SHOCK WAVE THERAPY

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Extracorporeal shock wave therapy (ESWT) was first introduced in the early 1980s as a non-invasive method for treating kidney stones. Over the past two decades, this modality has been increasingly used to treat a variety of musculoskeletal conditions in humans and veterinary patients. Benefits of ESWT include: increased bone, tendon, and ligament healing, accelerated wound healing, anti-bacterial properties, and pain relief[1]. These properties have led to ESWT use in the treatment of chronic tendonopathies, delayed and non-union fractures, chronic wounds such as diabetic ulcers, and in the management of pain associated with osteoarthritis[1-4].

Extracorporeal shock wave therapy is an acoustic energy modality. Shock waves can be created by electrohydraulic, electromagnetic, and piezoelectric mechanisms. The initiation of a wave that rapidly rises in pressure, typically reaching a peak pressure around 50 Mpa within 10 nanoseconds, followed by a period of negative pressure is common to all methods of shock generation. Shock waves are highly focused (2-8 mm) and have a predictable depth of penetration based on the shock wave source. Extracorporeal shock wave therapy is applied superficially, and waves enter tissue and are absorbed or reflected. Energy is released when a wave meets an area of high acoustic impedance such as a bone-tendon interface. Compressive and tensile forces result in cavitation and mechanical micro-stress to cells and tissue[1].

The unit of energy used to measure ESWT is mJ/mm^2. Therapeutic effects have been documented using energy levels between 0.0001 to 0.6 mJ/mm^2. Shock waves over 0.6 mJ/mm^2 have been shown to have detrimental effects on tendons in animal models. Administration of energy levels below 0.12 mJ/mm^2 tends to be well tolerated by patients; however, at higher levels, treatment can be painful, necessitating local or general anesthesia[1].

The exact mechanism of action of ESWT has yet to be fully elucidated; however, the mechanical stimulation of cells is hypothesized to result in increased expression of cytokines and growth factors. Extracorporeal shock wave therapy applied to an area of chronic inflammation may enable acute inflammatory mediators to be released, facilitating appropriate progression of healing. The mechanism behind the pain-relieving function of ESWT is thought to be due to increased seretonin activity in the dorsal horn and descending inhibition of pain signals[1]. For these reasons, ESWT has been used clinically in humans for the treatment of painful, chronic musculoskeletal conditions such as Achilles tendinosis, lateral epicondylitis, supraspinatous tendonopathy, plantar fascitis, and patellar tendonitis[1].

Bench-top and experimental animal studies have provided evidence in support of ESWT in the management of orthopedic conditions. For example, ESWT has resulted in histologically increased vascularization of the Achilles tendon and enhanced spinal fusion in rabbit models[5,6]. Clinical studies are now being performed worldwide in order to enhance the evidence-based use of ESWT in practice.

Tendonopathies are often the result of repetitive activity or overuse injuries and typically cause pain and loss of full function. These conditions are typically non-inflammatory. Rather, degeneration of the tendon fibers and insufficient vascular supply to the area lead to loss of mechanical properties of the tendon. Treatment of these conditions has typically relied on physical therapy and/or surgery, along with anti-inflammatory medications such as non-steroidal anti-inflammatories or cortisone injections. However, it has recently been appreciated that therapies such as ESWT that are aimed at increasing blood supply and/or inflammation may actually enhance tendon healing[6].

Achilles tendonitis is characterized by pain, swelling, and increased vascularization of the tendon, but current studies have shown that inflammation is not involved in the pathogenesis[7]. A randomized, double-blind, placebo-controlled clinical trial was recently performed that evaluated the outcome of ESWT in people with chronic Achilles tendonitis. Patients received 2,000 shocks at 0.12-0.51 mJ/mm^2 or 0 mJ/mm^2 once a week for four treatments. While both treatment and control groups improved over the study period (placebo effect), significantly better functional outcomes were seen in the treatment group at 8 and 12 post treatment. However, although function improved with therapy, ESWT did not affect pain. The authors postulate that this was due to increased activity despite a constant, tolerable level of pain[7].

