

Physics of shockwaves

Shock wave generation in therapeutic devices.

- They are 2 classes of shockwaves generators to be considered

– **Focused Electromagnetic Shockwaves**



– **Radial pressure waves**



Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

Indications
Contraindications

Practical guide

Intellect RPW overview

Hand Piece/transmitters



Physics of shockwaves

Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

Indications
Contraindications

Practical guide

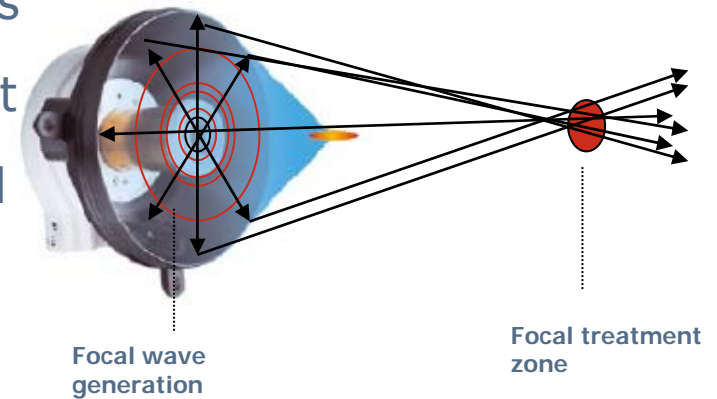
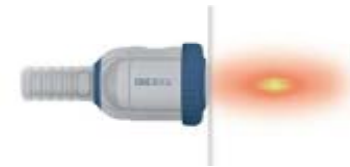
Intellect RPW overview

Hand Piece/transmitters



Focused Shockwaves could be electromagnetically generated

- Based on the physical principle of electromagnetic induction, as used for example in loudspeakers. The arrangement of coils and membranes is optimized to generate powerful and short acoustic pulses.
- The cylindrical arrangement of the coil primarily generates a divergent cylindrical wave, which is transformed into a convergent spherical wave using a special rotation parabolic.



The shock wave energy can be distributed over a large surface area of the body with little pain and can be precisely focused on the focal zone inside the body at the same time

Physics of shockwaves

Shockwave
introduction

History

What are shock waves

Physics of shockwave

Physiological effects of
Radial pressure waves

Indications
Contraindications

Practical guide

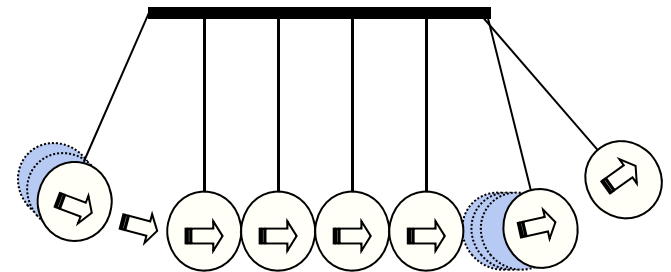
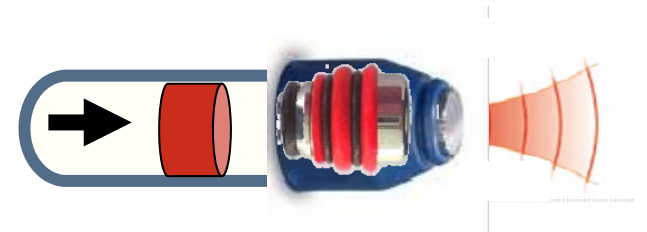
Intellect RPW overview

Hand Piece/transmitters



Radial shockwaves: Radial shockwaves are often referred as Radial Pressure Waves (RPW).

- The radial pressure waves (in physical terms this is the correct definition) are pulses generally generated by compressed air.
- The compressed air is used to drive a projectile in a cylinder inside the hand piece to a shock transmitter.
- The kinetic energy generating from the motion and weight of the projectile, converts into acoustic energy when the projectile hits the shock transmitter. The acoustic pulses then transmit into the underlying tissue, treating a larger area.



