Extracorporeal shockwaves in musculoskeletal system (Orthotripsy) is gaining fast and steady recognition worldwide because of consistent and good clinical results either with controlled or non-controlled studies in proximal plantar fasciitis of the heel, lateral epicondylitis of the elbow, calcifying tendinitis of the shoulder and non-union of long bone fracture.

In the past, many physicians remained skeptical in attitude toward orthotripsy because of lack of basic scientific documents despite good clinical data and few sporadic animal experiments. Now, things have changed dramatically. The results of many basic researches had demonstrated that shockwave application produced biological responses at the tissue level including the induction of neovascularization associated with increased expressions of angiogenic growth factors (eNOS, VEGF, PCNA and BMP etc). The discovery had changed the concept of shockwave from pure physical and mechanical implications to biological mechanism. Therefore, in musculoskeletal tissues, shockwaves manifested themselves as biological mechanotransduction which differs from shockwaves in urology (Orthotripsy). The preliminary results of other recent studies in animal models also showed that high-energy shockwaves might be associated with the release of NO free radicals and cell apoptosis by altering Wnt and DKK-1 molecules at the sub-cellular level. Based on this new concept, many new applications of shockwaves other than musculoskeletal disorders had been reported including not limited to chronic skin lesions, osteonecrosis of the femoral head, stable angina pectoris, second degree burn, plastic flap reconstruction and antibacterial application etc. These new indications had widely opened up the field of shockwave in clinical application.

Currently, there are many unsettled issues that ISMST must play a role to resolve them:
1. Many shockwave devices are manufactured with different mechanical principles including "electrohydraulic, electromagnetical and piezoelectric. Each device recommended its own energy level and the numbers of treatment, and the information are not inter-exchangeable in mathematical and physical models.
2. There has been no clear definition on "high-energy" and "low-energy" shockwaves based on scientific data.
3. There is no study documenting the dose-response effect of shockwave despite the fact that the time- and dose-dependent effects of shockwaves were observed in clinical applications.
4. It was speculated that NO free radicals might be involved in the signal transduction and mediation of physical shockwave at the sub-cellular level. Obviously, further studies are needed including genome micro-array analysis to validate the actual biological mechanism of shockwaves in musculoskeletal tissues.
5. In clinical application, shockwave should be recommended as one of the initial choices of treatment for acute and chronic insertional tendinopathies rather than only for chronic refractory conditions of 6 months or longer duration.
6. Furthermore, the off-label indications of FDA guidelines such as osteonecrosis of the femoral head, knee and ankle, OCD of the knee and ankle, infrapatellar tendinopathy (jumper knee), chronic skin ulcers, non-union of long bone fracture and stress fracture etc should be recommended as routine practice.
7. The last and the most important issue is that shockwave should be regarded as a surgical procedure since shockwaves cured most diseases with one single treatment. Unfortunately, many third party insurances regarded shockwave as a therapy modality and reimbursed the cost of treatment unfavorably. Therefore, the term of "Shockwave therapy" to be changed to "Shockwave biopsy surgery" similar to other procedures such as radiosurgery. This change may assist the insurance companies to properly reimburse the cost of shockwave treatment.

Under the leaderships and the guidelines of ISMST, we together have made significant improvement in the field of musculoskeletal shockwaves in the past many years. However, we must work harder and closer together to further strengthen the biological concept and the clinical implication of shockwaves to our peers, and make this new effective and safe, non-invasive and non-surgical device available to patients in need worldwide.
Zusammenfassung


Introduction

For the first time in February 1988 kidney stones were successfully fragmented in the body of a patient using externally applied shock waves. The mechanical energy of the shock wave was able to be transmitted to the body and brought into effect on the stone without significant damage to the tissue. The granular fragments were flushed out of the body in a natural way, eliminating the need for an invasive operation, which had been usual up to that time. This date marks the beginning of a new era characterised by the targeted application of therapeutically effective acoustic energies in human tissue. The special feature of this new form of energy in the medical field is the possibility of generating the energy at a distance and bringing it into effect on target areas deep inside the body without damaging the surrounding tissue. A new form of energy is thus available in addition to the known forms of ionising radiation for a multitude of medical applications.

