

Introduction to

# ***Shockwave Therapy***



***Dr. Larry Basch, D.C., CCSP, CCEP, ICSC***

*Certified Sports, Extremity, International & Military Sports Chiropractor*

[www.RechargePulseWave.com](http://www.RechargePulseWave.com)

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## Dr. Larry Basch, D.C., CCSP, CCEP, ICSC

**Certified Sports, Extremity, International & Military Sports Chiropractor**  
U.S. Navy Sports Medicine / U.S. Marine Corps Sports Chiropractor  
USMC School of Infantry Chiropractic Clinic, Camp Pendleton, CA



First a little about me. My goal is to share my years of clinical experiences and these 21<sup>st</sup> century therapeutic tools, which I have been using in one of the nation's busiest military Sports Medicine clinics and help others in developing a successful non-invasive natural therapies practice.

The products I recommend are newer technologies, extremely safe, natural, non-invasive therapies which can be used alone, or better when used in conjunction with other therapies or treatment modalities. And if needed, can be used along with medication or other non-invasive and invasive medical procedures.

As a highly credentialed, experienced, and progressive Board-Certified Sports, Extremity, International & Military Chiropractor, I have over 32 years of experience in multi-discipline clinics including over 16 years of military Chiropractic clinic management in 4 different multi-discipline Military Sports Medicine clinics. I also have past HMO Utilization Management & Clinical Review experience as a Clinical Care Manager for the Nation's largest Chiropractic HMO. I also have years of experience providing Acupuncture in Chicago, as well as nutritional sales and hormone lab experience.

Over my career, I have worked in 28 different clinics, and I have treated tens of thousands of patients from U.S. Military, U.S. Special Forces, and foreign military, from infants to seniors to world champion power lifters, NFL & NBA professional athletes and even some Rock n Roll superstars as well as many patients with unique and special conditions. I am also a 10-year Veteran of U.S. Marine Corps and Illinois Army National Guard.

I was one of only nine Chiropractors working for the U.S. Marine Corps. Over the years, within both my military and civilian clinics, I have met with manufacturers, owners, CFO's and sales managers of many brands of PEMF, Shockwave and Lasers and more, searching for the best therapies for the best value. In my busy military practice, I have done extended, long-term demo use of numerous therapies. I will share this knowledge with those progressive practitioners looking for the best non-invasive products at the best price.

***If you are looking to purchase, Please don't just buy from a sales rep; invest and learn from an EXPERIENCED CLINICIAN & COLLEAGUE while supporting others in our profession.***

I have done the product comparisons and extensive clinical use and can share my experiences with you.  
Please feel free to contact me. Thank you, Larry

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# Shockwave Therapy Is A Revolutionary Cellular Healing Modality

## Introduction

Neuromusculoskeletal (NMSK) disorders are one of the leading causes of morbidity and mortality worldwide and their non-surgical therapeutic treatment options remain limited. Numerous research and clinical studies have shown the potential of extracorporeal shockwave therapy (ESWT) as a **safe, non-invasive, cost effective** and innovative option to address many NMSK disorders.



***This amazing technology is a successful modality for many soft tissue and neuro-musculo-skeletal conditions seen in athletes, non-athletes and seniors.***

Extracorporeal means outside the body, hence Extracorporeal Shock Wave Therapy (ESWT). Extracorporeal shock wave therapy is the non-invasive transcutaneous application of high-energy acoustic waves to break down tissue or to promote natural cellular healing and repair. ESWT evolved from the much higher intensity extracorporeal shock wave lithotripsy (ESWL) which is used to break up kidney stones. It was later found that decreasing the energy used could produce beneficial effects on a wide variety human tissues.

Physically, a shockwave is an abrupt change in pressure with a velocity higher than the speed of sound in the medium where it propagates. Thus, shockwaves are pressure waves with a very short rise time, very high pressure, followed by a wave of negative pressure (tensile wave), longer in duration but much lower in amplitude than the initial peak.

# Shockwave History

The effects of shockwaves on the body were first noticed during World War II with the use of naval depth charges against submarines. These underwater explosions near humans led to lung disruption, despite the fact that there were no signs of outer physical trauma. In Germany in the 1950s thru the 1970's there was a flurry of studies into shockwave use in medicine. Lab experiments had shown that shockwaves could disintegrate ceramic when shot through water. In 1971 in Munich, Germany the first experimental machine was developed and used to break up kidney stones, this was called Lithotripsy. In 1983, the First Commercial Lithotripter, The Dornier Lithotripter HM3, was produced in Germany. Since 1985, shockwave has been used to treat organs such as the Gall Bladder, Bile Duct, Pancreas, Salivary Glands.

Over the last 35 years, interest in these modalities grew, researchers began exploring their therapeutic potential of shockwaves. During the 1990s and early 2000s, numerous research teams shared findings suggesting that Extracorporeal Shockwave Therapy (ESWT) could be used as a therapeutic tool. In the 1990's reports about shock wave therapy on tendinitis were published. Further investigations lead to successful treatment of epicondylitis and heel spur with reported success rates between 70% and 80%. Researchers demonstrated the use of ESWT to reduce pain and promote healing in bone, tendon, ligament and fascia in patients with musculoskeletal disorders, and to reduce spasticity in patients with neurological disorders. Because of the increasing significance of shockwave therapy on soft tissue diseases, commercial machine development accelerated. Design, protocol, and contents of the published studies may differ slightly from manufactures, but all publications agree that ESWT show high efficiency but very low complications and side effects.

Extracorporeal Shockwave Therapy (ESWT) has evolved into an effective, non-invasive treatment for musculoskeletal injuries. Whereas the original shockwave devices were used to disintegrate tissues, orthopedic ESWT therapy can cause regeneration in tissue. This therapy elicits a number of biological responses at the tissue level and deeper into the cellular and even molecular levels, which impact the management of many injuries. But some treatments are very painful and require numbing cream or anesthesia.

## Applications

### Lower Extremities

- Plantar fasciitis / heel spur
- Achillodynia
- Tibial stress syndrome
- Patellar tendinitis
- Calf muscles
- Thigh muscles
- Trochanteric tendinopathy
- Pseudarthrosis

### Upper Extremities

- Low Back & Hip Pain
- Shoulder Pain
- Neck pain
- Calcific Tendinitis
- Craniomandibular dysfunction (CMD)
- Lateral & Medial Epicondylitis
- Carpal tunnel syndrome (CTS)

### Biological Effects of Shockwave

- Increased Microcirculation
- Vasodilation due to release of nitric oxide
- Cell matrix stimulation (mechano-transduction)
- Release of Substance P
- Analgesia effect (pain-gating)
- Increase of cell wall permeability (cell metabolism)
- Stimulation of growth factors (neovascularization)
- Stimulation of stem cells (cell proliferation)

# Many Names and Manufacturers of Equipment

Both forms of Extracorporeal Shockwave Therapy (ESWT) are acclaimed among today's most innovative medical technologies as they revolutionize treatment possibilities. ESWT is evidence-based, accelerates healing, treats the root cause of pain, and dramatically accelerates recovery time which is especially advantageous in treating athletes. Both types of ESWT are non-invasive and require no downtime for the patient.

There are two types of Extracorporeal Shockwave Therapy (ESWT):

**Acoustic or Radial Pressure Wave, (RPW)** is well suited for patients and athletes suffering from acute and chronic musculoskeletal and connective tissue disorders. Due to lower speed and lower peak pressure during the mechanical generation of radial pressure waves, this form is best suited for broader, superficial structures.

**Focused Shockwave (SW or fSW)** penetrates deeper into the tissue, allowing delivery of more **focused** power to targeted depths. This non-invasive approach with true shockwaves is used to treat chronic tendinopathies and various other soft tissue injuries to reduce pain and inflammation quickly while accelerating repair and generating natural healing with stimulation of the body's own innate growth factors and stem cells. In medical circles and athletics, it is hailed as an evidence-based technology and an alternative to painful steroid injections and sometimes even surgery.

Much of the research and cellular benefits have been misrepresented between Radial Pressure Wave (RPW) and (SW) aka True ShockWave. Not all shock waves are created equal. Many people confuse the Radial Pulsed Wave (RPW) created by a mechanical stylus tool with the advanced technology Electromagnetic or Electrohydraulic Extracorporeal ShockWave Therapy. Unfortunately, the term "shockwave" is very often misused, and the science can be complicated. There are many names, manufactures and types of "shockwave" therapy machines. Most are **not True Shockwave**, but rather the less expensive, less advanced technology, less powerful acoustic or radial pulse wave therapy machines. Radial Pressure Wave devices have been incorrectly referred to as "shock wave" for so long that it has stuck, though it is technically not correct. These machines **Do Not** produce True Shockwaves according to shockwave experts and associations such as the *International Shockwave Institute* and *International Society for Medical Shockwave Treatment (ISMST)*.

While RPW has limits, it also has many therapeutic benefits.

To better understand the differences in the technology, we will discuss both RPW and focused ESWT in detail.

## Two Distinct Types of Technical Principals of Extracorporeal Shock Wave Therapy (ESWT)

### 1. Acoustic or Radial Pressure Wave (RPW)

### 2. Extracorporeal Shockwave Therapy (ESWT) aka True Shockwave or SW

These two technologies differ in their generation of the wave and physical characteristics and in the mechanism of action. However, they do share some similarities.

## Names / Types

- Radial Pressure Wave (RPW)
- Acoustic Pressure Wave Therapy
- EPAT (Extracorporeal Pulse Activation Therapy)

\*Not a True Shockwave

- Piezoelectric Therapy
- ESWT (Extracorporeal Shockwave Therapy)
- fESWT (focused Extracorporeal Shockwave Therapy)
- Shockwave / focused Shockwave (SW or fSW)
- Focused "StemWave" brand
- Less focused "SoftWave" brand
- Storz Duolith fESWT

These Generate a True ShockWave (SW)

# Introduction to Radial Pressure Waves

Radial shockwaves, also called extracorporeal pulse activation technology (EPAT), uses a set of pressure waves to stimulate the healing of damaged tissues and breakdown of scar tissue and soft tissue adhesions. EPAT is not a true shockwave, but it does have a moderate regenerative effect on superficial tissues. It is good for repairing superficial muscle tissue and makes a good companion to focused and defocused shockwave therapy.