"Tennis elbow", or lateral epicondylitis is a condition affecting 1-3% of adults, and is often the result of minor trauma to the extensor muscles of the forearm. This results in force transmission to the muscular origins at the oseotendinous junction of the lateral epicondyle, the area becoming hypovascular, and hypoxic degeneration of the tendon[8]. This condition can be difficult to treat, although it tends to be self-limiting over a period of months to years. Several groups have investigated the effects of ESWT in treating this condition and have found conflicting results[1]. Recently, Staples et al hypothesisized that ESWT would result in decreased pain and improved function compared with placebo control in patients with lateral epicondylitis.

In this study, the treatment group received 2000 shocks at the maximal tolerated energy level once a week for three weeks, while the control group received shocks at subtherapeutic levels. Both groups showed improved pain and function at 3 and 6 months post intervention, and there was no statistically significant difference between the groups.

The contradictory results in this study compared to others may lie in different treatment protocols and different mechanisms of shock creation (for example: piezoelectric vs. electrohydraulic)[9]. Treatment of plantar fasciitis and patellar tendonitis has also shown varying results in clinical trials[1]. Further studies may be indicated to evaluate the most appropriate dose (number of shocks and level) and most effective mechanism of delivery in treating chronic tendinopathies.

An additional benefit of ESWT is the mechanical dissolution of calcium deposits in tissue, and this effect has been exploited not only in the treatment of kidney stones, but also for the treatment of calcifying tendonopathies. A randomized, double-blind, placebo controlled clinical trial was performed that examined the effects of low energy (600 shocks, 0.08 mJ/mm2) and high energy (1500 shocks, 0.32 mJ/mm2) ESWT in the management of chronic calcifying tendonitis of the rotator cuff in people[10]. This study found that both therapeutic protocols resulted in improved pain and function scores and decreased radiographic appearance of calcium deposits compared with placebo. Additionally, the high energy group had significant improvements relative to the low energy group[10].

Extracorporeal shock wave therapy has been demonstrated to increase osteoblast number and activity through microtrauma-induced stimulation[9]. Therefore, several clinical studies have been conducted investigating the use of ESWT in the treatment of complex fractures and delayed bone union. In a randomized study of human patients with high-energy fractures of the long bones, Wang et al found that treatment with ESWT immediately following surgical repair (6,000 shocks, 0.62 mJ/mm^2) resulted in significantly faster fracture healing and decreased incidence of non-union compared to control (no ESWT treatment)[11]. Similarly, Schaden et al showed that one treatment of ESWT resulted in bony consolidation in 75% of human patients with previous delayed or non-unions[4].

Based on positive results seen in experimental animal studies and human patients, the use of ESWT has expanded to include veterinary patients. Laverty and McClure published the first case series of six dogs treated with ESWT[2]. Four dogs were treated for fracture non-union, and significant progression in bone healing was seen in three of the four dogs following ESWT. Extracorporeal shock wave therapy was used to treat osteoarthritis in two dogs: one with bilateral hip dysplasia and one with chronic elbow arthritis. Improvement in function and decreased pain was reported following ESWT of the hip but not the elbow.

To date, two prospective studies have been conducted to examine the effects of ESWT in dogs[12,13]. The first report found that dogs with severe osteoarthritis of the knee that were treated with ESWT had a trend toward improved knee range of motion and peak vertical force compared to control dogs; however, subjective assessment of function by owners was not different between groups[12]. The most recent clinical trial demonstrated that dogs with hip osteoarthritis treated with ESWT had improved limb function as measured by peak vertical force and vertical impulse[13].

Adverse effects of ESWT have been reported in humans and animals and tend to be mild, including erythema, bruising of the treated area, and transiently increased pain and lameness following treatment[2]. However, syncope and migraine headaches were reportedly associated with ESWT in one human study[1].

As previously mentioned, protocols have not been fully tested or established to determine the most effective means of utilizing ESWT in humans or animals. This modality is relatively new, and further understanding of it's mechanisms of action and therapeutic capabilities, along with establishment of "best protocols", will hopefully lead to more consistent results in clinical trials and clinical practice in the future.

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