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Physical Principles of Shock Waves and Pressure Waves

Different Technical Solutions for Medical Applications

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Shock waves in medicine are utilized for different applications such as fragmentation of kidney stones, stimulation of healing processes and as treatment option for certain chronic pain diseases. Shock waves are generated mainly by three different physical principles: electro-hydraulic, electromagnetic and piezo-electric mechanisms. They are characterized by a high peak pressure ($P_+ = 5-100$ MPa), steep rise of pressure amplitude ($T_r \ll 1$ Microsecond), short time duration ($T_d < 1$ Microsecond) and low tensile pressure amplitudes ($P_- < 10\% P_+$). Extracorporeally generated shock waves are generated within in a tissue like medium (usually water) to be transmitted into the body without significant reflection losses. Shock waves are distributed over a large surface area for gentle and lesion free transmission and are concentrated (focused) to ensure high treatment efficiency within the target zone. Whenever required, defined treatment zones may be selected within predetermined and localized regions of the body. As long as energy transmission is not obstructed by bony or gas filled organs remote tissue areas may be reached.

Although often mixed up, shock waves can be clearly differentiated from lower amplitude pressure waves, not featuring the above mentioned typical characteristics of shock waves. These types of pressure waves are usually generated by mechanical impact of colliding bodies resulting in extended pressure pulses ($T_d > 200$ Microseconds) superposed by a small ultrasonic vibration in the range of 100 kHz containing only a small part of the applied energy.

In spite of being physically different from shock waves as defined above, pressure waves may also be efficiently used for stimulation of healing processes and pain therapy, but not for stone fragmentation in distant locations. Effective energy application is limited to superficial areas close to the point of skin contact.

Stone fragmentation is based on the disintegration power of shock waves. Stimulating effects and tissue engineering qualities of shock waves require a different mechanism. Reorganisation of pathological reflex patterns on a neuronal memory level may be an important mechanism involved and followed by biochemical reactions and improved metabolism. The hypothesis of modulation of reflex patterns by shock waves is briefly outlined.

Treatment of Painful Heel Syndrome With Shockwaves

Author: Dr K. Raveendran

Institution: Hospital Fatimah, Ipoh, Perak, Malaysia

A prospective non-randomised clinical study on the effectiveness of shockwaves for painful heel syndrome was done on 126 patients. There were 57 males and 69 females. There were 22 cases with bilateral treatments making a total of 148 treatments. Each heel had 800 impulses. All patients presented with plantar tenderness and heel pain.

89 (71%) patients were examined or contacted at a minimum 6 months follow up. 74% had no pain or minimal pain. 3 patients said they were worse off after the treatment.

18 patients had no improvement and had a second treatment. None of the patients had more than 2 treatments.

No systemic or local complications were noted.

Shockwave therapy has been the most effective modality for treatment of the recalcitrant painful heel syndrome in Malaysian patients compared to physiotherapy and steroid infiltration used prior to the advent of shockwave therapy.

Shockwave Therapy for plantar fasciitis : retrospective study

Authors: P Rockett, A Souza, P Santos

Institution: Ortosom, Porto Alegre, Brazil
Cortrel, Rio de Janeiro, Brazil
Orthomaster, São Paulo, Brazil

Aim:

The aim of this study was to evaluate the efficacy and the safety of extracorporeal shock wave therapy for the treatment of plantar fasciitis in three Brazilian Orthopaedics Clinics.

Material and Methods:

In a multi-center, retrospective study, the effect of shockwave therapy was investigated in 103 patients with plantar fasciitis treated in the period of 39 months from March 2001 to May 2004. There were 55 women and 48 men with an average age of 56 (range, 31-90) years. The criteria for inclusion were at least three months of unsuccessful conservative therapy or six months of pain. Criteria for exclusion were inflammatory arthritis, previous corticosteroid injection, acute infection, neurological abnormality, gout, malignant diseases, blood coagulation disorders and ruptures of the plantar fascia. Each patient was treated with 1200 - 1500 impulses of shock wave, a 20 mm focus depth, and with an energy flux density of no more than 0.14 mJ/mm after local anaesthesia or ankle block. One treatment was performed on 96 patients, 6 patients underwent a second treatment and 1 patients underwent a third treatment. The subjects were evaluated by means of a clinical evaluation according to Roles and Maudsley score , subjective outcome on Visual Analogue Scale (VAS) analysis, 45, 90 and 180 days after the end of the therapy.

Results: The study showed the efficacy and safety of ESWT were excellent in 36.9%, good in 32%, acceptable in 9.7%, and poor in 21.4%, 180 days after ESWT.

Extracorporeal Shockwave Therapy (ESWT) in The Treatment of Plantar Fasciitis

Authors: P.Papandrea MD, M. Ciurhuini MD, A. Ferretti MD

Institution: “Kirk Kilgour” Sports Injury Center,
Department of Orthopaedic Surgery
St. Andrea Hospital, University of Roma “La Sapienza”, Italy

Objectives: evaluate medium-term clinical results of symptomatic treatment of plantar fasciitis.

Methods and Measures:

From October 1998 to December 2004, 82 patients affected by plantar fasciitis, 14 of whom with a bilateral pathology, for a total of 96 cases, were treated with ESWT. On the basis of the inclusion criteria indicated by ISMST, 58 patients (67 cases) were included in the study. 44 patients (29 males and 15 females) aged between 21 and 77 years (average 56 year) were reviewed at 1 month, 4 month, 17-month follow up. 9 patients were affected by bilateral plantar fasciitis, for a total of 53 cases re-examined. 25 patients (30 cases) played sports activity. X-rays showed the presence of calcaneal spur in 34 patients.

In the pre-treatment phase, the symptomatology was classified into 5 stages according to the severity of pain and its effects on daily activities.

- a. Stage 0: lack of pain;
- b. Stage 1: pain only after intense physical activity or after playing sports;
- c. Stage 2: pain and stiffness during intense physical activity or during sports;
- d. Stage 3: pain during daily activities;
- e. Stage 4: pain at rest and at night.

An average of four sessions (min 3, max 5) of shockwaves were administered (power from 0.04 to 0.250 mJ/mm², 2000-2.500 impulses for each session).

Clinical outcomes were evaluated according to the following criteria (based on the symptomathological classification mentioned above):

- Excellent: lack of pain (stage 0);
- Good: stage I with an improvement of at least two stages;
- Fair: improvement of one stage;
- Poor: no improvement.

Results:

At 1 month follow-up, 49% of patients reported satisfactory results (excellent and good results), at 4 months follow-up the percentage increased to 68%, at 17 month follow-up to were 81%. At 40 month f. up it was possible to review 15 patients (19 cases), satisfactory results were 84%.

Regarding the 34 patients affected by plantar fasciitis in association with calcaneal spur, at 17 month follow-up satisfactory results were 73%, no radiological evidence of disappearing of the spur was obtained. Among the 25 sport players (30 cases) satisfactory results were 57% at 1 month, 80% at 4 month, 90% at 17 month follow-up.

Conclusion:

Shockwave therapy represents a valid, non-invasive symptomatic treatment for patients with plantar fasciitis.

Extracorporeal Shock Wave Therapy (ESWT) in the Treatment of Recalcitrant Plantar Fasciitis - Affecting Factors For the Results

Authors: Ki-Won Young, M.D., Kyoung-Tai Lee, M.D., Jae-Young Kim, M.D., Seung-Do Cha, M.D., Eung-Soo Kim, M.D

Institution: Department of Orthopedic Surgery
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Seoul, Korea

Purpose:

The plantar fasciitis is the most common cause of heel pain. Standard treatment of plantar fasciitis is a conservative therapy and include nonsteroidal anti-inflammatory drugs(NSAID), heel cups, night splints, orthoses, electrotherapy, physiotherapy with stretching exercises and local steroid injections. After unsuccessful conservative treatment of at least 6 months, surgery is eventually recommended. The aim of this study was to investigate the results of extracorporeal shock wave therapy and various affecting factors to the results in patients with a previous unsuccessful no surgical treatment of at least 6 months.

Materials and Methods:

63 patients with a previous unsuccessful no surgical treatment of at least 6 months were included. A clinical investigation was carried out before ESWT and at follow-up appointments(1, 3, 6 months). Patient satisfaction, pain caused by manual pressure, pain on walking were scored with visual analogue scale(VAS). And the patients estimated the comfortable walking time. The mean duration of follow-up was 5.5 weeks(range, 3 11). Body weight, age, previous treatment, duration of symptom as clinical factors were estimated and calcaneal spur size in simple X-ray, thickness of plantar fascia and soft tissue oedema in ultrasonography. Treatment comprised 1000 impulses of shock wave at 14-16 kV(OssaTron) in local block.

Results:

At sixth months, the rate of good and excellent outcomes was 36.5% and 22.3% of patients was not changed. After ESWT pain caused by manual pressure decreased from 75 point to 34 point on the visual analogue scale(VAS) and pain on walking from 72.5 point to 38 point. The comfortable walking time had increased from 0.3 hour to 3.4 hours. The rate of good and excellent outcomes in patients with non-invasive previous treatment was 66.6% and 47.8% in calcaneal spur size less than 5mm. It seemed that the result was more improved as less as the steroid injection number. No adverse events were reported after 3 months follow-up visit.

Conclusions:

The non-invasive nature and minimal complications of appropriately applied ESWT are its primary advantages. The effects of ESWT seems to be time dependent. Steroid injection and large calcaneal spur might effect on less satisfactory results.

Extracorporeal Shock Wave Therapy applied to chronic plantar heel pain

Authors: BF. Meyer, KK. Simões, E. Thober, M. Meyer

Institution: Centro de Ondas de Impacto(COI)
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The Chronic Plantar Heel Pain (CPHP) can be incapacitating to patients and a challenge to doctors. This is reported at about 20% of general population. The most common local pain is the insertion of plantar fascia in the medial tuberculum of the calcaneum bone, being the Fasciitis Plantar the most common diagnosis. Histological evaluation in patients with CPHP demonstrate changes like: proximal thickening of plantar fascia, vascularization decrease, inflammation of peri-tendon, decrease of flexibility and modification in the nociceptors. The objective of this study was to evaluate the effectiveness of the Extracorporeal Shock Wave Therapy (ESWT) in the treatment of CPHP. Patients with minimum age of 18 years old and symptoms for more than six months were included, with no success on conservative treatments. Twelve months of minimum time of attendance after the first application of ESWT. It was excluded patients with contra-indications to ESWT and received local corticoid infiltration at least one month. It was used the evaluation functional protocol of AOFAS Score. The equipment used was the ORTHIMA(Direx), that uses an electrohydraulic generator. The treatment consisted of 1500 impulses, with energy of 0,35 mJ/mm², being accomplished between 1 to 3 sessions with interval of 60 days; however we only repeat sessions on those patients that persist with incapacitating pain. The focus was the site of maximum reproduction of local pain at digit-pressure. No anesthesia was dispensed. It was treated 104 patients, and 94 patients answered the questionnaire. Seven cases were bilateral, that totalized 101 feet in this study. Were evaluated 34 men and 60 women, with 57,3 average age, 79,68 kg average weight and 22,87 months of previous pain. The time of attendance after-ESWT was 19,14 months. 63% received only a single application. Subjectively 80% were satisfied in relation of pain relief. There was a significant increase of the AOFAS Score in 94% of the patients (p<0.001). The Extracorporeal Shock Wave Therapy is an alternative of the effective treatment of the Chronic Plantar Heel Pain.

