PulseVet®
Leadership in Veterinary Regenerative Technology

REGENERATIVE WOUND HEALING WITH SHOCK WAVE TECHNOLOGY

A WHITE PAPER FOR VETERINARIANS AND VETERINARY CARE PROFESSIONALS

VersaTron®

Overview

Regenerative Healing with Extracorporeal Shock Wave Technology (ESWT)

- Non-invasive, high-energy, pressure wave technology used in human and veterinary medicine.
- Relieves pain, speeds healing and improves quality of healing.
- "Shock wave" is a physics term to describe a rapid increase in pressure and does not refer to electrical shock.
- VersaTron and VersaTron 4 Paws ESWT administer a much higher energy that penetrates deeper than other types of energy modalities, such as laser, therapeutic ultrasound, electromagnetic pulse therapy, or radial pressure wave therapy, allowing for a more effective treatment of a wider range of indications.
- Extensive in vitro research and multi-center, randomized, prospective studies have been conducted in human patients demonstrating clinical efficacy in treating a wide variety of chronic wounds with VersaTron's shock wave technology. Small pilot studies and case studies have been conducted in veterinary medicine utilizing VersaTron with similar results.

ESWT has been extensively used and proven safe and effective to treat a variety of conditions including tendonitis, non-healing bone, and degenerative joint disease.[1-14] Due to the technology's promising results in clinical settings and published trials, ESWT is also becoming a treatment of choice for treating burns and chronic wounds in human and veterinary medicine.[15-25]

HEALING CHALLENGING WOUNDS WITH PRESSURE WAVES

ESWT works by creating a physical stimulus at the cellular level to help the body to heal in a timely and healthy way. The exact mechanism of action of ESWT for wound healing continues to be investigated, but it has been clinically shown that the treatment causes a substantial localized increase in specific proteins such as Proliferating Cell Nuclear Antigen (PCNA), Endothelial Nitric Oxide Synthase (eNOS), and Vascular Endothelial Growth Factor (VEGF), which are known to lead to neovascularization, or new capillary formation.[1] It also reduces leukocyte infiltration, decreases tissue apoptosis (cell death) and recruits skin fibroblasts all contributing to the improved quality and speed of healing.[20-22] Furthermore, ESWT has been shown to have significant antibacterial effects making it a favorable treatment option for challenging infections.[15]

ESWT causes improved wound healing in the following ways:

- Increased localized perfusion (increase in growth factors)
- Decrease in inflammation
- Decreases localized cell death (apoptosis)
- Increases skin fibroblasts

ESWT has been shown to increase tissue perfusion and also suppress local inflammatory response, allowing wounds to heal in a more normal manner. ESWT increased VEGF and PCNA, reduced leukocyte infiltration, and suppressed Tumor Necrosis Factor, or TNF alpha.[20] Additional studies demonstrated that ESWT increases tissue flap survival by altering free radicals, preventing an over abundance of leukocyte infiltration, decreasing cell death (apoptosis) and recruiting skin fibroblasts. Fibroblasts are particularly important in wound healing as these cells create the extracellular matrix and produce collagen, which form a healthy connective tissue framework.[21]

There is a growing trend of utilizing ESWT for treatment of burns as well. Due to its ability to increase perfusion, stimulate growth factors and decrease inflammation to accelerate wound healing, it is an effective treatment method for deep partial/full thickness burns.[16,24] Persistent inflammation, sloughing of dead tissue, bacterial colonization and neutrophil-directed protein degradation are all common issues that hinder healthy healing in burn wounds. Essentially, the body may overreact to a severe or chronic wound and it is important to control and modify these factors in order to prevent further damage and promote healthy healing. ESWT can mediate the acute response, allowing the burn wound to heal appropriately.[24] In a murine model, it was demonstrated that ESWT blunts an over-abundance of white blood cell infiltration, decreases acute proinflammatory cytokine expression and decreases the breakdown of the extracellular matrix.[25] In a study with 15 human patients with <5% total body surface area burns, 80% healed uneventfully prior to 3 weeks. It was concluded that "ESWT can decrease the need for surgery and therefore morbidity".[24]

ESWT AND CHRONIC WOUNDS

ESWT can be particularly effective as it can help not only heal acute wound injuries, but also chronic conditions. It is currently being evaluated in the treatment of diabetic foot ulcers in human patients. These wounds are often particularly difficult to treat and can often lead to lower extremity amputation. In one study, 92% of patients with chronic ulcers lasting more than 6 months achieved closure following 4 ESWT treatments over the course of 2 weeks.[17] In a study of 30 human patients, ESWT decreased healing time and significantly improved rates of complete wound closure in patients with neuropathic diabetic foot ulcers compared to the standard of care.[26] Significant improvement was also seen in re-epithelization rates.