## A brief history of shock wave therapy

Shock wave therapy as we know it first came into practical use in the 1980s in Germany, originally in the form of focused true shock wave (F-SW). As with the emergence of any new intervention, there was immediately a great deal of interest and hype surrounding it. Researchers began conducting clinical trials, but with no real guidelines on parameters, results were conflicting. At the same time, therapists were treating through trial and error, with outcomes ranging from very good to poor. This led to a drop in interest during the 1990s, with practitioners becoming disillusioned with F-SW, due also in part to the relatively large size and high cost of the devices.

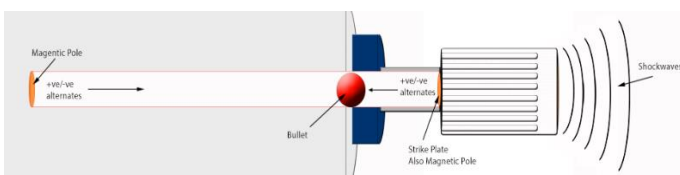
However, with the advent of modified modalities, better research, and advanced technology to study the therapeutic effects on a molecular level, interest in shock wave therapy was rekindled around the end of the 1990s. Manufacturers began building more affordable clinic-based F-SW devices, and therapists became better at incorporating shock wave therapy into their treatments, all of which helped lead to better outcomes for patients.

Then, towards the end of the 1990s, a newer lower cost technology emerged: radial pressure wave (RPW) therapy. Just as F-SW machines were becoming more affordable, RPW devices turned out to be even cheaper and could be used to treat on a more superficial level over larger areas.

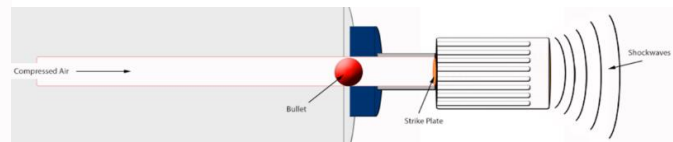
**Radial Pulse Waves (RPW)** are produced by a less expensive technology. These types of machines generate a radial or pulse type wave, which travels much slower, therefore it is not a true shockwave. RPW does not produce the same deep cellular benefits as a true shockwave. RPW manufacturers describe radial pressure wave as the same as true shockwaves, and sales reps and even practitioners often unknowingly or purposely mislead consumers when suggesting the research and benefit are the same, hence they often claim that the lower priced acoustic or radial pulse wave machines produce the same physiological benefits and clinical results as the more complex and costly true shockwave machines. Unfortunately, this is false and misleading. Actually, these Radial Pressure Wave are more like ordinary sound waves since they achieve a significantly lower peak pressure, a slower rise time and propagate outward without a focal point.

Radial Waves are produced by mechanical stimulation within the handheld probe or applicator which basically pounds on the area treated. Within the probe, a metallic bullet is accelerated at very high speed by pneumatic compressed air or by an electromagnetic mechanism. This metallic bullet hits the tip of the applicator at high speed which creates a pressure wave that can penetrate tissue. The energy of the bullet impacting against the tip of the applicator itself directs kinetic energy which is transferred to the skin on the area of treatment.

This pressure wave propagates from the skin into the body as a spherical or ball-shaped waves, that is in a radial fashion, that gives them the descriptive term of “*radial waves*”. RPW or acoustic waves travel at speeds of approximately 10 meters per second, or **22 MPH**, which is very slow and only a small fraction compared to true shockwave speed. This speed does not break the sound barrier, so no actual shockwave can be produced. These radial waves are not focused into the deeper layers. Radial Pressure Waves have their greatest energy felt at the probe tip and on the surface of the skin, causing pain and as this energy spreads outward, it weakens and dissipates the farther it travels away from the probe. This prevents a deeper, more precise, and effective treatment. These machines require a wave generation mechanism.



**Electromagnetic RPW (Ex. Zimmer)**



**Compressed Air RPW (Ex. Storz)**

## RPW units often have different probe tips for treating various tissues.



Radial Pressure Wave Therapy causes physical / mechanical stress and cellular microtrauma, and this trauma leads to the biological reaction that can aid in the breakup of scar tissue and triggers the neovascularization of the tissue which is the increase production of new capillaries to aid in more blood flow to the tissue. It is an effective treatment method that is used to accelerate healing and recovery for acute and/or chronic muscle, tendon and scar tissue pain, without invasive operations and medications. *Radial Pressure Wave can be used to break up scar tissue, adhesions & calcium deposits.*

## Recommended Radial Pressure Wave Devices

### Zimmer enPuls

*made in Germany*

*Electro-Magnetic, High Quality*



### Storz D-Actor 100

*made in Switzerland*

*Electro-Hydraulic, High Quality*



### Chattanooga Intellect

*made in USA*

*Electro-Hydraulic, High Quality*



RPW are the most common type of “wave” used in most NMSK clinics due to lower cost of the machines. They often call their treatment something wave, whether its Shock Wave, Acoustic Wave, Pulse Wave, Miracle Wave, Pains Wave, or anything to differentiate themselves with others.

**\* CAUTION: Be Aware of the Many Cheap, Poor Quality, low priced Knock-offs or copies of the European brands made in China now on the U.S. Market. Cheaper Radial Wave is not Shockwave Wave.**

### Various Radial Brands - Made in China

**\*CAUTION\* NOT RECOMMENDED**

**Cheaper, Lower price = Lowest Quality, No Training, No Repair Service, No Product Insurance**



**\*CAUTION\* THESE CHEAP KNOCK OFFS ARE NOT RECOMMENDED**

# Summary of Radial Pressure Waves (RPW)

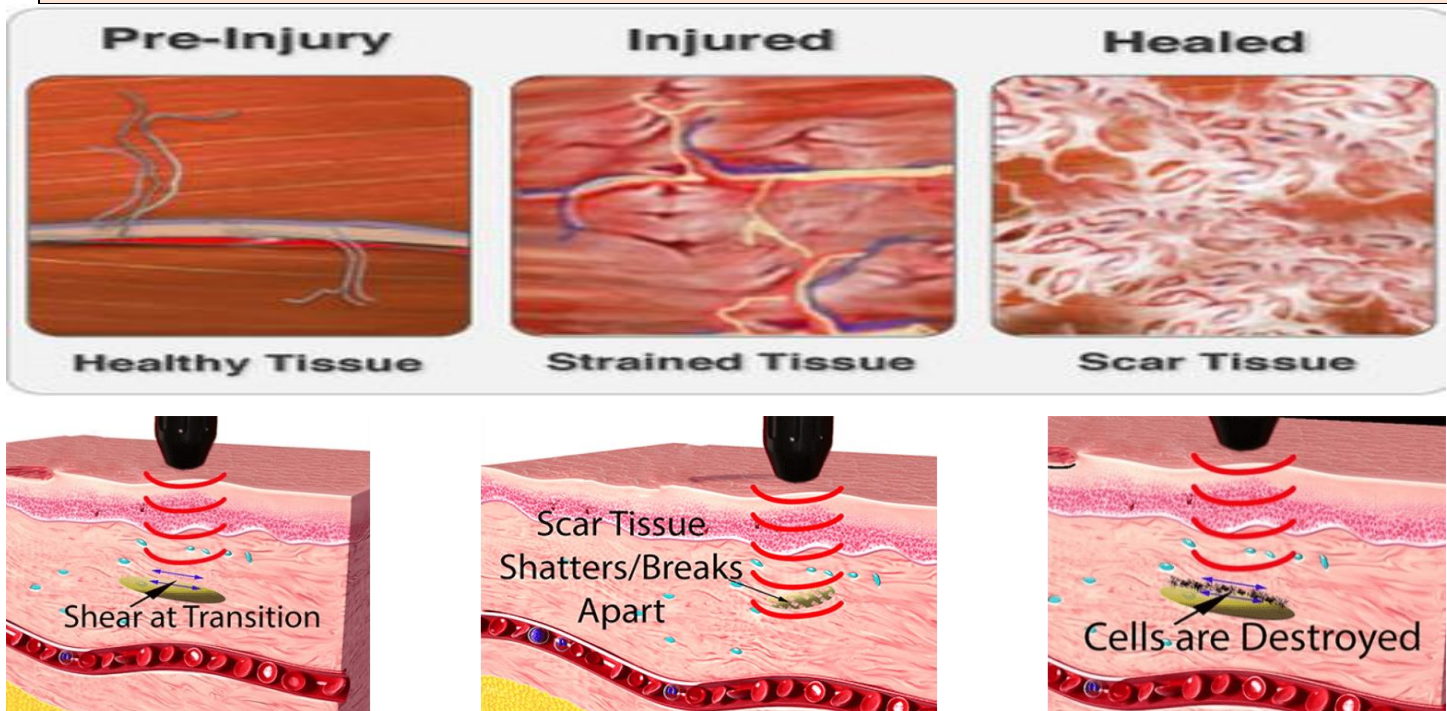
- RPW is a low cost, effective therapy good for Tendons, Muscle Tissue.
- Typical Treatment 8-12 sessions
- RPW Penetration is 3-4 cm maximum or **1.5 Inches**
- RPW is not a True shockwaves.
- RPW is slower speed compared to True shockwaves. These acoustic waves travel at speeds of approximately 10 meters per second, or **22 MPH**, a small fraction of true shockwave speed. This speed does not break the sound barrier, therefore, no actual shockwave can be produced.
- RPW does create Micro Trauma or Tissue damage so typical protocol is one treatment per week.
- RPW is low power, therefore, the penetration depth is only up to 1.5 inches. These are best used on wide areas of the body; the energy produced by the pressure wave is highest at the skin surface, causing pain and diverging and weakening as it penetrates deeper.
- Cannot use over bones, joints, too painful.
- RPW may not be effective for Stress Fractures
- Lower Cost of the Machine, many knock-offs made in China.
- Radial Pressure Waves devices are designated as a Class 1 Medical devices, a status given to personal massagers and do not require regulatory approvals and can be used by anyone, no license required.