Physics of shockwaves

Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

Indications
Contraindications

Practical guide

Intellect RPW overview

Hand Piece/transmitters



Therapeutic shockwaves or Radial pressure waves PW are acoustic waves

The physics laws of acoustic waves are applicable

- **Propagation:** Acoustic waves require a medium for propagation of the acoustic wave. The pressure is transmitted through the displacement of particles.
- **Reflection and refraction:** These effects occur at interfaces with different acoustic impedance. The higher the difference, the higher the reflection
- **Absorption and energy:** Media of high density result in high acoustic impedance and high energy absorption capacity.

The acoustic impedance of the medium is define by his capacity to absorb the wave

Tissue	Acoustic Impedance (x10 ³ Ns/m ³)
Air	429
Lung	260-460
Fat	1 380
Water	1 480
Muscle	1 650-1 740
Bones	3 200-7 400

The maximum refecton and thus energy absorption occurs at medium interface. The Higher the acoustic Impedance difference the higher the energy. **This is, the key principle to remind in order to understand therapeutic effect of Shockwaves**

Physics of shockwaves

Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

Indications
Contraindications

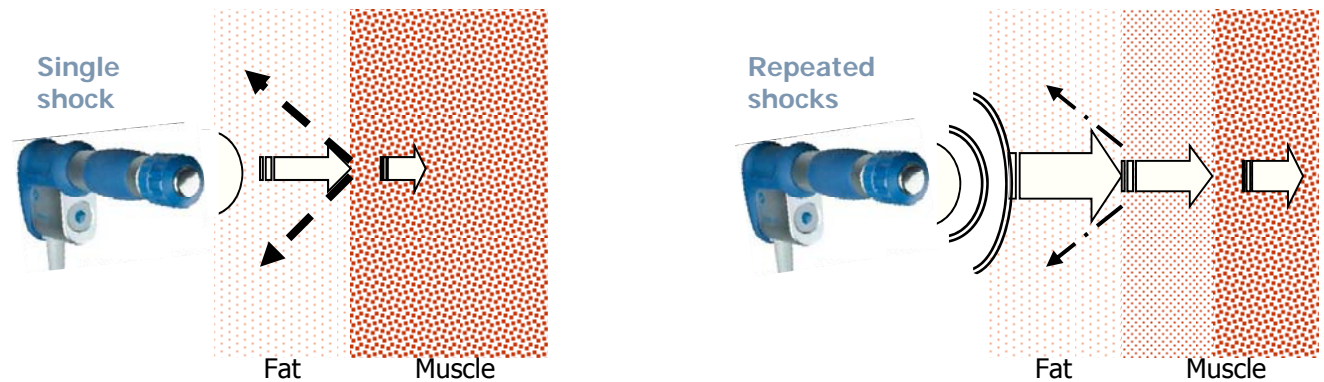
Practical guide

Intellect RPW overview

Hand Piece/transmitters



The wave frequency results in resonance effect generating an energy accumulation effect at the media interface



$IF < IM$
High refraction at the interface
Less penetration

$IF < IMM < IM$
Lower refraction at the interface
Enhanced penetration

IF: Fat Acoustic Impedance
IM : Muscle Acoustic Impedance
IMM: Modified Muscle Acoustic Impedance

Physics of shockwaves

Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

Indications
Contraindications

Practical guide

Intellect RPW overview

Hand Piece/transmitters

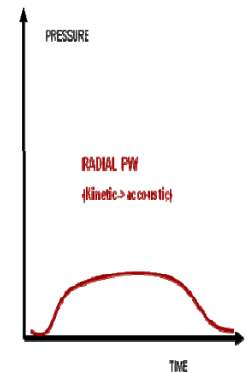
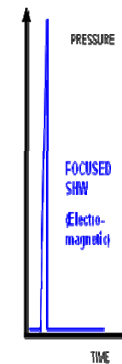


Key parameters

Energy Flux density

- Given in millijoules per mm² (mJ/mm²) meaning the maximal quantity of energy transmitted on a 1mm² surface This factor is of the applied shock waves is an important parameter for practical applications. Shock waves only have an effect on tissue when certain energy thresholds are exceeded.
- Time curve** of the compression pulse duration
- The surface** in which the pressure is effective is also decisive

The Joule (J) is defined by The work required to continuously produce one watt of power for one second; or one *watt second* (W·s)
The Mega Pascal (MPa) It is a measure of force per mm², defined as one Newton per millimeter square.



