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The treatment with low frequency acoustic pressure waves (ultrasound diathermy): therapeutic considerations and clinical reports

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Introduction

Ultrasound, a form of mechanical energy that is transmitted through and in biological tissues like a wave of sound pressure at frequencies above the limit of hearing, are widely used in medicine as a therapeutic, surgical and diagnostic instrument [6, 7].

Therapeutic ultrasound uses high intensity as 1-3 W / cm2 and can cause significant heating in living tissues. These levels of ultrasound can be used in order to decrease joint stiffness, reduce pain and muscle spasms, and improve the elasticity and mobility of the muscles. The use of ultrasound as a surgical instrument involves even higher levels of intensity (5-300 W / cm2), these energy levels are used for the treatment of renal calculi, to reactivate the healing in nonunion fractures, for the ablation of diseased tissue such as cataracts, and also to remove the methyl methacrylate cement during the revision of the prosthesis [8]. Quantities much lower (1-50 mW / cm2) are used in diagnostic devices for non-invasive imaging of vital organs, fetal development, peripheral blood flow and metabolic diseases such as osteoporosis and evaluate the state of the callus during the healing, at the opposite end of the spectrum intensity [9, 10]. The level of intensity used for imaging, which is five orders of magnitude lower than that used for surgery, is considered as a non-thermal and non-destructive [11].

The ultrasounds are constituted by elastic mechanical vibration very similar to the normal sound waves, but the frequency is above the threshold of audibility to the human ear.

In particular ultrasound at low frequency (LF), which fall in the range of 20-100 KHz constitute the lower limit among possible bands of ultrasound (MF 0.7 -1 KHz, HF 1-20 KHz) (*Exposure to Pulsed Low Intensity Ultrasound Stimulates Extracellular Matrix Metabolism of Bovine Intervertebral Disc Cells Cultured in Alginate Beads Miyamoto, Kei MD, PhD *; An, Howard S. MD *; Sah, Robert L. MD, ScD§; Akeda, Koji MD *; Okuma, Masahiko MD , PhD *; Otten, Lori MS *; Thona Eugene J.M.A. PhD * † ‡; Masuda, Koichi MD * † Plugs: 1 November 2005 - Volume 30 - Issue 21 - pp 2398- 2405*)

The US propagate in a means with energy transfer and not of particles; the latter, in fact, simply oscillate around their equilibrium position, with transfer of energy from one particle to another (*What is ultrasound? - TG Leighton - Institute of Sound and Vibration Research, University Southampton, Highfield, Southampton, UK - 2007*)

The molecular oscillation can propagate in the medium in various directions, therefore, it can be distinguished:

1) **Longitudinal Waves**: The oscillating movement of the particles of the transmission means is parallel to the propagation direction

2) **Transversal Waves**: The oscillating movement of the particles of the transmission means is perpendicular to the direction of propagation.

The longitudinal waves (compression) can propagate in any means, while the transverse wave only in those solids, because of the weak links that are established between the atoms and molecules in the tissue liquid.

The ultrasonic wave is longitudinal and is characterized by the alternation of compressions and rarefactions of the means in which it propagates, that entail pressure variations of it.

The physical parameters that characterize an ultrasound wave are represented by:

Wavelength [m]: Distance, in a periodic wave, between two successive crests or between two points with the same speed (vector).

Frequency [Hz = s-1] (f): number of repetitions of a wave in the time unit.

Period [s] (T): The time between two repetitions of the same wave.

Speed [m /s] (c): Speed of movement of the surface wave

Width (A): Linked to the amount of energy transported (What is ultrasound? - TG Leighton - Institute of Sound and Vibration Research, University Southampton, Highfield, Southampton, UK - 2007).

The parameter relating to the intensity [I = Wu / s], or the amount of energy flowing in the time unit through a surface of unit area, perpendicular to the direction of wave propagation is particularly important for the characterization of the wave.

The generation and detection of ultrasound is done artificially through so-called transducers that exploit the phenomenon of piezoelectricity, discovered by the brothers Pierre and Jacques Curie in 1880.

In the therapeutic field, ultrasound are artificially produced by exploiting the inverse piezoelectric effect, which consists in the properties of some mineral crystals to dilate and constrict, and then emit vibrations, when they are subjected to the action of an electric field of alternating current. The frequency of the sound waves emitted by the crystal depends on its thickness and the frequency of the applied current.

The piezoelectric crystals are thus able to convert electrical energy into mechanical and vice versa (*Guirro, R. S Britshcy Dos Santos Evaluation of the acoustic intensity of the new ultrasound therapy equipment, Ultrasonics 39 (2002) 553-557*).

As it regards the propagation of ultrasound, when an ultrasound wave passes from one means to another, there is usually the occurrence of phenomena which contribute in some way to the redistribution of the energy carried by the wave itself: a portion is reflected and a part is transmitted, according to the laws of classical mechanics. Each means flowed is characterized by an inherently complex quantity, the impedance Z, which summarizes the acoustic characteristics of the means and quantifies the resistance that the means itself opposes to the passage of sound waves.

The acoustic impedance is defined as the product of the density r of the means (kg / m3) for the propagation velocity c (m / s) (*Humphrey VF 2007. Ultrasound and matter - Physical interaction. Biophys. Mol. Bio. 93: 195- 211*). The sound waves propagate faster and better in liquid rather than air. So in the soft tissues, which consist for the most part of water, the acoustic impedance is a key parameter in applicative field, therefore, its value is essential to know in different biological means.

Ultrasound, when it comes in contact with the tissue interface, does not propagate perpendicularly but its interaction with the tissue produces the physical phenomena known as reflection and refraction. Reflection is the portion of the sound that is returned back from the limiting surface of a means (echo). The Refraction is the change in direction of a sound when it passes from one means to another (film). The incidence angle is a parameter that affects both reflection and the refractive index of sound waves.