## POSITIVE BENEFITS of Radial Pressure Wave

- Good for Tendons, Muscle Tissue, Breaks up Scar Tissue, Angiogenesis
- Typical Treatment 8-12 sessions
- Affordable Machines
- Staff Can Perform, All Cash

## NEGATIVE CONCERNS of Radial Pressure Wave

- Can create Micro Trauma or Tissue damage, so only 1 treatment per week
- Can be Very Painful when treating over or near Bone & Joints
- NOT A TRUE SHOCKWAVE
- Little to No MCS / Stem Cell Activation
- Little to No Growth Factor Stimulation

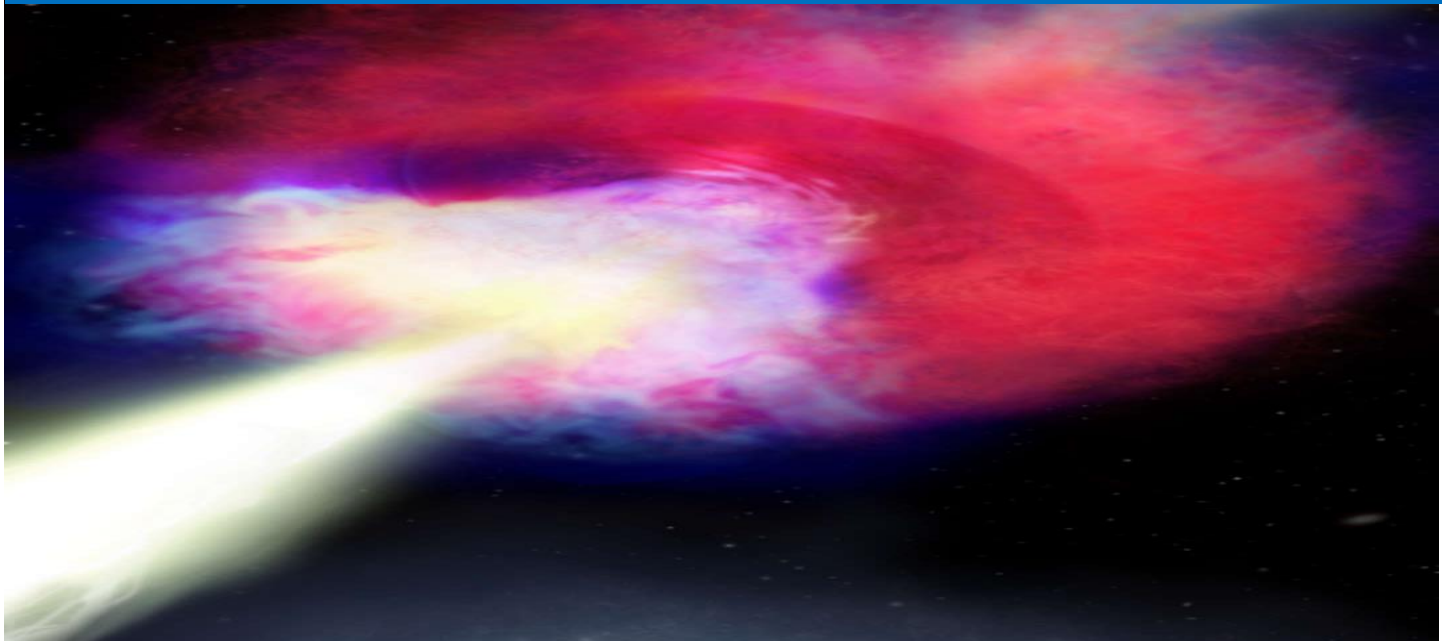


**\* Next, we will discuss ESWT or TRUE SHOCKWAVE DEVICES.**



## ***Introduction to FOCUSED Shockwave***

***True Focused Shockwaves Travel up to 3350 MPH***



***This causes injured cells to rapidly contract and expand, stimulating your body's own natural Stem Cells & other Growth Factors to assist in safe, Non-Invasive, Natural Healing.***

**True Focused Shockwaves represent a revolutionary form of mechanotherapy producing deep penetrating acoustic shockwaves.**

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## ESWT or True Focused Shockwave devices

**FOCUSED EXTRACORPOREAL SHOCKWAVE OR TRUE SHOCK WAVE** is growing in popularity, due to decreasing equipment costs, clinical outcomes, advanced research, the increased treatment options, treatment depth, treatment precision and patient comfort over bones, joints and in more acute cases.

Focused and Radial shockwaves differ not only in regard to their physical properties and mode of generation, but also in terms of the magnitude of the standard parameters (pressure amplitude, pulse duration, impact) used and the therapeutic tissue penetration depths achieved.

Orthopedists, Physiotherapists and Urologists are using both devices, but Focused ESWT devices have been shown to be much more effective in certain conditions, less painful, and don't cause micro damage to tissues compared to Radial models.

However, many clinicians are using radial models because of the economical price, and not based on actual research and clinical outcomes.

Urologists prefer Focused ESWT devices for the treatment of diseases like Erectile Dysfunction and Peyronie's disease. However, based on the cost of equipment, the radial devices (RPW) are more common for muscle, tendon conditions such as Achilles tendon, bone fracture treatment, plantar fasciitis.

### Why Choose ESWT Over Alternative Injection Treatments?

While corticosteroids offer rapid relief, they come with a plethora of potential complications, including increased risk of infection, atrophy, pain, rupture of tendon or tissue, bleeding, and so on. On the flip side, ESWT allows athletes to stay active as tolerated (as dictated by the injury and the patient). Most patients and athletes can continue with ADLs / training sessions while undergoing ESWT treatments. ESWT is well tolerated by most all ages.

PRP (Platelet Rich Plasma) is commonly utilized in sports medicine settings and can stimulate healing and reduce pain without toxicity within the body. Despite the positives, studies reveal that weight-bearing limitations and reduced activity may be necessary post-treatment, and restrictions may last from 7 days to 6 weeks. Again, ESWT allows for a more rapid return to sport and ongoing training with little to no restriction.

*While ESWT machines are an investment, remember, just one patient case per month will cover the cost of the lease.*

***This therapy will expand your scope of treatment while helping more patients avoid risky and painful injections. It will also expand your cash collections and help you grow your practice and be more competitive. More and more clinics are adding ESWT to their practice.***

***\*To be the best clinician, you need the best, most advanced tools, don't be left behind.***

## True Shockwaves have well defined characteristics which differentiate them from the Radial Pressure Waves

True Shockwave or focused Extracorporeal Shock Wave Therapy (ESWT) activates the body's own endogenous Mesenchymal Stem Cells (MSC's). ESWT causes the release of Chemoattractant factors and a number of regeneration and growth-associated molecular signaling factors in the treatment area, which stimulates Migration, Proliferation, and Differentiation of Mesenchymal Stem Cells, resulting in Revascularization, inhibition of Inflammation, Tissue Regeneration and Remodeling. The Spectrum of treatable conditions is constantly increasing from MSK, to Wound Healing, Nerve Regeneration, Cardiovascular, Urogenital dysfunctions.

### Examples of Shockwaves in Nature



**The different focused Extracorporeal Shockwave Therapy (fESWT) machines require a Generator and a Focuser.**

## True Shockwaves are generated by three different types of energy sources

**1. Piezoelectric** - The piezoelectric principle is based on a high-voltage discharge across a pattern of piezoelectric crystals. Each element expands, generating a pressure pulse that spreads toward the focal region, of the arrangement. The placement of the crystals and the shape of the sphere focus the shockwave into the tissue .

**2. Electromagnetic** - Electromagnetic shockwaves are generated by an electric current that passes through a coil. This produces a magnetic field, which produces a shockwave via the conductive membrane in surrounding water. Acoustic lenses are used to focus the shockwave into the tissue.

**3. Electrohydraulic** - The electrohydraulic principle is that in which the shockwaves are generated by a spark plug submerged in fluid. The shockwaves spread in a medium (water) and are then focused in one place by a parabolic mirror or reflector. There are two types of electrohydraulic shockwaves, less focused or unfocused electrohydraulic shockwaves (uESWT) and true focused electrohydraulic shockwaves (fESWT).

