

Acupuncture Reduces Pain in Patients with Temporomandibular Joint Disorders. A Systematic Review

Paraskevi Georgakopoulou^{ID}, Evangelia Anastasiadi^{ID}, Eleftherios Paraskevopoulos*^{ID}

Department of Physiotherapy, Aegean College, Athens, 105 64, Greece

Corresponding Author: Eleftherios Paraskevopoulos, E-mail: e.paraskevopoulos@aegeancollege.gr

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ABSTRACT

Aims: Acupuncture is an alternative method used to treat patients with Temporomandibular joint disorders (TMD). However, it still has not been well established, as an effective and safe option, in literature. This systematic review aims to investigate: (a) the quality of the methodology used in previous Randomized Controlled and Clinical Trials, concerning the effectiveness of acupuncture, in reducing pain, in patients with TMD, (b) the effectiveness of acupuncture, in reducing pain, in patients with TMD. **Method:** Electronic databases were investigated to identify available Randomized Controlled and Clinical Trials concerning the effectiveness of acupuncture in reducing pain in patients with TMD; Specific criteria were used to select eligible studies; the quality of studies was assessed using the PEDro scale; an evaluation of differences was performed between the qualified studies. **Results:** A total of ten Randomized Controlled and Clinical trials were included in this systematic review. The methodology used in most studies was determined to be low to moderate. Nine out of ten studies showed statistically significant results in reducing pain. However, acupuncture was not more effective than other therapeutic methods used in most of the studies. Only 2/10 studies revealed that acupuncture was more effective, when compared to other methods. Acupuncture reduced pain faster and the results lasted up to one month, when compared to other methods. **Conclusion:** Acupuncture is an effective method, in relieving pain, in patients with TMD. There is, however, need for more, qualitatively improved studies in order to verify acupuncture effects in patients with TMD.

Key words: Joint Disorder, Temporomandibular, Temporomandibular Joint Disease, Analgesia, Acupuncture, Complementary Medicine, Pain.

INTRODUCTION

The temporomandibular joint (TMJ) is a diarthrosis, connecting the temporal bone and mandibles condyle (Bender et al, 2018). The masseters, the temporalis and pterygoid muscles are responsible for the functioning of this joint (Wilkie & Al-Ani, 2022). The proper movement of the mouth, the mandible and the face is feasible through the TMJ (Bender et al., 2018). The basic movements, depending on the smooth functioning of the TMJ, are chewing, breathing and sucking, as well as opening of the mouth and proper jaw movement (Bordoni & Varacallo, 2019). Vocalization, facial expressions and swallowing consist important operations of the mandible (Huys et al., 2022). The cooperation and coordination of both sides of TMJ, are required in order to achieve the proper functioning of the mandible (Huang et al., 2014).

Temporomandibular joint disorders (TMD) are the most common cause of non- dental pain, (Saranya et al., 2019; Madani et al., 2019), affecting 82% of the general population (Madani et al., 2019). It mostly affects young people and women 20-40 years old (Khayamzadeh et al., 2020).

Huang et al., (2014) reported that 75% of the affected patients present with at least 1 symptom, while 30% of them suffer by more than one of the following symptoms. Local and peripheral pain at the connecting muscles, as well as the head, the cervical region, face and ears are described as the most common symptoms (Serritella et al., 2021; Chidambaranathan & Culathur, 2022). Other symptoms reported are mandible and jaw disfunction (Huang et al., 2014; Zhang et al., 2020), crepitus and locking of the joint, during chewing (Huang et al., 2014; Bijjaragi et al., 2015; Khayamzadeh et al., 2020), reduced Range of Motion (ROM), (Liu et al., 2021) and insomnia (Khayamzadeh et al., 2020). Finally, Chidambaranathan & Culathur (2022) suggest that patient often suffer from vertigo, tinnitus and full ear sensation.

TMD is an umbrella term, ranging from simple muscle spasm to malocclusion and idiopathic trigeminal neuralgia (Ichida et al., 2017). TMJ receives much information and is affected by alterations of the whole body (Bordoni & Varacallo, 2019). Causes of TMDs include stress, emotional disorders, such as depression (Bijjaragi et al., 2015; Liu et al., 2021), as well as autoimmune disorders, such as rheumatoid

arthritis, psoriatic arthritis, ankylosing spondylitis, fibromyalgia and multiple sclerosis (O' Connor et al., 2017). Moreover, Ferreira et al. (2017) report that injuries and genetics are also causes of TMDs.

Clinical examination is necessary in order to diagnose TMD (Singh et al., 2014). The process begins by taking the medical history. Description of the symptoms and examination of the physiological movements of the joint is the first step (Sojka et al., 2015). Moreover, the examiner observes the whole face and mouth internally and externally to inspect the symmetry of the concerning structures and their movements (Bordoni & Varacallo, 2019). The palpitation of the muscles and lymph nodes is essential in order to exclude other pathologies. (Bordoni & Varacallo, 2019).

Muscle strength is then, measured by using specific tools and scales (Camacho et al., 2014) while the examiner tests the mandibles' passive moments in order to inspect the ligaments' function (Bordoni & Varacallo, 2019). The last part may include the examination of XRAYs and MRI (Jung et al., 2015).