In the course of propagation in a means, the acoustic wave is subjected to a progressive loss of associated energy and, more properly, it causes a decrease of the intensity functional related to the distance from the source.

The causes are essentially two:

1) **ABSORPTION**: Process in which the mechanical energy of the wave is partially converted into heat, as a result of this phenomenon, the intensity of the beam is attenuated as it passes through the tissues.

2) **EFFECT OF BOUNDARY LAYER**: When an ultrasound beam meets the acoustic interface of two means with different acoustic impedances Z1 and Z2, a part of its energy is reflected and the remaining part continues it way in the means as transmitted beam. When the ultrasound encounters a surface with different acoustic impedance, a specular reflection occurs, which follows the normal laws of physics, according to which the angle of incidence equals the angle of reflection.

The interaction of ultrasound with biological tissue produces energy absorption of the beam which depends on the type of tissue flowed and on the frequency of the waves.

A low uptake and so high penetration of the ultrasound beam (a = 0.14 and 0.42 respectively at 1 and 3 kHz) is observed in water and fat (as tissue rich in water); in the bone tissue and tendons instead absorption is higher (Dyson, 1987). The US at a frequency of 1 kHz are absorbed primarily by the tissues to the depth of 3-5 cm (Gann, 1991) and, because of this property, those are recommended for deeper lesions and in patients with a bigger quantity of subcutaneous fat. The US at a frequency of 3 KHz are recommended instead for more superficial lesions, to the depth of 1- 2 cm (Gann, 1991; Ziskin, 1990); for this reason, they are also used in the aesthetics (medical and non-medical).

A high frequency is indeed associated with a low penetrating power, on the contrary a low frequency is associated with a high penetrating power (*L.Feril, Jr and T.Kondo "Biological effects of low ultrasound: the Mechanism Involved, and its implication on therapy and on biosafety of ultrasound »J.Radiat 45: 479-489*).

As mentioned the penetration of ultrasound in the tissue depends on:

1) **Frequency**: in clinical practice using longitudinal waves that have a frequency varying between 0.3 and 3 KHz

2) **Intensity**: Low (<0.3 W / cm2 Media (0.3-1.2 W / cm2) High (1.2-3 W / cm2)

3) **Type of tissue**: the depth reached by the US is inversely proportional to the frequency.

The US, flowing the tissues, determine traditionally separate effects that can be "Thermal" and "nonthermal".

The thermal effects are due to exposures CW, non-thermal effects to pulsed wave.

The two effects are not completely separable, so, the presence of a type of effect than the other cannot be assumed (F Ahmadi, McLoughlin IV, Chauhan S-ter Haar G 'Bio-effects and safety of low intensity, low frequency ultrasonic exposure "Prog Biophys Mol Biol 2012).

The thermal effect essentially depends on the absorption characteristics of the biological means and on the energy reflection at the interface between tissues with different acustic impedance.

The passage of ultrasound through "soft" tissues increases temperature for: absorption related to viscosity, absorption due to thermal conductivity and chemical absorption (Ahmadi F, McLoughlin IV, Chauhan S-ter Haar G 'Bio-effects and safety of low intensity, low frequency ultrasonic exposure "ProgBiophysMol Biol2012).

The thermal effects are determined by the dissipative effects due to the progressive reduction of the amplitude of the acoustic wave, the consequent loss of energy, the attenuation of the beam due to the absorption while the ultrasound propagating in a means. The US produces heat through vibration, shock and friction of the cellular and intercellular structures that make up the tissues flowed.

The temperature rise of the means can cause chemical or structural changes of the biopolymers.

The thermal effect is most evident at the interface level of the tissues and in particular at the level of the periosteum and of the zone of passage between fat and muscle; the periosteum, due to its anatomical structure and because of its continuity with the bone, absorbs a large amount of energy and is, therefore, site of high heating. Heat increases mainly in the tissues less vascularized (tendons, adipose tissue) and tissues that conduct heat (bones).

Non-thermal effects are mechanical, chemical and cavitation. The vibration induces the oscillation of the tissue particles with creation of micro-flows, cleavage of molecules complex (protein), micromassage. The cell membrane is capable of absorbing the mechanical energy from the ultrasonic field, transforming the acoustic energy into mechanical stress, through expansions and contractions of the intermembrane space; the induced mechanical modifications are represented by: acceleration of the processes of diffusion through cell membranes, separation of complex molecules (proteins, polysaccharides), micromassage tissue *(F Ahmadi, McLoughlin IV, Chauhan S-ter Haar G 'Bio-effects and safety of low intensity, low frequency ultrasonic exposure "Prog Biophys Mol Biol 2012).*

The chemical action with local Ph modification and permeability of cell membranes and with molecular changes is caused by strong forces of acceleration to which particles of tissue are subjected to the passage of the ultrasonic wave *(T. Kodama, Hamblin MR, and Doukas Cytoplasmic AG Molecular Delivery with Shock Waves: Importance of Impulse Biophysical Journal Volume 79 October 2000, 1821-1832*).

The exposure of the cells to intensity of about 0.04 W / cm2, below the threshold of cavitation, fixed in the literature in 100 mW / cm2 (Krasovitski, 2011), for 30 minutes at a sample-transducer distance of 3 cm, leads to a statistically significant increase of free radicals, which can alter the balance cell, inducing peroxidative stress on cell components (such as the phospholipid component of the plasma membrane), modifying the permeability of the membrane itself, without inducing cell death. (Riesz, 1992; Barnett, 1998).

The cavitation effect is related to the implosion of microbubbles of gas within the interstitial tissue (*acoustic pressure amplitude thresholds for rectified diffusion in gaseous microbubbles in biological tissue - L. Bjorno A. Lewin, 1981. ACOUSTIC CAVITATION: A CONSEQUENCE OF POSSIBLE BIOMEDICALUSES OF RE ULTRASOUND- APFEL- 1980*).

