The Effects of Transcutaneous Electrical Nerve Stimulation on Osteoarthritic Knees: A Literature Review

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Abstract: Osteoarthritis (OA) is reportedly the most common joint disease among older adults. This condition is a primary cause of pain and disability and results in more than 700,000 total knee replacements in the US each year. Transcutaneous electrical nerve stimulation (TENS) has long been a safe, non-invasive way to treat OA of the knees, however the overall benefit of TENS remains questionable. A review of literature on the effectiveness of TENS on OA of the knees indicates that benefits are typically seen in pain reduction and increased function. However, similar benefits are frequently seen with the use of sham-TENS introducing the possible influence of a placebo effect. For this reason the effectiveness of TENS remains inconclusive. The combination of TENS and acupuncture (electroacupuncture) is less studied, nevertheless available results indicate benefits in reducing pain and increasing function with statically significant higher benefits than sham-electroacupuncture.

Keywords: Electroacupuncture, Osteoarthritis, Placebo-effect, Placebo-TENS, Sham-TENS.

INTRODUCTION

Transcutaneous electrical nerve stimulation (TENS) is seen as a safe, non-invasive way to treat a variety of conditions that cause pain [1]. There is a variety of published research regarding its use in medical pain prevention and alleviation [2-30]. TENS has been theorized to work on the afferent neurons, which in turn inhibits the pain signals running from the injured body part through the spinal column and into the brain. This theory has been substantiated by several studies finding increased pain threshold in subjects undergoing TENS [2,11,26]. Healthcare providers utilize this theory of heightened pain threshold for dealing with a variety of painful conditions including osteoarthritis. However, the current trend towards evidence-based rehabilitation has prompted a look at the available research regarding the effectiveness of TENS.

The strongest sources of research in the area of TENS for both acute and chronic conditions are three Cochrane Collaboration reviews in the field [19,20,31]. Each review examines the available evidence regarding TENS as a viable treatment for various medical conditions. One notable similarity in the three reviews is the absence of studies that use multiple treatments simultaneously including the combination of TENS and acupuncture.

Osteoarthritis (OA) is reported to be the most common form of joint disease and a primary cause of pain and disability among older adults [31]. Furthermore, OA of the knee is one of the primary factors resulting in the more than 700,000 total knee replacements in the US each year [32]. For these reasons, we narrowed our focus to the effects of TENS on knees with OA. We also examined the reported benefits of the combination of TENS and acupuncture, due to its apparent increase in popularity over the past decade.

METHODS

Electronic searches for scientific articles on TENS and OA of the knees and electroacupuncture and OA of the knees were conducted using the search engines PubMed, CINAHL, MEDLINE and PEDro. Articles were selected based on scientific content and availability in the English language. Articles were limited to the last 6 years (≥2008) although literature reviews containing information from earlier research were included. Key words and phrases used for the search were: transcutaneous electrical nerve stimulation; non-invasive treatments of osteoarthritis; transcutaneous electrical nerve stimulation and osteoarthritis; transcutaneous electrical nerve stimulation and osteoarthritis of the knee; acupuncture and electrical nerve stimulation, benefits of acupuncture and transcutaneous electrical nerve stimulation for osteoarthritis of the knee.

Transcutaneous Electrical Stimulation

The concentration of the current paper focuses on the effects of TENS on knees with OA, thus we first

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examined the Cochrane review completed by Rutjes *et al*., a comprehensive meta-analysis review of the same topic. The 2009 report included multiple large and small trials totaling 813 patients [31]. The results of this systematic review revealed that people with OA of the knees that used TENS for up to 4 weeks had a 2 point improvement in their pain on a 0-10 scale with 0 equaling no pain and 10 equaling extreme pain. However, those that used sham-TENS treatments for up to 4 weeks also had a 2 point improvement in pain level on the 0-10 scale. Similarly, individuals with OA of the knees that used TENS for up to 4 weeks had a 2 point improvement on a disability scale with 0 equaling no disability and 10 equaling extreme disability. However, individuals that used sham-TENS for up to 4 weeks had a 1 point improvement on the disability scale. Thus, people using TENS had a 1 unit higher improvement on a 10 point scale than those using sham-TENS. The overall conclusion of the reviewers was that they could not confirm that TENS is effective in the amelioration of pain or disability and that the comprehensive review had to be declared inconclusive concerning the benefits of TENS for individuals with OA of the knees [31]. The authors did state that the inclusion of many small trials of questionable quality was a limitation in the review.