TMD treatment includes a variety of methods, mostly conservative, targeting in reducing painful symptoms and inflammation (Madani et al., 2019). Use of Non-steroidal anti-inflammatory drugs (NSAIDs) and anti-inflammatories is widely used (Singh et al., 2014; Bijjaragi et al., 2015; Liu et al., 2021; Chidambaranathan & Culathur., 2022) while it is, mostly, combined with other therapeutic methods (Khayamzadeh et al., 2020).

Counseling and Cognitive Behavioral Psychotherapy (CBT) has been proved to be helpful in reducing symptoms in patients with TMD (Singh et al. 2014; Huang et al., 2014; Serritella et al., 2021). Moreover, occlusion splints provide joint stabilization reducing pain and promoting correct joint position (Liu et al., 2021; Chidambaranathan & Culathur., 2022). Khayamzadeh et al., (2020) and Chidambaranathan & Culathur (2022) report that botulinum toxin or cortisone injections improve pain and reduce muscle hyperactivity and inflammation.

Therapeutic exercise is an important tool in TMD rehabilitation, improving ROM and mandibles function (Huang et al., 2014; Chidambaranathan & Culathur, 2022). Exercise may be used individually or as a part of a physiotherapy programme (Khayamzadeh et al., 2020; Liu et al., 2021; Serritella et al., 2021). Physical therapy may include modalities, such as Low Laser Therapy (LLT) (Madani et al., 2019; Serritella et al., 2021) and TENS (Bijjaragi et al., 2015; Zhang et al., 2020). Ferreira et al., (2013) describe that TENS improves acute pain, however, it presents mediocre results in chronic pain (Madani et al., 2019; Khayamzadeh et al., 2020). Bijjaragi et al. study (2015) has shown that MENS also produce analgesia in patients with TMD.

Ultrasound is used in physical therapy for the treatment of TMD (Serritella et al., 2021) along with heat therapy (Madani et al., 2019), and vibrational therapy (Serritella et al 2021). Liu et al., (2021) proved that moxotherapy reduces pain by spreading heat in specific points on body. Moreover, studies have shown that acupuncture can be a useful tool in eliminating painful symptoms cause by

TMD (Bijjaragi et al., 2015; Chidambaranathan & Culathur, 2022)

However, depending the case, surgical treatment might be suggested (Liu et al., 2021; Serritella et al., 2021; Chidambaranathan & Culathur, 2022). Arthroscopy in some cases is able to establish proper function of muscles and ligaments (Khayamzadeh et al., 2020).

Acupuncture is an ancient Chinese therapeutic method and is a part of Traditional Chinese Medicine (Huang et al., 2014; Sen et al., 2020). Acupuncture is used over 3000 years eliminating a variety of physical and psychological conditions. In recent years its' main use is reducing pain in musculoskeletal disorders (Yuan et al., 2016; Wu et al., 2017). More and more studies are conducted in order to understand who acupuncture works (Grillo et al., 2015).

Needles made of steel are carefully inserted in specific areas of the body during an acupuncture session. Acupoints are located in muscles and ligaments while, needles may be inserted even in scar tissue. The needles are manually or electrically stimulated, in order to reach the proper feeling of Deqi (Serritella et al., 2021). Hormonal and biochemical changes are being produced, reducing pain (Law et al., 2015; Yap, 2016) and dysfunction (Dunning et al., 2022), while quality of life (QoL) is also being improved (Huang et al., 2014). The main goal of acupuncture is analgesia produced by endorphins, serotonin and enkephaline (Chidambaranathan & Culathur, 2022). Moreover, spinal cords' descending inhibition is activated, while, peripheral stimulation, increases brains' blood flow and oxygen (Ichida et al., 2017). Wang et al., (2013), report that acupuncture creates changes in ions conductivity and hyperpolarization of neural membrane, leading in potassium, sodium and calcium concentration changes.

Acupoints are created based on the Meridian theory, a network in the body that is connected through Qi (Salles-Netto et al., 2020). Xiang et al., (2018) state that "Qi represents a complex pattern of neurophysiological sensations which suggests the involvement of a broad spectrum of myelinated and non-myelinated nerve fibers, particularly in tendinomuscular layers".

Acupuncture is an effective therapeutic method with minimum side effects and contraindications (Ichida et al., 2017) in the management of TMD and research has shown that pain can be reduced by 84%, after just a month of acupuncture sessions (Canales et al., 2021). However, acupuncture is often rejected due to fear of the needle or due to the belief that it is an aggressive method (Madani et al., 2019). Moreover, in some cases, insertion of the needles is difficult or contraindicated such as in genitals. New studies have been conducting researching new ways of stimulating acupoints, such as, LLT (laser acupuncture) (Law et al., 2015). The results of these studies are ambiguous (Madani et al., 2019)

World Health Organization (WHO) includes TMD as 1 out of the 28 disorders that can be cured by acupuncture (Sen et al., 2020). Chidambaranathan & Culathur, (2022) reports that fascial pain, pain produced by Idiopathic Trigeminal Neuralgia, crepitus and locking of the TMJ can be reduced by acupuncture. Moreover, local anesthesia can be achieved as well as reduce of dental pain and dry mouth caused by TMD.

