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Mechanism of Action:
StemWave® ESWT delivers shockwaves through a high energy electrical discharge in water. The electrical charge, produced in the shockwave generator unit sitting in the cabinet below the device, passes through the cathode (positive pole) to the anode (negative pole). The gap between the two poles is called a gap junction. The electricity passes through the gap, superheating the saline solution between the two poles to thousands of degrees Fahrenheit, creating a plasma bubble. In essence, the electricity is dissociating the water molecule, splitting it into hydrogen and oxygen molecules. The reaction is quite violent as the plasma bubble first implodes, creating a radial wave, and then explodes, forming the shockwave. This is what occurs to the plasma bubble. The wave pattern of a true shockwave is unique. ONLY a plasma bubble explosion can create a true shockwave pattern.

Although piezoelectric and electromagnetic are considered forms of shockwave, they do NOT meet the exact criteria of a true shockwave as there is no singular 5-10nm (n=billionth of a second) high amplitude/pressure spike of 100 MPa (1000 Bar) with an immediate drop off to a tensile wave. Both piezoelectric and electromagnetic form from an accumulation of acoustic waves distal to where they are being created. Only electrohydraulic is produced at one instantaneous short period of time at a specific location. Please note that all forms of ESWT have been shown in the literature to have merit, depending on the application. It is not my intent to discredit other forms of acoustic therapies, but rather to extol the advantages of focused, true eh-ESWT (StemWave®).

The eh-shockwave spreads out in all directions, and the focused applicator head concentrates the energy like a funnel in a forward direction. This is different from an unfocused ESWT, which more-so moves the shockwave in a straight direction, not unlike a wide flashlight beam. The shockwave travels into the body at 1500 m/s, or 3355 mph. The narrowest point of the shockwave is at 4.1 cm from the formation of the shockwave. Once at this point, it diverges again. In effect, the shockwave is more like the shape of an hourglass vs. a funnel, as the shockwave converges and then diverges. Focused shockwaves allow for deeper penetration and less energy use as the size of the impedance

zone is decreased when applying similar amounts of EFD (energy/electronic flux density) compared to other technologies. Despite the speed of the shockwave, it does NOT create any micro trauma. This is not to say that true eh-ESWT cannot create cell damage if too much EFD is used. It can. However, when used with proper parameters, learned from training, the risk potential is negligible.

When we discuss radial pressure waves, their wave form is 3 μs (millionth of a second) and they move at 30 m/s. Radial pressure waves have a low steeping effect and slow rise time. Most all the energy of a radial wave is dissipated at the skin surface. According to Jokinen, “A scientifically correct classification of shock waves used in contemporary ESWT would have to distinguish between focused shock waves, focused pressure waves, and radial pressure waves.” This is important to note. Radial is not shockwave producing.
A true shockwave (focused electrohydraulic ESWT such as StemWave), has 3 distinct components:

1. Acoustic pulses with high positive pressure (up to 100MPa)
2. Fast and steep rise time
3. Comparatively small negative pressure (tensile wave).

For those curious about how ultrasound works, it does not create shock waves, but rather periodic oscillations with no peak pressure or fast rise/drop times. There is nothing even remotely close to a shockwave created by ultrasound.

Mechanotransduction:
The mechanical input delivered by the shockwave is registered in our tissues and the body adapts in a biological/chemical way. It is important to note that although a shockwave is produced by electricity, the energy going into the body is mechanical. There is no electrical discharge into the body. The way the body responds to mechanical input is called Mechanotransduction. There are many biochemical changes that occur, but the main ones of interest are changes in voltage gated sodium channels, M1 to M2 macrophage phenotype change, and upregulation of immune function as well as recruitment of mesenchymal stem cells through Toll Like Receptor 3 (TLR3) identification of mRNA release from the cell following the administration of true Shockwaves.

Effects on the Body:
When we have an injury, be it a macro (big) trauma, or micro (small) trauma, our tissues must be able to communicate with the rest of our body to inform it of the harm. This is done by damaged cells releasing different constituents, such as chromatin (affects DNA health), proteins, fats, and RNA (it forms stable double helix RNA when released in this fashion). In some spaces, it is also called cytoplasmic/cytosolic, or messenger RNA. Researchers have given a name to the group of released chemicals and that is Damage/Danger Associated Molecular Patterns (DAMPs). DAMPs create inflammatory

processes and can even play a role in disease formation due to the inflammation they Create. What is interesting about this grouping of chemicals is that it is currently believed that RNA is responsible for the heavy recruitment of the healing agents. The body responds to injury by means of Pattern Recognition Receptors (PRRs). Many of these receptors are in the Interleukin and Toll Like Receptor family. The receptors, primarily Toll Like Receptor 3, trigger the innate immune system to aid with angiogenesis, which then allows for the recruitment of stem cells (to rebuild damaged tissues). The most involved and studied are the TLR2, TLR 3, TLR4, and TLR5. The human body has 10 TLRs but there is a bit of a debate to this. The ones that most apply to our discussion about reduction of inflammation and regeneration are the TLR3 and TLR4.
Let's now apply what we learned about mechanical stimulation creating the biochemical effects we read about earlier (Mechanotransduction). We learned above those injured cells leak certain constituents. This leads to the TLR response. Physically, shockwaves, moving at 3355 mph, in essence, first compress, then stretch the cell, and although they do NOT create damage of any kind or create heat, they trick the cell into thinking something is wrong. This shockwave effect stimulates the cells to release those same constituents that damaged cells leak, and as you can guess now, the TLR response.

