EQUUS

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THE WAVE OF THE FUTURE?

ALTHOUGH QUESTIONS REMAIN, EXTRACORPOREAL SHOCK WAVE THERAPY SHOWS PROMISE IN HELPING EQUINE BONES AND LIGAMENTS HEAL FASTER.

By Laurie Bonner

Nothing like a tendon or ligament injury to teach you the meaning of time. It's tough enough for a person to wait out the long months of inactivity it takes for those fibrous tissues to heal. It's even worse for a horse, whose injured leg must continue to bear at least a share of a thousand pounds of body weight. Tendon or ligament injuries are slow to heal and, if they don't lead to outright retirement, they can keep horses out of work for many months or even a year or more. Little can be done to speed the healing process, and for some horses no amount of time is enough for a return to soundness.

That may be changing. A growing number of veterinarians and researchers are becoming convinced that extracorporeal shock wave therapy (ESWT), a noninvasive treatment borrowed from human medicine, can speed the healing of several types of equine orthopedic injuries and conditions. Introduced in the United States about six years ago, ESWT uses a tightly focused beam of energy waves that can penetrate the skin and muscle tissue to reach injured ligaments and bones.

The therapy, adapted from the technology used to break up kidneys stones (a procedure called lithotripsy), has been used in Europe for more than a decade. In fact, European researchers have reported that some 85 percent of people who have received ESWT for chronic conditions like heel spurs and tennis elbow experienced pain relief and improved function. Success rates tend to be lower in more scientifically rigorous, placebo-controlled studies, but they were high enough for the U.S. Food and Drug Administration to approve ESWT for treatment of heel spurs and tennis elbow that fail to respond to conventional therapies for at least six months.

Based on these positive results, more and more veterinary practices around the country have begun offering ESWT. Though no nationwide figures are available, "the number of users has just skyrocketed in the last year or two," says Scott McClure, DVM, PhD, of Iowa State University. "When I first came to Iowa State two years ago, we were the only people offering ESWT between here and Chicago. Now it's in Omaha, Des Moines and every other major city."

As the veterinary use of ESWT continues to rise, research into the effects of the therapy on horses is only just beginning. The preliminary results, however, are encouraging. In multiple studies conducted at Iowa State University, the University of California–Davis and elsewhere, ESWT has been shown to measurably reduce lameness among horses with navicular syndrome, ligament injuries and other chronic orthopedic problems that had failed to respond to conventional treatments.

If ongoing research yields similar results, says Jack Snyder, DVM, PhD, of the University of California–Davis, ESWT may one day become the treatment of choice for some equine musculoskeletal injuries. "It takes a while for research to catch up with practice," says Snyder, "but it's becoming clearer that what research we have so far is showing that there is a positive effect from ESWT."

PHOTO BY MANEPHOTO; GRAPH COURTESY, SCOTT McCLURE, DVM, PHD

IN PRACTICE

Shock wave therapy equipment is portable, but the treatments are most often administered in clinics, generally at a cost of a few hundred dollars per session. Horses receiving shock wave therapy are typically sedated but left standing. The skin at the treatment site is shaved, and a contact gel is applied to ensure unbroken contact under the device. The machine makes a noise like a jackhammer, but, says Scott McClure, DVM, PhD, shown here treating a suspensory injury, the sound "doesn't seem to bother the sedated horse."

COURTESY, SCOTT McCLURE, DVM, PHD

Not so shocking

Despite its name, ESWT has more in common with ultrasound imaging than with electroshock therapy. "When people hear 'shock' they think it's electrical, but it's not," says Snyder. "It's a pressure wave." Any action that displaces its surrounding medium causes a shock wave—just as a tossed stone pushes away the water and causes concentric ripples on the surface of a still pond. "Thunder is the shock wave caused by lightning," Snyder explains. "An earthquake sends shock waves through the ground."

Like ultrasound technology, ESWT is the application of acoustic waves that penetrate living tissue. But ultrasound waves are of low intensity compared to those produced in ESWT. "The energy in ESWT is hundreds of times higher," says McClure.

