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## Extracorporeal Shock Wave Therapy (ESWT) in Orthopaedics and Traumatology

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### ESWT, the powerful approach to musculoskeletal diseases

Extracorporeally generated shock waves were first used for kidney stones in the early eighties. The treatment modality revolutionized urologic management and developed into today's method of choice. Since the waves are also used for several kinds of musculoskeletal applications: elbow, calcified shoulder, heel spur and non-unions. Analgesic effect effects due to enhanced metabolism, circulation and revascularization. Astonishingly, significant improvements up to complete reduction of complaints and stable reunion of non-unions are gained. Using basic technology as for stone fragmentation, extracorporeal shock wave therapy stands for shock wave application in general, with a specific impact on indications, both, non-unions and tendopathies as well as others.

Even in sports medicine ESWT becomes a valuable new therapeutic tool. In 1996, for the first time, an orthopaedic shock wave device was used by a team during the Olympics in Atlanta. Instead of stone disintegration, several types of tendopathies and persistent close to bone soft tissue injuries were treated. At the World Cup 1998 in France, three of the participating teams including the French national team made use of shock wave machines (MINILITH® SL1, STORZ MEDICAL) to keep the athletes on their top performance level on time. Today's athletes make use of ESWT on a regular basis.

### Shock waves for medicinal use

Shock waves in medicine are focussed high pressure acoustical waves of short duration. They are transmitted through soft tissue without major losses at interfaces of different organs. Shock waves are pulsed acoustic waves of short time duration (< 1 microsecond) very high pressure amplitude (up to 10 MPa (100 -1000 bar) and relatively low tensile wave components (approx. 1 MPa maximum pressure).

Shock waves are generated outside the human body in water and transmitted through a large skin transmission area onto the target region where the energy is concentrated to a focal area of 2-8 mm in diameter. Modern devices make use of coupling cushions instead of an open water bath to couple the waves into the body without significant losses. Targeting of the treatment region is achieved by an isocentrically attached co-axial ultrasound transducer or by a flexible localization device such as mobile C-arms.

Treatment of the affected tissue region is done by a sequence of 1000-2000 pulses.

pulses fired with a repetition frequency of 1-4 pulses per second. The lasts 15-30 minutes and is usually performed without or under consu local anaesthetic drugs.

### **Shock wave generation technology**

Within the last two decades several different methods of shock wave been developed. There is no question, that electro-hydraulic, piezo- magnetic techniques can generate shock waves for medicinal applica technical benefits and some disadvantages of the accordingly genera however, there is no "magic" feature which would qualify only one of effective. Possible differences in rise time of pressure increase are w passing through living tissue, thus being of no relevance with respect specific modality. Nevertheless, significant technical differences mak more favourable than others.

### **Electro-hydraulic-ellipsoidal reflector, the historic method**

The electro-hydraulic principle makes use of a spark plug like electro rapidly expanding plasma bubble heated by the spark channel repels water volume. The thereby developing spherical shock wave is focus rotational ellipsoidal reflector. The first kidney stone lithotripter was historic principle, first invented for soft tissue treatment 50 years ag wave generator is still in use, however, it features some significant c to modern shock wave devices such as costly wear of electrodes, ext level, non-uniform energy delivery etc.

### **Electro magnetic cylinder - parabolic reflector, present state**

The state of the art configuration of a shock wave device utilizes a c arrangement of an electro-magnetic generator with a parabolic refle coil system provides significant improvements over flat coil arrangen focussing. The cylindrical wave front is focussed virtually without ene rotational parabolic reflector. Simultaneously, it provides the approp central axis for implementation of either inline X-ray localization or i transducers.

Whatever technique of shock wave generation is used, to date, shock generated outside the human body, transmitted via a large skin area by means of focussing reflectors to the area of interest within the se order to target the energy precisely to the desired location, imaging and/or X-ray) are used. The most precise method utilizes co-axially configurations of imaging modalities and shock wave devices. Offline (transducer outside the shock wave application head) suffer from rec to different tissue to be passed by shock waves and imaging energie

Due to the technical benefits such as power, reproducibility, dynamic the electro-magnetic principle and i.e. the electro-magnetic cylinder parabolic reflector becomes more and more standard in high quality because of the additional benefit of inline localization features as dis

### **Orthopaedic shock wave devices**

Although side effects of ESWT are usually negligible high energy sho harm to certain organs if not applied properly. Precise targeting and tissue are mandatory. Apart from certain other organs especially lun

to potential shock wave lesions and bony tissue may obstruct shock ESWT devices, therefore, require some kind of localization modality : and/or X-ray in order to clearly control the shock wave propagation in human body. Different device configuration are commercially offered arrangements of shock wave applicator and localization modality.