USE OF SHOCK WAVE TECHNOLOGY IN VETERINARY WOUND INDICATIONS

Preliminary studies in veterinary applications for wound healing have proven to be just as positive as in laboratory animal models and human patients.[18] Wounds of the distal portion of the limbs in horses can be particularly difficult to heal due to the lack of soft tissue and immobility of the surrounding skin. Exuberant granulation tissue can delay healing or cause scarring. Researchers at Iowa State University studied wounds created in 6 healthy horses and found that ESWT significantly decreased the time of healing versus untreated wounds.[18]

The potential benefit of ESWT in equine wounds was recently documented in a case report of a horse which sustained deep second degree burn wounds covering approximately 25% of the total body with deep third degree burns on the left haunch. Shock wave was considered as a treatment for this horse when wound healing was not progressing at day 11. In preparation for the treatment, the horse was sedated with 7.5 mg detomidine HCL IV, the area was cleaned with saline and ultrasound gel was liberally applied over the entire burned area. The ESWT treatment was performed with the VersaTron focused high-energy device, using the 5mm trode at Energy level E2. A total of 4500 pulses were administered to cover the entire area including over the eschar and devitalized skin, but concentrating on the junction of the normal skin to the burned skin. One day post-treatment the wound improved, new blood vessel formation was visible at the margins and there was an observed decrease in discharge, and sensitivity to palpation. Wound contraction and skin slough followed on post-treatment day 4. Three more shock wave treatments were delivered within the next 30 days and the wound continued to heal well with proper wound care. Upon evaluation at 4 months post-burn, it was observed that the majority of the devitalized skin had been replaced with pink and black skin. Treatments were discontinued due to travel time (>4 hrs) and the horse had almost healed, but at 12 months a small wound remained and an additional treatment was used. ESWT helped the horse regain weight and muscle mass to pre-injury levels. *Case courtesy of Johnson JE, McClure SR, Liskey CL, Oakhill Shockwave, Calabasas CA.*

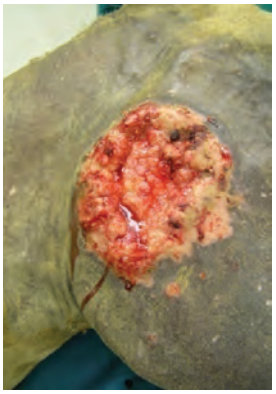
The recommended protocol for veterinary wound treatment is 8 pulses per cm^2, with a minimum of 500 pulses using the R05 trode and Energy Level E1 or E2. Because of the lower energy setting than is used for orthopedic indications, sedation may not be necessary for equine patients and a lower level of sedation may be suitable for canine patients.

Currently, ESWT is most often used only for the worst of the worst wounds for which other treatment modalities have failed. **Adding ESWT to the wound treatment protocol early on may further enhance outcomes and possibly prevent common wound-healing complications, thereby improving outcomes and providing more cost-effective care.**

CASE STUDIES

Case 1: 5-year old AQH Mare

Courtesy of Alison J. Morton, DVM, MSpVM, DACVS, University of Florida Large Animal Surgery

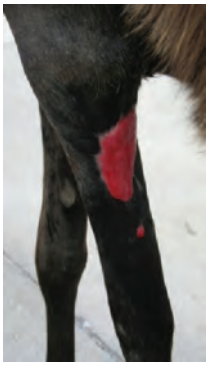


The mare presented with Habronemiasis > 1 y duration which was confirmed with biopsy. The wound was progressively worse despite multiple surgical debridement, ivermectin, moxidectin and corticosteroid treatments. Surgical debridement was conducted and moxidectin was repeated. Two treatments of ESWT were administered 3 days apart. (500 pulses, R05, E1) The mare was discharged 3 days following the second treatment and the owner reported complete healing at 7 days.