Two randomized control studies examining the effects of TENS on OA knees have been completed since the 2009 Cochrane Review. Vance *et al*. tested the effects of TENS on pain, pain sensitivity, and function on 75 individuals with OA of the Knees [33]. This study was a double-blinded randomized study on males and females aged between 31 and 94 years. Participants were divided into high-frequency TENS, low-frequency TENS and placebo-TENS. For both non-placebo TENS groups an asymmetrical biphasic waveform was used with the pulse duration set at 100 μs and the intensity set at 10% below the motor threshold. The frequencies for the non-placebo TENS were set at 100 Hz for the high-frequency TENS and 4 Hz for the low-frequency TENS. The placebo-TENS looked identical to the other TENS units but delivered a current identical to the high-frequency TENS for 30 second and then ramped down over a 15 second period to no current for the remainder of the treatment. The results contradict the results of the Cochrane Review in one variable only, pressure pain threshold (PPT). High-frequency and low-frequency TENS significantly increased PPT in individuals with OA while placebo-TENS showed no significant effect. The resulting increase in PPT supported earlier studies (2,11,26). However, all three groups showed significant improvement in pain at rest and during the functional examination with the Timed Up and Go Test which concurs with the Cochrane Review in that TENS and sham-TENS treatments had similar results [33].

Palmer *et al*. studied the benefit of TENS as an adjunct treatment to education and exercise for knee OA [34]. A total of 224 participants were randomly divided into three groups 1) TENS, education and exercise, 2) sham-TENS, education and exercise, and 3) education and exercise only group. Assessments were conducted in a blind manner at 3, 6, 12 and 24 weeks. The TENS parameters were set at a frequency of 110 Hz and a pulse duration of 50 μs. Pulses were asymmetrical and biphasic. The sham-TENS units displayed as the real TENS however no current was utilized. Each participant in the TENS and sham-TENS groups utilized their units on their own for 6 weeks. Each participant in all groups participated in a 6 week program of education and exercise. Once per week for 6 weeks, participants were provided 60 minutes of education and exercise concerning a self-administered home exercise program and tools to aid in goal setting. Factors assessed during this study were pain, stiffness and function. The results demonstrated that all groups improved significantly in all measured areas and that the TENS made no significant difference to the treatment [34].

The two recent blinded and randomized studies on the effect of TENS on individuals with OA demonstrated beneficial results in decreased knee pain and increased knee function, however in both studies the placebo-TENS or sham-TENS group also demonstrated a significant result in these areas concurring with the Cochrane Review of 2009 and a strong affinity toward the placebo-effect.

Bingel *et al*. reported evidence that an individual's expectation of a drug effect can critically influence its therapeutic efficacy [35]. We propose that the frequent findings of significant study results with the use of placebo-TENS and sham-TENS may provide the same influence on the expectation of benefits by TENS users with OA. The only factor that was not affected by placebo-TENS or sham-TENS was PPT. The results of the two recent blinded and randomly controlled studies on TENS and individuals with knee OA essentially concur with the Cochrane study of 2009 in that even though TENS treatments have shown benefits in these studies, they cannot be sufficiently separated from the benefits derived from the placebo effects of the placebo-TENS and sham-TENS.

Electroacupuncture

TENS in combination with acupuncture/dry needling treatment has been referred to as percutaneous electrical nerve stimulation (PENS) [36], electroacupuncture [37] and intramuscular electrical stimulation (IES) with trigger point dry needling (TrP-DN) [38].

Jubb *et al*. treated participants with knee OA with manual and electroacupuncture compared to a non-penetrating placebo needle [39]. Sixty-eight participants were randomly divided into the two groups (34 in each group). Electroacupuncture was delivered on both the anterior and posterior side of the knees (10 minutes each) at a frequency of 6 Hz and a voltage level of just under the pain threshold. The placebo needles (sham electroacupuncture) were 1.5 cm in length as opposed to 3.0 cm for the intervention needles and without current, although they did produce sound signals for 30 minutes. Participants were treated twice a week for five weeks with the primary end point for the study being a change in pain as measured by the Western Ontario McMaster Universities Arthritis Index (WOMAC) pain subscale. The manual and eletroacupuncture group showed statically significant improvement over the placebo needle. Nine weeks after the treatment began a within group analysis of the acupuncture group showed a highly significant improvement in pain scores compared to the placebo group [39].