These high-energy waves pass relatively unimpeded through the fluid-filled cavities and cells of soft tissue like skin, fat and muscle. But, says McClure, when they encounter the resistance of denser structures such as ligament or bone, the waves slow to a near halt. This "crash" releases large amounts of energy, which is absorbed by the surrounding tissue. This, in turn, unleashes several physical forces within the tissue. First, the tissue struck by the leading edge of a shock wave experiences *compression,* just as a torpedo shooting through water pushes on the water in front of its nose, squeezing it as it is pushed out of the way. But the bone or tendon cannot yield the way water does. Instead, sudden, intense *shearing* forces develop as the shock waves attempt to push aside the denser tissues but cannot. Also, in the wake of each high-energy wave is a trough, where the pressure in the tissue actually drops below its starting point; this sudden drop in pressure causes *cavitation,* the formation of gas or vacuum bubbles—just as bubbles form in the wake of the speeding torpedo. Those bubbles collapse almost immediately when the surrounding fluid moves back into the area it had just been pushed out of, restoring the original pressure level, but all of that motion causes a series of currents in the fluids within the tissues that continue after each wave has passed.

Careful where you point that

All of those physical forces produce measurable effects within the various types of tissue they encounter, and researchers are working to document how cells are affected by ESWT. "We know a lot of little pieces of the puzzle," says McClure, "but what one or combination of those effects creates our clinical results in the body, we don't know yet." Nevertheless, researchers from all over the world are beginning to amass evidence of ESWT's effects on different types of tissues in many species:

■ *Bone.* For almost a decade, researchers have been documenting the ability of ESWT to stimulate osteogenesis—the formation and development of new bone tissue—but exactly how the shock waves affect bone cells is still unclear. In one preliminary study with horses, McClure examined bone tissue for the presence of osteons, the cells that indicate that bone formation is taking place. He found 30 percent more osteons at the sites that had been treated with ESWT than in the control samples.

■ *Cells.* In vitro[0] studies have shown that ESWT can have a number of effects on tumor cells, including increasing the permeability of the cell walls and stimulating cell division. The shock waves also stimulate production of a number of bioactive substances, such as free radicals, nitrous oxides and growth factors, that contribute to many metabolic processes including growth and neurotransmission. However, it is not yet known whether all of these effects would also occur within live animals.

■ *Ligaments and tendons.* "We don't know the exact mechanics of how ESWT affects ligaments," says McClure. One possibility is that the shock waves stimulate the fibroblasts—the cells that generate new connective tissue. A 2003 study has shown that ESWT has an effect on people with calcifying

tendonitis—a condition in which inflammation causes calcium deposits to form within the tendons. In the Italian study, 108 people with calcifying tendonitis in the shoulder were treated with ESWT; one year later, X rays showed that the calcium deposits had disappeared in 68 percent of the cases, and significant reductions of the calcifications were noted in an additional 17 percent.

■ *Nerves.* McClure collected nerves from sheep treated with ESWT and found signs of swelling and inflammation that lasted about five days after the treatments—a finding which McClure suggests could cause an analgesic effect.

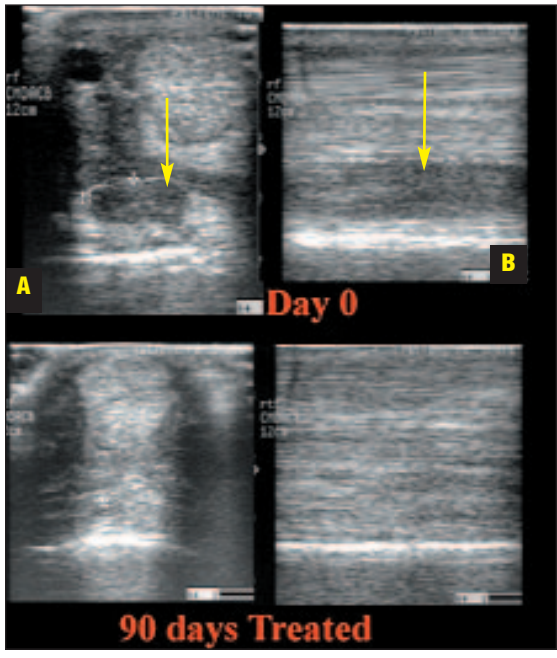
■ *Capillaries.* The application of ESWT to the Achilles tendons of dogs resulted in the development of new blood vessels (neovascularization), which in turn increased circulation in the area. But no one has yet begun to look for this effect in horses, says McClure, adding that some of the equine injuries most likely to be treated by ESWT—suspensory ligament strains, for example—involve structures that have few blood vessels to begin with. "You're starting out with a whole different environment in the ligament, so it won't shock me if we can't find that effect," he says. "However, circulation is better at the attachment, where the tendon meets the bone, so I would expect to find neovascularization there."

