I. Basic Principles

A. What is a Shock Wave?

1. A powerful acoustic sound wave that imparts pressure to targeted tissues. Much like an opera singer can break a glass with a high note, or a jet can break windows when it accelerates and breaks the sound barrier, sound waves can yield significant quantities of energy. Clinically, the energy of multiple sound waves can be coupled, focused, targeted, and applied to tissues to produce a biological response.

B. Characteristics

- Rapid pressure rise
- High peak pressure
- Short duration
- Broad frequency spectrum

Thiel et al Clin Orthop 2001

Unlike a sine wave, which has an equal positive and negative phase, a shock wave has a short, steep, and rapid positive phase, and a prolonged negative phase. The rapid phase accounts for the direct effect of the shock wave while the prolonged negative phases accounts for the indirect effect (see below).

C. How do you make them?

Shock waves are produced using commercially available shock wave generating devices. These devices are a byproduct of lithotripter technology. Several have been approved by the FDA and are available in the USA. There are many others available in other countries.

D. Types of devices:

1. Electrohydraulic devices use a spark plug to generate the shock waves
2. Electromagnetic devices use a coil to generate the shock waves
3. Piezoelectric systems use a crystal to generate the shock waves
4. Radial devices use pressure to generate the shock wave
E.  Focused vs radial:

Shock wave devices produce shock waves in either a focused or radial manner. Focused devices produce multiple waves and focus the waves via a lens like device so that the energy is delivered in a narrow range. Radial devices produce multiple waves that are not focused, but applied in a more diffuse manner. For this reason, focused devices allow for deeper wave penetration.

For tendons and superficial structures, the depth of wave penetration required to reach the targeted tissues is just a few centimeters. Hence, either a focused or radial device can be effective. For deeper tissues, such as bone, focused devices are usually utilized.

The little comparative data available comparing focused and radial devices generally shows no difference between the techniques.

F.  Effects of shock waves on tissue

1.  Direct effect
   - Like a powerful punch
   - Energy hits tissue and produces an effect
   - Classic “Injury and repair” paradigm of many orthopedic procedures

2.  Indirect effect
   - Like a grenade
   - Shock wave hits tissue and produces cavitation bubbles
   - Bubbles expand, collide, and burst
   - Results in “secondary” shock waves, additional energy, and a more prolonged effect on the treated tissues

G.  Energy and energy levels

1.  Energy levels....High vs Low energy treatments
   - No universal guidelines as to what is a high energy treatment and what is a low energy treatment.
   - In general...
   - 0.05-0.2 ml/mm² = low energy
   - 0.2-0.6ml/mm² = high energy
H. Treatment parameters

Variables that can be manipulated in a session or series of sessions

1. Number of treatments
   - Single
   - Multiple, usually 2-3, but sometimes more

2. Number of shocks
   - Often 1000 to 4000 per session

3. Frequency of delivery
   - Usually between 60-240 shocks/minute

4. Interval of time between treatments
   - Protocol specific
   1. Single treatment
   2. Weekly
   3. Two weeks apart
   4. Monthly

II. Biological Effects

A. Antinociceptive

- Using animal models, SW therapy has been shown to decrease substance P and transiently destabilize afferent sensory nerve fibers.

- Antinociceptive effects probably account for the early clinical response i.e. decreased pain, observed in treated patients.

   Takahashi et al. Auto Neurosci 2003


B. Growth Factor Stimulation

- Increases TGF beta
- Increases IDGF
- Increases PDGF
• ...all of the above are important in the inflammatory stage of tendon healing

C. Inhibition of MMPs

- The concentration of MMPs are higher in diseased tendons than in normal tendons.
- ESWT decreases the expression of MMPs

Han et al Foot Ankle Int 2009

D. Stimulation of Angiogenesis

• Rabbit model
• Achilles tendon
• Increased neo-vessels and angiogenesis-related growth factors in treated specimens

Wang et al 2003 J Orthop Res

E. Proposed mechanism of action:

ESWT has an early effect on sensory pain fibers. ESWT produces a relative neurogenic inflammatory condition in which regrowth of pain fibers is inhibited. Growth factors are released in treated tissues and MMPs are decreased in treated tissues. There is increased angiogenesis in the treated area, resulting in increased blood flow to areas that have a poor blood supply. The fibroblastic and remodeling stages of tendon healing are accentuated and healing progresses at a more rapid rate.

III. Technique

A. High Energy Procedures

Usually performed in the operating room or ambulatory surgical center using either a general or regional block. May be use for both tendinopathies and disorders of bone. Usually requires some type of imaging device such as ultrasound or fluoroscopy when used to treat bone disorders.

The number of treatments can vary, most commonly 1-3 treatments for Achilles tendinopathy.

B. Low Energy and Radial Procedures

Low energy and radial procedures are typically performed in the ASC or office setting without anesthesia. The procedures are fast, usually between 6-15 minutes, well tolerated, generally do not require use of imaging modalities, and do not require post treatment analgesia.

Because the total energy per session is lower, low energy procedures are usually repeated 2-4 times over various time periods. Common time intervals are weekly, biweekly, and monthly.
C. Steps

1. Choose a device
   
   FDA approved devices are Dolorclast, HMT, Sonocur

2. Choose a protocol
   
   High energy, single treatment
   
   Low energy, multiple treatment

3. Follow the protocol!

   Number of shocks

   Energy per session

   Energy per total therapy-cumulative energy delivered

4. Method of targeting the waves

   Image guidance-usually not needed for Achilles tendinopathy

   Clinical Focusing-“treat where it hurts”

IV. Results

1. Insertional Achilles tendinopathy

   - 35 ESWT pts/33 controls
   - High energy/one treatment
   - One year follow-up
   - 83% Good/excellent

   Furia JP AJSM 2006

2. Non-Insertional Tendinopathy

   - 34 ESWT/34 controls
   - High energy/one treatment
   - One year follow-up
   - 85% Good/excellent

   Furia et al AJSM 2010

3. Non-Insertional and Insertional Tendinopathy

   - Double blind/placebo controlled
• Sham SWT vs SWT
• AOFAS/VAS
  – SWT>>Sham SWT

*Rasmussen et al Acta Orthopedica 2008*

V. **Practice Considerations**

A. **Reimbursement**

Number one question I receive when I discuss ESWT! There are 3 CPT codes available for ESWT procedures. Each insurance company makes an individual determination regarding payment. Most large carriers in the USA consider the treatment “experimental” and as of yet, do not provide payment. That said, many worker’s compensation carriers do provide payment as return to work post ESWT is usually much quicker than after a surgical procedure for a tendinopathy.

B. **Current Pattern**

Most providers who perform ESWT in the USA provide the service as a “cash payment” procedure (like Lasix and many plastic surgery procedures). The procedures are usually performed in the office and without anesthesia, thereby making the procedure an affordable option for most patients.

C. **How to Learn More**

1. **Attend a meeting**
   Industry/nonindustry-sponsored meetings

2. **Visit an experienced provider**

Few available

I have had several visitors and am happy to visitors in the future.

VII. **References**