Radial Shock Wave Therapy for chronic heel pain

Authors: J. Ritz, L. Guiloff, A. Baar, E. Botello, M. Brañes.

Institution: Occupational Medicine. Facultad de Medicina.
Pontificia Universidad Católica de Chile.

Purpose of the study:

Evaluation of the effect of Unfocused or Radial Shock Wave Therapy (RSWT) on chronic plantar heel pain.

Materials and Methods:

Since July 2002, a prospective study was conducted including 74 heels in 63 patients with a minimum of 6 months of pain. All patients had a definite indication for open surgery after at least two unsuccessful different conservative treatment approaches. Informed consent of the patients was gained. There were 24 females and 39 males with an average age of 50 (17-79). History and physical examination were recorded in detail. The patients were asked to determine the effect of RSWT by a visual analogue scale (VAS) for walking, at rest and at night. The walking distance, onset of pain and return to daily activities or sports were registered as well as objective findings. All patients received 2000 shockwaves at a frequency of 5Hz and a work pressure of 2, 5 Bars, without local anaesthesia, in 3 weekly sessions. After each session, patients were given non-narcotic analgesic and an ice pack. All the patients tolerated the treatment well, and the majority were able to retake daily activities again. There were neither systemic nor local complications after treatment. No patient showed any kind of deterioration. Two independent orthopaedic surgeons did the follow up. At 12-month follow-up, and using the VAS a reference, the pressure-elicited pain decreased from 6,9 to 2 (p 0,05), the pain in sports decreased from 6,8 to 2,1 (p 0,05). Night complaints improved from a VAS score of 2,6 to 1,4 (p 0,05). Pain at daily activities also improved from 4,8 to 1,8 (p 0,05). Before the RSWT, only 17 patients were pain-free after walking more than 1000 meters. After the treatment, 38 patients were able to walk more than 1000 m without pain.

Conclusions:

The Unfocused or Radial Shock Wave Therapy (RSWT) is an attractive non-invasive and highly economical alternative for open surgery. The cost of the device is far cheaper than focused extracorporeal machines (ESWT). The results are very satisfactory and reduce the need for surgery in a high percentage of patients.

Two Year follow up: Ultrasound Measurements Post ESWT Plantar Fascia

Authors: Rob Gordon, Eric Crawford, Joey Pratile
Kanada

Purpose:

To determine whether ESWT is effective in decreasing the thickness of the plantar fascia as measured by the ultrasound.

Introduction:

Plantar fasciitis has exhibited hyaline degeneration ultrasound studies have shown thickening of the plantar fascia in patients with plantar fasciitis. This study attempts to determine whether ESWT alters the thickness of the plantar fascia.

Material and methods:

30 patients were treated with ESWT at 18KV 1500 shocks. Pre and post ultrasounds were taken of a minimum of 1year later. VAS was also recorded.

Results:

Minimum 1-year follow up shows that ESWT can decrease the plantar fascia thickness and VAS scores.

Conclusion:

ESWT is effective in decreasing pain and plantar fasciitis thickness in patients with plantar fasciitis.

ESWT - A Prospective Double Blind Study on Bilateral Plantar Fasciitis

Authors: Lowell Weil, Jr., DPM, MBA, FACFAS

Institution: Weil Foot & Ankle Institute, Des Plaines, Illinois, USA

Introduction:

Extracorporeal Shock Wave (ESWT) has become a common treatment modality for chronic plantar fasciitis worldwide. All studies in the literature evaluate ESWT for unilateral plantar fasciitis with comparisons to placebo control on another subject.

Purpose:

The purpose of this study was to use a patient as their own control to assess the value of ESWT in chronic bilateral plantar fasciitis.

Patients, Material, Methods:

36 patients with bilateral plantar fasciitis of greater than 6 months duration and pain of greater than 6 on a VAS on both feet and that failed to respond to conservative care were eligible to participate. Additional systemic and neurologic causes of heel pain were ruled out in all cases. Patients were anesthetized with intravenous sedation and an infiltrative local block to both heels. Computer randomization then determined which foot was to be treated actively while the other was left as placebo Utilizing an Ossatron by Healthtronics, the appropriate foot was treated with 2000 pulses at 19 kV from two different positions Patients were evaluated at 1 week, 6 weeks and 12 weeks by a blinded investigator. End point evaluation parameters were reduction in VAS and Roles and Mauldsey quality of life assessment.

Results:

The treated foot improved 70% of the time while the Sham foot improved 52% of the time. 67% of the treated feet improved by >50%, while 47% of the Sham feet improved by >50%. 65% of the treated feet attained a VAS of <3, while only 39% of the Sham group achieved <3 on a VAS. In 39% of the patients, both feet improved and in 4% of the patients, neither foot improved.

Conclusion:

This study, utilizing patients as their own control, shows that ESWT is a valuable and efficacious treatment for chronic plantar fasciitis. Placebo success is significant but not equal to treated subjects following ESWT for plantar fasciitis.

Economic Randomization of ESWT With Dolorclast And Ossatron Results

Authors: Rob Gordon, Kanada

Purpose:

To determine the efficiency of the Ossatron to the Dolarclast in the treatment of plantar fasciitis.

Introduction:

The efficiency of the Ossatron has been shown to be effective for the treatment of plantar fasciitis. A pilot study was determined to see the effectiveness of the Dolarclast machine in treating plantar fasciitis.

Materials and Methods:

Prospective Patients were asked to choose treatment by either the Dolarclast or Ossatron by economic reasons.

Results:

Both the Ossatron and Dolarclast improved pain relief for plantar fasciitis.

Conclusion:

Economics and perceived gold standard play a role in the treatment of plantar fasciitis. Both the Ossatron and Dolarclast appear to improve symptoms of plantar fasciitis.

Radial extracorporeal shock wave therapy (rESWT) in chronic plantar heel pain - a RCT

Authors: L.Gerdesmeyer, L.Weil, B.Scurran, J.Stienstra, C.Frey, K.Fedder, M. Maier, M.Henne, M.Russlies, H.Lohrer, J.Vester

Institution: Technical University Munich
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Aim: The study has to determine the effectiveness of rESWT for chronic plantar heel pain.

Materials and methods:

A total of eight study centers enrolled 254 patients in this study, 252 patients were randomized, 251 patients received assigned treatment (129 active-ESWT, 122 Placebo-ESWT). All patients were suffering from painful heel syndrome for at least 6 month, all of them previously get unsuccessful conservative treatments. Basically the radial extracorporeal shock wave therapy was performed without local anesthesia. 2000 treatment-impulses were applied with the working pressure of 0.4 MPa (4 bar). Subjects received 3 shock wave treatments with 2000 therapeutical shock wave impulses each. Between each treatment, a treatment-free interval of 2 weeks was observed.

The primary Criteria were: Heel pain when taking the first steps of the day (VAS) and Heel pain while doing daily activities (VAS). Second criteria were defined as: Pain on pressure, measured with standardized pressure device (Dolormeter), Roles and Maudsley-Score, SF-36, physician's global judgment of effectiveness, subject's satisfaction with the outcome of the treatment, Subject's willingness to recommend treatment

The primary point in time for comparison of groups was three months after last treatment.

The patients of the ITT (intention-to-treat) population were defined in the final blind review report (individual listing) before blind was broken. A total of 125 ESWT patients (96.9% of all treated ESWT patients) and 118 placebo patients (96.7% of all treated placebo patients) were evaluated for the ITT analysis.

The size of the treatment effects were quantified using the Mann-Whitney superiority measure with associated confidence intervals. Efficacy was analysed by comparing the success rates between the treatment and placebo groups, with success being defined on a per patient basis for each of the two primary efficacy criteria as at least a 60% reduction in VAS pain scores from baseline to 3 month after ESWT.

The study was performed in accordance to GCP guidelines.

Results:

With regard to the demographic criteria, sex, BMI, age and other baseline characteristics including the baseline efficacy criteria, groups are well comparable, all effect sizes are denoting only marginal group differences, all p-values are statistically not significant ($p \geq 0.1$).

With regard to the primary criteria the analysis showed statistically significant results ($P = 0.0059$, one-sided, ESWT success rate 55.20% vs. placebo success rate 38.98). With regard to the secondary criteria the clinical relevant data criteria mental/physical health score of the SF36, the Roles and Maudsley Score, global judgment of effectiveness, therapy satisfaction and therapy recommendation all showed better outcome at the primary endpoint in favour to the ESWT group ($P \leq 0.025$ one-sided) and all effect sizes (Mann-Whitney) denote more than small superiority of the ESWT group.

The a priori ordered hypotheses of the final statistical analysis plan are statistically significant ($P \leq 0.025$ one-sided): Composite score (sum score) of heel pain (VAS) when taking first steps of the day, heel pain (VAS) 'while doing daily activities and heel pain (VAS) after application of the Dolormeter ($P = 0.0220$ one-sided, $MW = 0.5753$, $LB-CI = 0.5023$). Overall success rate with regard to heel pain defined as percentage decrease of heel pain larger than 60% from baseline at visit 7 for at least two of the three heel pain (VAS)

measurements ($P = 0.0020$ one-sided, $MW = 0.5937$, $LB-CI = 0.5314$).

The other criteria also demonstrate superiority of the ESWT group with p-values below the level of significance. All effect sizes (Mann-Whitney) denote more than small superiority of the ESWT group.

Only minor side effects as petecheal bleeding, swelling and discomfort during treatment were detected.