**\* CAUTION: Be Aware of the Many Cheap, Poor Quality, low priced Knock-offs or Copies of the Extensively Research European brands, made in China & USA now entering the U.S. Market. \*CAUTION\* NOT RECOMMENDED**

## Three Types of ESWT / True Shockwave

**Good**

### Piezo-Electric Shockwave

**Zimmer** (pending approval for USA sales)

Not Available in USA



**PiezoWave**

Less Research



**Better**

### Electro-Hydraulic Shockwave

**StemWave**

Knock off of Softwave - Made in Turkey \$50,000

Probe Spark plug Change 4-8 weeks



**SoftWave Ortho-Gold**

Highest Quality - Made in Germany \$60,000-89,000

Recommended, **except** Expensive Probe Refurbishment

Costly New Probe every 100,000 -350,000 Pulses or 6-8 weeks



**BEST**

### Electro-Magnetic Shockwave

*These are my recommendations based on quality, price, probe life & maintenance cost & clinical research*

**Storz Duolith SD1**

Highest Quality - Made in Switzerland \$50,000

**Chattanooga Intellect Focused**

USA version of Storz, Storz components, assembled & serviced in USA \$47,000

Probe Life on both is 2 Million Pulses or 8-12 months



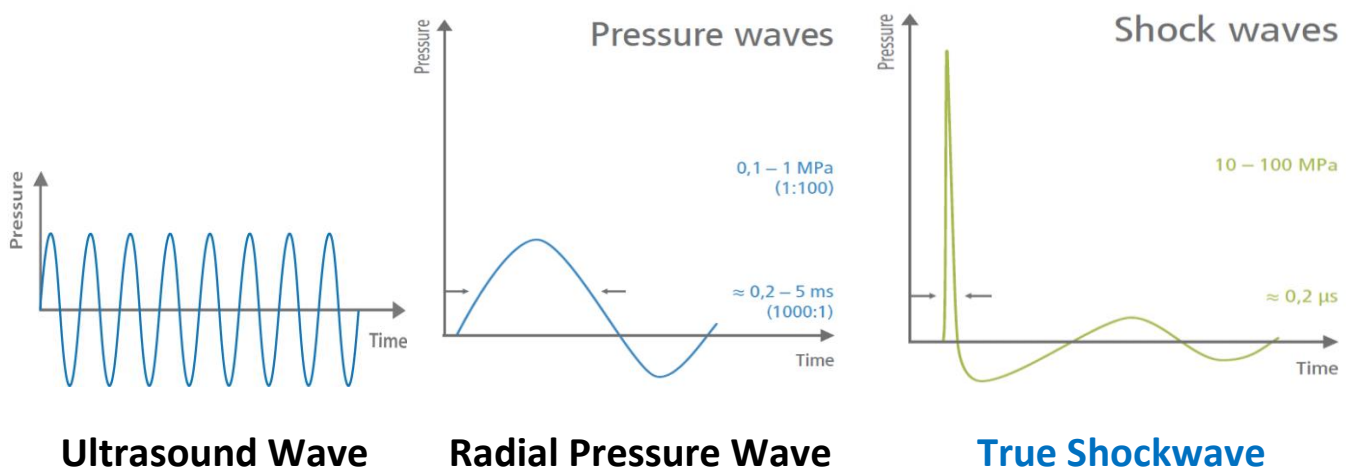
# Benefits of True Shockwave

## Stimulates

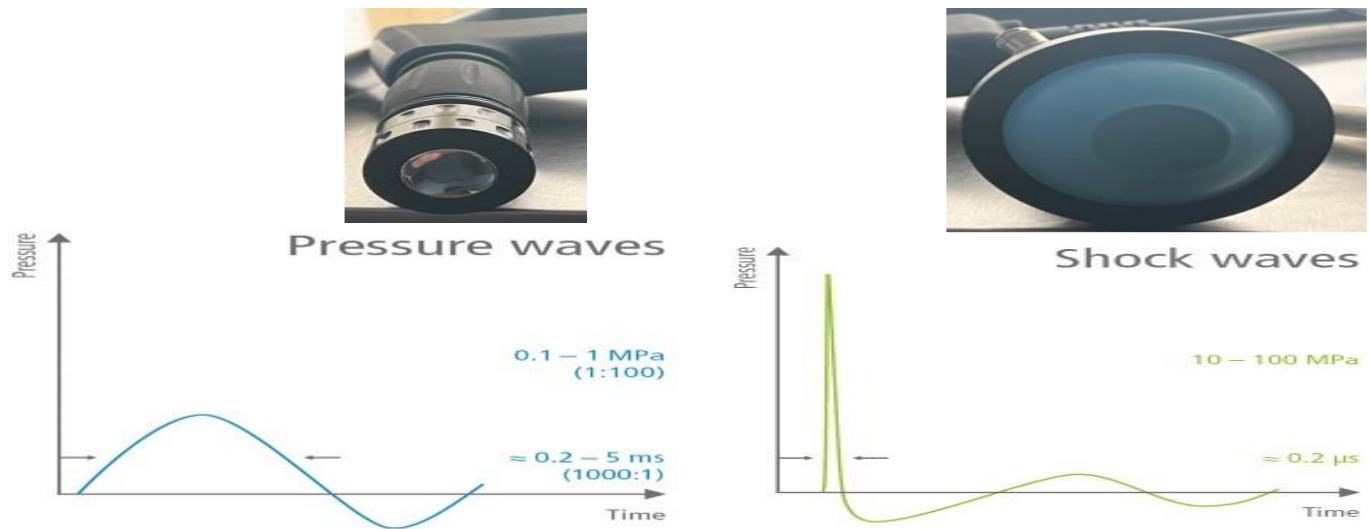
- Increased Growth Factor Migration
- Increased Stem Cell Migration
- Growth Hormone Production
- Anti-Inflammatory - **Toll Like Receptors**
- Release Substance P - **Reduces Pain**
- Increases Cell Permeability
- Accelerates Cellular Healing
- Release of Nitric Oxide
- Neovascularization
- Mild Side Effects

When our body recognizes an injury, whether it is a macro (big) trauma, or micro (small) trauma, those injured tissues have to be able to communicate with the rest of our body in order to inform it of the damage and then signal the body to naturally repair. This is done when damaged cells release different growth factors from the cell membranes, such as chromatin (affects DNA health), proteins, and RNA (it forms stable double helix RNA when released in this fashion). In some spaces it is also called cytoplasmic/cytosolic, or even messenger RNA. Researchers call this group of released chemicals, 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 (this is discussed below with research to validate this point). The body responds to injury by activating the innate immune system along with bringing in stem cells (to rebuild damaged tissues) due to a response from a certain type of receptors, called toll-like receptors (TLR). 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 TL4.

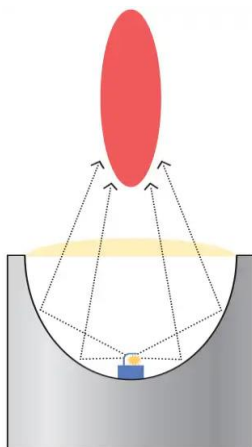
Ultrasound waves are periodic oscillations with narrow bandwidth and does not have peak pressure and fast rise times. True Shockwaves have 1000 times the pressure as ultrasound. Radial Pressure waves are acoustic pneumatic pulses with a low steeping effect, slow rise time with comparatively large negative pressure tensile wave **means more pain. The waves are shallow and have the highest energy and pressure located directly at the applicator's surface.** True Shock waves are intense acoustic pulses that build up extremely quick with **high positive pressure, fast and steep rise** time followed by comparatively **small negative pressure** (tensile wave).



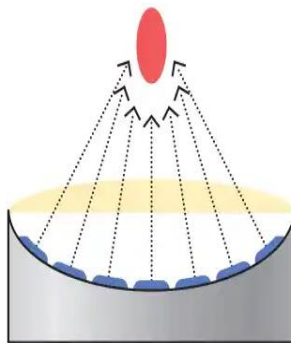
## RADIAL PRESSURE WAVE vs STEMWAVE



Stemwave technology is **FOCUSED**, utilizes a patented Ellipsoidal REFLECTOR which allows for a larger treatment area with increased accuracy and a lower re-treatment rate.



**Shockwave**



**Piezoelectric**



**Radial Pressure Wave**

**True Shockwaves have much higher energy, power, speed, depth of penetration**

	<b>True Shockwave</b>	<b>Radial Pressure Wave</b>
Pressure	10-100 MPa	0.1-1 MPa
Pulse Duration	0.2 nanoseconds	0.5-5 milliseconds
Energy	20-35 milli Joules	150-200milli Joules
Pressure Gradient	100-150 MPa/mm	0.1-0.5 kPa/mm
Pressure Field	Focused	Radial / Divergent
Penetration	<b>Larger / 4.7 Inches</b>	Small / 1.5 inches
Target	Cell Membranes	Tissues

MPa is mega Pascals 1=100 MPa is equivalent to 100 – 1000 times the atmospheric pressure.  
Pulse Duration is approximately 1000 nanoseconds, so much faster and stronger than RPW.

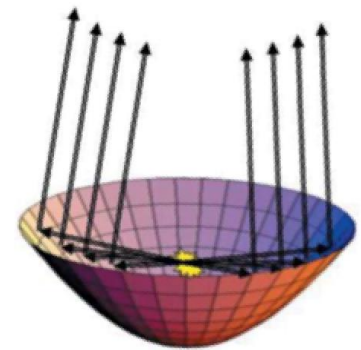
**True Shockwaves are generated in water because they travel faster than the ***SPEED OF SOUND (3350 mph)*** or the distance of 15 football fields in one second and travel up to 4.7 inches into the body.**

To put this into perspective, U.S. military fighter jet travels faster than the speed of sound and create a shockwave during flight. They occur in nature in the atmosphere during explosive events, such as lightning strikes, or when a jet breaks the sound barrier.

Shockwaves are produced within a probe where salt water and a spark plug create a “spark” of energy causing a rapid increase in pressure or a “micro-explosion” within the water filled probe. This energy is then reflected towards the injured tissues. Electrohydraulic fESWT is applied into small focal areas of 2–8 mm diameter in order to optimize therapeutic effects and reduce negative effects on the surrounding tissue. The physical effects seem to be dependent on the energy delivered to a certain area. The shockwave energy per unit area is called the energy flux density (in  $\text{mJ}/\text{mm}^2$ ). It reflects the flow of energy in a perpendicular direction to the direction of dissemination. The energy flux density is an essential parameter of dosage of fESWT.