The local acupoints mostly used for analgesia are ST6, ST7, SI18, GV20, GB20 and BL10, while LI4 is used as a distant point (Zotelli et al., 2017). Points on head, ears, mouth and fingers have promising results in reducing pain (Fernandes et al., 2017; Simma et al., 2018; Peixoto et al., 2021). Also, dry needling deactivates trigger points, improving painful symptoms (Gonzales- Perez et al., 2015). Head acupuncture is used over 30 years to reduce chronic pain as it affects the central nervous system (CNS) (Peixoto et al., 2021).

Moreover, electroacupuncture is widely used to treat a variety of pathologies by producing opioids in the body due to the electrical stimulation of the needle (Serritella et al., 2021). Electroacupuncture can achieve analgesia in TMD, however, these results have not been well established due to the ambiguous results of the conducted studies (Kuo et al., 2017).

Problem Statement

The prevalence of TMD poses a significant health concern, affecting a large portion of the population. Despite the availability of various treatment modalities, including medication, counseling, and physical therapy, the optimal management of TMD remains elusive. Acupuncture has emerged as a promising therapeutic intervention, offering effective pain relief with minimal adverse effects. However, the existing literature on acupuncture for TMD treatment lacks comprehensive synthesis and analysis, highlighting the need for a systematic review to evaluate its efficacy, safety, and overall effectiveness. A systematic review would provide valuable insights into the role of acupuncture in managing TMD, potentially guiding clinical practice and improving patient outcomes. Therefore, conducting a systematic review is essential to address the gaps in current knowledge and inform evidence-based decision-making in TMD management.

Based on the aforementioned information, this study aims to assess the quality of the methodologies employed in recent studies investigating the effectiveness of acupuncture in alleviating pain among patients with temporomandibular joint disorder (TMD). Additionally, it seeks to determine whether acupuncture is indeed an effective treatment modality for reducing pain in patients with TMD.

METHODS

Research Design

This systematic review has been conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al, 2021).

Literature Search

A systematic search of the literature was conducted following the PRISMA 2020 guidelines (Page et al., 2021). An electronic search was performed in the databases PubMed, PEDro and Science Direct. The key words used were “Temporomandibular Joint Disorders”, “Acupuncture”, “TMJ disorders” and “Pain Relief” from inception to 15th Nove-

meber 2023. The keywords were merged using the “OR” and “AND” operators to create the ultimate search phrase. In all databases, the search field was set to either “all fields” or “all text.” Various types of records (journal articles, books, conference papers, etc.) were included in the search. Additionally, supplementary studies were discovered from the reference lists of the included studies and were searched for and imported from Google Scholar.

Study Selection

Duplicates were removed. The inclusion criteria were (1) Greek or English language, (2) Randomized controlled trials or randomized clinical trials. The articles selected (3) were published between 2013 and 2023. Moreover, (4) full text should have been available and the studies (5) concerned some type of acupuncture. (6) Pain was the key factor measured in each study while only studies investigating (7) adult population with (8) TMD were included. The screening process involved two phases, conducted independently by two authors (PG and EA). Initially, studies deemed non-relevant were excluded based on title and abstract. Following this, a full-text review was conducted, and studies that did not meet the inclusion criteria were removed. Any disagreements regarding study selection were resolved through consultation with a third author (EP).

Studies that did not mention specific therapeutic parameters and while referred to acupuncture, in their title, used some other method, such as laser acupuncture, and were removed. The data obtained (Table 1) from each study were (1) adult population, diagnosed with TMD reporting pain over 6 months. No previous surgery was performed in any of the subjects. Different (2) types of acupuncture were included such as acupuncture in specific body points, dry needling in trigger point, head acupuncture or acupuncture combines with manual therapy. Acupuncture was compared with (3) control groups, or other therapeutic methods such as occlusion splint, botulinum toxin type A, ozone therapy, psychotherapy, manual therapy as well as different types of acupuncture. The (4) aim of the RCTs included was the elimination of pain.

Data Extraction and Synthesis

The relevant data from the included studies was extracted by one author (PG) onto a meticulously designed Microsoft Excel spreadsheet (Microsoft, 16.60, Redmond, WA, USA). The studies were categorized initially by sport and then further organized by author surname (A-Z) within the spreadsheet (Paraskevopoulos et al. 2022). The pertinent information was systematically gathered from the included studies for analysis.

Risk of Bias Assessment

The methodological quality and risk of bias of the included studies were evaluated using the PEDro scale, comprising 11 items focused on the articles' validity (Gashin & Mc Auley, 2020). The first item addressed external validity, although it

Table 1. PICOS criteria

Criteria	Inclusion	Exclusion
Population	Adults diagnosed with TMD	Children or adolescents with TMD
Intervention	Various types of acupuncture (e.g., specific body points, trigger point dry needling, head acupuncture, acupuncture combined with manual therapy)	Studies using methods other than acupuncture (e.g., laser acupuncture) or studies without specific therapeutic parameters mentioned
Comparison	Control groups or other therapeutic methods (e.g., occlusion splint, botulinum toxin type A, ozone therapy, psychotherapy, manual therapy)	Studies without a comparison group or studies comparing acupuncture with irrelevant interventions
Outcome	Elimination of pain lasting over 6 months	Studies with outcomes unrelated to pain relief or duration shorter than 6 months
Study design	Randomized Controlled Trials (RCTs)	Observational studies or non-randomized trials

was not factored into the final score. The remaining items pertained to internal validity, covering aspects such as random allocation, allocation concealment, baseline comparability, blinding of therapists, patients, and raters, experimental mortality, intention-to-treat analysis, and statistical measures. These criteria helped assess the studies for internal validity (items 2-9) and whether they provided sufficient statistical information for interpretation (items 10 and 11). The PEDro score ranged from 0 (low quality) to 10 (high quality).