Ahsin *et al*. compared two groups with knee OA receiving ten days of consecutive treatment [40]. The first group (26 participants) received electroacupuncture and the second was a sham group (38 participants). Participants were grouped on the basis of order of presentation at a medical clinic. An initial total of 84 participants were recruited with the final number as stated after multiple dropouts. In the electroacupuncture group six traditional points were chosen and the needles were stimulated with a biphasic pulse generator. Treatments were provided for 20-25 minutes daily over 10 days with the maximal current intensity tolerated and a frequency of 3 Hz. Needles were inserted to a depth between 10-30 mm depending on the size of the person. In the shame group six random points were chosen and the needles were connected to the sham stimulating device. While the device did not stimulate current through the needles it did have a flashing indicator light to keep patients unaware of their grouping category. Sham needles were inserted to a depth of 5-10 mm depending on the size of the person. WOMAC score, Visual Analogue Scale (VAS), plasma cortisol, and plasma β-endorphin were assessed at baseline and post-treatment [40].

The sham group had a reduction of 0.7% in their median WOMAC score compared to a 72% reduction in the electroacupuncture group. Results for the VAS were similar. The electroacupuncture group had a mean reduction of 72% in their VAS score while the sham group had no reduction in their median score. β-endorphin levels in the electroacupuncture group showed a median increase of 170% while the sham group showed a small decrease in levels post treatment. Median cortisol levels on the other hand fell by 29% in the electroacupuncture group and rose by 15% in the sham group [40].

Wu *et al*. studied 245 participants with 279 OA knees comparing the difference in the effects of electroacupunctuire and intra-articular hyaluronic acid injections over 5 weeks [37]. Electroacupuncture (8 Hz and 10 volts) was provided daily for 15 days followed by 5 days of non-treatment before a second 15 days of daily treatment. Participants were all randomly assigned into treatment groups and classified into 4 stages of OA severity (stage 1-4) according to the standards set by the American Association of Rheumatism. Factors studied were pain while walking, morning stiffness, pain at rest, joint swelling, joint mobility (flexion and extension) and activities of daily living. The results showed that symptom scores were significantly reduced for both treatment groups in stages 1-3 while neither treatment group provided significant changes for individuals with stage 4 OA. Between groups scores were only significantly different during stage 3 OA with the electroacupuncture group showing significantly better scores than the Hyaluronic acid injection group. The authors concluded that electroacupuncture can alleviate osteoarthritis symptoms and improve joint function through suppression of the secretion of cytokines reducing inflammation and decreasing cartilage degeneration. This study did not provide a sham-electroacupuncture treatment [37].

DISCUSSION/CONCLUSION

Numerous studies have shown improvement in pain and function of knees with OA after using TENS. However, in many of these studies similar benefits were shown with the use of sham-TENS which makes it difficult to declare benefits due to TENS when essentially no treatment provided similar results. This gives rise to the belief that there is a possible psychogenic component to treatment of OA of the knees. This theory was espoused by Castagna *et al*. after finding that Radio Electric stimulation of the ear, a treatment designed to improve emotional status,

provided greater results than Sodium Hyaluronate injections into the knee [41].

There are a limited number of available studies concerning electroacupuncture for the treatment of knee OA. The three studies reviewed for this paper all showed significant benefits in pain relief and function. However, contrary to TENS treatments alone, electro-acupuncture resulted in significantly higher levels of benefits than sham-electroacupuncture or other treatments. Although the reason for enhanced benefits from electroacupuncture beyond TENS alone is not currently understood, one possible reason may be that TENS and acupuncture have different mechanisms of action essentially doubling the treatments. While TENS alone sends electrical stimulation through the skin *via* surface electrodes in an effort to inhibit pain singles traveling from local receptors to the brain, acupuncture is thought to cause spinal release of endorphins, increase blood flow to the local area and relax muscle fibers in the local area [42]. Thus electroacupuncture may be simultaneously providing pain relief through multiple mechanisms. As TENS and electroacupunc-ture are studied further, clarity must be discerned concerning meaningful benefits and mechanisms of action. The possibility of a psychogenic aspect to OA knee conditions also requires further investigation.

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