Shockwave Therapy for tendinosis calcarea of the shoulder : retrospective study

Authors: P Rockett, A Souza, P Santos

Institution: Ortosom, Porto Alegre, Brazil
Cortrel, Rio de Janeiro, Brazil
Orthomaster, São Paulo, Brazil

Aim:

The aim of this study was to evaluate the efficacy and the safety of extracorporeal shock wave therapy for the treatment of tendinosis calcarea of the shoulder in three Brazilian Orthopaedics Clinics.

Material and Methods:

In a multi-center, retrospective study, the effect of shockwave therapy was investigated in 119 patients with tendinosis calcarea of the shoulder treated in the period of 38 months from April 2001 to May 2004.

There were 64 women and 58 men with an average age of 56 (range, 37-79) years.

The criteria for inclusion were at least three months of unsuccessful conservative therapy or six months of pain and calcifications grade I or II from Gartner's classification. Criteria for exclusion were inflammatory arthritis, previous corticosteroid injection, acute infection, gout, malignant diseases and, blood coagulation disorders.

Each patient was treated with 1500 - 2000 impulses of shock wave, a 35 mm focus depth, and with an energy flux density of no more than 0.14 mJ/mm after local anaesthesia.

One treatment was performed on 111 patients and 8 patients underwent a second treatment.

The subjects were evaluated by means of a clinical evaluation according to Roles and Maudsley score , subjective outcome on Visual Analogue Scale (VAS) , X-rays and ultrasound analysis, 45, 90 and 180 days after the end of the therapy.

Results:

The study showed the efficacy and safety of ESWT were excellent in 26.9%, good in 37%, acceptable in 12.6%, and poor in 23.5%, 180 days after ESWT.

Extracorporeal shockwave therapy in rotator cuff calcific tendinitis.

Authors: M., Pinho Teixeira Alves

Institution: HOSPOR - Santiago Hospital,
Department of Orthopaedics,
Setúbal, Portugal.

The author present the preliminary results of his study on the treatment of shoulder periarticular calcification with extracorporeal shock waves.

Fourteen patients suffering from subacromial impingement syndrome, with radiographic evidence of calcification inside the supraspinatus tendon and subacromial bursa, were studied. All patients were submitted to musculoskeletal echography in order to exclude rotator cuff tears. All patients presented with a painful reduction of shoulder range of motion, especially abduction and external rotation. Nocturnal pain was found in all patients. The analogic pain scale was used to evaluate the patients's pain. The treatment consisted of three sessions of extracorporeal shock waves (power of 0.2 mJ/mm² - 11,2 KV), one per week, each session of 2000 shots, in a 120 shockwaves per minute frequency. The equipment used was Siemens LithostarUro ®, with Siemens Siremobil Image Intensifier ® and Siemens Adara Echograph ®.

Follow up in two weeks after treatment and two months later showed in 86% of cases a reduction of pain and increase of shoulder range of motion. The nocturnal pain disappeared in 86% of patients. The analogue pain scale improved from a medium of 7 to 1,5. One patient (7%) abandoned the treatment. One patient (7%) was submitted to surgical treatment. X-rays two months after treatment showed a initial fragmentation of calcification in one case (there was a 1,5 cm calcification) and total resorption in the other cases, with smaller calcifications.

The author considers the technique a valid treatment method of subacromial impingement syndrome with periarticular shoulder calcifications.

Musculoskeletal Shockwave Therapy in Tendinosis Calcarea of The Shoulder Six Years of Experience

Authors: Dr. José Eid, Dr. Paulo Kertzman

Introduction:

The treatment of tendinosis calcarea goes since fisiotherapy, non anitiinflamatory drugs, infiltrations and surgical procedure to remove the calcification. We present the results of extrashockwavetherapy (ESWT) in 79 patients with tendinosis calcarea.

Material and Methods:

From 1998,october to 2004, March, we treated 129 patients with tendinopathy of the shoulder with ESWT. We have done 387 applications with 3 sessions per patient. Tendinosis calcarea was present in 79 patients, 48 women and 31 men , ages between 38 and 78 years. The treatment was done under the guideline conditions of the ISMST(International Society) and SBTOC (Brazilian Society) protocol, i. e., all the patients showed pain and limitation of motion for at least 6 months, in spite of traditional treatment. The device used was an eletromagnetic generator from Dornier (Compact S and Epos Ultra) and the focus was done by radioscopy or Ultrassonography of 7,5 Mhz. We did 237 applications, 3 sessions in each patient, with 2000 shockwaves (SW) in each session, in intervals of 7 day.

Results:

Patients were reviewed clinical with the Roles and Maudsley functional scale and through X-Rays and or Ultrassonography in the first 3 months, 6 months and 1 year. We observed a great improvement of pain and function in 63 patients. Resoption of calcification occurred in 54 patients.

Conclusions:

ESW is a therapy that shows effective in the treatment of tendinosis calcarea. We observed a great improvement of function and pain even in a safety and effective way, even in cases without resorption.

Complications of extracorporeal shockwave therapy in the treatment of calcifying tendinitis of the shoulder

Authors: Sabeti M MD⁽¹⁾, Dorotka R MD⁽¹⁾, Schatz KD MD⁽¹⁾, Schubert S⁽¹⁾, Ebenbichler G⁽²⁾, Trieb K MD⁽³⁾

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Objective:

Study investigates complications of the application of shockwaves in the treatment of shoulder joint disorders. To our knowledge, no one has investigated side effects of this treatment modality at the shoulder.

Design:

In this retrospective study, 130 patients were treated with extracorporeal shock wave therapy for symptomatic calcifying tendonitis between January 2000 and April 2003. The energy flux density applied was in the low or mid- energetic range (0.012-0.2 mJ/mm²). The evaluation of side effects and treatment complications was performed clinically during each treatment session, and clinically and radiologically 6 and 12 weeks after the end of therapy, respectively. Clinical assessment comprised patient- reaction for complications, pain assessment using Visual Analogue Scale and the assessment of the Constant and Murley Score. In cases of persisting pain after therapy additional radiographs were made.

Results:

Local erythema at the interface of skin and lithotripter occurred in 97% of the population. Pain due to lithotriptic therapy was observed in 10 of 130 patients. No other side effects, especially no bony alterations were observed.

Conclusion:

Low and mid- energetic shockwave therapy for calcifying tendonitis of the shoulder appear to be a safe conservative treatment modality.

Treatment of shoulder pathologies with ESWT

Authors: Paulo F. Kertzman

Institution: São Paulo Brasil

This paper is about the treatment of shoulders calcification of supraspinatus and subscapularis tendons and “frozen” shoulder with ESWT. We use and Orthima-Direx device and treat patients with at least six months with pain and no good results with traditional treatments and surgical indication. We do not use anaesthesia, we do the localization of the point of treatment with palpation of the shoulder and all of the cases have good xray and ultrasound documentation. We make 1500 shock waves (300 level 1 low energy, 300 level 2 medium energy, 400 level 3 medium energy and 500 hundred level 4 high energy) and repeat after 3 and 6 weeks. We treat 35 patients between 2003 and 2004. 30 patients with supraspinatus calcification, 2 with subscapularis and 3 with frozen shoulder. After treatment we make x-ray after 2 months, 6 months and one year. On the patients with supraspinatus we have first improvement of pain and movement and after progressive reabsorption of the calcium deposits in 25 (80%) of the 30 patients after at least one year of treatment. on the 2 cases of subscapularis calcification we have good results and on the 3 cases of frozen shoulder in 2 we have after 3 months no more pain and progressive better movements. We conclude that ESWT on shoulder chronic pathologies is very safe and has very good results.

Extracorporeal Shock Wave Therapy for soft tissue diseases in shoulder with ultrasonographic localization technique

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Introduction:

Subacromial bursitis (SB) is a common condition that affects the shoulder joint. Subacromial bursitis is caused by overuse or repetitive movement of the shoulder (this may include an occupation which requires lifting, working above the head, etc.). Symptoms may include localized shoulder pain and tenderness. The pain will be worse when the arm is raised to the side. Inflammation of the long head of the brachial biceps muscle (ILBM) is a relatively common cause of shoulder pain. It is localized to the anterior face of the shoulder, is exacerbated especially by anterior elevation and external rotation. The biceps muscle splits into two tendons at the shoulder. A long one and a short one. The long tendon runs over the top of the humerus bone (upper arm) and attaches to the top of the shoulder blade. Inflammation of this tendon is a fairly common complaint especially with swimmers, rowers, throwers, golfers and weight lifters. Both Subacromial bursitis and Inflammation of the long head of the brachial biceps muscle (ILBM) can be treated with ESWT.

Objective:

In order to reveal the effect of Extracorporeal Shock Wave Therapy (ESWT) with ultrasonographic localization technique for subacromial bursitis (SB) and inflammation of long tendon of biceps muscle (ILBM), the comparative study was used between ultrasonographic localization technique and pain-point localization technique.

Method:

151 cases, 65 cases of SB and 86 cases of ILBM were treated with ESWT. 25 of 65 cases of SB were referred with ESWT of ultrasonographic localization technique, other 40 with ESWT of pain-point localization technique. 31 of 86 cases of ILBM were referred with ESWT of ultrasonographic localization technique, other 55 cases with ESWT of pain-point localization technique. Shoulder function and pain (visual analogue scale, VAS) were assessed before treatment and at one week and six months after treatment. The satisfied rate were compared between the ESWT with ultrasonographic localization technique and ESWT with pain-point localization technique in SB and ILBM.

Results:

Through 6 months follow up, the results showed that the satisfactory rates were respective 89.6% (SB) and 92.3% (ILBM) in the cases with the ESWT of ultrasonographic localization technique, the satisfactory rates were respective 76.9% (SB) and 79.1% (ILBM) in the cases with ESWT of pain-point localization technique. The difference of satisfactory rates were significant between two ESWT groups (ultrasonographic localization technique group and) in SB and ILBM cases, ($P < 0.05$).

Conclusion:

Through the study, we considered that the effect of the ESWT with ultrasonic localization technique was better than the ESWT with pain-point localization technique for SB and ILBM. The ultrasonic localization technique is of important role in advance of satisfactory rate in ESWT.

Shockwave Therapy for Lateral Epicondylitis of the elbow : retrospective study

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Cortrel, Rio de Janeiro, Brazil
Orthomaster, São Paulo, Brasil

Aim:

The aim of this study was to evaluate the efficacy and the safety of extracorporeal shock wave therapy for the treatment of Lateral Epicondylitis of the elbow in three Brazilian Orthopaedics Clinics.