Mechanisms for generating shock waves

Electrohydraulic shock wave generation

The method initially developed by Dornier is similar to a lightning strike. A high-energy electrical discharge across a spark gap is ignited in a water bath. (Fig. 3, 4, 5)

A capacitor charged with approx. 20 kilovolts (kV) is connected to two metal electrodes arranged at a distance of approx. 1 mm via a fast high-voltage switch. A thin current path, so called leader, first develops, which connects the two electrodes with each other. (Fig. 6)

The formation of the leaders requires a path of low resistance, which is the path with increased conductivity spreads from one electrode to the other. A bundle of different leaders gives rise to an electric field, which may cause the growth of a plant with several shoots. As soon as one branch of the bundle reaches the electrode on the opposite side, they connect and the electrons are established. An increasing avalanche of current rapidly heats up this current channel. A hot plasma form, which explosively expands at supersonic speed over the first millimetres and strongly compresses the surrounding liquid. Pressure peaks of more than 100 megapascals (MPa) = 100 bar are generated within a few nanoseconds.

The electric field of the disturbance spreads radially around the spark as a spherical, divergent wave into the surroundings and thereby rapidly loses intensity. After a few millimetres, the pressures have subsided to the point that a regular propagation takes place without taking significant nonlinearities into account.

For many indications, such as e.g. E.L. fragmentation of kidney stones, an effect deep within the body, away from the originating point, is desired. To this end, the shock waves are focused with an ellipsoid-shaped reflector, in the first focal point of which the underwater spark gap is generated. A corresponding arrangement was already proposed by
Frank Rieker in 1947 to treat biological tissue. (Fig. 7)

A considerable part of the primary spherical wave is directed outside of the reflector into the second focus of the semi-ellipsoid by the reflection on the reflector surface. The shock wave pressure can be increased several megapascals in the vicinity of the second focus and used for therapeutic purposes such as lithotripsy. Focusing makes it possible to locally limit the treatment area and prevent side effects to a large extent. (Fig. 8)

To make matters worse, electrohydraulically generated shock waves cannot be controlled so well and are sometimes perceived as very painful and loud, especially at low pressure settings that are frequently required for orthopaedic applications. The reason for this is that the plasma bubble growth can no longer be precisely controlled. After a few thousand shock wave pulses, the electrodes have to be replaced with new ones. The electrode spacing is limited by a critical limit due to Joule heating. Even before this occurs, the shock wave, since this has already moved approx. 1 metre away. The chronologic process of the electrohydraulic shock wave generation is shown in Fig. 11, 12.

After the overwhelming success of shock wave lithotripsy for kidney stones, it therefore stood to reason to look for alternative methods of shock wave generation that did not have the above mentioned disadvantages of the electrohydraulic method.

Piezoelectric shock wave generation

Electroacoustic transducers are known from ultrasonic technology, in which an arrangement using the piezo effect when a voltage pulse of several kilovolts (kV) is applied. If a large number of piezoelectric elements are arranged on a spherical shape, they can be displaced in the direction of the centre of the spherical shape by a displacement in the direction of the centre of the spherical shape. A convergent spherical wave thus spreads out, which increases its pressure according to the energy densities on its way to the centre. In contrast to the electrohydraulic method, one cannot speak of shock waves in the previously defined sense until the area of the focal zone, i.e., in the centre of the spherical shape. Due to non-linearities a steepening takes place forming a shock wave in the physical sense. (Fig. 13)

Piezoelectric systems have a high accuracy of repetition and are easy to control at higher energy densities. Pressures of up to 150 MPa (1500 bar) are attained in very small focal spots. Unlike electrohydraulics, technology, it is possible to frequently change electrodes. Despite the large-area spherical shape, the attainable total energy of the radiated shock wave can be regarded as rather low. In modern systems, this disadvantage is partially compensated by using double layers of piezoelectric electroacoustic transducers.

Electromagnetic shock wave generation

The method of electromagnetic shock wave generation is based on the physical principle of electromagnetic induction, as used for example in loudspeakers. The energy density can be optimized to generate powerful and short acoustical pulses. Two different configurations can be distinguished: 1. by placing focusing through an acoustical lens and 2. the cylindrical coil with a parabolic reflector.

In the case of the flat coil with focusing by an acoustical lens, a spiral wound coil that is separated from an electrically conductive metal membrane by a thin insulation layer is placed on a flat surface. If a short current pulse flows through the coil, the magnetic field is formed around the individual windings of the coil. This field penetrates through the insulation layer into the metal membrane. Due to the fast current increase, eddy currents are induced in the membrane, which in turn create a magnetic field that is opposed to the original magnetic field. This yields repelling forces that abruptly press the membrane from the coil into the adjacent water bath.

