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Management of temporomandibular disorders with ultrasound therapy and transcutaneous electrical nerve stimulation – a literature up-date

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Abstract

Introduction. Temporomandibular disorders are considered to have a multifactorial etiology; thereby different treatment modalities are available, from occlusal equilibration, medication and physical therapy. Among physical therapies, occlusal splints, low-level laser therapy, acupuncture, ultrasound, TENS frequently used in current practice. The aim of physical therapies is to re-establish the muscle physiology by increasing the local blood and lymphatic flow. The aim of this study was to provide some clinical guidance regarding ultrasound therapy and TENS in case of temporomandibular disorders. **Material and methods.** A research of literature has been performed - articles published over the last 10 years (January 2009 until December 2019) were searched by introducing a combination of different terms, using the Pubmed and Science Direct databases.**Results and discussion**. A total number of 611 articles were found. After applying the inclusion and exclusion criteria, 20 articles were taken into consideration for the present study. **Conclusion.** Based on the findings within this literature review it can be concluded that for patients suffering from TMDs, ultrasound therapy and transcutaneous electrical nerve stimulation represent an effective non-drug-based conservative option, in order to improve symptoms like pain or hyperactivity of the masticatory muscles. Because it was difficult to compare the studies included, as they do not offer an optimal usage (program, duration of sessions, or number of sessions) of each technique we consider that further randomized controlled clinical studies are necessarily to compare each physical technique as well their combined effect in case of patients with temporomandibular disorders.

Key words: *TMD, ultrasound therapy, TENS,*

Introduction

Temporomandibular disorder (TMD) is defined by the American Academy of Orofacial Pain as "a collective term which includes a number of clinical problems that involves the masticatory muscles, the temporomandibular joint (TMJ) and associated structures". Among the most common signs and symptoms in TMDs there is limiting of mouth opening because of pain, TMJ sounds, and asymmetrical jaw movements (1,2).

As TMD's etiology is considered to be multifactorial, different treatment modalities are available, including occlusal equilibration, medication, and physical therapy. Physical therapies refer to several treatment options such as occlusal splints, low-level laser therapy, acupuncture, ultrasound, TENS, etc. The aim of physical therapies is to re-establish the muscle physiology by increasing the local blood and lymphatic flow (3).

Definition of ultrasound is "sound wave oscillating at a frequency greater than 20000 cycles per second"(4). The medical use for ultrasound therapy (US Th) started to be analyzed in the 1930s as it was said to speed up the healing process and increase the quality of tissue repair (5). Currently this therapy is mainly used for muscle pain (6,7). US Th is known to reduce pain, increase joint mobility, accelerate the healing processes, increase the extensibility of collagen fibers, reduce muscle spasms (therefore a better mouth opening)(6).

Transcutaneous electrical nerve stimulation (TENS) is a non-invasive, non-medicated, treatment option used for pain management in different musculoskeletal pathologies, including for TMDs (8, 9). It is considered that TENS's may activate the endogenous opioids system with an impact on the central inhibition, as the technique involves the application of an electrical stimulus on the major nerves (10,11).

The use of physical therapy in case of TMDs is controversial, as some articles are suggesting that their effect on pain is minimal (12). *The aim* of this study was to provide some clinical guidance regarding ultrasound therapy and TENS in case of temporomandibular disorders.

Methods

In order to find relevant and adequate articles for this literature review, an automated search of PubMed and Science Direct databases was conducted from January 2009 and up to December 2019. A combination of these following keywords was used: "temporomandibular disorder", "TMD", "temporomandibular joint disorder", "TMJ disorder", "TM disorder", "ultrasound", "ultrasonography", "sonography", „TENS", "Transcutaneous Electrical Nerve Stimulation". Before initiating the search, we took into consideration the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines (13,14,15).

The following types of articles were *included*: 1. randomized clinical trials (involving patients with TMD), 2. systematic reviews and meta-analysis studies in which either ultrasound or TENS therapies were the treatment option for temporomandibular joint disorder (TMD) and 3. articles written in English. *Exclusion* criteria were as follows: abstracts that did not report data on the findings, articles written in other languages than English and studies performed on patients with systemic diseases or pain not related to TMJ.

Results

A total number of 611 articles were found. After applying the inclusion and exclusion criteria, 20 articles were taken into consideration for the present study.

Discussion

The aim of this study was to provide an up-date of literature regarding the use of physical therapy (ultrasound and TENS) in case of temporomandibular disorders. Thereby, the authors analyzed the articles included in this research and organized the findings based on topic and based on answering on some focus questions for each type of physical therapy.

a. What is the mechanism of action for each physical therapy?

Ultrasound therapy acts by the principle of a mechanical energy at increased frequency that stimulates tissue with sound waves that are beyond the upper limit of what the human ear can hear (4).

TENS involves the action of an electrical stimulus on the major nerves, as a neurophysiological mechanism is produced, depending on the parameters used (duration and amplitude).In clinical practice, there are two types of TENS – low frequency (LF, <5 Hz frequency of stimulation) and high frequency (HF, >100Hz). There is also a ultra low frequency stimulation TENS (ULF) (<4Hz of frequency). A conventional TENS stimulator device will be able to transmit different rages of frequencies, for both LF and HF TENS therapies (11).