#### **Focused ShockWave as Electrohydraulic**

- Deeper Penetration 8-12 cm deep or 4.7 inches
  - More Research on Focused or True Shockwave
  - Less Painful
  - Can use over Bones & Joints
  - Less Treatment 1-3 Sessions, More energy directed into the tissue
- Within Focused ESWT, there are three ways to produce the wave:
- **Piezoelectric**
  - **Electromagnetic**
  - **Electrohydraulic**



**ShockWave therapy *does not cause tissue damage*, can be used over bone & joints and treat a wide variety of conditions**

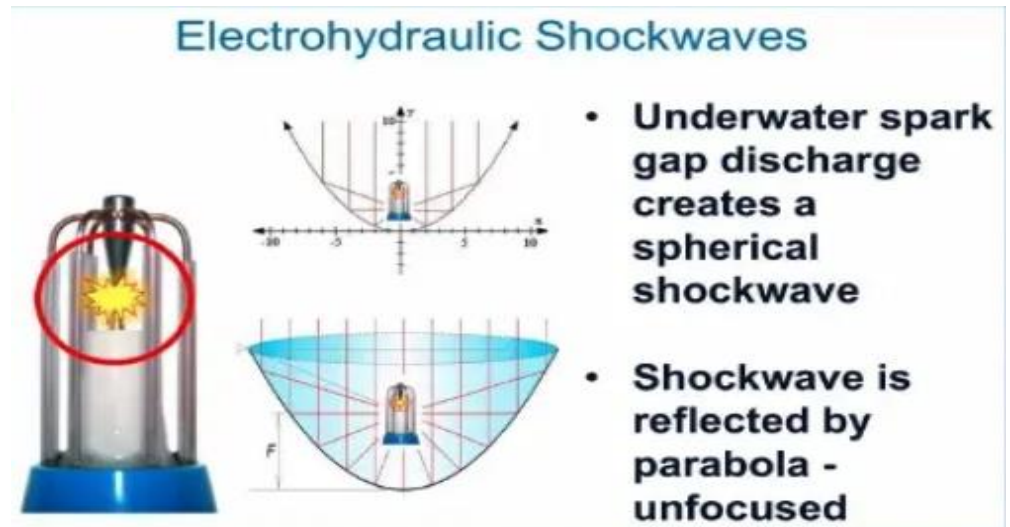
#### **STORZ Duolith SD1 Focused Shockwave Probe** (ElectroMagnetic) Below Left



#### **SOFTWARE Less Focused Shockwave Probe** (ElectroHydraulic) Below Right



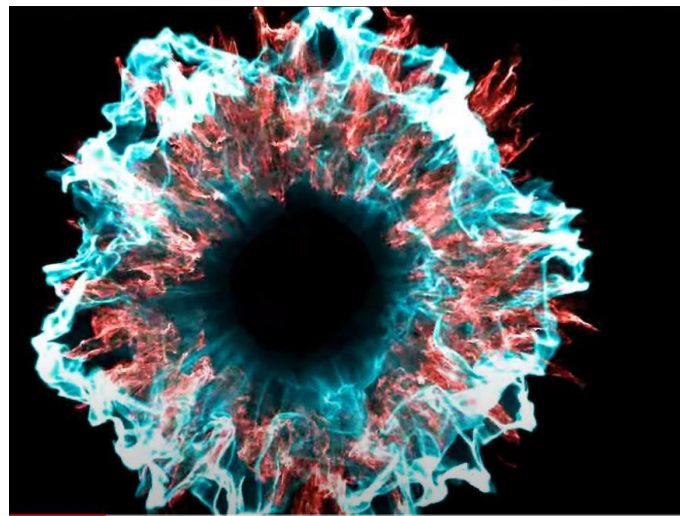
Shockwave technology utilizes a reflector to generate a shockwave within water in the probe which then travels into the body more than **4x the speed of sound** to stimulate the body's natural healing response. **This all occurs in a few nanoseconds**



The importance of mechanical stimuli on living beings, as well as the influence that biomechanical deformations can exert on cellular biology and physiology, in health and diseases, have been recently seen a renewed interest in scientific literature, especially with the purpose of possible therapeutical applications.

The reason the focused shockwave device is so effective is the machine allows us to control and focus these shockwaves to such an extent we are able to pass the shockwaves through the outer tissue of the body without any damage and little pain. The focused shockwave energy is delivered to a focus point inside the tissue where the blood vessel and soft tissue degeneration has occurred. Acoustic waves do not penetrate, they create surface level pressure outward causing redness and inflammation only in the outer tissue not deep inside where the rehabilitation needs to occur.

### ***Image of High Energy Shockwave Traveling at 3350 mph***



***High Energy Shockwaves imparts physical DIRECTED ENERGY  
to the tissues in the form of absorption, reflection, refraction, & transmission of  
energy to stimulate cellular growth, repair & regeneration.***

# Width and Depth Differences

Storz Duolith uses Electro-Magnetic system  
it can penetrate up to **12 cm or 4.7 inches** in a few nanoseconds



**Allows for Deeper  
Focused Treatment Area**

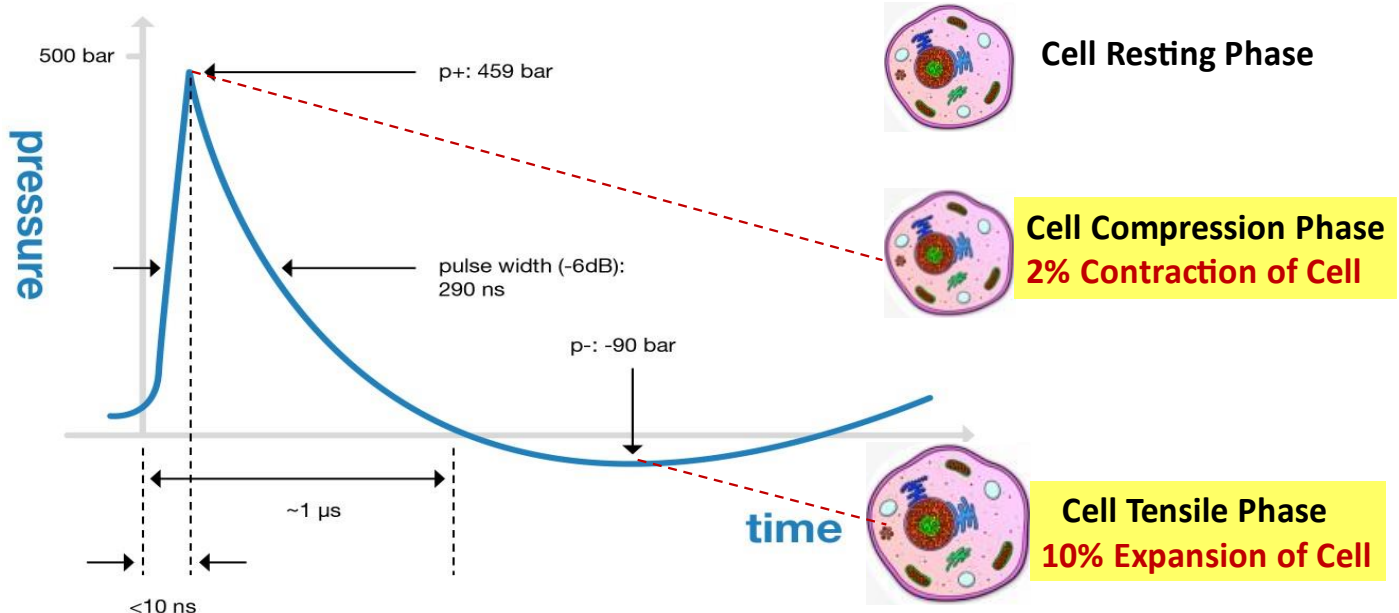


2 cm X 2 cm  
0.787 x 1.5 Inches

# Mechanotransduction

## Cellular Reaction to Shockwave Energy

Rapid High Energy cause **MECHNO-TRANSDUCTION** or very  
Rapid Contraction & Expansion of Cell Membranes



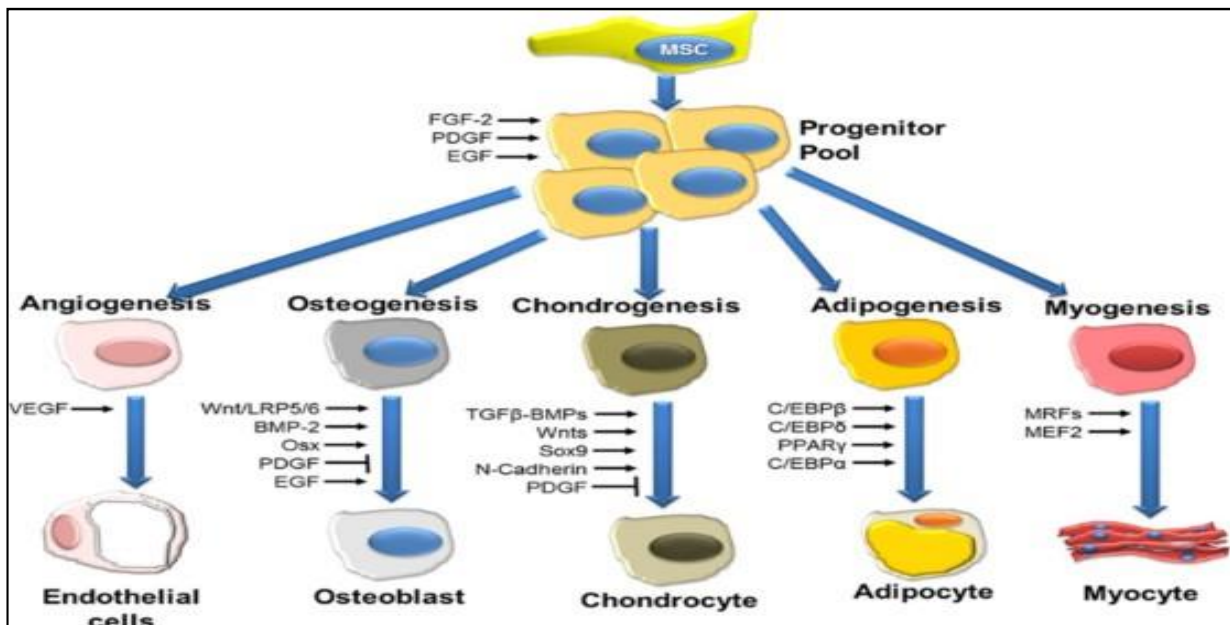
# Mechanotransduction

The High Speed of the true Shockwave causes the Stimulation, Migration and Differentiation of our own Mesenchymal Stem Cells to the targeted area.

Your Body uses its own Innate Mesenchymal Stem Cells to repair and promote long-term healing.