The cavitation effect is achieved by using frequencies around 40KHz. In recent years, the effect of cavitation has been further enhanced rhythmically varying the frequency (38 to 42 KHz), creating a deeper effect but paradoxically softer with a more even distribution of energy that is absorbed gradually by flowed tissue layers.

The maximum energy density on the skin is 3 W / cm^2 and fits perfectly within the safety limits set by WHO.

At the biological level the physical effects described above produce:

1) **Mechanical effects**: conveyance of fluids, drainage and tissue massage related to the movement of the particles in response to substantial pressure variations.

2) **Thermal effects**: increase of metabolism and vasodilatation linked to the rise in temperature.

3) **Chemical effects**: conveyance of fluids / absorption and increase in metabolism related to the modification of the local pH and permeability of cell membranes.

4) **Cavitation effect**: lipolysis for formation and subsequent implosion of microbubbles of gas in the interstitial tissue.

From the therapeutic point of view this translates into the ability to use ultrasound to induce an action:

Analgesic, muscle elasticity, anti-inflammatory, reduction of fibrosis and metabolic and circulatory stimulus.

It was, in fact, widely demonstrated in the literature analgesic, anti-inflammatory, relaxant, and trophic action of ultrasound that allows to treat edema and post-surgical and post-traumatic disorders bruising, and diseases of the musculoskeletal system, mechanically stimulating microcirculation, tissue regeneration and the production of fibroblasts with synthesis of collagen fiber by the intercellular matrix.

REPORTS clinical studies

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TREATMENT WITH ULTRASOUND DIATHERMY "SIRIO" IN EPICONDYLITIS

Introduction

Epicondylitis is one of the most common diseases of the upper limb and affects 1-3% of the population. It occurs most often between 40 and 50 years, with no gender preference. It was described for the first time in 1882 by Morris.

This syndrome with persistent and disabling pain in the elbow, particularly at the humeroradial joint, is known as lateral epicondylitis, tennis elbow or lateral epicondilalgia. The underlying cause is not yet well known. It is a musculoskeletal disease very painful and disabling.

It is very common in people who practice activities in which there are repeated movements of the forearm (tennis player and carpenter). It is frequently caused by repeated and rapid eccentric contractions and grasping activity of the hand. The most affected is the dominant limb, with a prevalence of 1 to 3% in the general population, but the incidence is growing rapidly at 19% between 30 and 60 years and seems to be more disabling in women. A painful episode of epicondylitis lasts on average between 6 months and 2 years. The main lesions are found at extensor radial carpi brevis (ERCB).

Epicondylitis is characterized by spontaneous parietal pain of medium degree of spatial localization with possible irradiation on the dorsal portion of the forearm and wrist, during and after exercise, extension against resistance and in pronation and supination of the wrist, pain on lateral epicondyle press, significant functional limitation (in severe cases). The most common clinical presentation includes reduction of force to grasp, functional limitation, with pain that limits even normal daily activities. The diagnosis can be quite simple and confirmed by tests that underline pain on palpation of the lateral aspect of the epicondyle, reduction the extension of the wrist and the third finger and pain to passive flexion of the wrist.

The diagnosis is possible by ultrasound examination and positivity: Mill test, test Maudsley, pain exacerbated by the extension of the wrist against resistance with pronated forearm, pain on the ERCB origin pressure on lateral epicondyle.

It is very important the differential diagnosis with: bursitis of the conjoined tendon, chronic irritation of the capsule or of the joint, chondromalacia, humerus-radial osteoarthritis, fractures of radial neck, Panner syndrome, elbow of the "Little League", dissecans osteochondritis of the elbow.

The treatment is usually conservative and involves the use of: ultrasound therapy, electrical stimulation, manipulation, soft tissue mobilization, neural tension, friction massage, myofascial treatment, corticosteroid injections, stretching exercises, oral NSAIDs, ESWT. There are no guidelines in which is indicated only definitive treatment, for which more than 40 types of different methodologies in the literature have been documented. The main goal is still to reduce the pain and for this reason are used oral anti-inflammatories, ultrasound and pharmaforesis.

Infiltration with corticosteroids, drug therapy, laser therapy, electrical stimulation, acupuncture and stretching and strengthening exercises against resistance were joined. Only 5-10% of patients who do not respond to conservative treatment are referred for surgery.

There is a vast literature on the effectiveness of ultrasound as a treatment approach for the epicondylitis with controversial results, a review by Trudel et al. evaluated the effects of ultrasound in treating epicondylitis showing that there is a reduction of pain and an improvement in overall disability. The low-intensity ultrasound have been found useful to accelerate the healing of fractures and have produced positive results in animal tendon repair.

Materials and methods

Between May 2013 and June 2015 30 patients has been recruited at the University Centre of Physical and Rehabilitation Medicine "G. D'Annunzio "University of Chieti-Pescara affected by epicondylitis with a mean age of 45 (range 25-60 years), the mean duration of pain was 3.5 months (range 1-24 months with an average of 4 months). The 80% of patients had the disease in his right elbow.

The rehabilitation treatment of 3 weeks duration was performed with 3 weekly sessions with application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment at a frequency of 38 kHz acoustic work in pulsed mode, with maximum power of the maniple of 3W / cm2 and transducer size of 50 mm diameter / 19.6 cm2.

At the first evaluation (T0) and at the end of the therapeutic cycle (T1) patients were clinically assessed and by palpation of the epicondyle, the Mills test, passive forced pronation with flexed wrist and extended elbow, assessment of pain was quantified using the Visual Analogue Scale (VAS), also using the Italian version of the Patient-Rated Tennis Elbow Evaluation Questionnaire (PRTEE Questionnaire) that evaluates pain, functional disability and daily life activities. It was made an initial ultrasound evaluation that showed focal areas of peritendinous edema and hypoechoic areas in tendon.

