Shockwave therapy in the treatment of enthesopathies

Fala uderzeniowa w leczeniu entezopatii

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SUMMARY

Introduction: To date, the methods of physical therapy used in patients with enthesopathies have not always allowed for achieving a fast therapeutic effect. The introduction of extracorporeal shockwave therapy (ESWT) increased the chances of effective treatment of this chronic disorder. ESWT is based on the release of high-energy waves in the air or water environment which then focus inside a patient's body at a selected site (secondary focus). The waves' energy stimulates the processes of healing and regeneration of tendons, soft tissues, and muscles. Biological effects of the stimulation include decreased pain and muscle tension, reduced oedema, accelerated healing, increased metabolism, improved microcirculation, and the dissolution of calcified fibroblasts. Contraindications include: thrombosis and blood coagulation abnormalities, advanced osteoporosis, neoplastic changes, and acute inflammation.

Aim: An assessment of the efficacy of shockwave therapy in the treatment of enthesopathy.

Material and methods: The study involved 15 patients with heel spur and 15 patients with lateral humeral epicondylitis. The diagnosis was formulated based on history-taking, a clinical examination, and an ultrasound scan. The treatment involved a BTL-5000 SWT POWER device. The patients underwent shockwave applications every 7 days with the following parameters: the pulse number was 2000, the pressure was 2.5 bars, and the frequency was 10 Hz. The patients with humeral epicondylitis received 3 applications while those with heel spur received 6. Pain intensity was assessed using a 10-point analogue VAS scale, hand grip strength was evaluated with a pressure manometer, and the morning walk distance was measured until the onset of pain. A follow-up examination (including an ultrasound scan) took place at 6 weeks and 3 months after the first examination.

Results: At 6 weeks, the pain decreased on average from 8.2 to 4.4 according to the VAS scale, the hand grip strength improved on average by 20%, and the morning walk distance measured until the onset of pain was longer by 50%. Follow-up ultrasound findings obtained after the procedures were the same as those from the first examination. A follow-up examination at 3 months revealed stabilization of the results while an ultrasound scan showed a reduction in the signs of tissue inflammation.

Conclusions: Enthesopathies are a difficult diagnostic and therapeutic problem. Shockwave therapy should be a therapy of choice in the treatment of these disorders.

Key words: enthesopathies, shockwave, treatment

STRESZCZENIE

Wstęp: Dotychczasowe metody leczenia fizykalnego chorych z entezopatiami nie zawsze pozwalały na szybkie uzyskanie efektu terapeutycznego. Wprowadzenie metody ESWT – pozaustrojowej fali uderzeniowej – zwiększyło szanse na poprawę skuteczności terapii tego przewlekłego schorzenia. ESWT polega na wyzwalaniu fal o wysokiej energii w środowisku powietrznym lub wodnym skupiających się wewnątrz organizmu we wtórnym ognisku. Dzięki dostarczonej energii stymulowane są procesy leczenia i regeneracji ścięgien, tkanek miękkich i mięśni. Efektem biologicznym oddziaływania są: zmniejszenie bólu i napięcia mięśni, redukcja obrzęku, przyspieszenie gojenia, zwiększony metabolizm oraz poprawa mikrokrążenia i rozpuszczanie zwapniałych fibroblastów. Przeciwwskazania to: zakrzepica i zaburzenia krzepliwości krwi, zaawansowana osteoporoza, zmiany nowotworowe, ostry stan zapalny.

Cel: Ocena skuteczności zastosowania fali uderzeniowej w leczeniu entezopatii.