When a patient receives HF-TENS therapy, the sensations are sometimes perceived as pleasant, or the subject does not feel anything. It is considered that HF-TENS analgesia appears rapidly, but can quickly stop once the stimulation is suspended (11).

On the other hand, the LF-TENS stimulation will determine analgesia after 20-45 minutes of administration, but the analgesic effect will last longer after the stimulation is suspended. Also, the LF-TENS must be administrated to such amplitude so it will feel uncomfortable for the patient (11).

Neuromuscular TENS is also known as ultra low-frequency TENS (ULF-TENS) and it will act as an exciter for the motor fibers of the facial nerve, which will lead to a relaxation of the masticatory muscles. The practitioner using this technique will achieve this way a physiological rest position of the jaw (11).

The effects of ultrasound therapy and TENS are resumed in Table 1.

b. What are the indications and contraindications?

US Th can be used to reduce pain, to increase joint mobility, to accelerate the healing processes, to increase the extensibility of collagen fibers and to reduce muscle spasms (therefore a better mouth opening)(4).

In case of temporomandibular disorders, ultrasound therapy is indicated in order to reduce the muscular activity of masticatory muscles. This therapy produces low-amplitude, low-frequency stimulus which will induce vibrations. When applied bilaterally those vibrations are able to reach some superficial divisions of the facial nerve as well as the mandibular division of the trigeminal nerve(18).

In dentistry, TENS has two major indications. The first indication is when the patient is suffering from musculoskeletal pain, like the pain in temporomandibular disorders; in those cases an antalgic TENS can be used to reduce pain. The second indication is for neuromuscular TENS, which is also used as a therapeutical strategy; as it produces a contraction of the muscle(s), neuromuscular TENS can be used by practitioners to conduct the mandible in Central Relation (10,11).

Monaco et al. also conducted a study in 2016, suggesting that ULF- TENS therapy might be able to

reduce the values of heart rate and breathing rate under acute mental stress conditions. The results of their preliminary study suggest that the antalgic effect obtained after TENS therapy might be induced by other mechanisms, such as an increase in parasympathetic tone associated with a decrease in the orthosympathetic tone, which leads to lower values for heart and breathing rate. (19).

US Th is contraindicated in some situations like infections, malignancy, bone fracture, cardiac pacemaker or other implantable devices, coagulopathies, untreated blood hypertension, pregnancy (20).

There are also situations when TENS therapy is not indicated, like patients having pace-maker or any other electrical device, in case of venous or arterial thrombosis or thrombophlebitis, patients with severe psychiatric disorders (dementia, Alzheimer's disease), and in case of pregnant patients(8,21,22).

c. What are the protocols for using US Th and TENS?

The protocols of using both physical therapies differ between the studies included in this review. Table 2 resumes the protocols found in the clinical studies considered in this study.

d. What results can be obtained after using US or TENS therapy?

It is known that in case of ultrasound therapy, a small amount of the sound waves reach the profound muscles as well as the TMJ(12). In this context, Haseeb et al. reported that US Th might be able to reach even the trapezoid muscle (7).

Panhoca et al. performed a clinical study, testing the efficiency of a combination treatment - US Th and photobiomodulation Th (PBMT)- on 13 patients (ages between 23 and 66; all suffering from TMD). The results showed that the patients' quality of life has improved, and the therapy effects were still lasting one month after the end of the treatment(6).

Hussain et al. compared US Th to sham US Th on 20 female subjects with bilateral maseter myalgia. Ultrasound therapy produced an immediate increase in the pressure pain thresholds for the maseter muscles (which is considered a therapeutical effect), and an increase in intraoral temperature on subjects treated with US. Also, their results suggest that therapeutic ultrasound may be more effective than sham ultrasound for patients suffering from bilateral maseter myalgia(7).

Ramakrishnan and Aswath conducted a clinical study in 2017, on 50 patients suffering from temporomandibular disorders. The patients were divided in 2 groups and they received US therapy – for first group an acoustic gel without pharmacological agents was used and for the second group a gel containing aceclofenac was used (the technique is called phonophoresis). The results have been analyzed with the help of a visual analogue scale (VAS) and by immunoturbidometry (measures the C reactive protein = CRP). The authors concluded that both therapies were efficient in reducing pain (VAS) and inflammation (CRP); also, phonophoresis was slightly superior compared to US Th, but no significant difference between the two therapies was obtained(17).

Overall, ultrasound therapy seems to be more effective as an adjunct to other therapies, than used alone (16) Khairnaret al. compared US Th with low-level laser therapy (LLLT), on 42 patients with TMD, distributed in 2 groups. All patients received non-steroidal anti-inflammatory drugs (Myospaz Forte) twice a day, 5 days preceding the treatment. Both methods have had good results reducing pain (VAS) and mouth opening, yet LLLT's results were considered superior in both cases (2). The beneficial effect of LLLT on patients suffering from temporomandibular disorders is also confirmed by other clinical studies (24). When Us Th and TENS were compared, researchers found that both of them were able to determine a significant thickness reduction of the maseter muscle. While both therapies were found to be effective on pain reduction, their results showed that US therapy is more effective compared to TENS (11,16).