Results and discussion

The clinical diagnostic investigation performed at time T1 showed a reduction in pain on palpation and of the Mills test, a significant reduction in pain assessed by visual analogue scale from an average 7.5 to 1.7 and the score of PRTEE Questionnaire which decreased on average from 93 to 28. Instrumental examination with ultrasounds has shown a reduction of peritendinous edema and a reduction of intratendinous hypoechogenicity.

Epicondylitis is the result of repeated stress, but can also be caused by direct trauma. The disease is very common among tennis players, especially in amateur, where the mechanics are less efficient.

The cause seems to be repeated contractions by the extensors of the arm, particularly at the origin of the ERCB, which leads to consequent micro-lesions, with degeneration, ineffective repair and tendinosis; moreover, because of particular position of the ERCB, it is submitted to repeated abrasion against the radial head of the elbow. The inflammatory process appears to have originated from the humeroradial bursae, the synovial, periosteum and annular ligament.

Effective treatment of the epicondylitis has been always difficult to find, although the therapeutic possibilities were many. A lot of studies have been performed to evaluate the effectiveness of different treatments, but the only thing found was the suspension by physical activity. In our study, we evaluated the effectiveness of a treatment program consisting of treatment with low-frequency ultrasound which is effective in the treatment of edema and inflammation in the muscle-tendon improving pain symptoms and functional disability.

The results obtained show confirmation of the effectiveness of therapy with low-frequency ultrasound diathermy instrument with frequencies of 38 KHz inducing to take into consideration the possibility of future studies with a control group and a greater number of cases.

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TREATMENT WITH ULTRASOUND DIATHERMY "SIRIO" OF THE CARPAL TUNNEL AND DE QUERVAIN SYNDROME

Introduction

The carpal tunnel syndrome is caused by entrapment of the median nerve at the wrist, mostly idiopathic or resulting in overuse of the wrist (for repetitive manual tasks, using tools squeezing the palm, vibrating tools, keyboards and mouse), but sometimes secondary to arthritis with tenosynovitis of one of the tendons with which the nerve takes contact within the carpal canal or thickening of the connective tissue (as occurs sometimes in some systemic diseases of the endocrine system and metabolism). The main symptoms of the syndrome are made at an early stage by nocturnal paresthesia (probably due to the posture assumed during sleep) at the level of the first three fingers of the hand; with the progression of the disease dysesthesia and pain arise even during the day, until the appearance, in advanced stages of atrophy of the thenar eminence with weakness of the brevis abductor pollicis muscle and drop objects from the hand. Paresthesias in the distribution of the median nerve is induced or enhanced by the intermittent percussion on the palm aspect of the wrist (Tinel's sign) or by pressure on the extensor surfaces of the two opposing wrists in hyperflexion (Phalen sign).

A distinct condition but that can get in the differential diagnosis with carpal tunnel syndrome regarding etiology and symptomatology is de Quervain's syndrome, tenosynovitis of the brevis extensor muscles of the thumb and long abductor of the thumb at the point where they cross the fibrous sheath of the the radial styloid process. The most common cause of inflammation are repetitive movements of flexion and extension of the thumb and twist of the wrist (like those made during occupational or recreational activities such as screw, sew, use the mouse or keyboard of the phone, play the piano, play golf, tennis, volleyball, bowling), but the condition may also occur during or after the pregnancy, is likely to hormonal alterations or water retention; patients complain of pain in the gesture of pinching, and are often associated swelling and pain in the finger pressure at the radial styloid process and, in advanced stages of the disease, the phenomenon of shooting or lock the first finger extension or abduction. The tendons friction generated by gripping the thumb and by pulling the hand in ulnar deviation (Finkelstein sign), or by placing the thumb in flexion and adduction and closing the remaining fingers of a fist (sign of Eichoff) evokes intense pain.

Materials and methods

Between May 2013 and June 2015 60 patients were recruited at the University Centre of Physical and Rehabilitation Medicine of "G. D'Annunzio "University of Chieti-Pescara with localized pain and paresthesia in the distribution of the median nerve at the level of the hand. After electromyographic confirmation of suffering of the median nerve at the wrist, 10 subjects were excluded for detection of conditions predisposing to secondary forms of the syndrome (4 rheumatoid arthritis, 4 diabetes mellitus type II, 1 hypothyroidism), therefore patients enrolled were 50, including 37 males and 18 females, mean age 63.7 years (range 55-70 years).

In the same period, they have come to our attention 9 patients with de Quervain tenosynovitis, with sonographic signs of thickening of the tendon sheath in all patients and the presence of minimum bursitis in 2 patients.

Patients thus recruited were submitted at the beginning and at the end of treatment, at a clinical examination, somministration of VAS for pain assessment and instrumental assessment (using electromyography in the group suffering from carpal tunnel syndrome, ultrasound in the group affected by de Quervain tenosynovitis), and then treated 3 times per week for 3 weeks with application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment to an acoustic frequency of 38 kHz pulsed mode, with maximum power of the maniple of 3W / cm2 and size of the transducer 50 mm diameter / 19.6 cm2. The use of a latest generation software ensures maximum efficiency of the signal, irrespective of the treated tissue.

Results and discussion

At the end of the 3 weeks of treatment, in all patients of both groups it was found a marked improvement of the painful symptoms, with reduction of the average score of the VAS scale (from 7.8 to 4.2 in the group suffering from carpal tunnel Carpal, from 8.1 to 4.1 in the group suffering from de Quervain tenosynovitis); in patients with carpal tunnel syndrome it has also been reported reduction of paresthesias, with disappearance of the same in 20 patients.

With regard to instrumental investigations, the group suffering from carpal tunnel syndrome, at the electromyography evaluation showed an improvement in both the distal motor latency (from 6.7 to 4.3 ms) and in sensory nerve conduction (from 30.6 to 44.2 m / s); the group affected by de Quervain tenosynovitis at the ultrasound examination documented reduction of tendon sheaths thickening in 6 patients and complete resorption of bursitis in both patients in which it was present.