The pressure disturbance created in this way spreads out as a plane wave into the transmission medium until it is transformed into a convergent spherical wave by an acoustical lens. (Fig. 14, 15)

Due to the large apertures and the according large support angle, the shock wave energy can be distributed over a large surface area of the body with little pain and can be targeted accurately to the focal zone inside the body at the same time. In addition, this makes it easily technically possible to integrate electromagnetic shock wave sources such as ultrasound transducers or X-ray paths "in-line" on the axis of the shock wave head, in order to treat target areas deep in the tissue with high precision.

In the case of both electromagnetic shock wave generators as well as piezoelectric methods, shock waves in a physical sense are not generated until the focal zone, where the pressure amplitudes have become so high that steepening effects are activated by non-linear propagation. The steepening of a wave front, the shock wave is shown in Fig. 18.
Propagation of shock waves (reflection, refraction and scatter)

As acoustical waves, shock waves require a medium for propagation. In the case of medically used shock waves, it is usually water in which the shock waves are generated and biological tissue in which they are brought into effect. The pressure is transmitted through the displacement of mass particles, as shown in Fig. 19.

As previously mentioned, the generation of shock waves in a water bath or a tissue-like medium is decisive for preventing a large part of the energy from being lost through reflection when it is induced into the body. For this reason, the first device for kidney stone fragmentation required the patient to be submerged in a water-filled tub. Today’s devices work with the so-called “dry” coupling, in which the water bath is connected to the body via a flexible diaphragm. Regardless of this, it must be ensured that no organs that contain gas (lungs) or large bone structures are in front of the actual treatment area that shield the target area from the shock waves and thus prevent the desired therapeutic effect.

The water bath is important for the medical application of shock waves because the transition to body tissue takes place without a significant change in the acoustical impedance. Acoustical interfaces at which the acoustical properties of density (\(\rho\)) and sound velocity (\(c\)) change produce a distortion of the straight and propagation of waves due to familiar optical phenomena such as refraction, reflection, scatter and diffraction. These effects must be taken into consideration when applying shock waves to human beings, in order to ensure that the energy can become effective in the treatment zone. On the other hand, these properties of shock waves can be used to selectively focus and locally release energy in particular areas of the body. (Fig. 20, 21)

Shock wave parameters/ measurement of shock waves

Shock wave pressure

Shock waves are mainly characterised using measurements with pressure sensors. This requires a very small sensor with a high loading capacity and wide frequency response. As shown in Fig. 22, the measurement of a shock wave field consists of a multitude of point measurements at different places in the shock wave field.

In each measurement, the peak pressure \(p_{\text{peak}}\) as well as the time profile of the pressure \(p(t)\) is determined. The tensile phase \(p_{\text{tensile}}\) is used for diagnosis and the compressive phase \(p_{\text{compressive}}\) for therapy. The peak pressure \(p_{\text{peak}}\) is used to determine the effectiveness of the shock wave. The highest pressures are usually found near the active focus, where the shock wave is emitted from the transducer. The energy concentration is obtained by integrating the pressure over time (see equation for energy).

\[
E = \frac{\int p(t) \, dt}{\rho \, c^2}
\]

As previously mentioned, the therapeutic effect of shock waves is affected by whether the shock wave energy is distributed over a large area or concentrated within a smaller treatment zone. A measure of the energy concentration is obtained by calculating the energy per area (E/A) (\(E/A = E/\pi \cdot r_0^2\)) or energy flux density (EFD) (\(E/\pi \cdot r_0^2\)).

\[
E/\pi \cdot r_0^2 = \text{EFD}
\]

5 MPa treatment zone

For the selective treatment of locally limited areas in deeper tissue layers (pseudarthrosis, femoral head necrosis, kidney stones...), shock waves are bundled to be able to correspondingly limit the desired effects. The highest pressure values are measured in the compression zone. If the pressure sensor is moved away from the centre of compression, the pressure values continually decrease. As a result of the physical characteristics, it is not possible to draw a sharp boundary beyond which pressures abruptly fall to zero. For this reason, it is not possible to sharply define the effective zone of the shock wave with a fixed spatial contour. Physically, the focal zone is defined as the area of a shock wave field in which the measured pressures are greater or equal to half of the peak pressure measured at the centre (Fig. 24).

