Shockwave therapy in musculoskeletal treatment

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Contents of presentation:

- Shockwave Therapy – physical principles & technology
- Shockwave Therapy – medical background
- Shockwave Therapy - clinical demo
Biophysical background
**Biophysical background**

Shock wave is a transient acoustic wave

- Unique opportunity to transmit **high** energy for **long** distances
- First observation – Second World War
- First technical interest in 1966 Dornier Aircraft Labs
Different mechanisms were observed during kidney stone disintegration

Picture by Shriwastava, J.Biosci., March 2005
Shockwaves in medicine

Shockwave is an acoustic wave which carries its high energy to the painful spot and provokes healing and repair processes.

Main fields of application:
- Orthopedics
- Rehabilitation
- Sport medicine
- Other (veterinary, aesthetics, urology, dermatology)

Most common applications:
- Shoulder tendonitis
- Achillodynia
- Heel spur (calcar calcanei)
- Lateral epicondylitis
Terminology

- **Low energy** shockwave
- **Radial shockwave** therapy
- **Pressure pulse** therapy
- **Acoustic wave** therapy

- All refer to **one** therapy defined by:
  - **Shape of the pulse**
  - **Energy** \( 1 \text{ - } 5 \text{ bar} = 0.15\text{–}0.47 \text{ mJ/mm}^2 \text{ EFD} \)
Energy Flux Density vs Pressure in Bars

Energy flux density

Pressure (Bar)

Energy flux density (mJ/mm²)

15 mm fokus
9 mm multifokus
15 mm multifokus
SWT - TECHNOLOGIES
The beginnings..

- **1985** Extracorporeal Shock Wave Lithotripsy (ESWL) - kidney stones disintegration
From history to present

- **1990** - First applications in **musculoskeletal apparatus**
- **1999** – **Radial shockwave** principle introduced
- **2011**:  
  - more than 1000 clinical studies  
  - widely accepted therapy in **rehabilitation & orthopaedic** surgery  
  - Emerging new fields&clinical indications

1993
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1997

TODAY
SHOCKWAVE TECHNOLOGIES

- Spark discharge
- Piezo-electric
- Electromagnetic
- Pneumatic

Focused
- Hard shockwave

Radial
- Soft shockwave
Radial vs. Focused principle

Radial = BTL pneumatic principle

Focused:

- Electrohydraulic principle
- Electromagnetic principle
- Piezoelectric principle
Radial vs Focused devices

- Differences in size, cost per therapy and treatment and in the procedure..

- Both the same shape of the pulse and clinical effect when equal energies are used!
Radial vs focused principle

**Radial:**
- Designed for *superficial treatment*
- Clinically focused
- No anesthesia, no analgesics
- Higher comfort of the therapy
- Low costs of the unit = faster reimbursement

**Focused:**
- Developed to reach *internal organs*
- X-ray or ultrasound guided
- Anesthesia necessary
- Costs per unit, treatment
More of terminology

**ESWT vs. RSWT**

- **ESWT** = Extracorporeal Shockwave therapy = applied outside of the body, treatment of musculoskeletal apparatus
- **RSWT** = Radial Shockwave therapy
- **RSWT** is ESWT!!!
Radial, pneumatic principle by BTL

- Projectile is accelerated by high-pressure pulse
- Hits the transmitter, emits the SW
- Semi-focused, focused and trigger tip
Applicators-Transmitters:

- **9 mm** – for acupuncture points and for more accurate applications (finger joints)

- **15 mm** – universal transmitter for all applications

- **Focused 15 mm** – for more targeted applications (deep trigger points)
Shockwave energy

What energy is still meaningful?

♦ Litothriptors, HE focused shockwaves, radial acoustic waves:

![Diagram showing repair potential of cells and energy flow density with different therapeutic applications like pain therapy, lithotripsy, and osteotherapy.](Source: Rompe, „Extrakorporale Stosswelletherapie“)
SHOCKWAVE THERAPY – BIOLOGICAL EFFECTS
ESWT – effects generally

- Tissue regeneration and repair
- Neovascularization and angiogenesis
- Analgesia, myorelaxation
- Calcific deposits reabsorption
Prompt and longlasting analgesic effect
Extracorporeal shockwaves induce the expression of ATF3 and GAP-43 genes in rat dorsal root ganglion neurons
Murata et al., Auton.Neurosci., 2006

Initiation and acceleration of tendon healing process involving collagen and glycosaminoglycan (GAG) production.
Significant increase in degraded collagen and GAG levels shortly after treatment. After 6 weeks, metabolism decreased significantly as GAG levels were lower than in untreated controls.
Bosch et al., EquineVet J., 2007
Stimulation of local metabolism, neovascularisation, osteogenesis and bone remodelling

In adult hip necrosis, significant increase in vWF, platelet endothelial cell adhesion molecule, VEGF, proliferation cell nuclear antigen /PCNA/ levels was observed in patients undergoing SWT prior to total hip arthroplasty.