Therefore, we can say that treatment with application of elastic waves at low frequency, although not supported today by a consolidated literature, can be proposed as a non-invasive alternative and not harmful in the treatment of carpal tunnel syndrome and de Quervain tenosynovitis even alongside the traditional conservative therapy (splint) and pharmacological (local infiltration of corticosteroids and local anesthetic or oral intake of NSAIDs), and to delay the use of the surgical decompression option.

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TREATMENT WITH ULTRASOUND DIATHERMY "SIRIO" OF ILEO-TIBIAL BAND SYNDROME

Introduction

The ileo-tibial band is a thick band of fibrous tissue that runs along the lateral aspect of the thigh and inserts on the tubercle of Gerdy on anterolateral proximal tibia. It has small insertions on the lateral patellar retinaculum and the hamstring. As the knee moves from full extension to flexion, ileo-tibial band moves from a front position to a posterior position respect to the lateral epicondyle. The transition occurs at approximately 30 ° of knee flexion. The repeated flexion and extension of the knee - as occurs during activity such as, for example, running, cycling, skiing - can cause an inflammation of ileo-tibial band while going back and forth over the lateral epicondyle of the femur. Next, becomes inflamed and become painful also the surrounding soft tissues and bursae.

The patient usually complains gradual onset pain, retraction or burning sensation on the lateral side of the knee, which is established during running. Symptoms usually disappear at rest. Clinical examination revealed tenderness and sometimes swelling localized on the lateral epicondyle of the femur and the tubercle of Gerdy: the mobilization of the knee throughout its ROM, when the ileo-tibial band passes the epicondyle can cause pain, clocks, noises or rattles. Symptoms of ileo-tibial retraction can be highlighted with the Ober test.

Factors that predispose the runner to the friction syndrome of the ileo-tibial band are the poor training, a recent increase in the distance traveled and the race track. Other etiologies include a limb-length discrepancy, over-pronation of the foot and repeatedly run in a single direction on a sloping surface.

The basic progression of the treatment is the immediate suspension of predisposing activity, the early reduction of acute inflammation (through local application of ice and oral intake of nonsteroidal antiinflammatory drugs), followed by stretching of the ileo-tibial band, from reinforcement of the hip abductors and eventually the use of one side thickness in the shoe to reduce the retraction of the soft tissues, and finally the possible modification of athletic movement performed incorrectly.

Materials and methods

Between May 2013 and June 2015 30 patients were recruited at the University Centre of Physical and Rehabilitation Medicine at the "G. D'Annunzio "University of Chieti-Pescara with the ileo-tibial band syndrome, including 19 males and 11 females, mean age 27.2 years (range 15- 36 years).

Patients thus recruited were evaluated at the beginning and at the end of the treatment, by clinical examination and administration of the VAS for pain assessment, and then underwent a rehabilitation treatment lasting three weeks consisting of three weekly sessions with application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment at a frequency of 38 kHz acoustic working in pulsed mode, with maximum power of the maniple of 3W / cm2 and size the transducer of 50 mm diameter / 19.6 cm2. The use of a latest generation software ensures maximum efficiency of the signal, irrespective of the treated tissue.

Results and discussion

At the end of 3 weeks of treatment in 25 patients there was a net improvement of pain symptoms, reducing the average score of the VAS scale (8.2 to 1.9). In the remaining patients, the pain is reduced, however, even if in a not important way (VAS from 8.4 to 5.3).

Because of the results obtained, it can be stated that treatment with low-frequency elastic waves can be fully integrated into rehabilitation protocols for the ileo-tibial syndrome, to supplement and complete other interventions already established in the literature.

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TREATMENT WITH ULTRASOUND DIATHERMY "SIRIO" IN ACHILLEUS TENDINOPATHY

Introduction

The Achilles tendon is the tendon most thick and more robust of the body. Injuries of it are frequently associated with the impact of repetitive loads due to race or jump; the main factors that result in damage to the Achilles tendon are mistakes in training, such as a sharp increase in activity, a sudden increase in the intensity of training (in terms of frequency, distance, etc.), a resumption of training after a long period of inactivity and the ride on rough or mushy terrain. Degenerative lesions of the Achilles tendon can also be found in inactive individuals, and to be put in relation with postural dysfunction (eg., Attitude in pronation of the foot), with the use of inappropriate footwear (with poor support to the hindfoot), with a gastro-soleus muscle complex not flexible.

Achilleus Tendinopathy characteristically presents pain localized in the distal portion of the tendon, approximately 2.6 cm from the heel. The pain is described as sharp and stabbing, initially present only during plyometric activities, then also during the performance of activities of daily living, being relieved by rest. They may also be present swelling and stiffness of the ankle and increase of thermotouch.

The imaging studies help to confirm or exclude the diagnosis and to monitor the effects of proposed treatments. In particular:

• X-rays are usually normal. Sometimes calcifications can be observed in the tendon or its attachment. With the X-ray inflammatory arthropathy (erosions) and apophysis exostosis of the posterior heel can be excluded (Haglund's deformity or pump bump);

• ultrasound is inexpensive and rapidly performed and allows dynamic assessments, but may be susceptible to the inexperience of the operator; nevertheless, represents the most reliable method to determine the thickness of the tendon in case of degeneration, the presence and the extent of effusion and neovascularization and the size of the gap in the case of complete rupture;

• magnetic resonance imaging is not used for dynamic assessments, but is more sensitive than ultrasound in the diagnosis of partial lacerations and staging of chronic-degenerative changes, such as thickening and peritendinous inflammation; It can be used to monitor the healing of the tendon when suspecting a partial tears relapsing, and represents the best imaging method for programming purposes of surgery.