Material and Methods:

In a multi-center, retrospective study, the effect of shockwave therapy was investigated in 65 patients with Lateral Epicondylitis of the elbow treated in the period of 39 months from March 2001 to May 2004. There were 25 women and 40 men with an average age of 51 (range, 33-74) years. The criteria for inclusion were at least three months of unsuccessful conservative therapy or six months of pain. Criteria for exclusion were inflammatory arthritis, previous corticosteroid injection, acute infection, gout, malignant diseases and blood coagulation disorders. Each patient was treated with 1200 impulses of shock wave, a 05 mm focus depth, and with an energy flux density of no more than 0.13 mJ/mm after local or regional anaesthesia. One treatment was performed on 55 patients and 10 patients underwent a second treatment. The subjects were evaluated by means of a clinical evaluation according to Roles and Maudsley score, subjective outcome on Visual Analogue Scale (VAS) analysis, 45, 90 and 180 days after the end of the therapy.

Results:

The study showed the efficacy and safety of ESWT were excellent in 43%, good in 30.8%, acceptable in 10.8%, and poor in 15.4%, 180 days after ESWT.

Treatment of Soft Tissues Pathologies with Extracorporeal Shockwave Therapy

Authors: Santos Paulo Roberto

Institution: Hospital Santa Rita - São Paulo - Brazil

Introduction:

The purpose of this study was to clinically evaluate the efficacy of Extracorporeal Shockwave Therapy using an electro hydraulic shockwave device to treat soft tissue pathologies.

Materials and Methods:

The study was conducted in Hospital Santa Rita in São Paulo where an Ossatron - HMT is installed. From January 2002 to December 04, 132 patients (63 female and 59 male), with an average age of 51 years (min 28 and max 83 years) were submitted to shockwave therapy in the following soft tissues pathologies: 32 tendinitis calcarea of the shoulder, 13 tendinosis of the shoulder, 36 plantar fasciitis, 19 epicondylitis, 18 Achilles tendon tendinosis, 12 trochanteric bursitis of the femur, 2 patelar tendinosis.

Inclusion criteria were at least 6 months of unsuccessful conservative treatment. To evaluate the intensity of pain, the outcome was assessed in four categories using Roles and Maudsley and VAS (visual analogue scale). One to three sessions of shockwave therapy were performed using the standard protocols; patients were reviewed at 3-6 weeks, 3 and 6 months after treatment. Local anaesthesia and/or general anaesthesia was performed.

Results:

Twelve patients were excluded because of inadequate follow-up, 120 patients were included in the analysis. The results were as follows:

Pathologies	Results excellent	good	poor	nil
tendinitis calcarea of the shoulder	64%	13,3%	11,6%	11,1%
tendinosis of the shouder	54,5%	18%	18,5%	9%
plantar fasciitis	54%	10%	18%	18%
Achilles tendon tendinosis	60%	10,7%	17,6%	11,7%
trochanteric bursitis	70%	8,4%	5%	16,6%
patelar tendinosis	50%	50%	0	0
Epicondylitis	58,7%	16,3%	10%	15%

Conclusions:

The results of the study showed that extracorporeal shockwave therapy is an effective and safe treatment for entesopathies.

ESWT for Lateral Epicondylitis and Heel - Our New Protocol of Anaesthesia

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Recent clinical observation indicates the beneficial effect of shock wave on inflammatory region of soft tissues. We started a protocol of treatments with no sedation or general anaesthesia, using local anaesthetics at the doctor's office. However, some studies showed that the simultaneous use of local anaesthesia has a negative influence on repetitive low-energy shock wave therapy for chronic plantar fasciitis and results without local anaesthesia have been significantly better than with local anaesthesia even in higher energy-treatment . The purpose of the study is to demonstrate a new protocol of anaesthesia with a regional block of the elbow and of the ankle, to treat lateral epicondylitis, Achilles tendinopathies and plantar fasciitis; a procedure that can be done in doctor's office. We started this new protocol to observe if there was or not, influence between the use of local anaesthesia in the our follow-up results and to further prospective studies to evaluate this influence.

Influence of Energy and Local Anesthesia on the outcome of Low Energy Extracorporeal Shockwave Therapy (ESWT) on Plantar Heel Spur.

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The question of doing low energy ESWT with or without local anaesthesia is still in discussion and hasn't been validated in a randomised comparing trial yet. In the large multicenter-trials of the German orthopaedic society (DGOOC) local anaesthesia has been used for blinding. The results of the study concerning tennis elbow have been controversially to the average outcome results in literature. Aim of this pilot study has been to evaluate the influence of local anaesthesia on the clinical outcome of ESWT.

We have started a prospective, randomised trial on plantar heel spur including patients, who have been unsuccessfully treated conservatively but sufficiently according to the guidelines of the International Society of Muskuloskeletal Shockwave Therapy (ISMST). Severe low back pain, segmental pain in L5/S1 level or no clearly definable pain by local pressure has been excluded. Treatment has been done with a Sonocur Plus (Siemens) device. Follow-up-time have been minimum 6 weeks. Three groups have been randomised:

- Group A (20 patients, 24 heels): No local anaesthesia, energy flux density (EFD) 0,04 mJ/mm².
- Group B (20 patients, 22 heels): With local anaesthesia by 4 ml 2% Scandicain, EFD 0,09 mJ/mm².
- Group C (20 patients, 24 heels): With local anaesthesia by 4 ml 2% Scandicain, EFD 0,04 mJ/mm².

For evaluation parameters we have chosen VAS (visual analogue scale) in weight bearing and non weight bearing situations as well as pain under pressure, addition-ally the need of further therapy at the moment of follow up.

We have registered a significant better result in VAS ($p < 0,016$ to $p < 0,009$ in different situations of weight bearing) and need of further therapy ($p < 0,01$) in group A (no local anaesthesia) in comparison to group C (local anaesthesia, same EFD) in a 6-weeks follow up. Similar results we found between groups A and B (VAS p_i 0,026 to p_i 0,003). There has been no significant difference between groups B and C. Successful therapy (painless or low pain and no further therapy needed) in Group A has been reported in 65,3%, in groups B and C with local anaesthesia only in 36,3% ($p < 0,01$) and 29,2% ($p < 0,001$). The results have been stable in a long term follow up too.

In our pilot study the results of ESWT on plantar heel spur without local anaesthesia have been significantly better than with local anaesthesia even in higher energy-treatment of group B. We have found strong clues, that blinding by local infiltration is influencing the results in a negative way and has to be assessed as a systematic error in study design. Even some articles were published supporting our results further investigations concerning the influence of local anaesthesia on the results of ESWT are recommended.

Outcome of surgery after failed ESWT

Authors: Gerold Labek, V. Auersperg, N. Poullos,
E. Hinterreiter, A. Handelbauer, N. Böhler

Institution: Orthopaedic Department, AKH, Linz

Introduction:

ESWT is used in the therapeutic spectrum in our department for patients, which have done intensive conservative treatment for months without any success. This procedure and ESWT might lead to a selection process for patients. Aim of this retrospective study was to evaluate, if the chance for success of surgical interventions are decreased by this process and to evaluate the outcome of surgery after failed ESWT to these patients.

Material and Methods:

From 1993 to 2002 760 patients have been treated by ESWT at AKH Linz. 189 of them for lateral Epicondylitis and 183 for plantar fasciitis. 53% of EHR and 80% of plantar fasciitis treatment were successful according to Auersperg - Score levels 6 and 7, which includes only excellent and good results. Out of the patients with failed treatments 34 patients suffering lateral epicondylitis and 18 patients suffering plantar fasciitis have been treated by a surgical procedure, most of them in our clinic. EHR was treated by a Hohmann operation (originally described by G. Hohmann: *Das Wesen und die Behandlung des sogenannten Tennisellenbogens*. Münch Med Wochenschr 1933; 80: 250-252), plantar fasciitis by a tenotomy of the plantar fascia and denervation of the calcaneal periosteum.

13 patients (out of 18) suffering plantar fasciitis and 26 (out of 34) suffering EHR could be evaluated by a follow up period of at least 1 year after operation. Auersperg-Score and VAS was recorded.

Results:

Plantar Fasciitis:

6 Patients were pain free, 4 reported major improvement without need of further therapy. 3 patients has no or unsatisfying improvement by the operation. 76% of the patients had satisfying benefit by a Hohmann operation after failed ESWT.

EHR:

17 patients were pain free, 7 reported major improvement without need for further therapy, 2 patients had no or unsatisfying improvement by the operation. 92% of the patients had satisfying benefit by a tenotomy procedure after failed ESWT. This is similar to reported success rates in the literature without ESWT before.

Conclusion:

Low Energy ESWT seems not to influence the success of surgical procedures by selection of patients or other reasons. Further studies should be performed for more detailed evaluations. Larger multicentre databanks for recruitment and description of patients would be recommended.

Validation of a “Patient-Rated Tennis Elbow Evaluation” (PRTEE) Questionnaire

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Background:

Though the most often diagnosed pathology of the upper extremity there is no consensus on how to measure treatment outcome for lateral elbow tendinosis (LET). The aim of the study was to determine the reliability of a questionnaire designed specifically to assess forearm pain and function in patients with a chronic tennis elbow.

Methods:

Seventy-eight patients with chronic, unilateral MRI-confirmed LET (of whom 78 were studied twice without therapy and 38 were studied 3 months after appropriate treatment) completed the 3-section, 15-item patient-rated tennis elbow questionnaire.

Results:

The test-retest reliability coefficient of determination ($R^2 = 0.95$) and internal consistency (Cronbach's alpha = 0.94) were both good. Convergent validity was attested by good correlations with the Disabilities of Arm, Shoulder and Hand Questionnaire (DASH), and the Numeric Rating Scale-based Thomsen test ($R^2 = 0.75$ and 0.87 , $P < 0.0001$). Only a poor correlation was found with the Roles and Maudsley Score and the Upper Extremity Function Scale ($R^2 = 0.02$ and 0.03 , $P = 0.2767$ and 0.1798). Sensitivity to change was demonstrated by correlating pre-treatment - post treatment changes to those in DASH and Thomsen test ($R^2 = 0.66$ and 0.84 , $P < 0.0001$).

Conclusion:

The patient-rated forearm evaluation questionnaire for LET is an internally consistent score, correlating well with other, non-elbow specific scores, and is sensitive to change on treatment.

Clinical Relevance:

Reliability of the score for lateral elbow tendinosis has been confirmed independently in North America, Asia, and Europe. It is therefore recommended as standard scoring system in future clinical trials on tennis elbow.

Extracorporeal Shock Wave Therapy for Treatment of Navicular Syndrome.