Small area



High density

Large area



Low density

Physics of shockwaves

Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

Indications
Contraindications

Practical guide

Intellect RPW overview

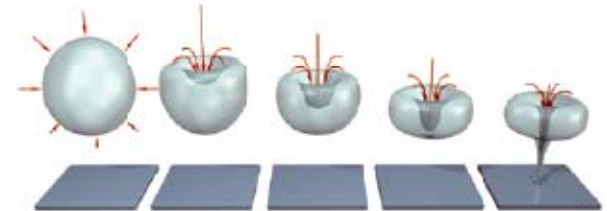
Hand Piece/transmitters



Cavitation

- In addition to the direct dynamic effect of shock waves on interfaces, so-called cavitation occurs in liquids and sometimes in tissue (containing high % of water) as well.
- Cavitation bubbles occur directly after the pressure/tension alternating load of the shock waves has passed the medium.

Cavitation is the formation of vapour bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapor pressure.



The creation of micro-jets contain a high amount of energy and penetration power so that they not only erode the hard interfaces of stones but can also penetrate the walls of small vessels. Because of the cavitation effect Shock waves can't be used on body part rich in gas such as lungs and intestines.



Physics of shockwaves

Shockwave introduction

History

What are shock waves

Physics of shockwave

Physiological effects of Radial pressure waves

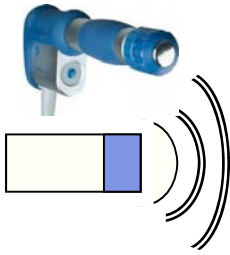
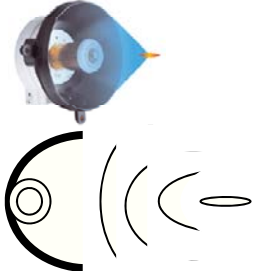
Indications
Contraindications

Practical guide

Intellect RPW overview

Hand Piece/transmitters



Technologies	Radial Pressure wave	Focused shockwave
		
Focused	Larger area	Very small spot
Energy	Max 0,3mJ/mm ² at skin surface	Max 1,5mJ/cm ² In the body
Positive pressure peak	0-10MPa	0-100MPa
Compression pulse duration	200-2000*µs	0,3µs
Penetration	0-3cm depends on transmitter type and shape	0-12cm
Need pre examinations	No	Yes (XRay, MRT, Imaging US, ideally 3D image)
Users	Physiotherapists, aesthetics medicine, orthopedists	Urologists, Cardiologists, Orthopaedists

Physics of shockwaves

Shockwave introduction

History

[What are shock waves](#)

[Physics of shockwave](#)

[Physiological effects of Radial pressure waves](#)

[Indications](#)
[Contraindications](#)

[Practical guide](#)

[Intellect RPW overview](#)

[Hand Piece/transmitters](#)



KEY TAKEAWAYS

- Shock wave are acoustic waves that has an extremely short build up time and very high amplitude.
- They are two kind of technologies:
 - The focused Shockwave and the radial shockwaves (correctly named radial pressure waves)
- Focused shockwaves need pre examination and are not to be used by Physiotherapists
- Radial pressure waves can treat larger area at a depth of 3 cm.
- The wave penetration depends on tissue absorption capacity, the shape and the type of transmitter, the pressure and the Frequency used.
- The Physically induced energy can cause biological reactions via different mechanisms