Materials and methods

Between May 2013 and June 2015 35 patients were recruited at the University Centre of Physical and Rehabilitation Medicine at the "G. D'Annunzio "University of Chieti-Pescara with pain in the calcaneal region during active dorsiflexion of the foot and sonographic finding of hypoechoic Achilles tendon. After radiographic evaluation, 5 subjects were excluded because carriers of Haglund's deformity, so the patients enrolled were 30, including 21 males and 9 females, mean age 29.4 years (range 20-37 years).

Patients thus recruited were evaluated at the beginning and at the end of the treatment, by clinical examination, administration of VAS for pain assessment and the VISA-A questionnaire for assessing the severity of achilleus tendinopathy, and therefore the patients has been subjected to a rehabilitation treatment in 3 weeks duration consisting of 3 weekly sessions with application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment to an acoustic frequency of 38 kHz pulsed mode, with maximum power of the maniple of 3W / cm2 and transducer size of 50 mm diameter / 19.6 cm2. The use of a latest generation software ensures maximum efficiency of the signal, despite of the treated tissue.

Results and discussion

At the end of the 3 weeks of treatment, it was found a marked improvement of the painful symptoms, with reduction of the average score of the VAS scale (from 7 to 4) in all patients. VISA-A questionnaire showed a reduction of the severity of the disease, with change in the average score from 74.6% to 87.8%. In none of the patients insurgents adverse events.

Therefore, we can say that the treatment with low-frequency elastic waves, like other physical instruments whose effectiveness, is well documented in the literature and in the context of individualized rehabilitation protocols, is an effective and not harmful in the conservative treatment of achilleus tendinopathy, allowing it to act on the reduction of pain and on functional recovery.

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TREATMENT WITH ULTRASOUND DIATHERMY "SIRIO" IN PLANTAR FASCIITIS

Introduction

Plantar pain is due to a spectrum of disease entities including plantar fasciitis, the nerve entrapment of abductor of the fifth finger, periostitis and subcalcaneal bursitis.

Plantar fasciitis is caused by inflammation of the plantar fascia, a thick, fibrous band of connective tissue that originates from the medial tuberosity of the calcaneus. The central portion of the band originates from the medial process of the tuberosity of the calcaneus superficially to the origin of the flexor digitorum brevis, the quadratus plantae and abductor of the allucis; the band extends, in individual bundles, along the medial longitudinal arch and is inserted on the basis of each proximal phalanx. The sensitivity of the medial heel is provided by the medial calcaneal nerve; Baxter and Thigpen (1984) suggest that in some rare cases the nerve compression of the abductor of the fifth finger between the intrinsic muscles of the foot plays a role in the onset of pain in the lower face of the heel.

From the functional point of view, the plantar fascia is an important static support for the longitudinal arch of the foot: a stress on the longitudinal arc exerts its maximum tension on the plantar fascia, especially at the level of its origin on the medial process of the calcaneal tuberosity; the plantar fascia stretches with the load to act as a shock absorber, but its ability to stretch is limited, especially with the reduction of the elasticity related with age. As result, some anatomical features appear to favor the onset of plantar fasciitis: according to Campbell and Inman (1974), in patients with flat feet or heel valgus there is an increase in tension of the plantar fascia that predisposes patients to heel pain; pronation of the subtalar joint prone the heel and stretches the plantar fascia, in the same way a little elastic gastrocnemius (with increased pronation as compensation) predisposes patients to plantar fasciitis; again, it was observed that the cavus foot with the relative rigidity exerts greater stress on the plantar fascia in load; finally, some studies have shown an association between plantar fasciitis and obesity.

The plantar fasciitis can be associated, especially with increasing age, the presence of a heel spur, but this is thought to be enshrined as the cause, and the association between the two conditions is still controversial. According to some studies, 50% of patients with plantar fasciitis is affected by ipsilateral heel spur, but most of these also has a spur in the controlateral asymptomatic foot; this estimate exceeds 15% the prevalence of spurs radiographically showed in asymptomatic subjects detected by Tanz (1963). Anatomical studies showed that the spur is located on the origin of the short flexor rather than on the origin of the plantar fascia, casting further doubt on its role in contributing to the heel pain.

Whatever the origin, plantar fasciitis occurs classically with gradual and insidious pain localized in the inferior-medial heel at the insertion of the plantar fascia. Pain and stiffness get worse when you get up in the morning or after walking for a long time and can be aggravated by climbing stairs or get up on tiptoes. It is rare for patients suffering from plantar fasciitis to not complain pain or stiffness when run through the first steps in the morning or after prolonged rest.

Although it may be quite debilitating in the acute phase, plantar fasciitis rarely causes symptoms that persist throughout life: it has been estimated, in fact, that 90-95% of patients with true plantar fasciitis heal with conservative treatment; However, with only the stretching of the plantar fascia and Achilles tendon, the recovery can take anywhere from 6 to 12 months, and patients often need many reminders to continue to wear proper shoes and to continue to avoid high-impact activities or stand for a long time on hard surfaces. In selected cases where conservative treatment has failed result, it may prove useful to surgery, which recorded a success rate between 50% and 85%.

Materials and methods

Between May 2013 and June 2015 40 patients were recruited at the University Centre of Physical and Rehabilitation Medicine at the "G. D'Annunzio "University of Chieti-Pescara with pain in the plantar mid-foot. After radiographic evaluation with an oblique projection at 45 °and with the three standard views of the foot, 10 subjects were excluded because carriers of heel spurs, so the patients enrolled were 30, including 19 males and 11 females, mean age 37.13 years (range 25-44 years) .

Patients thus recruited were evaluated at the beginning and at the end of the treatment, by clinical examination and administration of the VAS for pain assessment, and then underwent a rehabilitation treatment lasting three weeks consisting of three weekly sessions with application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment at a frequency of 38 kHz acoustic working in pulsed mode, with use of two specific applicators alternately used with maximum power of the maniple of 3W / cm2 and transducer size of 50 mm diameter / 19.6 cm2. The use of a latest generation software ensures maximum efficiency of the signal, despite of the treated tissue.