Materiał i metody: 15 chorych z ostrogą kości piętowej oraz 15 chorych z zapaleniem nadkłykcia bocznego kości ramiennej. Rozpoznanie ustalano na podstawie wywiadu, badania przedmiotowego, badania USG. W terapii zastosowano aparat BLT-5000 SWT POWER. Chorym wykonywano zabiegi fali uderzeniowej co 7 dni, o następujących parametrach: liczba uderzeń – 2000; ciśnienie – 2,5 bara; częstotliwość – 10 Hz. W przypadku zapalenia nadkłykcia były to 3 aplikacje, w przypadku ostrogi piętowej 6. Oceniano nasilenie bólu w skali analogowej 10-punktowej VAS, siłę chwytu ręki manometrem ciśnieniowym, dystans marszu porannego do wystąpienia bólu. Badanie kontrolne (w tym USG) po 6 tygodniach i 3 miesiącach od pierwszego badania.

Wyniki: Po 6 tygodniach uzyskano ustąpienie bólu, w skali VAS średnio z 8,2 do 4,4, poprawę siły chwytu ręki średnio o 20%, dystans marszu porannego do wystąpienia bólu zwiększył się o 50%, w kontrolnym badaniu USG po zabiegach zapis jak w badaniu wstępnym. W badaniu kontrolnym po 3 miesiącach obserwowano stabilizację uzyskanych wyników, a w obrazie USG zmniejszenie objawów zapalenia struktur tkankowych.

Wnioski: Entezopatie są trudnym problemem diagnostycznym i leczniczym. Leczenie falą uderzeniową powinno być metodą z wyboru w leczeniu schorzenia.

Słowa kluczowe: entezopatie, fala uderzeniowa, leczenie

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INTRODUCTION

Enthesopathy, which is a disorder of tendon attachments, is caused by repeated strain and accumulating microinjuries resulting in microstructural changes in the tissues of the tendon and ligament system [1, 3, 5, 8]. The bone is not covered by the periosteum in the region of tendon attachment and the tendons are anchored to the bone by the osteochondral plate. Irritation of the attachments by excessive tension forces leads to single fibre strain and chronic inflammation. This results in the development of an inflammatory response (hyperaemia, inflammatory infiltrates of lymphocytes and plasma cells, rarely granulocytes). "New" bone tissue is created in the form of a spike or needle and further bone remodelling is possible, to the point of tearing the tendon fibres and replacing them with connective tissue. Physical therapy is a part of comprehensive enthesopathy treatment. It is aimed at eliminating or decreasing the pain in the joints and adjacent tissues, improving muscle tone influencing the movement in the affected joint, decreasing the tension of muscles in permanent contractures (due to pain), and improving circulation in the tissues affected by inflammation. Stimulating internal antinociception mechanisms, physical therapy methods have become a basic form of chronic pain treatment. Intensive low frequency irritation causes analgesia developing gradually after several minutes of latency and continuing for a few hours following the procedure. Pain is one of the factors determining the patient's behaviour. Nowadays, it is believed that in a vast majority of cases, acute pain is based on a physiological nociception process, while chronic pain, even though it is originally caused by nociception, stops being directly connected to it over time. Its persistence results from specific pathological mechanisms within the nervous system as well as psychological factors. Differentiating the mechanism of pain is crucial from the point of view of pain treatment efficacy. In the case of acute pain, the easiest form of inhibiting nociception involves administering analgesics or blockades. This treatment is effective in most patients. However, it does not influence the intensity of suffering in chronic pain, such as enthesopathy. The sensation of acute muscular pain results from the stimulation of group III (A gamma fibres) and group IV (C fibres) muscle nociceptors as well as nociceptors present in other affected soft tissues. These nociceptors become hypersensitive due to neuropeptide release from nerve endings having direct or indirect influence on the receptor. In the end, this results in "hyperalgesia" and hypersensitivity of central neurons of the dorsal horns, causing long-term neuron firing, increased responses to harmful stimuli, responses to harmless stimuli, and the widening of receptive fields. To date, the methods of physical therapy used in patients with enthesopathies have not always allowed for achieving a fast therapeutic effect [2, 4, 7]. The introduction of extracorporeal shockwave therapy (ESWT) increased the chances of effective non-operative treatment of this chronic disorder [6, 9, 10, 11, 12]. ESWT is based on the release of high-energy waves in the air or water environment which then focus inside a patient's body at a selected site (secondary focus). The waves' energy stimulates the processes of healing and regeneration of tendons, soft tissues, and muscles. Shockwaves are acoustic waves carrying energy to the painful sites in the musculoskeletal system and tendons affected by subacute and chronic disease. The waves' energy stimulates the processes of healing and regeneration of tendons and soft tissues. Shockwaves are characterised by a jump increase in pressure, a high amplitude, and non-periodicity. The kinetic energy of the projectile, created by compressed air, is transferred through the shock to the shockwave transmitter. The analgesic effect and faster healing result from:

