture to be effective, 31 had TMD, and only 1 of the 4 TN patients reported a significant improvement. (Fig. 1)

Mario Vincente-Barrero et al. conducted a randomized trial on 20 patients who were diagnosed with TMD and compared the efficacy of acupuncture and decompression splints after a treatment session of 30 days. The result showed that patients treated with decompression splints experienced reduced subjective pain, pressure pain on the masticatory muscles, and an increased mouth opening range, but the difference did not reach statistical significance. However, patients treated with acupuncture reported improvements in all parameters (i.e., reduced subjective pain, stronger pressure to produce pain on masticatory muscles, increased mouth opening range), and the pain reduction is statistically significant. Taken together, these studies show that acupuncture has short-term analgesic effects that are comparable to those of decompression splints in TMD patients.

To compare the long-term treatment efficacy, List et al. conducted a one-year follow up in 1992. In the beginning, they recruited 110 patients with symptoms of TMD for more
than 6 months and randomly divided them into 3 separate treatment groups: acupuncture treatment, occlusal splint therapy, and a control group that received no treatment. Patients were evaluated by subjective and clinical assessments before and immediately after the treatment. During the short-term period of observation, the acupuncture and occlusal splint groups both reduced symptoms, compared to the control group. However, acupuncture produced better subjective results with statistical significance, compared to occlusal splint therapy. After 1 year, 80 participants returned for the follow up. The result showed that 57% of the patients who received acupuncture treatment and 68% who received occlusal splint therapy benefited subjectively and clinically (p < 0.001). Although the acupuncture group showed a smaller percentage of patients who benefited from treatment, there was no statistical significance between the two groups. Furthermore, this difference may be due to the fact that the occlusal splint was worn every night throughout the year, whereas there was no follow-up regimen for acupuncture treatment.

Despite such evidence, we should still address the possibility that acupuncture is only a placebo. Executing double-blind experiments in acupuncture treatments was difficult until Park et al. invented the Park Sham Device. Subsequently, Smith et al. (2006) published a report comparing the efficacy between acupuncture needles and Park Sham Devices by measuring subjective values, VAS, joint and muscular pain, and other values in 27 TMD patients. The patients were randomly divided into real and sham acupuncture groups. After 5 weeks of treatment, the real acupuncture group showed statistically significant improvements for nearly all parameters, whereas the sham acupuncture group showed insignificant improvements.

### Review Article

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**Acupoints for treating patients with temporomandibular joint disorders**

Because traditional Chinese medicine views the etiology of TMD differently compared to western medicine, the acupoints chosen for treatment are different, too. For example, some authors suggest scalp acupuncture for treating TMD and related headaches. Unfortunately, an evidence-based review or controlled trial from the perspective of traditional Chinese medicine or scalp acupuncture is still lacking. Some systematic reviews have suggested acupoints for TMD treatment, however, these acupoints are located mainly around the temporomandibular joint, or local tender spots, and echoed the concept that myofascial trigger points correlate anatomically with classical acupuncture points in 70% of the cases. The review of Rosted et al. included reports treating pain dysfunction syndrome (PDS), which includes joint symptoms, masticatory muscle symptoms, limitations or deviations in mandibular movement, and headache by means of acupuncture. Only randomized and blind trials limited to needle acupuncture were included. Finally, three publications met the criteria of the author, and a total of 27 acupoints were evaluated in these reports. As summarized in Table 2, seven acupoints that at least two from the three authors used the point as a standard point in treatment were included. These acupoints will be discussed individually later. Of the 7 acupoints, 3 were located near the TMJ and 2 were located on the neck (many patients also complained of soreness in the neck). GV-20 (百会) and LI-4 (合谷) are located away from the region that TMD patients usually complain of, and the mechanism underlying these two acupoints is not as clear as the ones for the surrounding muscles.

Six treatments in average were sufficient to control the symptoms, and the treatment fre-
quency was once a week. In another review by Jung et al.\textsuperscript{13}, the mean treatment duration is 1.4 weeks, ranging from only 1 treatment to a session that lasted 6-12 visits.