Results and discussion

At the end of 3 weeks of treatment, there was a sharp reduction in the average score of the VAS scale (from 8.6 to 2.1) in 25 patients, with improvement in pain symptoms at the foot. Of the remaining patients, the pain in 3 subjects was almost unchanged (VAS from 8 to 7 and 6 to 7, respectively), in 2 subjects was increased (VAS 8 to 9 and 7 to 8, respectively). In addition, the study can highlight as through therapy with low-frequency elastic waves is possible to shorten the recovery time compared to those reported in the literature.

Therefore, we can say that the treatment with low-frequency elastic waves is effective and not harmful in the conservative treatment of plantar fasciitis, and also allows a more rapid resumption of work activities and competitive, with savings for the health care costs.

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HAEMATOMA KEEN TO MUSCLE INJURY: TREATMENT WITH ULTRASOUND DIATHERMY "SIRIO"

Introduction

Muscle injury can be determined from direct trauma, definable as contusion, due to a sharp impact transversely to the plane of the muscle that goes to compress with the underlying bone plane or by indirect trauma that are carried out parallel to the major axis of the muscle, they are typically determined by an abrupt traction acting on the muscle in the contraction phase or overload condition.

The myofascial system is able to adapt to workloads progressively greater when the muscle recognizes the increased load as training stimulus, producing physiological changes necessary to the achievement of the performance.

When a stimulus exceeds suddenly and largely, the acquired skills will come directly to exhaustion and then to the lesion.

Based on the number of fibers affected by the break are distinguished the distractions, tearing and rupture of the muscle.

The condition of fatigue, inability to maintain a given performance over time, due to the impossibility to produce ATP at the same speed with which it is used, causes a decrease in the ability of the muscle tendon to adapt to the workload.

The pathophysiological framework is due to the inability to provide the ATP needed to remove the actino-myosin bridges, with consequences on the flexibility and elasticity of the muscle-tendon unit during cycles of contraction-elongation.

The action of opposing forces (stretch-contraction) not more balanced determines the breakage of the elastic anchorage points of myosin, in one or in both bands of the sarcomer.

The trauma, direct or indirect, involves the breaking of myofibrils with the eventual separation of a variable number of muscle fibers, with involvement of both the connective tissue by anatomical and functional contiguity, and of the vessels with extravasation in relation to the entity of the lesion.

In addition to the muscle belly, lower-strength sites are: 1) the muscle-membrane passage, where interposition between muscle and fascia of a loose tissue, rich in mitochondria, sometimes fails to protect the membrane from the effects of stretching, practiced by massive contractions in the process of elongation, 2) the muscle tendon passage, where the amplitude of the surfaces of interdigitation between tissues ensures a distribution of the suitable spatially tension but with lower resistance to the traction, compared to the muscle or tendon if there are incongruous tractions.

The new classification (Mueller-Wholfart HW et al. BJSM 2013) of muscle damage distinguishes injuries caused by direct and indirect trauma and for the latter stands in nonstructural accidents with no macroscopic evidence (US / RM) of muscle injury and structural accidents with macroscopic evidence of structural damage of muscle fibers:

- 3A: partial minor lesion- localized pain, stinging, sharp attributable to a specific gesture, sometimes preceded by a perception of "pop" or "overlap". Instrumental examination: intramuscular hematoma;

- 3B: partial moderate lesion-breaking of a larger number of primary bundle (≤ 50%) Throbbing acute pain attributable to a specific gesture; the patient reports one "pop" or "overlap" followed by the sudden onset of pain well localized. Immediate functional impotence. Instrumental examination shows break of fibers, including possible retractions. With fascial lesions, it is present intermuscular hematoma;

- 4: lesion involving ≥ 50% of the muscle belly or tendon avulsion. Oppressive deep, worsening pain, attributable to a specific gesture, often preceded by a "pop" or "overlap". Immediate functional impotence with frequent fall. Instrumental examination: subtotal discontinuity or complete muscle-tendon rupture. Possible retraction. With fascial lesions, it is present intermuscular hematoma.

Immediate treatment of skeletal muscle damage is known as PRICEM or protection - rest - Ice - Compression - Elevation - magnetic therapy. After the first 48 to 72 hours after trauma, the following physical therapies can be used: a) electro-analgesic therapy (taking care not to cause muscle contractions); iontophoresis with painkillers, anti-inflammatory, antiplatelet and fibrinolytic substances; b) laser therapy, for pain relief, anti-edema and anti-edematous c) ultrasonic diathermy with analgesic effect - The heat and the direct action of ultrasound on sensitive nerve endings, relaxant action of micro-tissue massage induced by the passage of ultrasound, fibrolytic - disruption of the collagen fibers of fibrous tissues, or sclerotic, trophic - vasodilation, facilitates the removal of catabolites and forward in the tissues nutrients and oxygen; these facilitate the repair of tissue damage and accelerate the resolution of inflammatory processes. It can determine exactly the extent of the lesion with a ultrasound examination and / or by NMR and then program the recovery phase during the healing process.

Materials and methods

Between May 2013 and June 2015 30 patients were recruited at the University Centre of Physical and Rehabilitation Medicine at the "G. D'Annunzio "University of Chieti-Pescara with muscle injuries Grade 3 A 48 -72 h after trauma.

The symptoms were characterized by pain and functional impairment and ecographic evidence of intramuscular hematoma.

All were assessed at the beginning of treatment (T0) and the end (T1) with objective clinical examination, visual analogue scale for pain assessment, ultrasound and MRI.

The rehabilitation treatment of 3 weeks duration was performed with rest during 3 weeks, local compression during 1 week and with 3 weekly sessions for 3 weeks application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment at a frequency of 38 kHz acoustic work in pulsed mode, with maximum power of the maniple of 3W / cm2 and transducer size of 50 mm diameter / 19.6 cm2.