A second tool to increase therapeutic shock wave efficiency is to concentrate wave energy to a well confined treatment area and keeping the energy as low as possible anywhere else. This simple but efficient idea simultaneously avoids side effects. Technically, the goal is to use large aperture angles of the shock wave head which also provide high energy concentration (therapeutic effect) and low energy (low pain and tissue lesions) in the coupling area and anywhere else.

Due to the large variety of indications, the shock wave applicator needs to reach a number of distinct areas of the human body from top to toe. This requires a degree of mechanical flexibility of the shock wave head which usually is provided by ordinary lithotripsy machines for urinary stone fragmentation. Several specific orthopaedic devices with a flexible support of the applicator head with or without inline ultrasound or X-ray targeting configurations.

Modern ESWT devices have all the beneficial features required by the musculoskeletal indications. The latest generation also offers sufficient penetration depth up to 15 cm to fragmentize all kinds of human calcifications. Interdisciplinary devices as for example the MODULITH SLK Storz Medical contribute to significant cost reduction due to multiple use in different specialties.

### Medicinal aspects

After its introduction in 1994, more than 100'000 shock wave treatments were successfully performed on various indications. Approximately 70 to 80% of patients gained significant improvements of their complaints although to mention - their chronic disease was unsuccessfully treated before using conservative treatment methods. Many thousands of patients could be freed from their complaints without open surgery which would have been the only treatment choice, also promising a limited success rate only.

Apart from treating chronic diseases after several months and years of conservative treatment approaches an interesting subgroup of indications within sports medicine. Top athletes need to be fit on time and do not want to consume time consuming conservative therapies unless absolutely required. ESWT is a fast and effective therapeutic procedure which allows continuation of training usually the following day after treatment. ESWT is a non-invasive therapy with no significant side effects. Often immediate pain relief and muscle relaxation allow continuation of training and participation in sports events.

The situation for other than top athletes turned out to be different. Several of the below listed indications may be successfully treated by conservative methods like injections, massages etc. at lower costs the shock wave treatment would have been a frustrating treatment (minimum 6 months) by conservative methods. Chronic pain indications feature the negative and most difficult to treat indications suitable for open surgery. Even surgical methods promise an improvement in 80% of the patients. Extracorporeal shock wave treatments are successful in a high percentage of patients with the extraordinary advantage of being completely non-invasive. Most important also is the fact that patients may continue their training the following day. Taking into account the significant reduction of the inpatient stay

the short healing time not only compared to open surgery, ESWT is ( than several months of conservative treatment efforts.

### Indication Range

The therapeutic potential of ESWT is by far not yet fully known. The is still under discussion. Improvement of circulation and metabolism the most stringent mechanism responsible for muscle relaxation, pai enhanced healing processes in case of non-unions.

The following four indications are considered well established due to successful treatments all over the world.

- | Non-unions
- | Tendinosis calcarea
- | Plantar and dorsal heel spur
- | Tennis elbow

All those indications are successfully treated by ESWT predominately This does not mean that treatment in the acute phase will be less efl simple conservative treatment strategies may gain equally good resu For financial reasons doctors restrict themselves to use ESWT only fo frustrane treated chronic diseases.

Further indications such as hip necrosis and others are under investi results are promising.

### Financial Aspects

Due to the high success rate and the almost complete lack of side ef a frequently used treatment alternative for tennis elbow, heel spur, 1 and others. Surprisingly, this seems to be the reason for preventing of the method in some countries.

In spite of all over excellent medicinal success, published in several 1 statistically proven evidence supported by prospective double blind s lacking. Several studies are currently performed and FDA approval fo indications is pending in the US. Interestingly, most of all other acce and reimbursed medicinal procedures are also lacking statistically pr the first glance, ESWT seems to be costly due to expensive technical times of lack of financial resources and cost explosion in medicinal c: extremely sensitive issue. Whenever a fixed amount of money is shif medicinal speciality to another concerns and growing suspicion of th group and health care authorities are generated. Taking into account reimbursement costs of public health care systems, but all recovery convalescence time, the financial benefit is obvious.

### Conclusion

ESWT has proven to be a new and very effective treatment modality wave technology established since 20 years in urological stone thera fragmentation power shock waves turned out to provide significant t various musculoskeletal diseases. There is no doubt about final acce technology by the medicinal community even if financial restrictions care systems presently prevent ESWT from being as well accepted a



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