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Navicular syndrome is a common cause of chronic lameness in horses. The exact aetiology of navicular syndrome is unknown. Mechanisms of disease onset proposed include bone remodelling, ischemia, and chronic bursitis. The objective of this study was to evaluate ESWT in decreasing the lameness associated with navicular syndrome. Case records of horses that were diagnosed with navicular syndrome and treated with ESWT from June 1999 to August 2001 were evaluated for this study. Each navicular bone involved was treated with 2000 pulses (1000 pulses through the frog and 1000 through the heel) at 0.89 mJ/mm² by an electrohydraulic shock wave generator. A follow-up examination was performed 6 months post-treatment. Further follow-up information was obtained by repeated clinical evaluation of the horse and by telephone and/or personal interview with the owner or trainer. Outcome was evaluated three ways: 1) unmasked veterinary evaluation, 2) client perception of lameness, and 3) masked evaluation of video tapes taken pre- and 6 months post treatment. A series of radiographs were taken of each foot for evaluation of the navicular region prior to treatment and 6 months post-treatment for the 16 horses with follow-up. A radiologist blinded as to outcome or pre- or post- treatment evaluated the radiographs and scored them from 0 = normal to 3 = dramatic changes for; 1) medullary sclerosis, 2) distal border synovial invaginations, 3) flexor cortex erosions, 4) abaxial margins, 5) medullary cysts, and 6) the deep digital flexor tendon. Extracorporeal shock wave therapy was effective in decreasing the lameness associated with navicular syndrome in 81% of the horses as determined by an unmasked evaluator and in 56% of the horses with masked evaluators. There was no significant change in the radiographic scores between pre- and post- treatment ($P=0.54$). There was no significant relationship between pre-treatment radiographic score and outcome for lameness evaluation by the 3 masked graders for trotting at hand ($r^2=0.019$, $P=0.92$) or in a circle ($r^2= -0.23$, $P =0.26$). Extracorporeal shock wave therapy provided a non-invasive, effective mechanism to decrease the lameness associated with navicular syndrome. There were no complications associated with the procedure. Lameness in horses that responded to treatment did not regress in the year following treatment. The results of this study indicate that ESWT should be considered as a viable non-invasive mechanism to navicular syndrome in horses.

Radial Shock Wave Therapy for chronic insertion desmopathy of the proximal suspensory ligament in sports horses.

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Introduction:

Suspensory ligament desmopathy is a common disease causing primary and compensatory lameness in the sport horse. The disease can cause long-term lameness restricting the horse's ability to perform at the level of competition achieved prior to the onset of lameness. Current medical treatment options include confinement and rest, controlled exercise protocols, intralesional injections, corticosteroid therapy, anti-inflammatory therapy, bone marrow injection, and corrective shoeing. However, none of these methods consistently result in a satisfactory outcome. (McClure 2004)

Subjects:

Between April 2002 and August 2004, 40 sports horses with chronic proximal insertion desmopathies (23 in the hind limb, 17 in the front limb) have been treated with Radial Shock Wave Therapy (RSWT) The horses must have had clinical symptoms for at least 3 months and at least one failed conservative treatment approach prior to RSWT. Lameness was graded from 0 to 5 using a AAEP scale (American Association of Equine Practitioners)

Methods:

The horses were treated in 3 sessions (at intervals of one/two week, mean: 12 days) with 4000 shockwaves per session. Pressure of 3,5 bar (Energy flux density: 0,14 mJ/mm² approx.) and 6 Hz of frequency.

Device used: Swiss Dolor Clast (EMS-Switzerland).

The horses received sedation with Domosedan and Torbugesic.

The affected leg was lifted and the superficial and deep flexor tendon was pushed laterally and medially in order to be as close as possible to the origin of the proximal suspensory ligament. 2000 shockwaves were applied from each side (medial and lateral).

Evaluation was performed before the treatment, before 2nd RSWT, before 3rd RSWT, 30 days after last RSWT, 90 day after last RSWT: A special training program was elaborated for the time between the sessions and post shock wave therapy.

Analyses:

The no parametric Wilcoxon test for dependent samples to compare means of AAEP lameness scale.

Results:

The horses showed a considerable lameness decrease 30 days after last RSWT ($p < 0,05$), and 90 days after last RSWT ($p < 0,01$).

90 days after last RSWT, 26 horses (65%) were free of lameness (return to full work) and 8 horses had a distinct lameness reduction. 6 horses showed no improvement.

Side effect and complications were not observed.

Conclusion:

RSWT is an effective treatment method for chronic insertion desmopathy of the proximal suspensory ligament in sports horses. Further randomized and controlled studies are necessary to underline the results of this investigation.

Preliminary Results of Radial Extracorporeal Shockwave Therapy in Five Dogs With Cubarthrosis

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Introduction:

Although RSWT has been used in small animals with orthopaedic disorders for some years only a few studies exist detailing this kind of treatment in dogs. At the present time the authors are unaware of any prospective study using ground reaction forces evaluated on a treadmill-system. The purpose of this study was to show results of RSWT in dogs with cubarthrosis. To document the effectiveness of RSWT ground reaction forces (GRF) measured on a treadmill-system were evaluated.

Material and Method:

Five client-owned dogs of different breeds with cubarthrosis were included in this study. Age ranged from 6 to 11 years, bodyweight from 15.7 to 48 kilograms. Three dogs had bilateral and two dogs unilateral cubarthrosis. Radial Shock Wave Therapy was performed with the Swiss DolorClast Vet® (EMS Electro Medical Systems, Nyon, Switzerland). Treatment was given three times on a weekly basis using 1,000 radial shockwaves with a pressure of 2.0 bars were applied at the medial and lateral side of the affected elbow. Before first RSWT ground reaction forces were measured using a treadmill with four force plates. Parameters chosen for evaluation were peak maximal force (Fz), mean vertical force (Fm) and Impulse (Imp). Mean values of five valid steps were calculated and symmetry indices were calculated as described¹. Deviation of absolute symmetry was expressed as a percentage. Re-evaluation was performed before subsequent treatments and one month after last RSWT. A paired t-test was performed to compare pre-treatment GRF values with values of each evaluation point, p<0.05 was considered as statistically significant.

Results:

Percentage of deviation from symmetry before first RSWT was 16.59 (± 9.89) % for Fz, 18.66 (± 5.60) % for Fm and 25.48 (± 9.01) % for Impulse. No significant difference in values was found after the first RSWT. One month after last RSWT® all three values showed significant improved values compared to the basic GRF data: percentage of deviation of Fz was 4.79 (± 4.20) % (p=0.38), of Fm 7.59 (± 8.69)% (p=0.34) and of Impulse 9.55 (± 8.73)% (p=0.001).

Discussion:

Our preliminary results show that dogs with cubarthrosis responded well to Radial Shock Wave Therapy. Although studies with more animals and long term controls are needed, we recommend Radial Shock Wave Therapy as a non-invasive treatment option for dogs with degenerative joint diseases.

References:

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Evaluation of limb symmetry indices, using ground reaction forces.
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Ultrasonographic Evaluation of Extracorporeal Shock Wave Therapy on Collagenase Induced Superficial Digital Flexor Tendonitis

Authors: Kevin D. Kersh, DVM; Scott R. McClure, DVM, PhD;
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Injuries involving the superficial digital flexor tendon (SDFT) are common in performance horses of many disciplines. Many treatment modalities have been used to facilitate healing of these lesions, but there are currently no treatments that stimulate healing to proceed in a timely manner on a consistent basis. The methods that have been employed include prolonged periods of inactivity, controlled exercise programs, anti-inflammatory therapy, intra-lesional injections, peri-tendinous injection of counter-irritants, sclerosing agents, tendon splitting, annular ligament desmotomy, superior check ligament desmotomy, and numerous other therapies. None of these consistently promote healing in a timely fashion to allow earlier return to normal function. The objective of this study was to use the collagenase model to induce lesions and then to assess the rate of healing and histologic characteristics of the healing of tendons treated with ESWT versus untreated lesions. The goal of the study is to determine if ESWT will speed healing and improve quality of healing of SDFT lesions

Six mature horses were used in a blinded prospective study with untreated contralateral limb controls. Bilateral forelimb SDFT lesions were induced in each horse with collagenase. Ultrasonographic images were captured digitally and image analysis software was used to measure: 1) Percent lesion at the maximum injury zone (MIZ) 2) the gray scale of the SDFT at the MIZ 3) the percent disruption of the longitudinal fibers at the MIZ. The data were also summed for the ten sites from 4-22 centimetres distal to the accessory carpal bone. Physical examinations were performed on 4 occasions during the study to evaluate heat, response to palpation, presence/character of swelling over the SDFT, and lameness score. Measurements of the external width of the SDFT, and thermographic images were also evaluated. At the completion of the study all tendons were evaluated histologically.

There was no significant group by time interactions for any of the 3 variables at the MIZ or the sums for each variable. There was a trend toward a decrease in the external width, and there was a significant difference between the thermographic appearances of treated versus control limbs. There was an increase in neovascularization, increased mitotic activity, and greater degree of cellular reaction in treated tendons compared to untreated control tendons. The histologic changes indicate that ESWT may afford beneficial changes at the cellular level. While it is recognized that these are evaluations based on experimentally induced lesions, there does appear to be a beneficial reaction that takes in tissues in response to ESWT.

Radial Extracorporeal Shock Wave Therapy For Hip

Authors: B Bockstahler, DVM*; M Müller, MVM*; M Skalicky DTP; D Lorinson, DVM, DECVS*.

Institution:

University of Veterinary medicine, Project Group Motion Analysis in Dogs,

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Introduction:

Recently Radial Shock Wave Therapy (RSWT®) was introduced in small animal veterinary medicine, although only few studies have been published. RSWT is recommend for different orthopaedic conditions like osteoarthritis and tendinopathies. Although a lot of good results are emphasized, controlled clinical studies are rare. This clinical prospective study analysed the effect of radial shock wave therapy in dogs with coxarthrosis using a treadmill system with four force plates.

Materials and methods:

Thirteen dogs of different breeds with coxarthrosis have been included in this study. Radial shock waves were generated by the Swiss DolorClast Vet® (EMS Electro Medical Systems, Nyon, Switzerland) and three treatments on a weekly basis were performed in the hip joint-region. Ground reaction forces (GRF) were measured before each treatment and one week, one and three month after last RSWT. Symmetry indices (SI) were evaluated as described¹ for each dog using the following parameters: peak maximal force (Fz), mean vertical force (Fm) and impulse (Imp). After calculation of SI percentage deviation of absolute symmetry was described. The results were compared to the values of 10 healthy dogs. To compare values of healthy dogs and patients we used an unpaired t-test. To compare patients values during the course of the study we used a paired -test (p<0.05 was considered as statistically significant).