Studies indexed in the PEDro database retained their scores, while non-indexed studies underwent assessment by two independent reviewers, with a third reviewer resolving any discrepancies when necessary. Following established protocol, studies scoring ≥ 7 on the PEDro scale were classified as having high methodological quality, those scoring 5 or 6 were considered to have moderate quality, and studies scoring ≤ 4 were deemed to have poor quality (Paraskevopoulos et al. 2023).

RESULTS

The database search identified 129 articles. 62 studies remained after the duplicates removal and the abstract reading. 45 articles did not meet the inclusion criteria thus, they were excluded. Full text read reported 17 studies, 7 of which were removed due to the exclusion criteria (Figure 1). Ten studies were finally, analyzed (Table 2).

Participants

The subjects included in the 10 selected studies were consisted of adults diagnosed with TMD according to the Research Diagnostic Criteria for Temporomandibular Joint Disorders (RDC/TMD) axis I and II. The participants reported pain over a 6-month period and no previous surgery has been performed. Both genders were included. A total of 511 volunteers were measured and analyzed.

Interventions

10 Randomized Controlled Trials and Randomized Clinical Trials published between 2013 and 2023 were researched. Different types of acupuncture were compared to a variety of therapeutic methods.

In Gonzales- Perez et al., (2015) study, 2 groups of 24 volunteers accepted 3 sessions of acupuncture (intramuscular or on trigger points). In terms of comparison, the second group was suggested to drug therapy with anti-inflammatories. Pain was reduced in both experimental groups. The difference was statistically significant. Moreover, the acupuncture group showed a statistically significant difference in pain measurements (at rest) when compared to the second group in the 28th ($p=0,05$) and 70th day ($p=0.016$). Sen et al., (2020) conducted an experiment where 41 subjects were tested. 2 groups were created. The acupuncture group underwent 6 acupuncture sessions on specific acupoint (BL2, BL3, ST7, TE21, SI13, BL34, NS11-3). The control group was suggested to 6 sessions of sham therapy, selecting random points as distant as possible from meridians and acupoints. Both groups presented with a statistically significant reduction of pain (Group A. $p < 0.01$, Group B. $p < 0.023$). However, acupuncture group showed a significant difference in 2nd week, while Group B had the same results after the 3rd week.

Similar results were reported in Salles-Neto et al., (2020) study. Thirty-six volunteers divided into 2 groups and were suggested with 5 therapeutic sessions once a week. In the first group specific acupoints were selected (LI4, GB20, GB34, ST6, ST7, ST36, SI18, SI19). Control group underwent 5 sessions of sham acupuncture, using the same acupoints but without actually puncturing the skin. Pain was reduced in a statistically significant manner in acupuncture group ($p < 0.001$), when compared to control group. Pain was reduced by 61% in the first week and reached 84% in the one month's measurement. Dunning et al., (2022) created 2 groups of 60 volunteers who completed 8 sessions, twice a week, for 4 weeks. Group A underwent acupuncture in the following acupoints: ST5, ST6, ST7, ST8, Taiyang, BG2, SI19, along with cervical mobilization. In group B the subjects were given a splint, along with anti- inflammatories and cervical manipulation. The measurements revealed that pain levels were statistically significant lower in group A ($p < 0.001$) along with the improvement of mandibles function ($p < 0.001$).

54 volunteers were included in Canales et al., (2021) experiment. 4 weekly sessions were completed by the 3 groups. Depending on the group, the subjects were treated with either acupuncture in the acupoints LI4, LI11, SI19, LR2, GB20,