a. decreased muscle tension, inhibition of spasms – this effect is achieved by hyperaemia, which allows for better energy supply to the tense muscles and their ligaments. Moreover, the pathological interactions between muscle proteins and myosin are weakened.
b. increased dispersion of substance P – it is a pain mediator and growth factor which causes stimulation of afferent nociceptive fibres, increases oedema and histamine secretion. Consequently, the dispersion of substance P reduces pain in a given region and decreases the risk of oedema development;
c. increased production of collagen in deeper tissues – a sufficient amount of collagen is necessary for the repair of damaged musculoskeletal tissues and ligament structures;
d. increased metabolism and microcirculation – nociceptive metabolites are removed faster, the damaged tissue is better oxygenated and supplied with energy. It supports the elimination of histamine, lactic acid, and other irritating acidic substances.
e. restoring mobility – the dissolution of calcified fibroblasts starts a biochemical process of decalcifying primary calcifications and secondary symptoms of degenerative disease.

The ESWT method has a 70-80% efficacy in patients who were previously unsuccessfully treated with other non-operative methods. The analgesic effect results from the following: shockwaves damage nerve ending membranes, which prevents the receptors from producing potentials and transferring pain signals. Receptors hyperstimulated by shockwaves cause intensive pulses which inhibit pain signals in accordance with the gate control theory. Shockwaves generate free radicals in the region of nerve endings, thus altering the chemical environment, which inhibits pain signal release.

The biological effects of the stimulation include decreased pain and muscle tension, inhibition of muscle spasms, reduced oedema, accelerated healing, increased metabolism, improved microcirculation, and the dissolution of calcified fibroblasts. The most common indications for the use of shockwaves include lateral and medial humeral epicondylitis (tennis and golfer's elbow), patellar tendinopathy, plantar fasciitis, "heel spur", Achilles tendinopathy, tendinous band friction syndromes, calcifications within muscles and soft tissues of the joints, bursitis, muscle strain pain, post-traumatic conditions (haematomas, painful trigger points).

Contraindications include: thrombosis and blood coagulation abnormalities, advanced osteoporosis, neoplastic changes, and acute inflammation.

AIM

An assessment of the efficacy of shockwave therapy in the treatment of enthesopathy.

MATERIAL AND METHODS

The study involved 15 patients with lateral humeral epicondylitis (Group I) and 15 patients with heel spur (Group II). The diagnosis was formulated based on history-taking, a clinical examination, and an ultrasound scan. The treatment involved a BTL-5000 SWT POWER device. The patients underwent shockwave applications every 7 days with the following parameters: the pulse number was 2000, the pressure was 2.5 bars, and the frequency was 10 Hz. The patients with humeral epicondylitis received 3 applications while those with heel spur received 6.

Figures 1, 2, and 3 present examples of the changes found in the patients during an ultrasound examination.

RESULTS

At 6 weeks, the pain decreased on average from 8.2 to 4.4 according to the VAS scale, the hand grip strength improved on average by 20%, and the morning walk distance measured until the onset of pain was longer by 50%. Follow-up ultrasound findings were the same as those from the first examination. A follow-up examination at 3 months revealed stabilization of the results while an ultrasound scan showed a reduction in the signs of tissue inflammation (Tab. 1, 2, 3).