The area defined in this way is also called the -6 dB focus or described with the abbreviation FWIM (Full Width at Half Maximum). This is thus a spatial area in relation to the peak pressure, which, however, does not initially provide any information on the energy contained therein or the biological effect.

The energy of the applied shock wave is an important parameter for practical applications. It can be assumed that the shock wave only has an effect on the tissue when certain energy thresholds are exceeded. In addition to the time curve of the shock wave \(p(t)\) (see Fig. 1), the surface \(A\), at which the pressure can be measured, is also decisive. Using the acoustical parameters of the propagation medium density (\(\rho\)) and sound velocity (\(c\)), the energy can be calculated using the following equation for energy:

\[
E = \frac{1}{2} \rho c \int_0^{\infty} p(t)^2 \, dt
\]

Fig. 20

Schematic representation of the steepening of a sonic pulse due to non-linearities in the propagation medium. The sonic waves start to diverge with loss of energy, i.e., they become a shock wave front.

Fig. 21

Reflection and refraction of shock waves at interfaces with different acoustic impedance (density \(\rho\) and sound velocity \(c\)).

Fig. 22

Pressure distribution in a plane of the shock wave field, axially in the direction of the propagation of the shock wave and in a lateral direction in this plane. The peak value \(p\) is visualised at respective location in the shock wave field is plotted.

-6 dB shock wave focus

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Shock waves used in medicine show typical pressure values of approx. 10-100 megapascals (MPa) for the peak pressure \(p_{\text{peak}}\). This corresponds to 100-1000 times the atmospheric pressure. The rise times \(t\) are very short, at around <10-100 nanoseconds (ns), depending on the type of generation.

The duration \(\Delta t\) of the shock wave field is given from this data in a rather complicated procedure. If the peak pressures \(p_{\text{peak}}\) that were measured at various locations in the shock wave field are plotted in a three-dimensional representation (in the small section of the shock wave propagation and vertically to this as well), a pressure distribution like the one shown in Fig. 23 results.

\[
\int p(t) \, dt = ED \quad \text{(energy flux)}
\]

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Energy (E)

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\[
E = \frac{1}{2} \rho c \int_0^{\infty} p(t)^2 \, dt
\]
The energy flux density ED is given in milliequivalents per square metre (mJ/mm²). In the case of energy flux density, one also distinguishes between integral ED over the positive part of the pressure curve or the negative part as well. Without index (ED), the pressure curve is usually considered to not include the negative (tensile) components.

The effect of the focusing on the energy flux density is schematically represented in Fig. 26.

**Physical effects of shock waves**

**Direct effect on interfaces**

Shock waves have different characteristics as compared to ultrasound. Ultrasound has a high frequency alternating load on the tissue in the frequency range of several megahertz that leads to heating, tissue tears and cavitation at high amplitudes. One factor, on which the effect of shock waves is based, is an energy flux density called (EFD), the pressure curve is usually negative as well. Without index part of the pressure curve or the integration over the positive (tensile) area, the energy flux density will therefore decrease with focusing. Reducing the area concentrates the energy and thus increases the effect of the shock wave.

Reduction in the same total energy, the energy flux density increases with focusing. Reducing the area concentrates the energy and thus increases the effect of the shock wave. Increasing with focusing. Reducing the area concentrates the energy and thus increases the effect of the shock wave.

**Indirect effect**

**Cavitation**

In addition to the direct dynamic effect of shock waves on interfaces so-called cavitation occurs in certain media such as water and sometimes in tissue as well. Cavitation bubbles occur directly after the pressure alternation alternating load of the shock wave has passed the medium. A large number of bubbles grow until approx. 100 microseconds after the wave has passed and then collapse while emitting secondary spherical shock waves (Fig. 28).

Selective application of localized shock waves

Technical equipment for shock wave application is supplied with different focal distances, depending on the penetration depth. For applications at a depth of several centimetres, the equipment must be equipped with a localization. A X-ray or ultrasound localization is used, depending on the indication. The treatment area is represented with one of the imaging methods and brought into line with the treatment zone of the shock wave device via corresponding adjustment. Devices are offered with very different localization concepts in respect to effort, convenience, precision and localization modality. Devices can be offered at a correspondingly low price, since a localization device is a considerable part of the total expense.