Results:

A significant difference between values of healthy dogs and patients was found over the whole treatment period, except for Fz (one week) and Impulse (one week and one month). Comparison of patients pre-treatment values with the subsequent values showed no significant difference for Fz, whereas Fm and Impulse showed a significantly improvement at one week (Fz, Imp), one month (Imp) and three month (Fm, Imp).

Discussion:

Our preliminary results with RSWT showed positive effects of ground reaction forces in dogs with coxarthrosis. Although values of healthy dogs were not reached, Radial Shock Wave Therapy seems to help reducing pain and discomfort during locomotion. Although studies using a greater number of dogs and longer evaluation periods are necessary, we recommend RSWT as an alternative treatment for dogs with degenerative joint diseases.

References:

¹ Budsberg SC, Jevens DJ, Brown J, et al.

Evaluation of limb symmetry indices, using ground reaction forces.

Am J Vet Res 1993;54:10:1569-157

The Evaluation of Extracorporeal Shockwave Therapy in Naturally Occurring Osteoarthritis of the Stifle Joint in Dogs

Authors: J. Dahlberg, G. Fitch, R.B. Evans, S.R. McClure, M. Conzemius

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Extracorporeal shockwave therapy (ESWT) has expanded from the original uses of human urinary calculi treatment to veterinary orthopaedic applications. This paper investigates the feasibility and efficacy of treating dogs with osteoarthritis of the stifle joint with ESWT. In this study, dogs with persistent stifle lameness despite previous surgical or medical treatment were either treated with ESWT or served as untreated controls. The most lame rear limb of each dog was determined by force platform analysis. Range of motion of the stifle joints was assessed by goniometry. Force platform gait analysis and goniometry were performed on both groups for four visits at 3-week intervals and a final exam 4 weeks later. Shock wave therapy was performed three times on treated dogs during each of the first three examinations. Placebo treatment consisting of clipping and wetting the hair was performed on control dogs. Vertical forces were evaluated for objective analysis of treatment response. For peak vertical force (PVF), four of seven treated dogs improved while only one of five of control dogs improved. The PVF for the within group analysis showed no significant change for the treated group, however, the control group has a significant decrease ($p=0.05$) in PVF consistent with an increase in lameness. The range of motion of the stifle joint improved in five of seven treated dogs and three of five controls. Dogs in the treated group had a trend toward increased range of motion ($p=0.07$) and a positive slope compared to dogs in the control group which did not have a significant change ($p=0.78$) and had a negative slope indicating the dogs were developing a decrease in ROM. The subjective data provided by client questionnaire did not show significant difference between groups.

Reviewing The Biologic Effects: Radial And Focussed Shockwaves Induce New Bone Formation.

Authors: Maier M, Tischer T, Hausdorf J, Saisu T, Schmitz C;

Institution: Munich, Chiba, Maastricht

In recent years, extracorporeal shock wave application to the musculoskeletal system has been established in the therapy of non-unions. However, there is a controversial discussion whether both, focused and ballistic (radial) shock wave devices lead to comparable new bone formation. Maier et al. used focussed shock waves with energy flux densities between 0 mJ/mm² (sham-treatment) and 1.2 mJ/mm² were applied in vivo to the distal femoral region of rabbits (1,500 pulses at 1 Hz frequency each). To investigate new bone formation, animals were injected with oxytetracycline at the days 5 to 9 after shock wave application, and were sacrificed on day 10 after shock wave application. Application of shock waves with energy flux densities of 0.9 mJ/mm² and 1.2 mJ/mm² resulted in new periosteal bone formation and the presence of cortical fractures and periosteal detachment. After application of shock waves with energy flux density of 0.5 mJ/mm², however, for the first time clearly detectable signs of new periosteal bone formation were observed without cortical fractures or periosteal detachment. In 2004 the study group of Haupt described new bone formation in a rabbit animal model following radial shock wave application of at least 2000 pulses with 3 bar or 4 bar. 60 days after the treatment new bone formation was found. The activity was osteoblasts was described to be high with extended osteoid formation. Haupt et al. concluded from their rabbit experiment that radial shockwaves might be used in future times for the treatment of e.g. non-unions or diseases with decreased bone turn-over such as parodontitis. This present reviews actual basic science studies dealing with the effects on bone following focused and radial shockwave application. It seems to be possible that radial shockwaves have comparable effects on healthy bone as focused shock waves in an rabbit animal model.

Tibial Stress Fractures Treated with Shockwave Surgery: Five Years After.

Authors: Herrera Juan M. MD, Leal Carlos MD, Lopez Juan C. MD, Reyes Oscar E. MD

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Orthopaedic Research Laboratory - Bosque University
Bogota DC , Colombia

Tibial stress fractures represent 49% to 73% of all overuse bone injuries due to biomechanical fatigue or overload. The natural history of this fracture shows that it is symptomatic for several years without treatment. However, therapeutic protocols for this fracture are still controversial. Many options have been described ranging from conservative treatment to intramedullary nailing. Few cases are available in the literature, so there is not enough evidence to accept any of them as the standard choice, and the treatment will need individual decision making. Compression tibial fractures may become chronic because of a lag in vascular supply to the fracture. Chronicity is a response to hypovascularity, and hypovascularity leads to delayed union or no union. The current gold-standard treatment includes a progressive retraining that will place the athlete out of active competition for at least four months, and if there are persistent symptoms, it could be over a year. This same challenging situation has been seen in military recruits. Limitation of the activity causing the symptoms is the keystone to any treatment regimen. Either on athletes or military recruits, cardiovascular conditioning and flexibility should be maintained by non-weight-bearing alternative exercises. We have explored the benefits of ESWT in tibial stress fractures, based upon the known effects of shockwaves in bone. We believe that osteoinduction, due to the micro lesions on the trabeculae and the vascular effects on both periosteum and cancellous bone may accelerate the recovery process in athletes with this condition. All experimental reports suggest that top pressing of the marrow from the medullary canal, marrow hypoxia and subperiosteal haemorrhages, may cause and stimulate new bone growth. Hypovascularity in stress fractures leads to chronicity. Thus, there could be two theoretical advantages of shockwaves in the treatment of stress fractures: one, shockwave therapy promotes vascularity at fracture site, and two, shockwave therapy enhances bone remodelling. ESWT produces micro-cracks in cortical bone that may lead to an enhanced remodelling process in bone. This enhanced remodelling process actually increases the surface area over which the load is applied. Thus, the intrinsic strength of bone as a material is increased at the end of the remodelling process, decreasing the risk for new stress fractures. To determine if Extracorporeal Shock Wave Therapy enhances osseous remodelling and decreases the time of recovery in stress fractures, we performed a case series study in fourteen patients. We presented our first report in the 6th ISMST international congress in Winterthur 2002, showing the faster recovery in our study group. Now we want to present the follow up after five years follow up of the same group, as well as the results of our protocol in new subjects. In this series there were seven women and seven men, all of them 18 years old, first year cadets, with identical bilateral stress fractures located at the union of the middle and distal thirds of the tibia. The onset of the symptoms was 8 weeks before they were included in the study, and the diagnosis was made over clinical history, Tc-99 Bone scans, ultrasound tests and X-Ray positive to stress fractures. Two thousand 0.7 milli-Joule Shockwaves were applied to the more symptomatic Tibia and eight days later the shock wave dose was repeated. All patients went into a progressive retraining program. We controlled nutrition intake, activity, and the progressive retraining standard program for the management of stress fractures. The rate of success was measured by the presence of pain before, through, or after the training practice. All patients were free of pain during the retraining program on their shockwave treated tibia. All of them presented persistent pain during the progressive retraining program on the untreated Tibia. Treated tibias were pain free after the retraining program. Untreated tibias were painful after that time, and were the cause of incapacities. All patients were satisfied with the treatment, and are prone to repeat it in the untreated tibias. Treated tibias were significantly faster to recover than untreated tibias after three weeks of retraining and physical therapy. Results after five years showed that all of our patients recovered

with no recurrence of the symptoms, and finished their military career without any athletic limitation. Our protocol is currently used in athletes in Venezuela and Cuba, and our results have been reproduced with similar results. We believe this is a safe procedure that can be recommended for athletes with tibial stress fractures in order to recover their physical activity in a shorter period of time.

Osteonecrosis And ESWT

Authors: Coco Valeria¹, Buselli Paolo², Bosco Vincenzo³, Saggini Raoul⁴

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Introduction:

Osteonecrosis is a pathology characterized by a bone circulatory disorder leading to its necrosis, it can affect various joints, but hip, knee, talus are mostly affected. There are spontaneous and secondary types; the first ones usually take most advantages from the conservative treatment. The circulatory disorder, being the underlying condition of this pathology, leads through oedema and intra-osseous pressure rise to ischemia and then to necrosis. The ESWT, thanks to its pain-releasing, neo-angiogenesis effect, can be suggested as an effective conservative treatment of this pathology.

Materials and Methods: Seventeen subjects have been selected aged on average 51 years (range 36-66); the diagnosis was osteonecrosis of the femoral head (No. 13), of the femoral condyle (No. 2), of the talus (No. 2). All of them reported pain since at least 6 months. Pain has been evaluated by means of the VAS scale in all patients and by means of the Fisher algometer in those patients suffering from osteonecrosis of the femoral condyle and of the talus. Restriction of the functional activities has been evaluated by means of the Algofunctional Index of Lequesne.

Patients had also undergone radiographic as well as MRI examination.

The treatment suggested is one ESWT session performed with an electro-hydraulic unit H.M.T. administering a number of SW with an output varying according to the joint type (femoral condyle 1600 SW - 0,15 mJ/mm²; talus 1500 SW - 0,13mJ/mm²; femoral head 4000 SW - 0,25mJ/mm²). After treatment, according to injury type and degree, a period of 4 to 8 weeks of walking activity with no weight bearing on the treated side and a rehabilitation treatment to keep articular mobility and muscular tone-trophism were suggested to the patient.

One month after treatment a clinical examination was performed and in case of unsatisfactory response treatment was repeated in the same way.

Follow-up of the cases treated included an examination 1, 3, 6 months after the last ESWT session. The examination at 6 months also included a new MRI.

Results:

The evaluation of the VAS scale showed on average values equal to 6,8 before treatment and 4,5 after 1 month, 4,3 after 3 months, 4,2 after 6 months.