DISCUSSION

ESWT uses devices focusing shockwaves inside the human body with maximum wave intensity at the site treated.

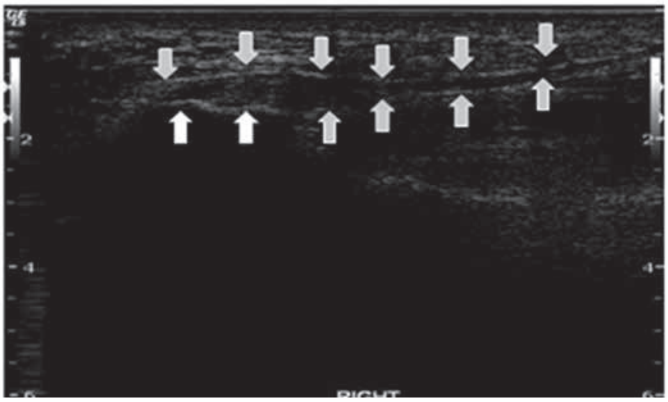

Figure 1. Attachment of the planter fascia.

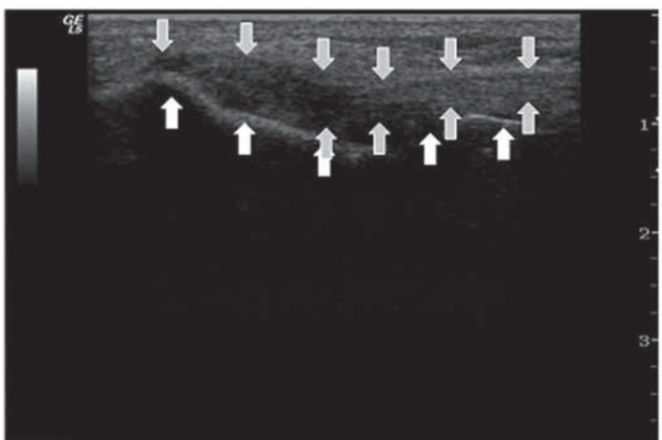

Figure 2. Attachment of arm extensors.

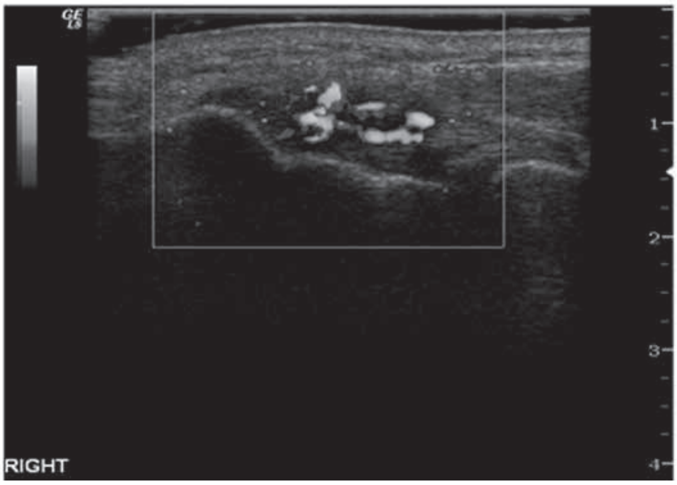

Figure 3. Attachment of arm extensors – active hyperaemia.

Table 1. Pain intensity assessment according to VAS scale.

Before treatment Mean values + standard deviation	After treatment Mean values + standard deviation
8,2 (+/- 1,6)	4,4 (+/- 2,1)

Table 2. Hand grip strength assessment.

	Affected limb Mean values + standard deviation	Healthy limb Mean values + standard deviation
Before treatment	25 mmHg (+/- 1,2)	40 mmHg (+/- 1,5)
After treatment	30 mmHg (+/- 0,5)	40 mmHg (+/- 1,5)

Table 3. Painless walk distance.