Results and discussion

The clinical diagnostic investigation performed at time T1 showed a significant reduction of pain and functional impotence, the evaluation with VAS found an average reduction of 8 to 3.2, the ultrasound examination (fig1) and MRI showed a resolution of the intramuscular hematoma, edema and an improvement in the lesion frame.

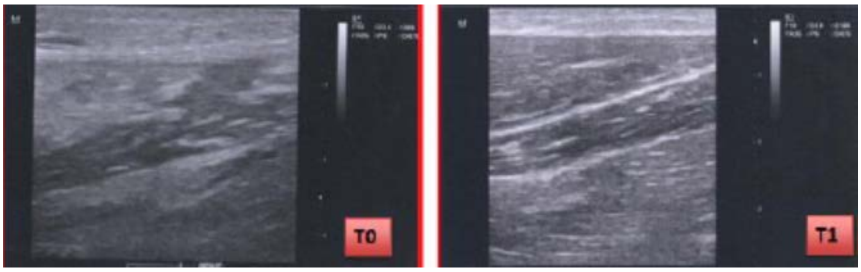

Fig. 1. Ultrasound examination pre- (T0) and after treatment (T1).

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TREATMENT WITH DIATHERMY ULTRASOUND IN POST-SURGICAL RETRACTILE HYPERTROPHIC SCARS

Introduction

The cutaneous scar is defined as the result of the healing of a wound with regeneration and replacement of the dermal tissue with fibrous tissue. The scars can develop after damage to the deep dermis for injuries, burns, abrasions, lacerations, surgery. When the healing process continues over time, is present a pathological accumulation of collagen with pathological scar formation. The wounds with healing problems are often "locked" in the inflammatory and proliferative phase of the healing process.

Local , locoregional and systemic factors can hinder the physiological healing or promote pathological healing: type of wound (incision with a scalpel or contused wound), bleeding, hematoma, serous collection, infections, mechanical obstacles to closing (exuberant granulation tissue), inappropriate aspiration of medications such as corticosteroids, disorders of vascularization, disturbances of innervation, local damage because of previous radiation treatment, deficiency of nutritional factors (proteins), vitamin deficiencies (vitamin E), deficiency of trace elements (Zn), endocrine factors, diabetes, antimetabolites and immunosuppressive drugs; among the factors predisposing to pathological scarring may include healing by secondary intention, orientation of the scar, the nature of the damage (the burn is most frequently related to hypertrophy), position of the scar (sternal, peri-orifice, under-ear) constitutional factors and idiopathic and related to age, sex, race.

The pathological scars are classified in atrophic and hypertrophic.

Those hypertrophic in turn are divided into simple and keloids. The scars over time can undergo many changes as: spontaneous regression, keloid formation, neoplastic degeneration and retraction.

In hypertrophic scars scar fibers are organized to form a rope very hard that exerts a pull on the surrounding healthy tissue causing functional limitation. The current treatment of pathological scarring is characterized mostly by prophylaxis by means of compression therapy, silicone gel, flavonoids.

The therapies currently used include intralesional injections of corticosteroids, cryotherapy, dermabrasion, surgical excision and scar revision, laser therapy, radiation therapy. Among the emerging therapies can be listed: intralesional injections of INF, ESWT and ultrasound.

It has been shown that ultrasound favors the regeneration process in different tissues and give greater extensibility in those containing collagen inducing restoring changes that eventually lead to an improvement both in the flexibility, both of the height of the scar and the state of the skin in general.

Materials and methods

Between May 2013 and June 2015 15 patients were recruited at the University Centre of Physical and Rehabilitation Medicine at the "G. D'Annunzio "University of Chieti-Pescara with post-surgical retracting hypertrophic scars one year after surgery, with an average age of 37.3 years (range 25-60 years).

The symptoms were characterized by pain and itching, ipercromia of the scar and functional limitation of joint ROM of the affected segment.

The rehabilitation treatment of 3 weeks duration was performed with 3 weekly sessions with application of elastic waves at low frequency produced by an ultrasonic device thanks to a sophisticated protocol managed by a microprocessor, delivering the treatment at a frequency of 38 kHz acoustic work in pulsed mode, with maximum power of the maniple of 3W / cm2 and transducer size of 50 mm diameter / 19.6 cm2.

All patients were evaluated at the beginning (T0) and at the end of treatment (T1) with objective clinical examination, visual analogue scale for pain assessment, the joint ROM of the district affected, the modified Vancouver Scar Scale (MVSS) for evaluation of the characteristics of the scar (vascularization, pigmentation, elasticity, thickness) (Fig1)

Vascularity	Normal	0
	Pink	1
	Red	2
	Purple	3
Pigmentation	Normal	0
	Hypopigmentation	1
	Mixed	2
	Hyperpigmentation	3
Pliablity	Normal	0
	Firm	1
	Ropes	2
	Contracture	3
Height	Flat	0
	< 2 mm	1
	> 2 < 5 mm	2
	> 5 mm	3

Legend: 0 = best; 12 = worst.

Figure 1. Modified Vancouver Scar Scale (MVSS)

Results and discussion

The clinical diagnostic investigation performed at time T1 showed a significant reduction in pain assessed by visual analogue scale from an average of 6 to 1.7, the joint ROM of the districts affected have increased significantly with increased functionality and mobility and scores on the modified Vancouver Scar Scale (MVSS) decreased significantly from an average of 10 to 4.

The aesthetic result of a surgical scar is related to several variables: some are related to the choice of the surgeon (the location and size of the incision, suture technique), others depend on the patient care (treatment of the wound and scar) others are more difficult controllable and are linked to skin type and characteristics of the skin (individual predisposition to develop depressed, hypertrophic or keloid scars).

The literature does not indicate a gold standard for the treatment of these scars, the results obtained confirms the efficacy of treatment with low-frequency ultrasound diathermy, in particular with the tool that uses frequency of 38 KHz, and open up new and interesting perspectives for research .

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