Wang et al., Rheumatology, 2004

Resorption of calcium deposits caused by tensile part of shockwave

Cosentino R et al., Ann Rheum Dis, 2003
ESWT – Biological mechanism in the tissue

Wang 2005
Immediate effects

- Local increase of microcirculation
- Immediate myorelaxation
- Immediate and strong analgesia
ESWT Effects on the Tissue II.

„Shockwave effects“

◇ Stimulation of **activity of osteoblasts** – increase of osteogenesis

◇ Stimulation of production of **collagen by fibroblasts** – acceleration of healing processes

◇ Ligament and bone **neovascularization**
ESWT Effects on the Tissue III.

Analgesia- how does it act?

- inhibition of spasm
- inhibition of nociceptive fibres - Gate mechanism
- endorphines and serotonine release
- acceleration of substance P washout

*Substance P: excitation mediator, stimulates nociceptive nervous fibres, supports resorption of oedema and secretion of histamine-anti-inflammatory effects of swt
Shockwave therapy and healing – the concept

Repair of the mechanical destruction caused by shockwave „hammer“ or just start-up of healing processes?

◊ **Mechanical model** „minor mechanical destruction causes repair reactions“

◊ **Biomechanical model**
Shockwaves in the cell - mechanotransduction

- **Cells sense** their physical surroundings **through mechanotransduction**
- = translating **mechanical forces into biochemical signals** such as changes in intracellular calcium concentration or by activating diverse signalling pathways.
- In turn, **these signals adjust cellular** and extracellular **structure**.
- This mechanosensitive feedback **modulates cellular functions** as diverse as migration, **proliferation**, differentiation and apoptosis, though crucial for organ development and homeostasis.

Mechanotransduction gone awry Diana E. Jaalouk and Jan Lammerding, 2009
SHOCKWAVES IN THE TISSUE

What cell are involved in this reaction?

❖ Specific cells activation:
  ▪ Neovascularization - pericytes
  ▪ Osteoblasts - osteogenesis
  ▪ Fibroblasts - collagen production

❖ Supported by vasodilatation
Fig. 2. Microscopic findings with HE stain showed significantly more viable bone and cell concentration and cell activity in study group than the control group.

**Study group with shockwave treatment prior to THA**

**Control group with no shockwave prior to THA**

Fig. 3. Microscopic findings with vWF stain showed significantly more new vessels (angiogenesis) in the study group than the control group.
Most Frequent Indications?

**Pain in muscles, insertions, Tendons**
- Groin pain
- Achillodynia
- Back pain
- Plantar fascitis
- Patellar tendinopathy - jumper’s knee
- Epicondylitis - tennis elbow

**Calcifications**
- Heel spur (calcar calcanei)
- Tendinosis calcarea
- Long tendon of biceps calcification
Shoulder tendonitis – X-ray documentation

Moreover, efficacy of ESWT in calcifying shoulder tendonitis was proved in 70% patients

Cosentino R et al., *Ann Rheum Dis*, 2003
Impingement sy & X-ray proved calcification–clinical example

Before treatment

After 3 SWT sessions, 1500 pulses at 3 bars per session
MOST FREQUENT INDICATIONS

II.

- Trigger points treatment
- Frozen shoulder syndrome
- Coxarthrosis, gonarthrosis
- Arthrosis of small finger joints
- Muscle spasticity
- Acupuncture points stimulation
- Scars
Unusuall clinical experience

- 6 moths old forefinger extensors incision injury
- rigid and prominent scar tissue
- first IP joint fixed in 30° flexion position

- 4 SWT applications with 2.5 Bars intensity the
- scar reformed, ROM - full extension and 100° flexion
Shockwaves in sports medicine

What are the greatest deals of sports medicine?

- Quick recovery and **fast return** to sport activity and training
- Symptoms associated with injury – **pain**, **swelling**, **muscle spasm**
Shockwaves in sports medicine

What is the main effectivity of shockwaves?

- Pain relief
- Muscle relaxation
- Local microcirculation increase
- Healing processes enhancement and speeding
Sports medicine most frequent indications

Three indication groups, is SWT for all?

