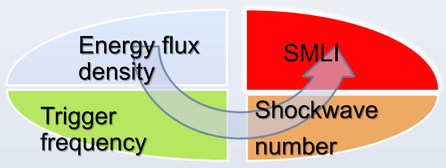
Fractionated ESW therapy for heel pain: Reproduction of successful post-therapeutic courses through standardized conditions; A clinical report



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Introduction:

Depiction of his heel pain by a Hungarian ironsmith before fractional ESW therapy.

Heel pain is usually attributed to a radiologically detectable so-called symptomatic heel spur with proximal bone outgrowths at the base of the soles of the feet with almost always accompanying inflammation of the plantar aponeurosis, plantar fasciitis. In addition, but also other causes can cause similar or similar pain symptoms such as Haglund's heel, Achilles tendon calcification, Achilles tendon calcification, Haglund's exostosis as well as tarsal tunnel syndromes, arthrosis, bone cysts.

3-5% of the global population suffers from heel pain, which can be attributed to various pathologies, such as plantar fasciitis with or without spurs, Achilles tendon shortening, or calcification. Furthermore, heel pain can occur in the context of rheumatoid arthritis, systemic diseases such as gout, diabetes mellitus and HIV. Nerve constriction syndromes can also be responsible for this.

For the treatment of heel pain, the results of dosage, standardization, validity and reliability of shock wave therapy from 2017 and 2018 were used.

The indication of therapy is only given in symptomatic cases.

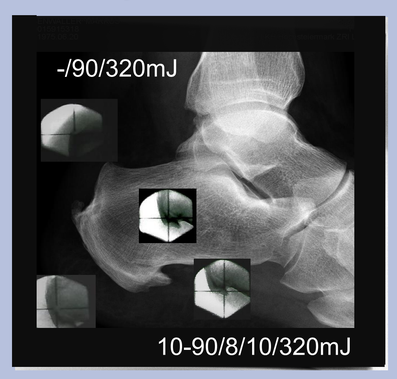
The pain symptom is described in the anamnestic as severe pain, which occurs at the first load after physical rest and improves after exertion, but recurs after prolonged strain. This leads to a relieving posture and to the point of being unable to walk.

Fractional ESWT has been applied since 2019 using empirically determined and theoretically calculated treatment conditions about 600 patients with heel pain of varying pathological severity. Successful post-treatment outcomes were reproduced in up to 95% of patients.

Material and method :

A Storz Medical Ag Lithotripter Duolith SDI which operates based on the electromagnetic principle was used as the shock wave generator. Detection of the shock wave with an ultrasonic diagnostic instrument in transmission after focus.

An X-ray image converter and an ultrasound detector integrated into the shock wave regenerator were used to focus and observe local changes.

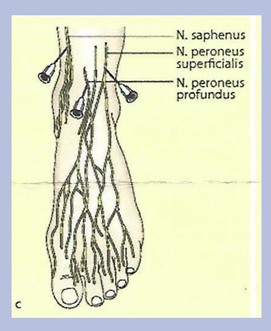


Fractionated application of shock waves depending on their intensity has been shown to be a beneficial treatment option both empirically and theoretically.

"The effect depends on the dose"

Energy flux density [mJ/mm²]	Energie Setting	Trigger frequency [1/s]	commutative shock wave energy [mJ]	Shockwaves
0,32	10	3	8	370
0,43	20	3	16	660
0,53	30	3	24	970
0,61	40	3	32	1110
0,73	50	2	40	1370
0,98	60	2	48	1416
1,31	70	2	56	1505
1,6	80	2	64	1585
1,84	90	2	320	3760

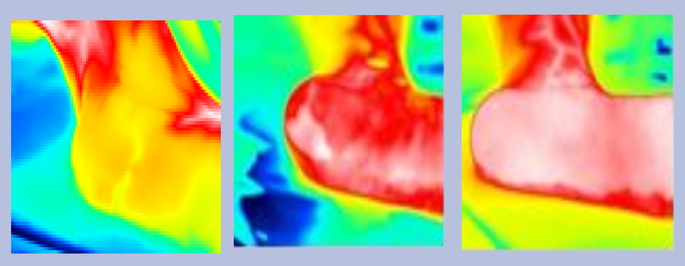
Before shock wave therapy all pain sensations were suppressed by local anaesthesia through infiltration of the local nerves of the foot with 5 ml of Mepivacaine.