The evaluation with the Fisher algometer showed on average values of 1,5 before treatment and 3,7 after 1 month, 5,4 after 3 months, 4,1 after 6 months.

The functional activities evaluated with the Algofunctional Index of Lequesne showed on average values equal to 7,1 before treatment and 5,2 after 1 month, 4,2 after 3 months, 4,1 after 6 months.

The MRI showed a positive evolution of the picture in 6 cases and stability of the imaging picture in 7 cases, whereas the evolution was negative in the remaining cases.

In 35% of the cases the MRI showed a reduction of the edema coupled with partial recovery of the cartilage as well as of the subchondral bone previously depleted.

During the treatments performed, no case reported significant undesired effects.

Conclusions:

The data obtained in the population treated show a good clinical result in the follow-up at 3 and 6 months. The pain evaluation shows a substantial reduction; the Algofunctional Index of Lequesne shows a 45% increase.

The effectiveness of the treatment with ESWT proves to be interesting for this kind of pathology, especially due to the scanty possible alternative therapies, although a limited number of subjects does not apparently report a significant improvement. Patients suffering from osteonecrosis of the femoral condyle and of the talus reported the most satisfactory results. The advantages of the SW Therapy prove to be especially interesting in the treatment of osteonecrosis with regard to the patient's compliance, to the reduced need of surgical treatment, to the absence of side effects, to the early outcome of positive response, to the reduced number of treatments necessary.

Extracorporeal Shock Wave Treatment For Osteonecrosis Of The Femoral Head

Authors: CJ Wang, FS Wang, KD Yang, LH Weng and CC Huang

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Purpose:

A prospective clinical study was performed to evaluate the efficacy of shock wave treatment for osteonecrosis of the femoral head.

Patients and Methods:

This study consisted of 22 patients with 29 hips in the study group and 5 patients with 5 hips in the control group. The study group included 18 males and 4 females with an average age of 43 years. The average duration of symptoms was 4.9 months and the average follow-up time was 20 months. Each hip was treated with 4000 impulses of high-energy shock waves at 28 Kv. The control group received sham treatment without shock waves. Clinical assessments included pain scores and Harris hip scores. Radiographs and magnetic resonance images (MRI) were used to evaluate the size of the lesion, congruency of the femoral head and bone marrow edema of the hip joint.

Results:

The study group showed significant improvement in pain scores ($p < 0.001$) and Harris hip scores ($p = 0.001$) after shock wave treatment, whereas the changes in the control group were statistically not significant ($p > 0.05$). The overall clinical outcomes of the study group were 76.2% improved, 19.1% unchanged and 4.7% worsened in patients with stage II lesions; and 62.5% improved, 12.5% unchanged and 25% worsened in patients with stage III lesions. All cases in the control group showed unchanged results. The complications are mild and negligible. MRI showed significant reduction in bone marrow oedema of the affected hip after shock wave treatment ($P < 0.000$) despite non-significant changes in the size of the lesion and the congruency of the femoral head.

Conclusion:

High-energy shock wave treatment appeared to be effective in pain relief and improvement of hip function for osteonecrosis of the femoral head in short-term follow-up. The results are more successful in patients with stage II than stage III lesions. Despite satisfactory early results, the results of long-term follow-up are needed to further verify the efficacy of this novel treatment.

ESWT For AVN of The Femoral Head-5-Years Results

Authors: R. Schleberger

Institution: Germany

Between the years 1995 and 2002 67 femoral head necroses have been treated by electrohydraulically generated shock waves. Most of them have been rated irreversible necroses through their ARCO stadium ≥ 2 . Aims of treatment have been painless weight bearing and survival of the genuine hip joint for 5 years or more. The 5 year survivorship of the genuine joint rates more than 90 percent all over, recovery of every day weight bearing could be observed in over 95% of the patients. Early progressive changes had been observed in 5 hips, repetitive treatment could stop progression in three hips.

Functional improvement had been measured by a VAS-Score questionnaire and presented an average improvement of 5 points in a 11 parts VAS-Scale (range 0-10). Improvement of function of hip joints in all ARCO stadiums will be presented according to the image controls and the morphological changes.

**Extracorporeal Shock Wave Therapy (ESWT):
How to plan and treat a patient with non-union in long bones fractures.
Effectiveness of ESWT (Extracorporeal Shock Wave Therapy) in pseudoarthrosis
and delayed union**

Authors: Alessandro Lettera MD, Davide Rozzati MD, Francesco Cravero MD,
Alessandro Littera MD, Francesca Travaglini MD, Giuseppe Sessa MD,
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Introduction:

Extracorporeal shock wave therapy is now accepted as an additional therapy, with low risks and invasivity, in the pseudoarthrosis and delayed union of long bones treatment. Our objective is to define and explain how patients with non healed long bones fractures can be prescribed and perform ESWT treatment. Our study also investigated the effectiveness of ESWT in the treatment of 30 patients with history of non unites fractures of long bones or pseudoarthrosis.

Materials and methods:

Patients with delaying in healing and consolidation of long bone fracture can be sent from the orthopaedic specialist to a radiology center to be treated by mean of ESWT.

The first step in our treatments with ESWT is to define the patient's exclusion criteria, such as pregnancy, heart disease, coagulopathy, epiphiseal plate within the shock wave fiel and brain or spine within the shock wave field, and inclusion criteria, non-union of long bones fractures defined as a failure to show bony union six months after initial close or open treatment. We select the treatment area (target) by mean of fluoroscopic or ultrasonographic guidance and we plan the number of treatments, the shock wave impulses for each treatment, the energy flux density and the proper generator of shock waves to use. Shock wave treatment is provided with a "REFLECTRON" (HMT, Kreuzlingen, Switzerland) ESWT System.

After the treatments, and a proper rest, we do an x-ray control, to define the progress of bone union.

In our Institute from 03/03/2004 to 31/10/2004 thirty patients, 10 female and 20 male (range 15-68 years) were treated. 15 patients had pseudoarthrosis and 15 delayed union of long bones. The treatment procedure was 3000 shocks with 240 shocks/min frequency for every treatment. Every patient had one treatment a week for 4 total treatments (one month).

A valuation schedule to define the upcoming of bony union was done for every patient.

In our study we didn't require immobilization, anesthesiologic support or hospitalisation.

Results:

The study was successful in 8 patients.

Pseudoarthrosis was successfully treated in 2 patients.

Delayed union of long bones was successfully treated in 6 patients.

Discussion:

Results in our study revealed that ESWT can be considered as first choice in the treatment of delayed union for long bones and pseudoarthrosis.

The femur seems to be the most responsive bone.

Treatment of nonunions with ESWT using Orthima-Dyrex

Authors: Paulo F. Kertzman

Institution: São Paulo Brasil

This paper is about the treatment of non-union after orthopaedic surgery with, at least, one year of evaluation and an biologic problem and not an poor fixation. We use and Orthima-Direx device and make the therapy on ambulatory, without use of anethesia and no inetranation

We localize the point of application using x-ray with an metal point over the skin or we make an measurement between the focus and one bone mark.

The treatment is done with 2000 shock waves (300 level 1 low energy, 300 level 2 medium energy, 400 level 3 high energy and 1000 level 4 high energy) and we repeat after 3 and 6 weeks. Between 2003 and 2004 we treat 8 patients with non-union. One radius, one ulna, one scaphoids, one humerus and 4 femur .

We have the consolidation of the non-union after 3 months of the last session in 7 patients.

The only one femur that does not consolidate was in fact an por fixation and we necessity to make a new surgery last month .

We conclude that its possible to treat non-unions without anesthesia and internation with good results.

Extracorporeal Shockwave Therapy for Bone Pathologies

Authors: Santos Paulo Roberto, Souza Ana Claudia

Institution: Hospital Santa Rita - São Paulo - Brazil

Introduction:

The aim of this study was to evaluate the effect of shockwave treatment in non-unions and delayed healing fractures, stress fractures and hip necrosis, with an electro hydraulic high energy device (Ossatron-HMT) at the Hospital Santa Rita, São Paulo - Brazil.

Method:

Since July 2002 until December 2004, 18 patients (8 female and 10 male) with average age 35 years (min=20, max=82 years) were submitted to shockwave therapy in different bone indications: Ten patients with non-unions or delayed healing fractures, of which one bilateral tibia non-union, (three patients underwent conservative treatment, eight had surgery prior to shockwave therapy, one non union was operated on once, three-twice and four- more than three times). Seven patients with hip necrosis (four- Arco Stage I, two- Arco Stage II and one- Arco Stage III), 1 patient with bilateral tibia stress fracture.

Pathologies patients sex age average:

non-union - delayed healing fracture 10 2 F / 8 M 20 - 82 44

hip necrosis 7 5 F / 2 M 18 - 68 41

stress fracture 1 1 F 19 19

All cases were treated with 26-28Kv and 3000-4000 pulses per treatment session. General anaesthesia was performed and fluoroscopy was used to localize the focus of the application. To evaluate bony consolidation of the non union and stress fracture conventional X-Ray and CT was used In the hip-necrosis the ARCO-classification was applied and MRI and X-Ray were used to assess the results .

Results:

In six patients with non-unions, the healing was achieved. Three patients showed no consolidation and two patients are in follow up . One patient with a bilateral hip necrosis showed complete recovery of the disease , 3 showed improvement in pain and function although the MRI-images showed little changes in the damaged area and no significant modifications in size. One patient Stage III showed no modifications and one patient is still in follow up . One patient with bilateral stress fracture showed improvement in pain and function.

Conclusion:

In this study the patients with non-unions, delayed healing fractures, stress fracture and hip necrosis showed a positive effect after being treated with shockwave therapy.