Generation of pressure waves

In addition to the above-described shock waves, also pressure waves with different features are used in medicine. Whereas shock waves typically travel with the propagation speed of the medium (approx. 1500 m/s for soft tissue), pressure waves are generally generated by the collision of solid bodies with an impact speed of a few metres per second. For a carefully targeted shock wave application, all deeper areas require an integrated localization device that has a precise spatial relationship to the actual shock wave application. If the configuration of the shock wave source allows the localization device to be centrally integrated on the shock wave axis (in-line), one has the advantage of very high localization accuracy and easy-to-interpret spatial relationships. Systems located outside of the treatment head (off-line) may be operated with some flexibility independently from it. The localization geometry, however, is more complex and generally not suited to directly detect obstacles in the shock wave path. In modern shock wave devices with in-line ultrasound localization and a treatment depth of up to 15 cm (Fig. 30).

The cavitation is not exclusively due to shock waves, which can be selectively used in localized areas, even in deeper tissue layers. The physically induced energy can elicit biologically relevant mechanisms of action. Frequently, these actions initially lead to an improved local circulation and then activate regeneration mechanisms as a result. In addition to the direct mechanical effects in tissue, stimulation effects can also be detected in the nervous system, which can lead to painful reactions or pathological reflex patterns and in the process lead to a lasting recovery.

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The motion of the impact body is transferred to the tissue at the point of contact, from where it propagates divergently as a pressure wave. (Fig. 31a, 31b, 31c)
The projectile and the impact body placed against the body are normally made from metal materials. When the two metal bodies collide, high-frequency harmonic oscillations (rod waves) are excited in the metal bodies. These oscillations are superimposed on the “slow” translational movement of the impact body. (Fig. 34a, 34b, 34c)

At the distal end of the impact body, the projectile hits the impact body. The pressure disturbance caused by the projectile passes to the distal end of the impact body and is reflected there as a tensile wave. If the projectile has passed through tissue, then the projectile waves return to the collision point with the projectile at the proximal end of the impact body. Only then does the impact body become decelerated by the projectile and move towards the tissue at a speed of several metres per second. At the same time, the rod wave that is reflected as a pressure wave passes through the impact body once more and is reflected at the distal end again as in the first passage. The process is repeated several times, so that the described wave in the impact body is superimposed on the “slow” translational movement.

Due to the great differences in the acoustical impedance between the metal impact body and the coupled water or tissue, a large part of the energy of these high-frequency oscillations remains bound in the impact body. Only a small part of the oscillation energy is also radiated into the water and can be picked up there using the usual hydrophones. This is a damped oscillation, as shown in Fig. 35. The pressure amplitudes show values of up to 10 MPa (typically < 1 MPa) and are thus below the pressure values usually achieved by shock waves by a factor of approx. 10 to 100. A damped pressure wave due to non-linearities in biological tissue can thus be disregarded.

As a result of its displacement, the impact body transfers a pressure disturbance to the coupled tissue, which shows the same time behaviour at the contact point as the displacement. The pressure pulses transferred to the tissue thus have a duration of 0.5 ms and are longer than with the above-described shock waves by a factor of approx. 1000. At approx. 10 MPa, typical peak pressures with this method are lower by a factor of 2-10.

The extremely long pulse duration in comparison to shock waves has a decisive influence on the propagation of pressure waves in tissue. Unlike the shock waves, such pressure waves cannot be focused on narrow tissue areas. In relation to the size of the human body, focusing cannot be achieved for physical reasons.

A detailed observation of the collision process between the projectile and the impact plate, however, shows a further phenomenon that can be seen in the sagittal shape of the curve in Fig. 32 and to a lesser extent in Fig. 33. Shock and pressure waves not only differ in their physical characteristics and the technique used for generating them, but also in the order of magnitude of the parameters normally used. The differences between the most important parameters listed here are approx. 1-3 orders of magnitude.

Interestingly, the simulation effects and therapeutic mechanisms seem to be similar, despite the physical differences and the resulting different application areas (on the surface and in depth respectively). However, the described pressure waves are not able to fragment hard condromata such as e.g. kidney stones deeper in the body (> 1 cm). Nevertheless, unfocused pressure waves seem to be well suited for orthopaedic indications near the surface as well as in trigger point therapy.

Figure 36 shows a combination device for focused shock waves and unfocused pressure waves. Depending on the indication, treatment zones several pressure amplitudes are found in the deep body can be treated in a focused way and zones near the surface can be treated using unfocused pressure waves.