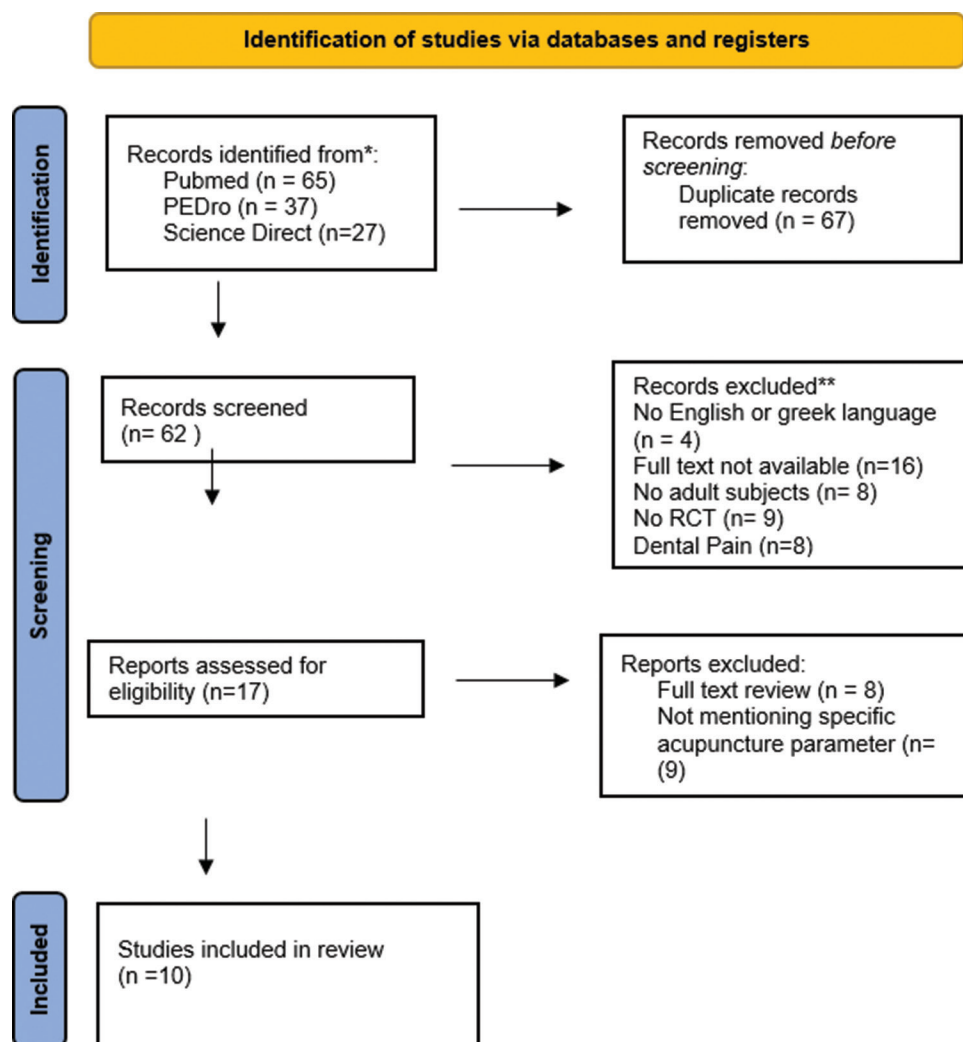


Figure 1. PRISMA Flow Chart

GB21, GB34, BL2, CV23, TE23 (group A), botulinum toxin type A injections (group B), or saline solution injections (control group). A statistically significant reduce of pain was reported in all 3 groups ($p < 0.01$). Moreover, groups A and B were found to produce a significant result in eliminating pain compared to group C ($p < 0.05$).

Pain was significantly reduced into 3 out of 4 groups in Peixotos' et al., (2021) study. In this study 60 volunteers were divided into 4 groups of 20 volunteers each. Group A, performed, 4 weekly sessions of counseling. Group B, was given a splint, while group C, performed 8 sessions (twice a week) of head acupuncture in specific acupoints (GV20, GV21, GV22, GV24). Group D, was treated with Manual Therapy sessions (hot and cold patches, massage on the masseters muscles, stretching and exercise in the mandible area). Pain statistically reduced in group B ($p = 0.01$), in group C ($p = 0.015$) and in group D ($p = 0.014$). Seritellas' et al. (2021) study compared 3 different types of acupuncture. The 60 subjects participating were divided into 3 groups and underwent 2 weekly sessions for 4 weeks. Group A was treated with body acupuncture (ST6, ST7, ST36, GB20, BL10, LI4, SP6, LR3). Group B was treated with electroacupuncture in the same points as in group A. Group C was treated with

body acupuncture (same acupoints) along with cupping therapy in points ST6 and ST7.). Pain was statistically improved in all 3 groups ($p < 0.05$). Group B also reported a significant improvement in sleep quality ($p = 0.015$).

Another experiment compared body acupuncture with splint (Grillo et al., 2015). 40 subjects were divided into 2 groups and completed 4 weekly sessions. The acupoints used in this study were: LI4, LI11, LR2, GB20, GB21, GB34, BL2, CV23, TE23). Pain levels were significantly improved in both groups ($p = 0.01$). However, there was no statistically significant difference between groups.

In Zotellis' et al., (2017), controlled trial 2 groups of 20 subjects were tested. Group A was treated with 4 sessions of acupuncture in acupoints ST6, ST7, SI18, GV20, GB20, while group B was treated with sham acupuncture (the needles did not puncture the skin) in the same acupoints. Pain was improved in both groups ($p = 0.2261$). Moreover, there was no significant difference between groups. Twelve volunteers participated in Tortellis et al., (2019) study. The subjects were divided into 3 groups. In group A LLT was performed in masseter and temporalis muscles. Group B underwent body acupuncture (ST6, ST7, SI18, GV20, BL10, LI4) while Group C was treated with ozone therapy in both