Case 2: 6-month old American Miniature Horse Filly

Courtesy of Alison J. Morton, DVM, MSpVM, DACVS, University of Florida Large Animal Surgery

The filly was referred for acute dsypnea (shortness of breath) after being attacked by the owner's dogs 36 hours earlier which resulted in multiple puncture wounds over dorsal muzzle and nasal passage and left proximal forelimb. Initial treatment consisted of antimicrobial and NSAID therapy, and appropriate wound care. A temporary tracheotomy was placed, IV antimicrobial and NSAID therapy was initiated along with more aggressive wound care. At 3 days post-attack, the filly was febrile, inappetant and depressed. Muscle necrosis was observed and clostridial infection was suspected. Aggressive debridement and double dose penicillin was started with IV fluid therapy. At 5 days post-attack, some improvement was seen, but necrosis continued and some areas were cool to the touch in addition to exhibiting a foul odor and discharge. The wound was debrided and ESWT was administered. 3 days following ESWT, improvement was seen and the treatment was repeated 2 more times q 3 days. The filly was discharged at 18 days post-attack. The patient was systematically healthy, the muzzle healed, medications were discontinued and the wound was healing. At the 2 week recheck (32 days post attack) the filly's wounds were healthy and healing.



Case 3: 12-year old male neutered Labrador retriever

Courtesy of Pam Nichols DVM, CCRP, of K-9 Rehab Center, Bountiful, Utah

The Lab presented for lethargy and inappetance, with a waxing and waning history of several months duration. He was found to have a large (10 pound) splenic mass. The mass was removed surgically with a routine recovery. He was discharged with instructions to wear a t-shirt to prevent licking. Unfortunately the shirt chosen was too restricting and both forelimbs became edematous due to pressure around and under both axillae. The shirt was removed; the limbs were massaged and appeared to be fine at that time. Two days later, the owner reported that he had been licking his right front foot "a lot" and that it seemed painful and had a foul odor. He was seen that night at the emergency hospital and treated for moist dermatitis with additional antibiotics (Clavamox® in addition to his postoperative Convenia®) and epsom salt soaks. His foot was not shaved at that time. His abdominal incision was healing nicely.

He presented to the K-9 Rehab Center for recheck the following week at which time, the foot was shaved and cleaned, however the skin sloughed completely off the dorsal surface of the P3 and P4. He was placed under anesthesia and the wound was then surgically debrided. The following day he was rechecked again, the tissue was more necrotic and the slough had progressed around the toes. He was anesthetized again and ESWT was used to stimulate healing with 750 pulses delivered at E3. He was then treated with wet to dry bandages daily for the next 7 days to resolve the infection and stimulate granulation.

At the next recheck, radiographs showed osteomyelitis of P4 with tremendous soft tissue swelling, although granulation tissue was beginning to appear all the way around the wound edges. 750 pulses of ESWT at E5 were delivered for the osteomyelitis and he was given IV Enrofloxacin. He was also prescribed 750 mg Ciprofloxacin BID. One month later, he was found to have necrosis of the last vertebral body on the tip of his tail, the skin was dead, the bone protruding. He was anesthetized again for tail amputation and ESWT 500 pulses at E5 were delivered to the dorsum of P3 and P4. Healing is much more advanced.

At 4 months since the original presentation he has not lost any nails, although one grows at an odd angle. The tissue is healed well and granulated in. Dr. Nichols states "I am not certain what the outcome would have been without ESWT, because in my experience I have never seen such invasive aggressive infection. We did support him throughout with antibiotics and pain medications. Incidentally, the tail healed with no complications and the splenic mass was a benign hematoma with a few atypical cells." At five months following initial presentation, he is doing well and the foot wound continues to improve.

Case 4: 9-year old male neutered Weimaraner

Courtesy of Pam Nichols DVM, CCRP, of K-9 Rehab Center, Bountiful, Utah

The Weimaraner presented in early February for a routine examination and the owner was concerned about his excessive licking of a granuloma on his left dorsal carpus. A lick granuloma was diagnosed in April of 2008, but topical drops of steroid and DMSO had not been successful. Treatment with ESWT was discussed and scheduled. The owner opted for ESWT with no other treatment. Two treatments were delivered at 2 weeks apart. He was administered general anesthesia and then 500 pulses at Energy level E2 with the VersaTron 4 Paws 5mm Trode. The owner declined the third ESWT treatment as the lesion had completely resolved within 3 weeks of the second treatment. At a 3-month follow-up there had been no further licking or irritation of the lesion and the hair had completely regrown.

Lick granuloma prior to treatment. 2 years duration. Failed conventional therapies.

Complete healing with 2 ESWT treatments.

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