However, the energy contained in the high-frequency harmonic oscillation is several orders of magnitude smaller than the energy contained in the aforementioned (low-frequency) pressure pulse. It is within the range of diagnostic ultrasound. Nevertheless, it cannot be ruled out that a certain treatment effect is related to this.

The previously described pressure pulse, which is long in comparison to shock waves, is difficult or impossible to detect with the common pressure sensors used in shock wave technology.

Pressure waves as described here emanate from the application point of the impact body and travel radially into the adjacent tissue. The energy density of the induced pressure wave quickly drops with increasing distance from the application point (by the proportion l^3), so that the strongest effect is at the application point of the application piece. One difference between focused shock waves and unfocused pressure waves is the fact that focused shock waves can be directed into deeper tissue, where they develop a therapeutic effect, with less stress to the skin. Unfocused pressure waves, on the other hand, primarily have an effect on the surface.

**Technical differences**

The technical differences are shown below:

<table>
<thead>
<tr>
<th>Shock waves (focused)</th>
<th>Pressure waves (unfocused)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Propagation</td>
<td>non-linear</td>
<td>linear</td>
</tr>
<tr>
<td>Steepening</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Rise time</td>
<td>typically 0.01 µs</td>
<td>typically 50 µs</td>
</tr>
<tr>
<td>Compression pulse duration</td>
<td>approx. 0.3 µs</td>
<td>approx. 200 - 2000 µs</td>
</tr>
<tr>
<td>Positive peak pressure</td>
<td>0 - 100 MPa</td>
<td>10.1 - 100:1</td>
</tr>
<tr>
<td>Energy flux density</td>
<td>0 - 3 mJ/mm²</td>
<td>0.0 - 0.3 mJ/mm²</td>
</tr>
</tbody>
</table>

**Discussion**

Shock waves have become an indispensable part of modern medicine, due to their means of bringing therapeutically effective energies to locally limited places in the body in a non-invasive way. The fact that shock waves selectively affect acoustical interfaces and pass through homogeneous elastic tissue without damage for the most part is medically important. Tissue damage outside of the treatment zone is almost completely avoided due to the possibility of concentrating energy through focusing. This significantly increases the therapeutic effects within the treatment zone, although moderate side effects (haematomas) cannot be entirely ruled out when especially high energies are used, as in lithotripsy.

In addition to the fragmentation effect in stone treatment, the stimulating effect of shock waves on biological processes has increasingly become the centre of interest in the last few years. Although the mechanism of action for this is still unknown to a large extent, shock waves seem to have a special biological potential here. It appears that the principle of action is so universal that a multitude of very different indications respond positively to shock wave therapy. In order to study the mechanisms of action, the shock waves that are used must be precisely characterized using the parameters described in the text. This is the only way to determine dosage/effect relationships and obtain sound knowledge about the mechanism of action. However, the fact that the focused shock waves and unfocused pressure waves, which have clear physical differences, show a similar effect especially in the area of stimulating healing processes suggests that both forms of energy do not have a direct mechanical effect but intervene in the specific healing reflex behaviour. It seems that a reorganisation of pathological reflex patterns that are anchored in memory due to the stimulating effect of shock and pressure waves cannot be ruled out. This would open up a previously unknown potential for further therapeutic uses of application.
Extracorporeal Shock Wave Therapy (ESWT) in Skin Lesions

W. Schaden
R. Thiele
C. Köpl
A. Pusch

Introduction
Since 1981 extracorporeal shock waves have been used very successfully for the disintegration of calcified deposits in urology as well as in orthopedics. Due to high efficacy and few side effects, this therapy soon becomes very popular around the world. Since 1980 (1) shock waves have also been used for a variety of orthopedic indications. The therapy proved effective for tendon insertion conditions such as fasciitis plantaris (heel spur) and calcific tendinitis of the shoulder. Shock wave therapy is also widely used for lateral epicondylitis (tennis elbow) as described within previous chapters. Due to the few side effects shock waves also gain ground for the treatment of pseudarthrosis (non union) and delayed union. Non-invasive and without clinical significant side effects, ESWT has also been used successfully in pilot studies for the treatment of osteochondritis dissecans (OCD) (2) as well as aseptic bone necrosis (AVN) (3, 4, 12). In Japan, shock waves were used successfully in animal experiments for the treatment of ischemia-induced myocardial dysfunction (5). Even skin flap survival in rats as improved as a result of shock wave therapy (6).