As researchers have documented the potentially beneficial effects of ESWT, they have also learned more about the inadvertent damage the technology can cause. For example, serious injury can result if ESWT is misdirected at any tissues not dense enough to absorb the pressure waves. A recent Taiwanese study with dogs found that shock waves can cause inner layers of the wall of the femoral artery to separate, leading to life-threatening weak spots. In addition, ESWT is dangerous when applied to gas-filled structures, such as the lungs or intestines. Because air is so much less dense than muscle, bone or connective tissue, the impact of the shock waves is much greater at the border zone and can lead to hemorrhage and severe tissue damage.

Evidence of efficacy

Although disagreement remains about the ultimate efficacy of ESWT, a growing body of research suggests that the therapy can do three things for horses: stimulate bone repair, reduce the pain of some injuries, and speed healing of injured ligaments.

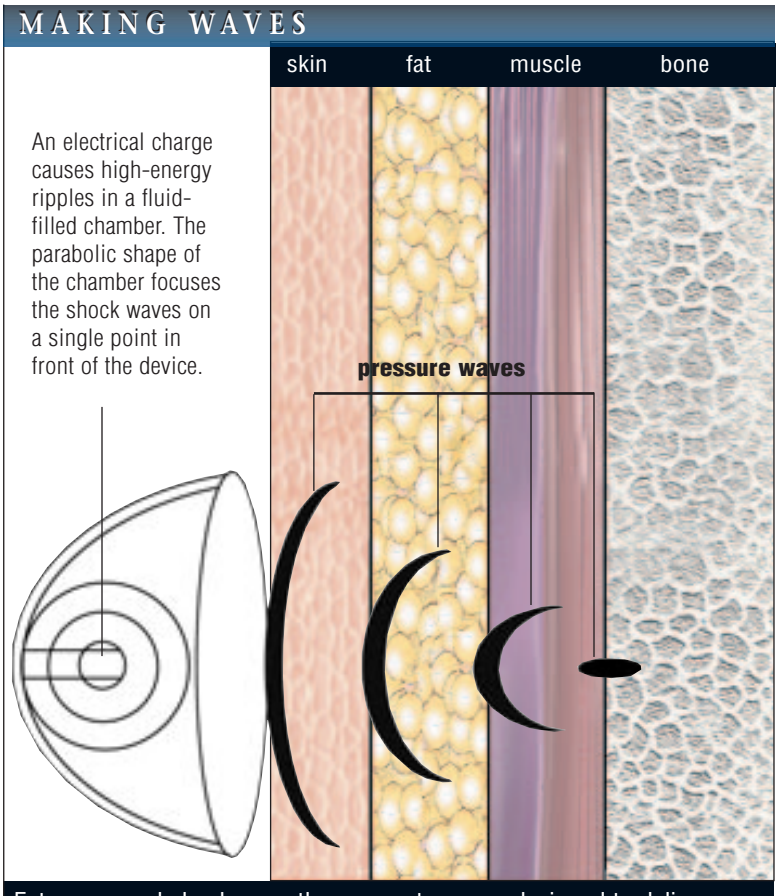
Because ESWT can stimulate the generation of new bone cells, it has been used extensively in Europe to treat nonunion fractures—fractures that fail to unite with conventional treatment over a standard period of time—since the early 1990s. "Studies with many people have shown that ESWT will stimulate bone healing," says McClure. "In a study where nonunion fractures were created in dogs, all five of the treated dogs healed, while only one of five nontreated dogs



These ultrasound images, taken for a recent study, show a lesion (arrows) in a horse's suspen-sory ligament, seen in cross section (A) and in longitudinal view (B).