- **Chronic pain and overuse syndromes**
- **Acute pain & minor injuries** /back pain, muscle distensions, minor ruptures/
- **Serious injuries** /complete ruptures, fractures/
Shockwaves in sport – new indications I.

„Overuse“, chronic subacute disorders

- Epicondilitis
- Jumper´s knee
- Achillodynia
- Chronic back pain
- Shoulder tendinitis

- Huge variety depending on the type of sports activity
- Unique efficiency
Shockwaves in sport – new indications II.

Acute injuries or post-surgical statuses

- Muscle and tendon *strains* – distensions and partial ruptures
- Ligaments *sprains* – distorsions
- Acute vertebrae blockage
- Regeneration support

- Post-surgical or post immobilization healing enhancement
Acute muscle rupture treated with ESWT (1st, 7th and 14th day)
Shockwaves in sport – therapeutic procedure

Support with other available therapies – healing and anti-oedematory effect

- Laser /after and between the sessions/
- Lymphatic drainage
- Thermopositive therapy

- Magnetotherapy /maximum frequency of the sessions /
- Ultrasound
- Electronalgesia
- Cryotherapy or spa procedures
Emerging fields - other

Dermatology, Aesthetics:
- Cellulite
- Scars
- Diabetic ulcers

Urology, veterinary
SWT IN SPASTICITY TREATMENT

SWT can decrease all types of muscle hypertonia

◊ Local muscle hypertonus or spasm
◊ Partial hypertonus – Trp

◊ **Muscular spasticity** caused by neurological disorder

Onose, T. *EXTRACORPOREAL SHOCKWAVE THERAPY FOR SPASTICITY MANAGEMENT, IN CHILDREN WITH CEREBRAL PALSY*, 2010


 SWT SUMMARY

- **Chronic** or semi-chronic conditions – non comparable results
- **Muscle, soft tissue and bone healing process start-up**
- **No harm of the tissue**, only anabolic processes proved!
- Long-term follow-up **efficiency about 70-80%** in main indications
- **3-6 sessions** usually maximum
- Necessary to follow **regimen restrictions and contraindications!**
- **Alternative to surgery**
SWT AND OTHER CLINICAL MODALITIES
Reduction of side effects and support of desired clinical result

- **Laser therapy** – more intense healing support in chronic inflammation
- **Electrotherapy** – to support analgesic effect
- **Lymphatic drainage** – sports medicine – regeneration and oedema removal
- **Magnetotherapy** – acceleration of bone and cartilage healing
Synergic Effect of SWT & Laser Combination

- **Biostimulation** – physiologically different supportive effect of SWT
- **Antiswelling and anti-inflammatory** effect - support of healing - dg associated with inflammation to reduce possible side effects of SWT = shorter interval between sessions: 4-5 days
- **Revascularization** = both effects of SWT and laser
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SWT AND OTHER CLINICAL MODALITIES – ACTIVE TRAINING

✧ Rest therapy after treatment?
✧ Stretching and post-isometrical relaxation during or immediately after treatment
✧ Instruct patient to do stretching and post-isometrical relaxation between sessions /i.e. elbow tendinopathies/
✧ Active training up to 40% of the muscle capacity, starting from 2nd day
✧ Regional stabilization and dysbalance corrections
CONTRAINDICATIONS OF ESWT

RELATIVE

◊ Skin defects – relative, some studies show improvement i.e. in DM ulcer
◊ TBC
◊ Tumor diseases
◊ Fever, flu or other infectious disease
◊ Application in the area of varices
◊ Application just above the nerve
◊ Application on certain tissues (eyes and periorbital area, myocardium, spinal cord, gonads, kidneys, liver)

ABSOLUTE

◊ Blood coagulation disorders, anticoagulation treatment
◊ Pregnancy – abdominal or pelvic application

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CONTRAINDICATIONS OF ESWT

- Application of **therapeutic X-rays** within last 6 weeks
- Pharmacotherapy by **corticosteroids** within last 6 weeks
- Sensational deficit in the treated area
- **Disc hernia or protrusion**

**ABSOLUTE**

- **Blood coagulation disorders, anticoagulation treatment**
- **Pregnancy**
- Abdominal or frontal pelvic application
Possible Temporary Side Effects

- Temporary hyper/hypo-sensitivity
- Erythema
- Petechia
- Haematoma
- Oedema

- Most of the patients never experience any of these side effects

- Can be maximally reduced in combination with other therapies e.g. Lasertherapy, magnetotherapy