Table 2. Studies selected in the systematic review

No	Author (Year)	Design	Participants	Intervention	Assessment	Results
1.	Grillo et al., 2015	Randomized Clinical Trial	40	A. Acupuncture (4 weekly sessions) B. Splint	VAS Ruler Algometer EMG	Significant pain improvement in both groups ($p < 0.01$) Improved mouth opening in both groups Reduce of RMS in both groups. Significant difference in Group B ($p < 0.05$)
2.	Gonzales-Perez et al., 2015	Randomized Single centered Clinical Trial	48	A. Dry needling (3 weekly sessions) B. Control Group (Nsaids)	VAS Ruler	Significant reduce in pain at rest in both groups. Significant difference between groups for Group A. in 28 ($p = 0.05$) and 70 ($p = 0.016$) day after the experiment Significant reduce in pain (chewing) in both groups on 28 day, but significant difference only in Group A on the 70 th day. Significant difference in pain levels between groups at chewing for Group A. in 28 ($p < 0.01$) and in 70 day ($p = 0.011$) Improved function in both groups. Results lasted until 70 th day in Group A
3.	Zotelli et al., 2017	Randomized Controlled Trial	40	A. Acupuncture (4 weekly sessions) B. Control Group (not breaking the skin)	NVAS RDC-Ruler PRRM	Pain levels improved in both groups Statistically significant improvement in pain during mouth opening in group A No difference in Meridian energy in both groups
4.	Tortelli et al., 2019	Randomized Controlled Trial	12	A. LLT B. Acupuncture (6 sessions) C. Ozone therapy	VAS RCD/TMD Questionnaire QoL Questionnaire Ruler	Statistically significant improvement in pain levels after the experiment ($p = 0.002$). No significant difference between groups. No difference in TMD Questionnaire No between group difference in QoL questionnaire. Significant pain improvement ($p = 0.012$) and in physical activity ($p = 0.028$) No significant difference between groups in mouth opening. Significant difference in mouth opening after the experiment ($p = 0.003$)
5.	Sen et al., 2020	Randomized Controlled Trial	41	A. Acupuncture (4 weekly sessions) B. Acupuncture in non specific points	NRS (CPI) Patient expectation Scale OHRQoL	Significant improvement in pain levels in both groups ($p < 0.01$ A.; $P < 0.02$ B.) Jaws function improved significantly in Group B ($p = 0.016$) No between group differences in patient expectations Oral health improvement ($p = 0.018$ A., $P < 0.001$ B.)

(Contd...)

Table 2. (Continued)

No	Author (Year)	Design	Participants	Intervention	Assessment	Results
6.	Salles- Neto et al., 2020	Randomized Controlled Trial	36	A. Acupuncture (5 weekly sessions) B Control Group (not breaking the skin)	VAS McGill MOPDS OHIP-14	Significant improvement in pain levels in Group A ($p < 0.01$) Pain reduced 61% on the first week and 84% in one month Significant improvement in jaws function and Qol (oreal health) ($p < 0.01$)
7.	Canales et al., 2021	Randomized Clinical Trial	54	A. Acupuncture (4 weekly sessions) B. Botulinum toxin type A injections C. Control Group	VAS Algometer ADS 1200 (EMG)	Significant improvement in pain levels in both groups . Significant between groups differences in Groups A and B over C. Significant improvement in PPT and muscle function in Group B ($p < 0.001$)
8.	Peixoto et al., 2021	Randomized Clinical Trial	60	A. Counseling B. Splint C. Head acupuncture (2 sessions per week=8 sessions) D. Manual Therapy	VAS PSQI WHOQOL	Significant improvement in pain levels in Group C ($p = 0.015$), in Group B ($p = 0.01$) and Group D. ($p = 0.014$) Sleep quality was improved in Group B. ($p = 0.002$) and D ($p = 0.29$) Significant difference in Qol in physical domain in Group D ($p = 0.011$) and in psychological domain in Group B ($p = 0.012$)
9.	Seritella et al., 2021	Randomized Clinical Study	60	A. Acupuncture (2 sessions per week=8 sessions) B. Electroacupuncture C. Acupuncture+Cupping	VNS BPI PGI-I	Significant improvement in pain levels in all groups ($p < 0.05$) Significant difference in Qol . Mood and sleep improvement in Group B over the other groups ($p = 0.015$ και $P = 0.014$)
10.	Dunning et al., 2022	Multi-center Randomized Clinical Trial	120	A. Dry needling+Manual Therapy (2 sessions per week=8 sessions) B. Splint. Anti inflammatory and Manual Therapy	VAS GROC	Significant improvement in pain levels ($p < 0.001$) and jaws function ($p < 0.001$) in Group A

masseters and temporalis muscles. The experiment lasted 1 month and 4 weekly sessions were completed. There was a significant improvement in pain measurements overall ($p = 0.002$). Pain was significantly improved in the Qol questionnaire ($p = 0.012$) along with physical activity ($p = 0.028$), and the mandibles function in all groups ($p = 0.003$).

In the methodological analysis, results were ambiguous. PEDro scale was used for this analysis. The studies were measured by the scales' 10 criteria, showing low to moderate results. Only two studies met 7 out of 10 criteria (Zotelli et al., 2017; Dunning et al., 2022). 3 of the selected studies reached 6 out of 10 criteria (Sales- Neto et al., 2020; Canales et al., 2020; Serritella et al., 2021). 5 out of 10 criteria were used in 2 more of the selected studies (Tortelli et al., 2019; Sen et al., 2020) while 3 more studies met only 4 out of 10 criteria (Grillo et al., 2015; Gonzales- Perez et al., 2015; Peixoto et al., 2021). Blinding of the therapist was the only criteri-

on that no study could meet since the nature of acupuncture does not allow this practice. Intention to treat analysis was only met in Dunning et al., (2022) study (Appendix).

DISCUSSION

Recent studies have shown that acupuncture is an effective method to reduce painful symptoms caused by TMD, however, the methodology used in studies should be carefully designed order to increase the quality of the studies (Fenandes et al., 2017). In this systematic review, 10 studies were selected and analyzed for their method and results. The effectiveness of acupuncture in reducing pain in patients diagnosed with TMD was explored.