It is important to note that TLR3 is not tricked by just any compound coming out of a cell. TLR3 is only triggered by RNA. This is where shockwave therapy gets even more amazing. Not only do the shockwaves imitate an injury scenario without actually creating any injury, but the shockwaves are effective at downregulating (reducing) the effects of TLR4 (the TLR that tends to create too much inflammation), while enhancing the effects of TLR3 (initial inflammation followed by an anti-inflammatory effect). This is quite convenient and amazing for regeneration. ESWT actually helps your body heal better than it can on its own!

As stated above, we have two primary Toll Like Receptors that aid in the healing and regeneration process. The problem is that one of these (TLR4) actually is responsible for too much initial inflammation and that can be harmful. TLR4 can be useful as it brings about inflammation to help with fighting off bacterial infection, but it tends to create a lot of issues by bringing about excessive inflammation that can exacerbate or create its own problems. We may want to consider this the case with over-swelling of an ankle injury that leads to compartment syndrome or too much swelling in the brain after a head injury, and more. Studies show that TLR4 can create vasospasm, neurodegeneration, CNS inflammation, and a host of other bad effects. Its deleterious effects on neuroimmune and neuroendocrine function can be quite scary. Ideally, we want more of a TLR3 effect vs. a TLR4 one.

TLR3 ultimately brings about a cell protective effect. It is also responsible for angiogenesis (new blood vessels). This is a result of the Mechanotransduction. The entire mechanism of how this occurs is still not entirely understood, but it is known to occur. TLR3 also triggers what we'd consider to be a more proper immune response and aids in delivering stem cells to help regenerate. Although TLR3 is known to trigger an

early inflammatory response, it has a potent anti-inflammatory effect following. We should keep this in mind when we are administering shockwaves as too many and too much intensity might not work in the patient's favor.

We know that TLR3 and TLR4 communicate. Ideally, communication between the two helps to bring out the best innate treatment effects. However, this is not always the case. TLR4 can sometimes be too inflammatory and decrease the efficacy of TLR3. Luckily, ESWT has been shown to aid with TLR3 function while reducing the adverse effects of TLR4. This is a unique effect of true eh-ESWT.

ESWT has been shown to not only help bone and tendons heal, but also increase blood flow in muscles, help prevent arthritis, help with, bone disease, motor function, regenerate muscles, be a better option many times vs. surgery, and so much more? How about aiding organ tissue? Well, there are studies that show it does just about all of this.

ESWT has been studied and shown to help with many health conditions, such as: Peripheral nerve regeneration, diabetic neuropathy, reduction of inflammation to aid heart tissue regeneration, coccydynia, stress fractures in athletes, stem cell activation, cell proliferation and wound healing, a viable option to avoid surgery for certain musculoskeletal disorders, progressive systemic sclerosis, knee osteoarthritis, chronic pelvic pain, spinal pathology, non-unions, early adult OCD, and more. I urge you to go to PubMed and conduct a thorough research review to see all that true ESWT can offer to you and your patients!

In regard to specific musculoskeletal conditions, a meta-analysis study showed that ESWT is more successful than ultrasound for lateral epicondylitis, and there's enough data to validate its use for a plethora of tendinopathies. ESWT was shown in 2019 to be a more successful treatment approach for plantar fasciitis than methyl prednisone injections, and a network meta-analysis determined that ESWT was the best intervention when compared to 7 other interventions for plantar fasciitis. It was even shown to be as effective as foot orthotics. ESWT has been shown to be a beneficial intervention when treating tough conditions like Achilles tendinopathy, along with insertional Achilles tendinopathy, with and without Haglund's deformity. ESWT has been shown to have positive effects with lateral epicondylitis and provide for grip strength improvement for a greater period when compared with physical therapy and corticosteroid injections.
When it comes to Greater Trochanteric Pain Syndrome, ESWT is likely the best

approach. ESWT is a spectacular intervention for low back pain, as evidenced by this systematic review and meta-analysis. There are too many studies to reference here regarding the positive effects of ESWT.

Some believe that use over the spine and growth plates is not indicated but the research is rather clear on this around growth plates and clinically, there is tremendous success when treating spinal conditions as well as youth injuries that might require ESWT over growth plate regions. Provided the parameters are correct, as learned through training, spine and growth plate region ESWT use has not been shown to have deleterious effects. In fact, a case study demonstrated that care of the interspinous ligament by ESWT yielded excellent results. (of course, follow proper protocols for EFD). Chronic low back responds quite favorably to ESWT.

Safety Issues:
Regarding safety, I quote the Dedes et. al. study Effectiveness and Safety of Shockwave Therapy in Tendinopathies, in Mater Sociomed, 2018 “From the results of the present study, extracorporeal shockwave therapy is an effective modality in relieving pain intensity and increase the functionality and quality of life in various tendinopathies such as plantar fasciitis, elbow tendinopathy, Achilles tendinopathy and rotator cuff tendinopathy. It can be done on an out-patient basis with no patient restrictions and there are no significant side effects.
Extracorporeal shockwave therapy as utilized in the current study seems to be a safe and effective treatment in all tendinopathies examined.
Thus, patients who failed to respond to conventional treatment for any of the above tendinopathies can use shockwave therapy as an alternative method, which can significantly improve pain, functionality and quality of life.”
Of course, ESWT is used for far more than just tendinopathies, and the data are clear that it is very safe and offers excellent results.

Regulatory Issues:
With each StemWave® purchase comes group training along with full customer support. StemWave® also has a medical/clinical advisory board to aid doctors with clinical use.

StemWave® is registered with the FDA (Class 1 registration) and is allowed to be used and marketed in the clinical setting for “minor aches and pains.” StemWave® may apply for Class II Clearance for several uses but at the current time, this is not necessary.