Regarding the use of TENS in TMDs, in 2013, Monaco et al. conducted a clinical study studying the effects of sensory and motor TENS therapy on masticatory muscles. They demonstrated that the application of TENS is effective in reducing the activity of the masticatory muscles, as well in increasing the interocclusal distance, for patients suffering of temporomandibular disorders (25).

Cesar et al. studied the use of TENS therapy on 40 patients suffering from TMD. They concluded that short-term TENS therapy (a total of 50 minutes, using variations of low and high frequencies) reduces deep pain sensitivity and improves masticatory muscles activity (measured on electromyography)(26).

We also found a systematic review which does not support the use of ultrasound therapy, or TENS, as there are insufficient clinical data regarding their use (12).

Conclusion

Based on the findings within this literature review it can be concluded that for patients suffering from TMDs, ultrasound therapy and transcutaneous electrical nerve stimulation represent an effective non-drug-based conservative option, in order to improve symptoms like pain or hyperactivity of the masticatory muscles.

Nevertheless, it was difficult to compare the studies included, as they do not offer an optimal usage (program, duration of sessions, or number of sessions) of each technique. Because of lack of possible conclusion, we consider that further randomized controlled clinical studies are necessarily to compare each physical technique as well their combined effect in case of patients with temporomandibular disorders.

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Table 1 – Mechanism of actions for Us Th and TENS

ULTRASOUND THERAPY	**TENS THERAPY**
US therapy is considered to be effective from both thermal (at a continuous frequency - 100% duty cycle) and non-thermal (at a pulsed frequency - 50% duty cycle) mechanisms (2,4,7). The acoustic energy that penetrates the soft tissue causes molecules to vibrate under repeated cycles of compression and refraction. If the intensity is increased, the frictional heat will also increase (2). Thermal US, at a depth of 8 cm, increases the temperature by 4 to 5 degrees Celsius, at 1.5 w/cm^2 or higher. At 1.25 w/cm^2 sound waves already cause tissue vibration (2). The cell metabolism and the cell permeability (which is altered to sodium in such a way that modifies the nerve conduction or the pain threshold) are directly influenced by the increase in temperature(16,17). The increase in temperature draws blood with oxygen, nutrients and removes inflammatory exudates. US prompts the de-granulation of mast cells, which release arachidonic acid (a precursor for the synthesis of prostaglandins and leukotriene)(2). The resolution of inflammation comes along with the reduction of pain(2).	Patil et al. resumed the three major theories by which TENS is considered to work (3): - first theory suggests that TENS stimulates the thick sensory fibers (or A-fibers), which will block the thin C-fibers (pain-modulating fibers); as a result, the gate of pain signals (at the entry into the spinal cord) is closed, and an antalgic result is obtained; - another mechanism by which TENS is believed to act, is the release of some endogenous morphine-like substances, with analgesic properties; - a third theory suggests that TENS causes mild, rhythmic muscle contractions which increase blood and lymph flow, reducing the interstitial oedema, as well as reducing the amount of noxious tissue metabolites.

Table 2 – Suggested clinical protocol for US Th and TENS

US TH	**TENS**
Khairnar et al. used a Bionics Innovation Unit at a frequency of 1 MHz and wavelength of 1.5 mm, 1.8 w/cm square for 10 minutes per session, with a coupling agent during therapy(2). Another study used Ultrasound Sonicator 740 device at 0.4 w/cm square with 100% duty cycle for 5 minutes, with acoustic gel pre-heated to 24 degrees Celsius (7). Panhoca et al. recommends using US Th for 2 sessions per week, for 4 weeks at a frequency of 1.0 MHz, 1 w/cm square, 50% pulsed work cycle, effective radiation area of 1.6 cm square. For better sound wave transmission an acoustic gel based on water can be used, and gentle, slow circular movements should be performed for 120 seconds (6). Shalu Rai used the US Th for 12 weeks, 3 times every 2 weeks(16) and Ramakrishnan et al. in his comparison used US Th3 times a week, for 2 weeks at a frequency of 1MHz, intensity 1.5 w/cm square for 8 minutes(17).	Patil et al. used TENS therapy for a duration of 6 days, for approximately 30 minutes per session. The frequency of the electric current ranged between 10 to 40Hz, with an amplitude between 1 to 5 µA(3). For ULF-TENS therapy, it is indicated to use a Myomonitor TENS Unit which will generate repetitive, synchronous and bilateral stimulus at 1.5 seconds intervals, with am amplitude between 0-24mA, for 500µseconds, a 0.66Hz of frequency. The electrodes should be positioned on the jaw (anterior to the tragus), and another electrode, placed posterior, on the midline of the neck, lower than the hairline. For this protocol, ULF-TENS should be applied for a duration of maximum 60 minutes in order to assure masticatory muscular relaxation (22).