Specific inclusion and exclusion criteria were established. Pain was one of the main measurements included in all studies and patients were treated with at least one type

of acupuncture. Texts should have been written in English and Greek languages while, the experiments included were Randomized controlled trials and Randomized clinical trials. Studies have been conducted between 2013 and 2023 and full text should have been available. Subjects were adult volunteers diagnosed with TMD. The experimental groups included different types of acupuncture and a variety of therapeutic methods. The methodological quality was analyzed in all 10 studies showing low to moderate results, ranging from 4/10 and 7/10 criteria on PEDro scale.

The effectiveness of acupuncture in reducing pain was statistically significant in 9/10 studies analyzed (Grillo et al., 2015; Gonzales- Perez et al., 2015; Tortelli et al., 2019; Sen et al., 2020; Sales- Neto et al., 2020; Canales et al., 2021; Peixoto et al., 2021, Serritella et al., 2021; Dunning et al., 2022). One more study have shown improvement in pain measurements however, it was not significant (Zotelliet al., 2017). The analysis revealed that in 7 studied the pain was reduced in all experimental groups. Grillo et al., (2015), reported that pain was eliminated in both groups (acupuncture and splint). Moreover, Peixotos; et al., (2021) study showed that symptoms were significantly improved in 3/4 analyzed groups (acupuncture, splint and manual therapy). CBT group showed to significant difference.

Fernandes et al., (2017) analyzed 4 studies comparing acupuncture with splint, LLT and trigger point release, revealing that pain improvement was statistically significant after acupuncture, compared to splint and placebo. Moreover, acupuncture shows significant results in reducing pain and improving mandibles and jaws function compared to splint therapy (Dunning et al., 2022). Dry needling and NSAIDs improved pain levels in Gonzales- Perez et al. (2015) study. However, measurements showed that acupuncture results lasted longer than the other group.

As mentioned above, acupuncture has been compared to other therapeutic methods such as botulinum toxin type A injections. Canales et al., (2021) compared 3 groups (acupuncture, botulinum toxin Type A, injections and a control group). All groups have revealed a statistically significant reduce in pain, however, the injections groups showed a bigger improvement in pain threshold and TMJs' muscle function.

The most common acupoints used in studies were GB20, ST7, LI4, SI19 and ST6. Moreover, the points BL2, BL10, CV20, GB34, BL3, TE21, BL34, SI3, ST5, ST8, CV22, CV33, ST36, LI11 and SP6, are usually chosen. Trigger points and painful points were also used in several experiments (Gonzales- Perez et al., 2015). Sen et al., (2020) introduced 2 acupuncture groups. Group A was treated with acupuncture in specific acupoints while groups B was treated with acupuncture in distal nonspecific points. Both groups resulted in statistically significant improvement in pain levels. TMJs' functionality and oral health was also improved.

Ozone therapy and LLT have also been compared to acupuncture. Tortelli et al., (2019) reported that pain was reduced in all 3 experimental groups. In recent studies, acupuncture was combined with LLT (laser acupuncture) were researchers used LLT in specific acupoints showing statistically significant results in eliminating pain. A study by Fer-

reira et al., (2013) examined the effectiveness of laser acupuncture in the points ST6, SI19, GB20, GB43, LI4, LR3, NT3, και EX-HN3 compared to a control group. Improvement was statistically significant in both groups however; laser acupunctures results were obvious in less time than the control group.

Moreover, Huang et al., (2014) used laser acupuncture in the points ST6, ST7 and LI4 (distal point), in 20 TMD patients. 85% of the subjects reported a statistically significant difference in reducing pain, however in different levels (mean score 2.5 ± 2.2). Similar results were found in Madanis et al., (2019) study. More specifically, laser acupuncture in specific points (ST6, ST7, LI4) resulted in a significant pain improvement in patients with TMD.

Laws' et al., (2015) meta-analysis showed ambiguous results. The quality of the studies was high and analgesia was accomplished however, the heterogeneity of the subjects was high in over half of the studies. Thus, the results were compromised.

Electroacupuncture has also been studied. Serritella et al., (2021), compared 3 types of acupuncture (body acupuncture. Pain reduced in all 3 experimental groups. electroacupuncture and body acupuncture along with cupping). Moreover, sleep and QoI was improved. On the contrary, Kuos et al., (2017) study reported ambiguous results.

Two studies in this systematic review revealed that only the acupuncture group showed significant improvement in pain levels compared to the other experimental groups. Acupuncture was compared to a control group in Zotellis et al., (2017) study. Pain was reduced and jaws function was improved in the acupuncture group. Similarly, Sales- Netos et al., (2020) study reported that pain was reduced 61% over the first experimental week in the acupuncture group and reached 84%, after one month. QoI and mandibles muscle function was also improved.

Secondary results were also examined. Acupuncture improves mandibles' function, mouth opening, and jaws movement (Grillo et al., 2015; Tortelli et al., 2019; Sen et al., 2020; Sales- Neto et al., 2020; Dunning et al., 2022). Gonzales- Perez et al., (2015) report that acupuncture results lasted up to 70 days. Oral health can also be improved by acupuncture in TMD patients (Sen et al., 2020; Sales- Neto et al., 2020) as well as physical activity (Tortelli et al., 2019). However, in Tortellis' et al., study (2019) no difference was reported in TMDs and QoIs' questionnaires. Moreover, Zotelli et al., (2017) revealed that no differences were found in meridians energy.