Depiction of anaesthesia by a Hungarian ironsmith.

Maintaining thermodynamic equilibrium has a positive impact on treatment management and success.

During therapy local temperature fluctuations were recorded using a thermal camera.



Results:

Shockwave therapy was administered according to the patient's individual pain sensitivity and a previously standardized and optimized fractional application of the total energy with an 8mJ accumulation. The total energy applied, which led to the successful therapeutic effect, was approximately 320mJ per diagnosed pathology.

The post-treatment course about 600 patients with heel pain from various pathologies, who were treated with this standardized application of shock waves was observed clinically on an outpatient basis for up to 7 years.

Approximately 95% of the treated patients showed significant pain relief both at rest and during exercise.

Approximately 3% of the patients requested repeat treatment.

Approximately 30% of the patients reported other complaints of varying locations.

Approximately 2% of the patients complained of a recurrence after 1-3 years.

Discussion:

- The shock waves are produced when the sound waves propagating from the sound source occur on a medium whose components have more than 1 degree of freedom, so that at high intensities the Khokhlov-Zabolotskaya-Kuznetzov nonlinear developmental equation applies.
- The vibrations is described in classical mechanics, from Newton as action = reaction. A sine wave is only generated after homogenization of the heterogeneously designed tissue parts. Hidden in the shockwave pulses (about 1000 periods) is an ultrasonic wave that oscillates at about 3Mhz, forcing the focused lesion to oscillate at this US frequency.
- Due to the counteracting local tissue-specific forces, this vibration is quickly dampened with amplitude $X=X_0e^{-ßt}$. This results in a so-called aperiodic oscillation. Due to the successive application of the shock waves, the physical character of the tissue is changed by storing energy, which is then transferred to the environment. With the duration of the application, the tissue takes on a form that is close to homogeneous for US, which allows a periodic non-damped sinusoidal oscillation with amplitude $X=X_0 \sin(\omega t)$ force the tissue components to vibrate in the focus with the ultrasonic frequency about 3MHz. The sinus waves can experience reflections from the boundaries of the tissue, which can cause a counter wave that leads to a superposition of the waves propagating back and forth. The consequence is a dissolution or amplification of the amplitudes, as with a harmonic oscillation.
- The mechanical interaction of sound particles, so-called phonons with the energy $E=h\omega/2$, with electrons and lattice atoms is described in quantum mechanics. The frequency of sound at about 3 MHz corresponds to a window for the propagation of sound into and through the tissues without significant absorption and reflection. This frequency at about 3MHz also seems to be responsible for the therapeutic effects.
- A pressure component of the propagating sound waves in the body arises and disappears again and again, in which the sound waves occur in an adjacent area of fluid and tissue, e.g. in joint cavities such as the knee joint, which are adjacent to a pathologically altered cartilage surface and fluid is increased. In such cases, effects such as cavitation and blistering occur, which can be visualized with a diagnostic ultrasound device. Such effects were not observed in the heel area during fractional ESWT.
- The focal temperature increases caused by the shock waves, result in burning pain, which gradually disappears after further application of shock wave impulses. This subsequent pain-free state is interpreted as a change in physical quantities in the tissue such as density and elasticity, as well as better propagation with reduced sound impedance. The result within the tissue is then a sine wave. In shock wave therapy, we strive for a harmonious oscillation in the tissue. During therapy, this harmonization of the waves correlates with the patient's positive feeling towards healing their disease.
- In contrast to HIFU, fractional ESWT keeps heat generation within limits, so that no necrosis or tissue subsidence occurs.

Summary:

Fractional SWT has been successfully applied to over 600 patients with heel pain of different localizations.

A retrograde study of 500 patients (treated between 2002 and 2017) showed that a therapy with so-called shock waves leads to a significant reduction in pain or total disappearance of the same.

The question always arose whether the application of the shock waves is a momentum transfer or energy transfer. In our view, a momentum transfer is always to be avoided. In our opinion, therapeutic success without therapeutic or post-therapeutic complaints can only be achieved through energy transfer.

In addition, fractionation of 8mJ depending on intensity and a cumulative dose of 320mJ per pathology is observed.

Depiction of succesful treatment by a Hungarian ironsmith

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