Before treatment Mean values + standard deviation	After treatment Mean values + standard deviation
40,0 m (+/- 2,0)	60,0 m (+/- 2,0)

The wave generates high pressure and penetrates the body up to approx. a dozen centimetres in depth. The pressure varies between 10 and 100 MPa. The mean range of the device is approx. 12.5 cm with a maximum at the depth of 6 cm. ESWT devices create energy from medium to high, using electrohydraulic, electromagnetic, or piezoelectric techniques. The pulses are generated with a frequency of 1 Hz to 10-15 Hz. An ESWT device creates a wave with the use of the electromagnetic method and transmits it to the painful region where the wave focuses in a secondary focus. In this way it precisely reaches the affected site, while not influencing the adjacent tissues. The wave's energy outside the site is too small to result in a biological effect. This allows for precise application of the wave at the affected site. The depth of wave penetration is regulated with gel pads of various thicknesses which allow for adjusting the treatment parameters to individual patients. The innovative ESWT method uses electromagnetic waves to conduct safe and highly effective therapy. ESWT results in a pronounced decrease in pain through non-invasive irritation of cellular membranes and nerve endings, which inhibits the release and transmission of pain signals. The method is used mainly in orthopaedics, rehabilitation, and sports medicine to eliminate pain connected with the musculoskeletal system. It is highly effective, minimally invasive, and the therapeutic effect can be observed as early as after several treatment sessions. Shockwave treatment is conducted at 5-7 day intervals. The mechanism of action of shockwaves has not been fully explained. It is assumed that in the case of calcifications, the increase in pressure at the site of shockwave focus causes cavitation in the region of ischaemic calcifications and their fragmentation, resulting in disorganisation and disintegration of the deposit. Calcium deposits may dissolve after shockwave application due to a molecular absorption mechanism depending on blood flow, which is increased after the treatment sessions. A positive influence of shockwaves used in strain disorders is probably connected with microdestruction. Presumably, the shocks cause microtears in sparsely or non-vascularised tissues, thus stimulating revascularisation through the release of local growth factors and the mobilisation of appropriate stem cells.

The majority of the disorders are thought to be caused not by inflammation, but by degenerative changes, resulting from chronic ischaemia. This does not result in inflammation, but in degenerative processes of the connective tissue: fibroblast atrophy, disturbed collagen fibre orientation, and the development of cysts, which may lead to partial or complete rupture of the muscle attachment. The presence of pain in the periarticular tissues of the musculoskeletal system is a common cause of significant limitation of mobility. Consequently, the patients are unable to function effectively in everyday and professional life or participate in recreation. Any disturbances of the normal musculoskeletal function due to disease or injury result not only in local, but also systemic responses and the limitation of mobility and pain influence the patient's personality and mental state. The sensation of acute muscular pain results from the stimulation of group III (A gamma fibres) and group IV (C fibres) muscle nociceptors as well as nociceptors present in other affected soft tissues.

These nociceptors become hypersensitive due to neuropeptide release from nerve endings having direct or indirect influence on the receptor. This results in "hyperalgesia" and hypersensitivity of central neurons of the dorsal horns, leading to long-term neuron firing, increased responses to harmful stimuli, responses to harmless stimuli, and the widening of receptive fields.

Ionotropic and metabotropic glutamate receptors may also participate in muscular hyperalgesia. The hypersensitivity of muscle nociceptors is the best known peripheral mechanism facilitating the subjective sensation of tenderness and pain when moving the damaged muscle.

As far as the literature is concerned, few papers presenting clinical studies on the subject have been published to date. They show that radial shockwave therapy improves metabolism, decreases muscle tension, eliminates calcified fibroblasts from the sites of tissue pathologies, and increases the dispersion of substance P and nerve growth factor (NGF) which participate in neuromodulation and the development of peripheral neurogenic inflammation directly connected to nociceptor stimulation.