QoI, mood and sleep quality were improved by electroacupuncture (Serritella et al., 2021). However, in Peixotos' et al. (2021) study, sleep quality, as well as, QoI in psychological domain was improved in splint group. Manual Therapy also improved QoI in physical domain Finally, botulinum toxin A injections significantly improved pain threshold in patients with TMD (Canales et al., 2021).

Limitations

Studies in this systematic review have shown some limitations such as the small number of subjects participating.

Moreover, most studies did not assign a control group but compared different types of therapeutic methods. Moreover, in some cases, a large number of the participants did not complete the experiment compromising the results.

Generalization of the results was not feasible in some studies as they included only women). Moreover, in most studies the experimental time was not adequate (4 sessions) (Serritella et al., 2021) as well as the follow up time (1 month). Due to this factor results cannot be established as long term (Canales et al., 2021). Due to the TMDs nature and the heterogeneity of the symptoms some researchers suggest that each patient needs an individual therapeutic plan in specific painful areas. Thus, the use of standard points in all subjects might limit the effectiveness of acupuncture (Peixoto et al., 2021). Moreover, most studies did not measure the psychological and emotional results of acupuncture (Zotelli et al., 2017, Canales et al., 2021).

This systematic review also shows limitations due to the low quality of the selected studies and the limited literature available. Moreover, the differences in the methodology structure between the studies limits the validity of the results,

New, methodologically improved, studies need to be conducted including larger sample size, of both genders and a larger age range. Adequate experimental and follow up time are necessary to establish the long- term effectiveness of acupuncture in improving pain levels in patients with TMD.

More Randomized controlled trials meeting more quality criteria are needed along with social and emotional measurements. Finally, TMD affects a large percentage of the population. Prevention and awareness are key factors in sustaining QoL. Campaigns and social media could be useful in order for people to be informed of the symptoms and the therapeutic methods available for these conditions.

Strengths

The systematic review demonstrates several strengths that enhance its value in understanding the role of acupuncture in managing temporomandibular disorders (TMD). Firstly, by analyzing findings from 10 studies, the review provides a comprehensive overview of various acupuncture techniques and their effectiveness in alleviating TMD-related pain. This broad scope allows for a thorough examination of acupuncture's potential in TMD management. Additionally, the review identifies specific acupuncture modalities, such as body acupuncture, laser acupuncture, and electroacupuncture, that show promise in reducing pain and improving mandibular function among TMD patients. This information can guide healthcare providers in selecting suitable acupuncture interventions tailored to individual patient needs and preferences. Moreover, the review explores secondary outcomes beyond pain relief, including improvements in oral health, physical activity, and quality of life (QoL). By considering these holistic benefits, the review highlights the multifaceted impact of acupuncture on TMD patients' well-being, thereby offering valuable insights for clinical practice.

Practical Implications

The findings of the systematic review carry practical implications for healthcare providers involved in the management of TMD. Firstly, the identification of diverse acupuncture techniques underscores the importance of offering patients a range of therapeutic options. From traditional body acupuncture to innovative laser and electroacupuncture modalities, healthcare providers can tailor treatment approaches to meet the unique needs and preferences of TMD patients. Additionally, the holistic treatment approach advocated by acupuncture aligns with patient-centered care principles, emphasizing not only pain relief but also improvements in secondary outcomes such as mandibular function, oral health, and QoL. By adopting this comprehensive approach, healthcare providers can address the multidimensional impact of TMD on patients' lives, ultimately enhancing treatment outcomes and patient satisfaction.

Suggestions for Future Studies

To address the limitations identified in the systematic review, future research should prioritize high-quality randomized controlled trials (RCTs) with larger sample sizes, rigorous methodology, and longer follow-up periods. Adequate control groups and standardized outcome measures are essential for generating robust evidence on the effectiveness of acupuncture in TMD management. Longitudinal studies with extended follow-up periods are needed to assess the long-term effectiveness and durability of acupuncture interventions in TMD patients. Comprehensive outcome assessment, including psychological, emotional, and social dimensions, should be incorporated to capture the holistic impact of acupuncture on TMD patients' well-being. Additionally, efforts to raise awareness about TMD symptoms, treatment options, and preventive measures through public health campaigns and educational initiatives can empower individuals to seek timely diagnosis and appropriate management for TMD-related concerns.

CONCLUSION

This systematic review suggests that acupuncture is an effective method in improving pain in patients with TMD. Most of the studies revealed significant reduce in pain and improvement in jaws function. Moreover, acupuncture improves sleep, oral health and QoL. However, due to the low quality of the literature available and the limitations stated, it is important that new, qualitatively improved studies should be conducted in order to establish acupuncture as a safe and effective therapeutic method for patients with TMD.

Statements & Declarations

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Data Availability

The datasets utilised in this review are available from the corresponding author upon reasonable request.

Authors' Contributions

PG, EA, and EP participated in the study design and drafted and critically revised the manuscript. PG and EA were responsible for selecting articles for inclusion and Quality assessment. PG, EA, and EP were responsible for data extraction and helped to revise the manuscript. All authors read and approved the final manuscript.

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