- Release of Macrovesicles = **mRNA, Growth Factors, Stem Cells**
- Increases cell Membrane Permeability
- Reduces Pain = Reduced Substance P = **Reduced Pain**
- Reversal of Chronic Inflammation = **Reduced Pain**
- Stimulation of Collagen Production = **Tissue Repair**
- Dissolution of Calcified Fibroblasts = **Tissue Repair**
- Stimulates New Blood Vessel Growth = **Neovascularization**
- Release of Trigger Points = **Tissue Repair & Pain Reduction**
- Increased Lactate Concentrations = **Activation Of Krebs Cycle**
- Increased Nitric Oxide Production = **Increased Blood Flow**

**True ShockWaves Increase Growth Factor Release**  
**Mesenchymal STEM Cells Release Innate, dormant Growth Factors**



Blood Vessels

Bone

Cartilage

Fat

Muscle

# Growth Factors and Cellular Effects

## Growth Factor

## Cellular Factor

### PDGF

*Platelet Derived Growth Factor*

Macrophage activation and angiogenesis  
Fibroblast chemotaxis and proliferative activity  
Enhances collagen synthesis  
Enhances the proliferation of bone cells

### IGF-1

*Insulin-like Growth Factor-I*

Chemotactic for myoblast and fibroblasts and stimulates protein synthesis  
Mediator in growth and repair of skeletal muscle  
Enhances bone formation by proliferation and differentiation of osteoblasts

### TGF- $\beta$

*Transforming Growth Factor- $\beta$*

Enhances the proliferative activity of fibroblasts  
Stimulates biosynthesis of type I collagen and fibronectin  
Induces deposition of bone matrix  
Inhibits osteoclast formation and bone resorption  
Regulation in balance between fibrosis and myocyte regeneration.

### PDEGF

*Platelet Derived Endothelial Growth Factor*

Promotes wound healing by stimulating the proliferation of keratinocytes and dermal fibroblasts

### PDAF

*Platelet Derived Angiogenic Factor*

Induces vascularization by stimulating vascular endothelial cells

### EGF

*Endothelial Growth Factor*

Cellular proliferation  
Differentiation of epithelial cells

### VEGF

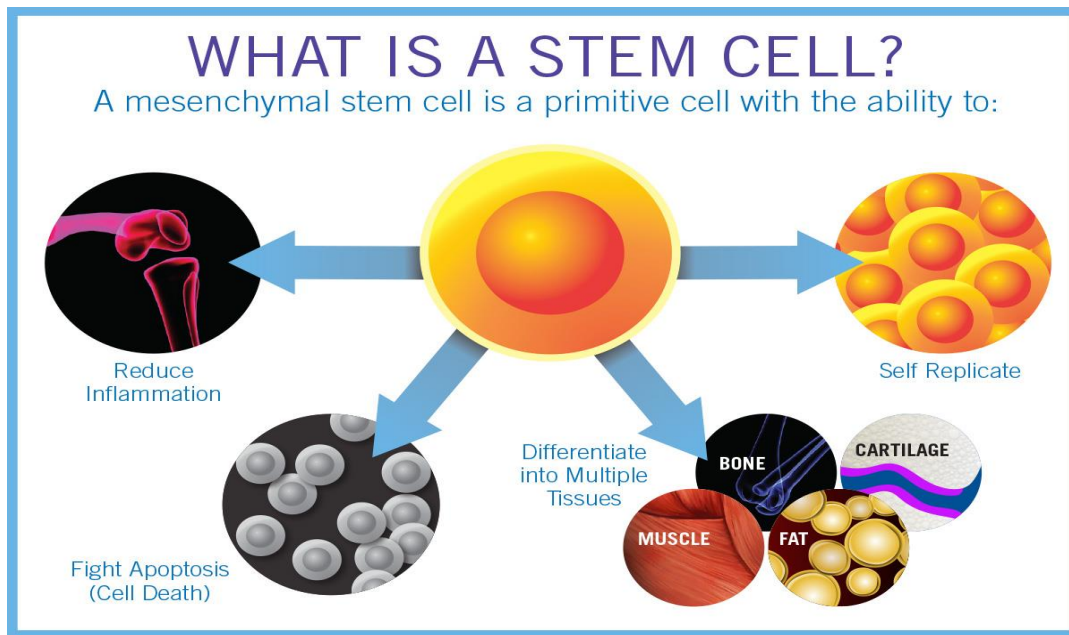
*Vascular Endothelial Growth Factor*

Angiogenesis  
Migration and mitosis of endothelial cells  
Creation of blood vessel lumen  
Creation of fenestrations  
Chemotactic for macrophages and granulocytes  
Vasodilation (indirectly by release of nitrous oxide)

### HGF

*Hepatocyte Growth Factor*

Stimulates of hepatocyte proliferation and liver tissue regeneration  
Angiogenesis  
Mitogen for endothelial cells  
Antifibrotic



MSC or Mesenchymal Stem Cells can be considered “Mother Cells” because they can ultimately transform into any other cell type and multiply indefinitely to self renew. In order to maintain the natural body functions, new cells have to be generated regularly. Stem cells are the body’s own reservoir to renew and repair tissue. But many cells lose the ability to renew themselves.

### Mechanism of Action

Based on the clinical success of the treatment, the mechanism of action of SW theories suggests the following 4 possible mechanisms of reaction phases of ESWT on tissue.

1. **Physical phase:** This phase indicates that the shockwave causes a positive pressure to generate absorption, reflection, refraction, and transmission of energy to tissues and cells<sup>11</sup>. Additional studies demonstrated that ESWT produces a tensile force by the negative pressure to induce the physical effects, such as cavitation, increasing the permeability of cell membranes and ionization of biological molecules.

ESWT participates in mechanotransduction, producing biological responses through mechanical stimulation on tissues. Many signal transduction pathways are activated thru **mechanotransduction** signaling pathway, the extracellular signal-regulated kinase (ERK) signaling pathway, focal adhesion kinase (FAK) signaling pathway, and Toll-like receptor 3 (TLR3) signaling pathway, to regulate gene expressions. **“Mechanotransduction”** is a *biological pathway* to which many cell types are sensible: after sensing and processing the mechanical information’s from the extracellular environment, these biomechanical forces are converted in biochemical responses, thus influencing some fundamental cell functions as migration, proliferation, differentiation, and apoptosis.

2. **Physicochemical phase:** ESWT stimulates cells to release biomolecules, such as adenosine triphosphate (ATP), to activate cell signal pathways.
3. **Chemical phase:** In this phase, shockwaves alter the functions of ion channels in the cell membrane and the calcium mobilization in cells.
4. **Biological phase:** Previous studies have shown that ESWT modulates angiogenesis (vWF [von Willebrand factor], vascular endothelial growth factor [VEGF], endothelial nitric oxide synthase [eNOS], and proliferating cell nuclear antigen [PCNA]), anti-inflammatory effects (soluble intercellular adhesion molecule 1 [sICAM] and soluble vascular cell adhesion molecule 1 [sVCAM]), wound-healing (Wnt3, Wnt5a, and beta-catenin), and bone-healing (bone morphogenetic protein [BMP]-2, osteocalcin, alkaline phosphatase, dickkopf-related protein 1 [DKK-1], and insulin-like growth factor [IGF]-1).

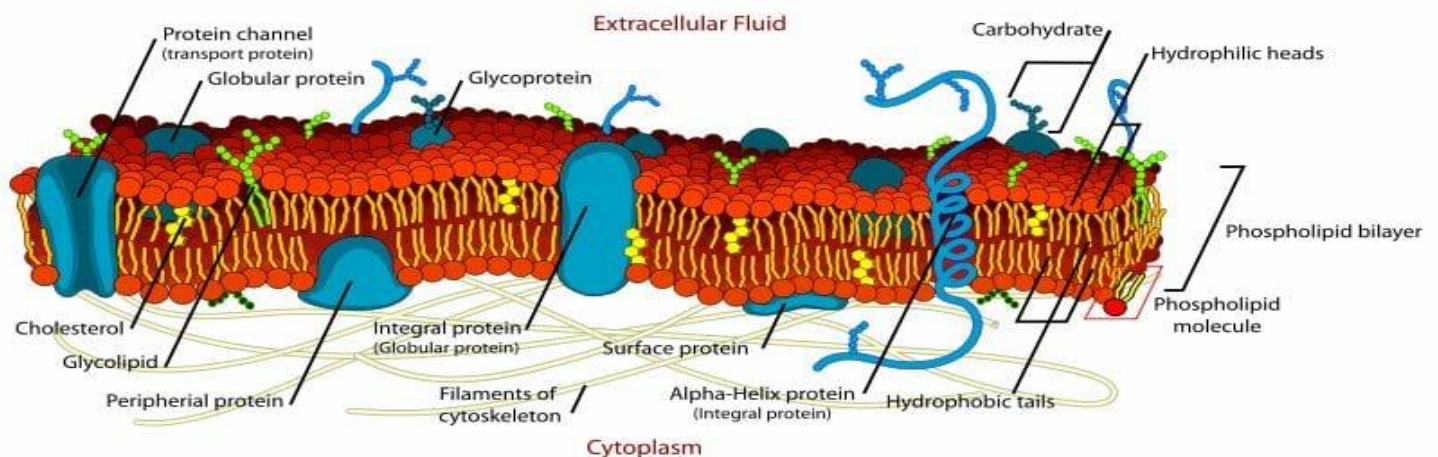
The effects of ESWT with new functional proteins induced by ESWT promoting a chondroprotective effect, neovascularization, anti-inflammation, anti-apoptosis, and tissue and nerve regeneration. Furthermore, ESWT stimulates a shift in the macrophage phenotype from M1 to M2 and increases T-cell proliferation in the effect of immunomodulation. ESWT activates the TLR3 signaling pathway to modulate inflammation by controlling the expression of interleukin (IL)-6 and IL-10 as well as improves the treatment of ischemic muscle