Pain is a feature of the musculoskeletal system and all the system's tissues are supplied by numerous sensory nerves and their receptors.

Sensory receptors are connected with:

- fast conducting A beta fibres of a large diameter, insulated with a thick myelin sheath (velocity of > 30 m/s) and found mostly within fibrous periarticular structures, including ligaments, tendons, and the joint capsule. They are activated by harmless stimuli and fall into the category of mechanoreceptors/proprioceptors,
- medium-velocity A gamma fibres with a thin myelin sheath (velocity of 2.5-30 m/s),
- unmyelinated C fibres (velocity of < 2.5 m/s) which are most common in the synovial membrane, fibrous joint capsules, adipose tissue, ligaments, and periosteum.

The effect of the substance present in the extracellular space may enhance or inhibit the activity of peripheral sensory neurons through numerous mediators.

In emergency situations, mediators such as bradykinin facilitate the development of pain, directly stimulating nociceptors through cell surface receptors.

Other mediators, such as endogenous opioids (endorphins) and cannabinoids, acting on peripheral centres, decrease nociceptor activity. These are mediators of negative feedback with respect to adenylate cyclase. They block the excitability and activation of nociceptive fibres, thus decreasing pain.

In the case of unremitting (chronic) course of the disorder, the increased receptor activity and secondary signalling become important. Neurotropic factors causing nerve growth (nerve growth factor, NGF) are present in the afferent fibres of articular receptors.

This mediator has a general influence on the activity of nociceptors, regulating the expression of neuropeptides such as substance P and bradykinin B2 as well as sodium channels.

Peripheral hypersensitivity in the form of excessive responses to stimuli, e.g. pulling, is immensely important in the development of most cases of musculoskeletal pain. The excitability of nociceptors which previously had a high "silent" receptor excitability threshold increases under the influence of inflammation to the point where they may respond to mild mechanical stimuli, such as compression. The presence of numerous mediators in the intercellular space facilitates stimulating or inhibiting the activity of these nerve fibres.

The correlation between this mechanism and the symptoms may be based on the fact that musculoskeletal pain and tenderness, originally caused by peripheral hypersensitivity, are well localised and directly connected to mechanical stimuli with respect to excessive responses to normal stimuli.

In prolonged tissue pathology, which in time results in excessive responses to normal stimuli, receptive fields are widened and the process of activation by newly formed signals is decreased.

In such a situation, motor neurons of the second level of neuroplastic pain become hypersensitive, which results in enhanced pain perception at the site of damage (primary hyperalgesia) and the development of pain and tenderness in healthy tissues, including those adjacent to the primary site of damage (secondary hyperalgesia) as well as those located far from this region (referred pain).

It seems that these mechanisms may provide us with the explanation of possibly one of many effects radial shockwaves have with respect to decreasing musculoskeletal pain.

Even though the existence of hypersensitivity has been confirmed on a supraspinal (third level of neuroplastic pain) or cortical level, functional consequences of changes in nociceptive stimuli processing have not been proven.

Peripheral hypersensitivity allows for the integration of various types of stimuli, medullary hypersensitivity integrates numerous somatic signals from the entire body, and cortical hypersensitivity is inevitably subject to external signals, which reflects the importance of environmental factors in pain perception, influencing the general responsiveness level. The question then arises: do factors such as anxiety and depression facilitate the development of pain or exacerbate the already existing nervous system disorders?

Radial shockwave therapy improves metabolism and tissue microcirculation, decreases muscle tension, eliminates calcified fibroblasts from the sites of tissue pathology, and increases the dispersion of substance P and nerve growth factor (NGF) which participate in neuromodulation and the development of peripheral neurogenic inflammation directly connected to nociceptor stimulation.

A full explanation of these mechanisms of pain development requires further clinical studies.

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