When treating septic pseudoarthrosis (osteomyelitis), often linked to skin lesions (fistula formation, skin defects O), bone tissue would consolidate and skin defects would heal particularly fast in many cases. In addition, Gerdsemeyer (7) found in vitro bactericidal effect of shock wave therapy. Encouraged by such findings, a pilot study on the treatment of skin lesions with ESWT was conducted.

Material and Methods
To conduct the study an OrthoWave 180c from MTS was used. Since most often surface defects are involved, the shock wave head was modified in that the shock wave would no longer be focussed but be roughly plane to the treatment area. Energy Shock Waves in Medicine. Georg Thieme Verlag, Stuttgart 1997. The therapy proved effective for tendon insertion conditions such as fasciitis plantaris (heel spur) and calcific tendinitis of the shoulder. Shock wave therapy is also widely used for lateral epicondylitis (tennis elbow) as described within previous chapters. Due to the few side effects shock waves also gain ground for the treatment of pseudarthrosis (non union) and delayed union. Non-invasive and without clinical significant side effects, ESWT has also been used successfully in pilot studies for the treatment of osteochondritis dissecans (OCD) (2) as well as aseptic bone necrosis (AVN) (3, 4, 12). In Japan, shock waves were used successfully in animal experiments for the treatment of ischemia-induced myocardial dysfunction (5). Even skin flap survival in rats as improved as a result of shock wave therapy (6).

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The views expressed in this publication are independent of the sponsor. Any product mentioned should be used in accordance with the prescribing information provided by the manufacturer.

Discussion

Based on the initial encouraging results of our pilot study, a completely new potential of shock wave therapy appears to emerge. The patients enrolled in our pilot study are reported as a negative selected patient group because all cases refused to get any surgical intervention. Patients willing to get surgery were referred to and shock wave therapy was not offered. The promising outcome after this non invasive treatment option in chronic wound care justifies to indicate shock wave in those soft tissue condition as described above. For sure further studies have to performed to determine optimum treatment parameters. Finally subsequent prospective, randomized controlled double-blind studies may demonstrate the efficacy and safety of ESWT in treating skin lesions.

Literature


**PODER rápido e prolongado**

Em um estudo clínico de odontalgia pós-operatória realizado com ARCOXIA 120 mg:

O início da analgesia começou já aos 24 minutos.

**PODER rápido e prolongado**

O efeito analgésico persistiu por até 24 horas.

**ARCOXIA 120 mg** só deve ser utilizado durante o período sintomático agudo.


**CONTRA-INDICAÇÃO**

- Contraindicação: A administração concomitante de ARCOXIA e um contraceptivo oral com etinilestradiol aumentou a concentração plasmática do etinilestradiol. Um aumento na exposição ao etinilestradiol pode aumentar a incidência de eventos adversos associados aos contraceptivos orais.

**INDICAÇÕES**

- Tratamento agudo e crônico dos sinais e sintomas da osteoartrite e da artrite reumatóide, da gota aguda e da dismenorréia primária; alívio da dor aguda e crônica.

**INTERAÇÕES MEDICAMENTOSAS:**

- **Ácido acetilsalicílico em baixas doses:** pode ser utilizado concomitantemente a ARCOXIA; este, porém, não exerce efeitos sobre as plaquetas e não substitui o ácido acetilsalicílico para profilaxia cardiovascular.

**REATORES ADVERSAS:**

- **Insuficiência renal:** o tratamento com ARCOXIA não é recomendado para pacientes com doença renal avançada.

**POSOLOGIA:**

- **Inferior a 65 anos:**
  - **Insuficiência renal:** dose de 60 mg, 120 mg uma vez ao dia (somente durante o período sintomático agudo).
  - **Insuficiência hepática:** dose de 60 mg em dias alternados.

- **Pacientes com idade superior a 65 anos:**
  - **Insuficiência renal:** dose de 60 mg, 120 mg uma vez ao dia (somente durante o período sintomático agudo).
  - **Insuficiência hepática:** dose de 60 mg em dias alternados.

**ATENÇÃO:**

- Antes de prescrever ARCOXIA, recomendamos a leitura da Circular aos Médicos (bula) completa para informações detalhadas sobre o produto.

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