**The ESWT long term benefit is the fact that the patient's own resident stem cells have been activated within 45 minutes after treatment. The true healing will come later when those stem cell have been produced and migrated to the treated area 8-10 weeks later. Again, the patient's own stem cells are activated to come out of this dormant state and are called into action within hours of treatment. This eventually results in a 200%-300% improvement in permanent blood supply 10-12 weeks later.**

There are a number of profound benefits from using focused, low intensity lithotripsy:

- therapeutic energy zone is vastly larger in all dimensions than that of focused designs, causing greater efficiency of treatments...and you need less treatments!
- unlike the radial pulse units, shockwaves do not create or rely on micro traumas, instead it non-traumatically causes cells to shed membrane micro vessels, which signals a healing cascade and communicates on a cellular basis. You don't need to put numbing cream on 20 minutes before treatment.
- shockwaves are scientifically validated through peer reviewed studies. It immediately shuts down the inflammatory response at the treatment site. This has been linked to modulation of various signaling molecules including toll-like R3, nitric oxide, ATP, micro vessels and exosomes. Results are typically immediate and creates sustained relief from chronic pain. Improved blood flow: this has been linked to the release of VEGF and other key growth factors and cytokines as well as a boost in ATP, leading to the neo angiogenesis at the treatment site, typically resulting in accelerated and sustained regenerative effects.
- shockwave technology is scientifically validated to recruit and activate endogenous mesenchymal stem cells.
- shockwave therapy elicits biofeedback by which origins of pain can be precisely identified, serving an invaluable role in treatment effectiveness and efficiency.

Spinal cord injury (SCI) is a devastating condition with poor prognosis and very limited treatment options. Most injured patients are severely restricted in their daily activities. ESWT has shown to have potent regenerative properties for bone fractures, wounds, and ischemic myocardium via activation of the innate immune receptors called Toll Like Receptors, specifically the TLR3 or Toll Like Receptor-3. ESWT improved motor function and decreased lesion size in spinal cord injuries (SCI). Research suggests that the TLR3 signally is involved in neuroprotective and spinal cord repair and suggest that TLR3 stimulation via ESWT can be a potent treatment option for these serious conditions.



D'Agostino et al described in a comprehensive review in more detail that fESWT has been described in experimental studies to reduce expression of several metalloproteinases (enzymes capable of degrading the collagen) and inflammatory interleukins and, in turn, to upregulate gene expression of typical tendon markers (such as scleraxis) and anti-inflammatory cytokines (e.g., interleukin-10).

Electrohydraulic fESWT in animal experiments, fESWT was shown to promote healing of “collagenase - Achilles tendinitis,” by inducing transforming growth factor beta 1 and insulin-like growth factor I. Histological observations demonstrated that fESWT resolved swelling and edema as well as inflammatory cell infiltration in affected tendons.

Furthermore, at the bone level, after fESWT exposure, there has been described early expression of angiogenesis-related growth factors, including endothelial nitric oxide synthase, vascular endothelial growth factor, and proliferating cell nuclear antigen, therefore producing new vessel in-growth with improved blood supply as well as increasing cell proliferation.

Electrohydraulic fESWT have been shown to be able to **enhance regeneration** of damaged tissue by leading to migration, homing, and differentiation of human stem cells.

fESWT is commonly used in the management of musculoskeletal disorders, and there is increasing evidence for its clinical effectiveness. Pain relief, destruction of calcifications, and the described mechanotransduction-initiated tissue regeneration and further remodeling processes seem to be the most important working mechanisms.

The modern Hospital Lithotripsy units are very large, powerful and very expensive.- ( \$500,000)



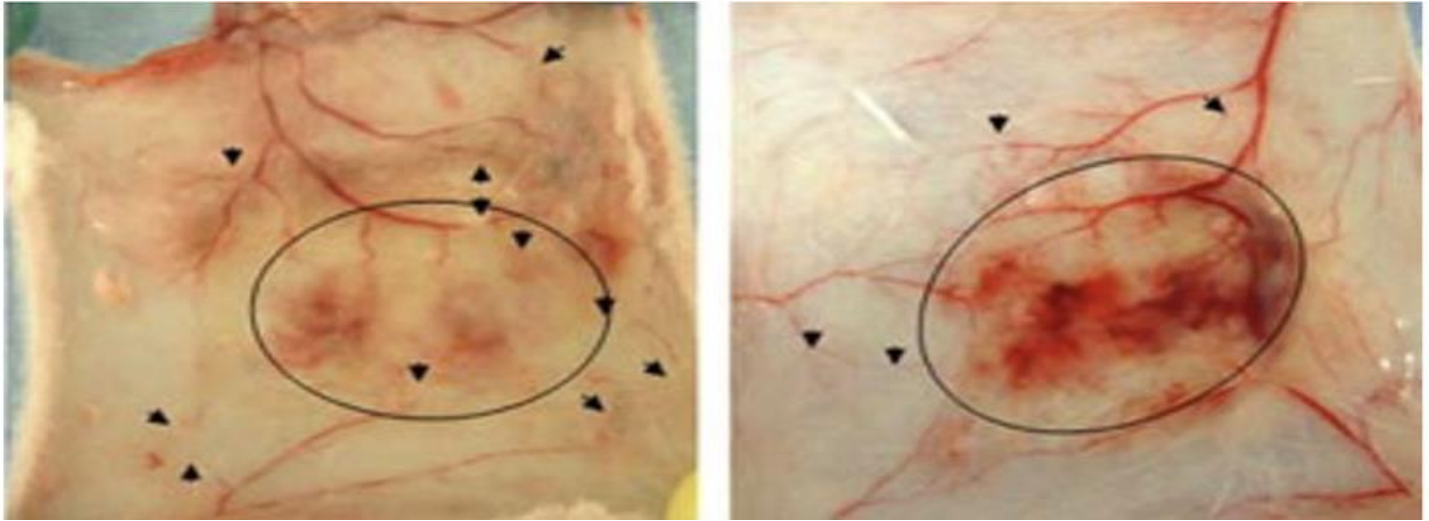
**Over the last four decades Shockwave Machine Technology has Made Significant Advancements**



# Shockwave changes seen at the cellular level to initiate healing

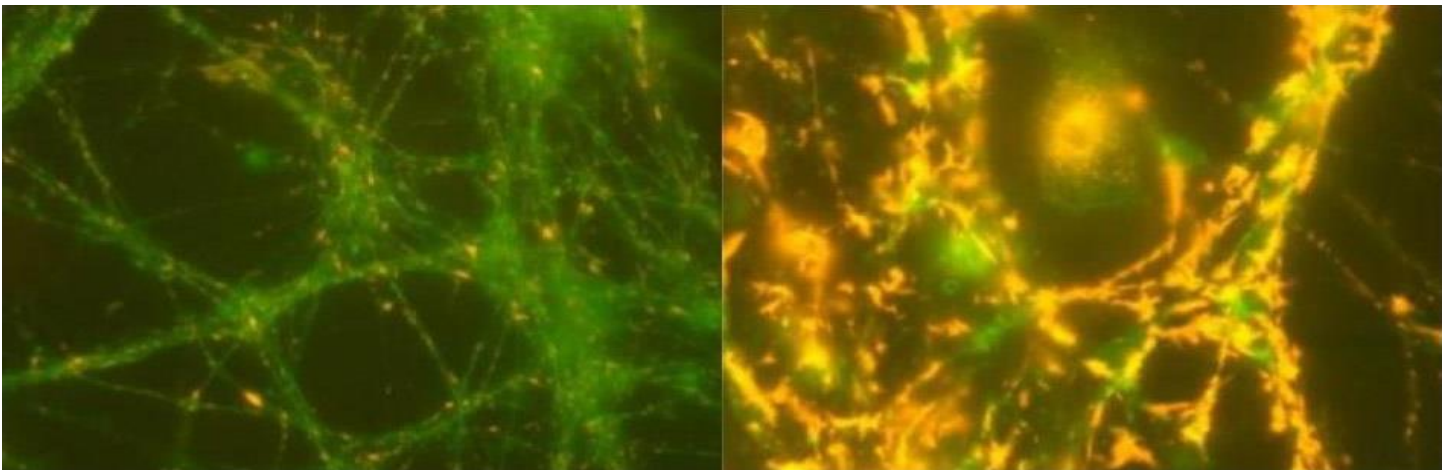
Changes seen at the cellular level to initiate healing.

Electrohydraulic Shockwave shown to **INCREASE** in small, medium & large blood vessel growth by **300%** within 12 weeks of tx.



**Angiogenesis (New Blood Vessel Growth) changes Before and After Shockwave**

**Fluorescent stained MITOCHONDRIA**  
**Before & After true focused Shockwave**



## ❖ **CONTRAINDICATIONS for ESWT include:**

- ❖ Treatment over air-filled tissue (lung, gut)
- ❖ Pregnancy
- ❖ Over Cancer
- ❖ Presence of local tumor or infection
- ❖ Less than six weeks since local corticosteroid injection
- ❖ Age less than 18 (except for patients diagnosed with Osgood-Schlatter disease)
- ❖ Treatment of pre-ruptured tendons
- ❖ Blood-clotting disorders, including local thrombosis

# Non-Invasive Tissue Regeneration is Now Possible without Needle Injection

## 1<sup>st</sup> Plant the Seeds

Use shockwaves to stimulate the migration of Mesenchymal Stem Cells (MSC) & Growth Factors to the Injured area, like planting the seeds. This can be used as an adjunctive therapy to Stem Cell or PRP Injections or as an alternative to injection when used in conjunction with high power PEMF therapy.

## 2<sup>nd</sup> Fertilize

Over the next 8-12 weeks, these MSC and Growth factors will migrate to the injured tissues to lay down new cells and generate healthy new tissue. We MUST provide these tissues with proper stimulation to ensure the best outcomes. Much like planting a seed in the ground. These seeds require good dirt, sunlight energy, fertilizer, and water.