After inserting the needles and achieving the de qi sensation, the needle should be left in the acupoints for 30 min in each treatment session. The patient should return for maintenance treatments once every 3 months, until the remission of symptoms.\textsuperscript{31}

\textbf{ST-6 (頰車穴，足陽明胃經)}

ST-6 is on the stomach meridian, and it is located near the mandible angle and one middle-finger’s breadth from the angle of the mandible. (Fig. 2) The original meaning of the acupoint in Chinese is the "axis" on the cheek that controls mouth opening, which is quite appropriate because the mandibular angle can be seen as the jaw’s axis of centric movement when just looking from the face. When the mouth is wide open, a depression can be felt on the acupoint, and when teeth are clenched, a bounce from masseter muscle can be felt. The acupuncture needle should be inserted at a perpendicular angle to the skin surface until it reaches a depth of approximately 2 cm in the masseter muscle (Fig. 3).\textsuperscript{32}

\textbf{ST-7 (下關穴，足陽明胃經)}

ST-7, like ST-6, is also located on the stomach meridian, under the zygomatic arch. Palpating from the taurus toward the face, the practitioner first feels the condylar head and then there is a triangular depression between the mandibular notch and zygomatic arch, and the acupoint is located in the depression (Fig. 4). When the mouth is wide open, the condylar head will bounce up from the depression, and when the mouth is closed, the depression can again be felt. This acupoint was considered to be the ‘machine’ (機關) to control jaw movement because of this "bouncing" effect, and it is the lower as opposed to the upper one (GB-3). For treatment, the needle should be inserted perpendicularly to the skin surface for approximately 1.5 to 2.5 cm, and a de qi feeling should be reached by that level. We can imagine when needle is inserted at the acupoint, we will penetrate through masseter muscle and reach the fascia of lateral pterygoid muscle or even the muscle, and the stimulation of these muscles brings relief of tenderness.\textsuperscript{33}
BL-10 (天柱，足太陽膀胱經)

BL-10 is located on the meridian of the bladder. This acupoint is on the depression lateral to the trapezius muscle, at the same level of the spinous process of the second cervical vertebra (C2). The original name of the acupoint refers to the pillar on the neck and the support of the head, so the main purpose of the application of the BL-10 is to relieve neck and shoulder pain, as well as dizziness and headache. For the treatment effect, the acupuncture needle should be inserted at a depth of 2.5 cm to reach the trapezius muscle beneath the skin (Fig. 8, 9). 35-38

GV-20 (百會，督脈)

The governor meridian (督脈) runs along the center of the human body and circles around it. GV-20 is on the topmost of the me-
sensory nerve fiber located in the muscle layer is the foundation of acupuncture analgesia. Needle stimulation at the acupoint ascends the CNS in a similar way as a pain signal, but it also activates the descending inhibitory system and thus, modulates pain. Several neurotransmitters, such as the opioid peptides, coordinate to regulate the effect to reduce pain and modulate inflammation. In studies on animals, it was shown that different patterns of stimulation can activate different opioid receptors and thus different pathways to produce varying treatment effects. Within the limitations of our review, the evidence shows the effectiveness of acupuncture in treating TMD, with comparable treatment effects as those of using occlusal splints in short-term observation. For patients with pain dysfunction syndrome of TMD, we would suggest acupuncture as a treatment option. The treatment should be conducted once a week, 30 minutes each time, over six treatment sessions. Patients should then be followed up every 3 months until the symptoms are relieved. Local acupoints on the head and neck recommended for treatment are: ST-6, ST-7, SI-18, GV-20, GB-20, and BL-10. Distant point LI-4 is also recommended. Although the efficacy of acupuncture is comparable to those of other treatments, identifying the etiology is still very important so that patients can seek help from other professions to treat their specific etiologies.

LI-4 (合谷，手阳明大肠经)
LI-4 can be used in various situations. From the perspective of Chinese medicine, LI-4 is effective for relieving all symptoms occurring in the head or face, including fevers, headache, and trismus. As mentioned, Chiang et al. reported acupuncture manipulation of LI-4 to be effective in elevating the pain threshold. LI-4 is located on the meridian of the large intestine on the dorsum of the hand, between the thumb and index finger, radial to the midpoint of the second metacarpal bone. The original name of LI-4 in Chinese refers to a river valley, which describes the shape of the depression between the thumb and index finger. For the treatment effect, the acupuncture needle should be inserted at a depth of 2.5 cm into the muscle tissue to gain the de qi feeling (Fig. 11).

Conclusion
Acupuncture in traditional Chinese medicine is described as the manipulation of qi using needles and a method of curing people by smoothing the flow of qi. As modern science progresses, we can understand that it involves not just yin and yang, but also the physiology and the work of neurotransmitters in the body and brain. The afferent signal from A and C

![Location and needle insertion of LI-4](image)
References