Ninety days after treatment with shock wave therapy, the lesions are gone. Untreated control lesions in the same study (not shown) were still visible after 90 days.

COURTESY, SCOTT McCLURE, DVM, PHD



Extracorporeal shock wave therapy systems are designed to deliver a tightly focused beam that affects target areas as small as a few millimeters across while avoiding other sensitive tissues such as arteries and nerves. Pressure waves travel relatively unimpeded through fluid-filled tissue like skin, fat and muscle but "crash" when they encounter denser structures such as ligament and bone. The resulting increase in blood flow to the area is believed to stimulate healing.

ART BY CELIA STRAIN BASED ON AN ILLUSTRATION COURTESY, SCOTT McCLURE, DVM, PHD

Earthquake in a bottle

A shock wave that reaches a magnitude of 100 times atmospheric pressure is a formidable tool, and generating and controlling that force requires some careful engineering.

Several manufacturers are selling ESWT systems that use different technologies for generating shock waves, but they all work in a similar way: A displacement is generated at the base of a satellite-dish-shaped grid encased in fluid; that displacement sends pressure waves through the fluid, which are focused by the parabola to reach their peak of intensity on a small point out in front of the instrument. The shape of the parabola can be adjusted to change the focal point, depending on how deep into the tissue the shock waves need to reach.

"All of these are focused, high-energy systems, but there are some differences in the amount of the focus and the shape of the waves themselves," says Scott McClure, DVM, PhD, of Iowa State University. The slight differences in the shock waves generated by each of these systems may also translate into variance in their therapeutic value. In time, research may discover that one system is more effective than the others at treating certain types of injuries.

In recent years, some work has been done with a new type of treatment called radial pressure wave therapy (RPWT), which generates shock waves radically different from those produced in ESWT. Instead of a parabolic grid, the RPWT uses a system that is more like a gun barrel that, when "fired," sends a cylinder down a tube to create a shock wave at the surface of the animal's skin. Whereas the shock wave produced in any ESWT device reaches its strongest point at the focal point, deep under the muscle, RPWT generates a pulse that is strongest at the surface, and the power decreases as it radiates into the tissue. Also, ESWT is tightly focused, directing most of its energy into a spot as small as a few millimeters in diameter, while the shock waves generated by RPWT radiate outward in a diffuse halo.

Little research has yet been published on veterinary uses of RPWT, but one human study reported success rates of more than 80 percent in treating tennis elbow and heel spurs. And preliminary equine studies with RPWT have shown success rates as high as 71 percent in returning chronically lame horses, who had failed to respond to conventional treatments for more than a year, to soundness.

did." The research on horses is only just beginning in this country, but two separate studies—one at Iowa State and another at UC–Davis—showed a positive response to ESWT among horses with navicular syndrome. In both, about 65 percent of horses improved by at least one lameness grade.

Another type of equine injury that seems to respond well to ESWT is inflammation of the suspensory ligament, which runs from the back of the upper cannon bone to the pastern bones and supports the fetlock joint, preventing it from sinking to the ground. When McClure induced suspensory ligament lesions in four horses, he found that the ESWT-treated injuries healed significantly faster. After 15 weeks, ultrasound examinations showed that the treated lesions were a third smaller than the untreated controls. A group of German researchers used ESWT to treat 30 horses who had chronic suspensory ligament inflammation that had failed to respond to conventional treatments for at least three months. Six months after the last treatment, 24 were sound, and 18 of those horses were back in full work; only three of the original 30 showed no improvement. "There's no question that ESWT has made a difference in how we treat suspensory injuries," Snyder says.