**We need to add PEMF therapy to provide the best cellular environment to stimulate and maximize MSC & Growth Factors in the development of new tissue.** I also recommend Electrically Charged Hydrogen Alkaline water.

**Please Contact me for more details on High Power PEMF, LED, Hydrogen Water**



Shockwave is True Cellular Regenerative Medicine

**Over the last 25 years, this Technology has evolved in SPORTS MEDICINE & REGENERATIVE MEDICINE**

Progressive clinics now use SW combine with other therapies such as Stem Cell Injections, PRP Injections, PEMF, Laser, LED to successfully treat a broad range of musculoskeletal disorders to include:

- Overwhelming Research & Evidence for MSK conditions
- Stimulate Stem Cells (MSC) & Numerous Growth Factors
- Bone Healing disorders
- Degenerative Tendon conditions
- Muscle Injuries
- Skin Lesions /Cosmetic Healing / Pelvic / Bladder Control / ED And much more.
- Used in Germany / Austria in ER for Acute Spine Trauma
- Used in Germany /Austria Open Heart Surgery
- Has been used to Increased Testosterone
- SW has 501K Class I FDA Clearance for reduction of Pain and improvement of circulation.

**The great news is this new SHOCKWAVE can be used in most any condition with very little discomfort and even more therapeutic benefits. Help your patients heal faster, more completely.**

***Having used many brands of PEMF and Radial & Focused ShockWave, I can help you select the best unit for your personal or clinical needs and budget.***

***One clinic patient per month will cover the lease payment, so this is an easy fit for any clinic.***

***Note: IRS Section 179 may allow business owners to deduct the full purchase price of qualifying equipment and software that was purchased or financed during the tax year, rather than depreciating it over the asset's useful life.***

***Some of these manufacturers I have used in clinic allow me to offer you the same "Special Military Discount Pricing" which you could not get from the traditional sales reps.***

***If you are looking to purchase, Don't just buy from a sales rep.  
Invest and learn from an experienced clinician & colleague while supporting others in our profession.***

Please feel free to contact me. Thank you, Larry

**Dr. Larry Basch, D.C. 858-945-8118 LBASCHDC@gmail.com**



This paper was organized and compiled by **Dr. Larry Basch, D.C., CCSP, CCEP, ICSC** U.S. Marine Corps Sports Chiropractor / U.S. Naval Sports Medicine

With over 32 years of clinical experience as a Board-Certified Chiropractor and having worked in 28 different clinics, I have treated tens of thousands of patients from infants to seniors to world champion power lifters, NFL & NBA professional athletes and rock n roll superstars. I am one of only 11 Chiropractors working on a Marine Corps base. In 2009, I was selected to work at the first full-time Chiropractic clinic at the Officers Candidate School, USMC, Quantico, VA. In 2010, I transferred to Twentynine Palms Naval Hospital, USMC, CA. Since 2011, I have been at the Navy Medicine Multi-Discipline Sports Medicine clinic at Camp Pendleton. I am one of only about 4000 Chiropractors to complete the post-graduate program Certified Chiropractic Sports Practitioner (CCSP) and be nationally certified by American Board of Chiropractic Sports Physicians. Additionally, I am a Certified Chiropractic Extremity Practitioner (CCEP) and International Certificate of Sports Chiropractor (ICSC). I have post graduate training from Olympic and Professional Sports Chiropractors. I have advanced certification in the treatment of whiplash injuries, spinal rehab, acupuncture and extensive training in Clinical Nutrition, Soft Tissue Injuries, Sports Injuries & Spinal Rehab, Laser and PEMF therapy as well as past employment as a Clinical Case Manager doing Insurance review for the nation's largest Chiropractic HMO. I am also a 10 yr Veteran of USMC and Illinois Army National Guard.



**Dr. Larry Basch, D.C., CCSP, CCEP, ICSC**

**U.S. Marine Corps Sports Chiropractor / U.S. Naval Sports Medicine**

# Suggested Shockwave Research Publications

## **Ultrasonographic Evaluation of Low Energy Extracorporeal Pulse- Activated Therapy (EPAT) for Chronic Plantar Fasciitis**

By: Robert Gordon, MD; Charles Wong, BHSc; Eric J. Crawford, BHSc Toronto, Canada

## **The Role of Extracorporeal Shockwave Treatment in Musculoskeletal Disorders**

Daniel Moya, MD, Silvia Ram´on, MD, Ph.D., Wolfgang Schaden, MD, Ching-Jen Wang, MD, Leonardo Guiloff, MD, and Jai-Hong Cheng, MD

## **The American Journal of Sports Medicine – Shockwave Therapy for Patients with Lateral Epicondylitis of the Elbow**

By: Ching-Jen Wang, M.S. & Han-Shiang Chen, M.D.

## **The American Journal of Sports Medicine – Extracorporeal Shockwave for Chronic Patellar Tendinopathy**

By: Ching-Jen Wang M.D., Jih-Yang Ko M.D., Yi-Sheng Chan M.D., Lin-Hsiu Weng M.D. and Shan-Lin Hsu M.D.

## **The American Journal of Sports Medicine – Eccentric Loading, Shockwave Treatment, or a Wait-and-See Policy for Tendinopathy of the Main Body of Tendo Achilles**

By: Jan D. Rompe, M.D., Bernhard Nafe, M.D., John P. Furia, M.D. Ph.D., and Nicola Maffulli, M.D., Ph.D., F.R.C.S.(Orth)

## **The American Journal of Orthopedics – Safety and Efficacy of ESWT for Chronic Lateral Epicondylitis**

By: John P. Furia, M.D.

## **Techniques in Foot and Ankle Surgery – Shockwave Therapy for Treatment of Foot and Ankle Conditions**

By: Alastair Younger, MB, ChB, FRCSC

## **Shockwave Therapy for the Treatment of Chronic Proximal Hamstring Tendinopathy in Professional Athletes**

By: Angelo Cacchio, Jan D. Rompe, John P. Furia, Piero Susi, Valter Santilli and Fosco De Paulis

## **Shockwave Therapy Compared with Intramedullary Screw Fixation for Nonunion of Proximal Fifth Metatarsal Metaphyseal-Diaphyseal Fractures**

By: John P. Furia, MD, Paul J. Juliano, MD, Allison M. Wade, MD, Wolfgang Schaden, MD, and Rainer Mittermayr, MD

## **Repetitive Low-Energy Shockwave Application Without Local Anesthesia is More Efficient Than Repetitive Low-Energy Shockwave Application with Local Anesthesia in the Treatment of Chronic Plantar Fasciitis\***

By: Rompe JD, Meurer A, Nafe B, Hofmann A, Gerdesmeyer L.

## **Radial Shockwave Therapy in Calcific Tendinitis of the Rotator Cuff**

By: Dr. P. Magosch, ATOS Clinic Heidelberg (Germany)

## **Radial Extracorporeal Shockwave Therapy Is Safe & Effective in the Treatment of Chronic Recalcitrant Plantar Fasciitis**

By: Ludger Gerdesmeyer, MD, PhD, Carol Frey, MD, Johannes Vester, PhD, Markus Maier, PhD, Lowell Weil Jr, DPM, Lowell Weil Sr, DPM, Martin Russlies, PhD, John Stienstra, DPM, Barry Scurran, DP, Keith Fedder, MD, Peter Diehl, MD, Heinz Lohrer, MD, Mark Henne, MD, and Hans Gollwitzer, MD

## **Physical Therapy – Effectiveness of Radial Shockwave Therapy for Calcific Tendinitis of the Shoulder: Single-Blind, Randomized Clinical Study**

By: Angelo Cacchio, Marco Paoloni, Antonio Barile, Romildo Don, Fosco de Paulis, Vittorio Calvisi, Alberto Ranavolo, Massimo Frascairelli, Valter Santilli, Giorgio Spacca

## **Low-Energy Extracorporeal Shockwave Therapy as a Treatment for Medial Tibial Stress Syndrome**

By: Jan D. Rompe, Angelo Cacchio, John P. Furia and Nicola Maffulli

## **Extracorporeal Shockwave Therapy Compared with Surgery for Hypertrophic Long-Bone Nonunions**

By: Angelo Cacchio, Lucio Giordano, Olivo Colafarina, Jan D. Rompe, Emanuela Tavernese, Francesco Ioppolo, Stefano Flamini, Giorgio Spacca and Valter Santilli

## **Efficacy of Extracorporeal Shockwave Therapy in Frozen Shoulder**

By: Badak Vahdatpour, Parisa Taheri, Abolghasem Zare Zade and Saeed Moradian

## **Efficacy of Extracorporeal Shockwave Therapy for Knee Osteoarthritis: a Randomized Controlled Trial**

By: Zhe Zhao, MD, Rufang Jing, MD, Zhan Shi, Ph.D., Bin Zhao, MD, Quan Ai, MM, and Gengyan Xing, MD

## **Current Concepts of Shockwave Therapy in Stress Fractures**

By: Carlos Leal, Cristina D'Agostino, Santiago Gomez Garcia, Arnold Fernandez

## **Clinically Relevant Effectiveness of Focused Extracorporeal Shockwave Therapy in the Treatment of Chronic Plantar Fasciitis. A Randomized, Controlled Multicenter Study**

By: Hans Gollwitzer, MD, Amol Saxena, DPM, Lawrence A. DiDomenico, DPM, Louis Galli, DPM, Richard T. Bouche, DPM, David S. Caminear, DPM, Brian Fullem, DPM, Johannes C. Vester, Carsten Horn, MD, Ingo J. Banke, MD, Rainer Burgkart, MD, and Ludger Gerdesmeyer, MD

## **Antibacterial Effects of Extracorporeal Shockwaves\***

By: Gerdesmeyer L, von Eiff C, Horn C, Henne M, Roessner M, Diehl P, Gollwitzer H. Klinik und Poliklinik fur Orthopadie und Sportorthopadie der Technischen Universitat Munchen, Munchen, Germany