ESWT also appears to produce at least some analgesic effect in horses. In a preliminary study conducted at Louisiana State University, radial pressure wave therapy (RPWT), a variation of ESWT (see "Earthquake in a Bottle," at left), seemed to affect the speed at which nerve impulses traveled, an effect that could dull pain sensation. For the study, RPWT was applied over the palmar digital nerve, which is associated with navicular and/or heel pain, of six horses, with noticeable results, says Daniel Burba, DVM, who led the study. "Their cutaneous sensation was affected immediately after application, which we determined by receiving no response to a pointed probe applied on the heel," he reports. When examined under an electron microscope, the treated nerves were found to have damage in the myelin sheath that covers the neuron. "The nerve sheath is responsible for the conduction of nerve impulses, so the disruptions we found are probably why the velocity [of nerve impulses] was dampened," Burba explains, adding that residual effects lasted up to 35 days.

Worried that, by masking minor orthopedic pain, shock wave therapy could increase an equine athlete's risk of breakdown, the Fédération Equestre Internationale and several state racing boards, including those in New York and California, have put in place rules forbidding the use of ESWT in the days before competition.

However, the analgesic effects of ESWT in horses are still being quantified. In one study, McClure attached electrodes to evaluate skin sensation over horses' cannon bones and slowly increased the dose of electricity applied to document the threshold of reactivity in the horse—as soon as each horse was able to feel the electricity, he would move as if a fly had landed on his skin. Then the horses were treated with ESWT, and their sensitivity threshold was measured again. "We found a decrease in the reaction for four to five days posttreatment," McClure says. Yet when McClure repeated his study on the nerve at the sesamoid level—which affects the heel—there was no noticeable change in the horses' response. "Clearly, there are still gaps in the data," he says.

RESEARCH

Sorting through the data

After nearly 20 years, research into extracorporeal shock wave therapy (ESWT) is still in the early stages. The work began in Germany in the mid-1980s, when researchers there began to look into how the shocks generated by lithotriptors affect other body tissues. One early discovery was that fractured bones treated with ESWT healed faster.

Soon ESWT was being offered—with good results—to patients with fractures that had failed to heal with conventional treatments. By the 1990s, ESWT was also being used to treat several types of chronic long-term injuries in people, including tennis elbow, calcified tendonitis of the shoulder and plantar fasciitis, a painful inflammation in the connective tissue that runs under the sole of the foot. In order to receive this experimental therapy, patients agreed to participate in case studies that would monitor their progress closely. Only people who had failed to respond to conventional treatments—such as anti-inflammatory medications, bracing and rest—for at least six months qualified to receive ESWT; usually, it was offered as a last resort before surgery.

Though researchers don't yet understand exactly how ESWT affects tissue to produce healing, one fact emerged from these early reports: Most patients treated with ESWT seemed to feel better. In study after study, the majority—usually more than 70 percent—were in time able to resume their normal activity with no further pain.

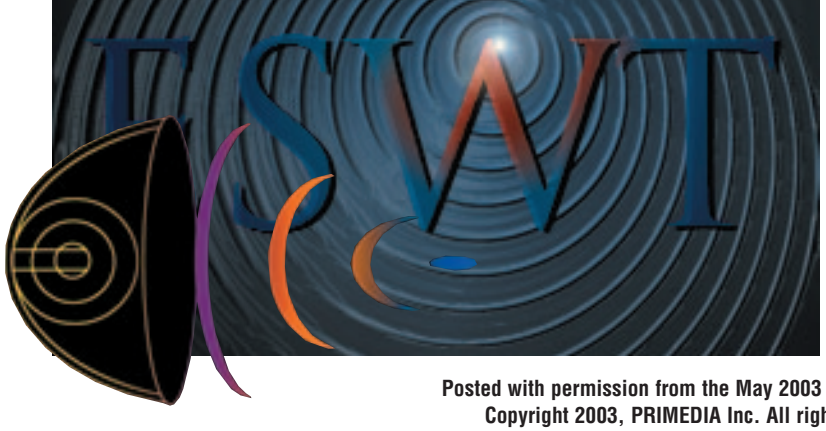
As promising as they may be, case studies alone aren't enough to validate a new treatment. There is always the possibility that the people will report improvement simply because they believe the treatment is working, a phenomenon known as the placebo effect. Controlled (also known as double-blind) studies rule out the placebo effect by giving half of the participants the actual treatment and half fake (placebo) treatments; neither the participants nor the technicians know which participants are receiving placebos or treatments until the end of the study.

The controlled studies done with ESWT so far have yielded mixed results:

◆ In September 2002 Australian researchers found no difference between the effects of ESWT and placebo treatments on 160 people with plantar fasciitis; 26.3 percent and 25.7 percent of each group, respectively, reported about the same amount of improvement after 12 weeks.

◆ German researchers reported much better results in a similar study of people with plantar fasciitis published in the same month last year: 88 percent of the group treated with ESWT were pain free and had improved function, while no one in the placebo group was pain free and only 33 percent reported improved function.

◆ A recent U.S. study of people with tennis elbow landed right in the middle—45 percent of the treatment group improved, while only 23 percent of the placebo group did.



The next wave

Over time, Snyder believes, many of the remaining questions about ESWT will be answered. "There will be a snowball effect," he predicts. "If we continue to see positive results, that encourages others to research it as well, and I predict that over the next five years we will be seeing a substantial amount of new studies coming out on ESWT."

In the meantime, practitioners using this new therapy sometimes need to use trial-and-error and/or educated guesses in applying ESWT as even basic treatment protocols—the intensity, length and frequency of applications—undergo refinement. "You would postulate that different types of tissue would require different treatment protocols," says Snyder. "We do know, for example, that bone gets a positive response with just one treatment, but with ligaments, it appears that you need to treat the horse as least three times. Even then, after the third treatment I wait 45 days. If the horse is still lame, I will treat again."

The optimal amount of energy to use in different situations is also still being investigated. In a 1990 study, low doses of ESWT were found to stimulate faster healing of skin wounds on piglets, while high-energy ESWT actually delayed healing, and moderate doses had no effect. In other studies with various animals, too much high-energy ESWT led to tissue death.

Even the type of tissue that will respond best to treatment is not entirely understood. "Personally, I don't see the same positive effect in tendons as I see in ligaments," says Snyder. "That doesn't mean it doesn't work in tendons but it may only mean that tendons would require different protocols." In horses, ESWT has so far shown promise with stress fractures, bucked shins, bone spavins and navicular syndrome, and, says McClure, "there has been some early interest in using it to treat osteoarthritis, but there's no data to support that yet."

For now, it seems, the limited studies and anecdotal evidence of ESWT's efficacy will be enough to fuel demand for the technology even as research to quantify the therapeutic effects continues. But for many horse owners and veterinarians, ESWT has already shown its value by helping particular horses overcome injuries that lead to chronic lameness.

By adding "a lot of case studies and data to our work" these ongoing applications will bolster research efforts, says McClure. Over time, he predicts, the resulting body of information will yield a better understanding of ESWT's benefits and shortcomings. "I think we'll still be using ESWT in 10 to 20 years for certain things," he adds. "The equipment has changed dramatically in the last four years, and it will continue to change for the better." ⌂

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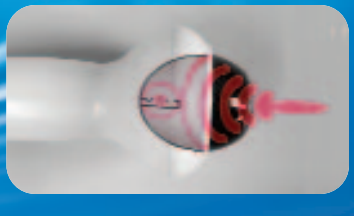

For more than 20 years, extracorporeal shockwave therapy (ESWT) has been established worldwide as the standard of care for the treatment of kidney stones. In 1991, High Medical Technologies (HMT) developed and clinically tested the first FDA approved shockwave device designed for orthopedic use in humans.

The positive results in human orthopedic medicine for a number of indications encouraged the development of the first device suited for veterinary medicine. To date, more than 10,000 horses have been treated and high energy shockwave therapy becomes increasingly popular for use in small animals.

Equine indications include, but are not limited to:

- Tendinopathies and desmopathies
- Delayed healing and stress fractures
- Osteoarthrithis
- Navicular Syndrome when associated with ligament disease or bursitis
- Back pain when associated with muscular soreness or Kissing spine disease

Canine indications include, but are not limited to:

- Tendinopathies and desmopathies
- Delayed or non-union fractures
- Osteoarthritis

Your veterinarian can evaluate your lameness problems and determine if shockwave therapy is indicated.

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