Shockwave Surgery and Autologous Growth Factors Combined Therapy for Non Unions and Pseudoarthrosis

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Bone healing in non unions and pseudoarthrosis has been a challenge for the orthopaedic surgeon since the beginning of times. Improved surgical techniques, better biomaterials and hardware, as well as the use of appropriate grafting and tissue banking has made the revision process for a non united fracture less often and more predictable. However, surgical procedures in non unions and pseudoarthrosis always involve large operations that significantly increase pre and postoperative risk factors, and also represent a longer and more difficult recovery period and rehabilitation process. Many non invasive techniques have been implemented to enhance the process of bone healing in difficult circumstances. Extracorporeal shockwave stimulation of bone has proved that enhancement of the production of endogenous growth factors, free radicals and NO's is possible, and results in bone healing in unfriendly soil. These effects have been studied in both molecular biology and clinical scenarios and ESWT is currently one of the most important tools in the orthopaedic arsenal of the 21'st century. By means of stimulating bone with focalized high energy ultrasound in the form of repetitive shockwaves, today we are able to enhance the healing process by causing neo-vascularization, periosteal stimulation and cell differentiation that result on bone callus in areas that would otherwise need surgical intervention and grafting. This procedure is non invasive, and has proven to be able to replace surgical procedures in stable non unions with no serious associated complications reported in more than 15 years of worldwide application. However, shockwave application in bone requires usually high energy generators that cause pain during the procedure, and in many occasions it must be done under general anaesthesia in an operating room. The cost of these devices is high for many countries, and difficult to introduce in the therapeutic arsenal of many hospitals. Being a non invasive procedure, rehabilitation protocols are shorter and recovery time reduced, but healing time, as seen in X-Rays, CT Scans or MRI's, is probably similar to large surgical interventions. In order to find a system that would reach the same minimally invasive goals as ESWT, using less expensive devices, we have tried Radial Shockwaves in combination with the injection of Platelet Autologus Growth Factors(AGF's). Both Orthopaedic and Maxillo Facial Surgeons have used AGF's for many years to reach the same goals as Shockwave Surgery. AGF's can be easily obtained from the alpha granules of platelets from the own patient's blood. It can be prepared in the form of a gel obtained from the Puffy Coat portion of centrifuged blood, which can be mixed to auto or allografts during a surgical procedure. We have developed a protocol to apply Radial Shockwaves with energies of 0.3mJ/mm², in order to stimulate vascularization and periosteal reaction in the area. We have used them only in non unions lying in bones not deeper than 1.5 inches, like tibia, ulna, distal femur and humerus. We give 4000 radial Shockwaves in the surrounding area, and under fluoroscopy we apply 10 cc of AGF's in different points of the fracture soft callus. In selected cases, where there is a defect larger than 2 cm², we mix the AGF's with lyophilised 300 micron bone allografts that act as an osteoconductor. All this procedure is done in a surgical room with no anesthesia and under aseptic surgical conditions. We have done 12 patients to date with stable postoperative non unions, in which the surgical procedure would have been a large incision that would involve hardware removal and replacement, bone drilling and grafting. Some of our patients also had thin skin after free grafts or vascular grafts from their original interventions that would indicate extra care for surgical approaches or higher energy ESWT. We have treated 5 tibias, 3 humerus, 2 distal femurs and 2 ulnas. All of them have healed promptly, with dramatic x-ray changes after 6 weeks. We have no complications related to the procedure and all patients and referring doctors are highly satisfied with the results. We believe that the use of radial shockwaves is not enough to create adequate bone healing

by themselves, both because of the lower energy and the loss of flux density as it goes deeper into the tissues. The use of single AGF's is also a good addition to surgical procedures where the trauma caused by the surgery itself will cause revascularization and cell migration to the area where the growth factors would cause some effect. However, used percutaneously alone, the AGF's would act only as a seed in a dry soil, not being able to help in the process of bone healing. We have very impressive results so far, and this has been an interesting finding that must be reported to the scientific community, as we have not found any previous report of any form of ESWT & AGF combined therapy. Of course we need to go further in the research of which one is the primary therapeutic element, so we are currently working on an experimental model in dogs, analysing in four groups the effects of single ESWT treatment, single AGF treatment, ESWT & AGF combined, and a control group. We will present in June 2005 in the ISMST meeting in Vienna our clinical results as a case- series study, and the preliminary results of our experimental study in animals. This new approach to non unions could make the treatment even easier than high energy ESWT or other surgical alternatives.

Extracorporeal Shock Wave Therapy in the treatment of delayed union and nonunion.

Authors: M.C. Vulpiani, M. Vetrano, F. Conforti, D. Trischitta, A. Ferretti

Institution: St. Andrea Hospital, University “La Sapienza” Rome, Italy

The pathologies of healing of bone fractures (delayed union and non-union) remain one of the major complications after skeletal trauma despite progress reached by surgical techniques and conservative approaches. Extracorporeal shock wave therapy (ESWT) has become a common treatment for orthopaedic disorders in the last decade. Many experimental and clinical studies have confirmed a positive effect of shock waves on fracture healing.

The purpose of this study was to examine the effect of ESWT on the treatment of delayed union and pseudarthrosis. Ninety-three patients were enrolled in this study. There were 52 males and 41 females with an average age of 42.6 years (range 15-73 years). 34 patients had a diagnosis of delayed union (mean, 4.9 months) and 59 were non-unions (mean, 16.7 months; range 6-84 months).

The results of treatment were assessed clinically and fracture healing was assessed with plain radiographs, CT, MRI and three-phase bone scintigraphy. High-energy shock wave treatment was applied using two different electromagnetic shock wave generators, Minilith® SL-1 (43 patients) and Modulith® SLK (50 patients), both developed by STORZ MEDICAL AG. The shock waves were applied in 3-5 sessions with 2500-6000 impulses at 0,25-0,4 mJ/mm² energy flux density for Minilith® SL-1 and at 0,25-0,84 mJ/mm² for Modulith® SLK. After treatment patients with fractures without osteosynthesis were immobilized with various plaster casts or orthotic devices until an osseous reaction was proven. Follow up assessments were done at short, medium and long term.

The Student T Test was used for statistical analysis of data.

The assessment of fracture healing showed total consolidation in 69 patients (74%), partial consolidation in 11 patients (12%) and no apparent changes in 13 patients (14%).

The analysis of our results showed similar results in delayed unions (79%) and non-unions (71%). As foreseeable, differentiation was noted in cases of hypertrophic and oligotrophic pseudarthroses which showed significantly better results than those relating to atrophic non-unions.

Although our results appear to be more successful with long bones rather than short bones, they cannot be considered statistically relevant. With respect to devices used, it is not possible at this time to evaluate the performance of the two devices on the basis of preliminary results. Evaluation will be possible at a later date.

The extracorporeal shock wave therapy to be a safe and effective alternative treatment for delayed union and pseudarthrosis.

Extracorporeal Shockwave Therapy for Non-Unions and delayed Unions

Authors: W. Schaden, A. Fischer, A. Sailler, A. Menschik, N. Haffner

Institution: Trauma Centre Meidling, Vienna, Austria

Introduction:

Since December 1998, more than 1,200 non-unions were treated with shockwave therapy in the Trauma Centre Meidling with an electro hydraulic device (Ossatron, HMT). To compare different technologies from April 2004 till January 2005, 149 Patients with non-unions or delayed unions were treated with an electro magnetical device (Modulith, Storz Medical). Till February 2005, the results of 62 patients are available.

Material and Methods:

The patients consisted of 25 (40%) female and 37 (60%) male with a mean age of 44,5 years (14-84). The mean age of the non-unions was 18,1 months. 31 (50%) were considered as delayed unions (3 to 6 months from the trauma or the last surgery concerning the bone) and 31 (50%) were older the 6 months (non-unions). All treatments were performed under general or regional anaesthesia. Analogue energy flux densities and number of pulses to the electro hydraulic device were used. If necessary immobilisation with plaster cast or splints were applied.

Results:

Out of 62 treated non-unions 48 (77%) achieved bony healing within 3 to 6 months after shockwave therapy. Compared to 593 (79%) bony fusions out of 755 treated non-unions with an electro hydraulic device no significant difference was observed.

Besides local swelling, petechial bleedings no adverse effects were reported in both collectives

Extracorporeal Shock-Wave Therapy in Chronic Stable Angina Pectoris

Authors: J.-P. Schmid

Institution: Swiss Cardiovascular Centre Bern,
Cardiovascular Prevention & Rehabilitation,
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Introduction:

Extracorporeal shock wave therapy (ESWT) has generated great interest in cardiology since the first report of enhanced neovascularization by shock wave application at the tendon-bone junction in a dog model. Ischemic heart disease is the single leading cause of death in the industrialized countries and chronic stable angina pectoris is the most common manifestation of this disease. The treatment of choice is coronary revascularization, either by percutaneous coronary intervention or aorto-coronary bypass surgery. A substantial number of patients continue to experience precordial ischemic pain, either due to a lack of revascularization options or progression of the underlying disease. Alternative methods in the treatment of chronic angina are therefore warranted.

Methods:

In patients with chronic stable angina, the myocardial region of exercise induced ischemia is defined by myocardial scintigraphy. By means of ultrasound guidance, the focus of the shock wave generator can be directed to the region to be treated. In general, 200 shots with an energy of 0.09 mJ/mm² are delivered per spot. According to the area at risk, between 9 and 40 spots are chosen to scan the whole ischemic region at each session. The treatment is delivered in 9 sessions, 3 sessions grouped in 3 to 5 days, with a time interval of 4 weeks between the second and third 3 sessions.

Results:

The treatment is well tolerated by the patients and no increase in cardiac enzymes or arrhythmias have been noted. Canadian Cardiology Society functional class and exercise capacity improved as well as the quality of life score of the Seattle Angina Questionnaire after a follow-up of 6 months. The amelioration of the clinical status after treatment correlated with improved myocardial scintigraphic perfusion images.

Conclusions:

In patients with chronic refractory angina ESWT is safe and well tolerated. It improves symptoms, exercise capacity and myocardial perfusion. The mechanisms by which shock waves promote perfusion are still unknown, but nonenzymatic nitric oxide synthesis and upregulation of VEGF mRNA expression might be some hints in favour of formation of new capillary networks.

Extracorporeal Shockwave Therapy for Adult Osteochondritis Dissecans of the Femoral Condyle

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Since extracorporeal shockwave therapy started to conquer the orthopaedics it determined new indications to be treated.

Aim of this report is to show the effect of ESWT on the adult Osteochondritis Dissecans of the femoral condyle.

As seen in earlier studies the shockwave application shows effect on bone-growth, on vascularization and on the cartilage tissue.

The mechanism of effectiveness is still under research but changes that take place in the body are described. High energy shock waves show a neosynthesis of bone, neovascularization and micro fractures that are induced by effects like cavitation, enhancement of higher production of TGF- β 1, VEGF, NOS and other factors. The Osteochondritis dissecans should therefore profit from these effects.

The study was performed with the Ossatron by HMT on a number of 71 patients. The patients included have suffered from Osteochondritis Dissecans Stadium I and II in MRI. All wanted to get a therapy except for surgery which was in their eyes, the last possibility. The patients were scored by a subjective score, a Visual Analogue Scale, the Larson- Score and the Brückl- Score.

Further the patients received MRI- examinations to show the development of the affected area. It will still be shown to be the best course of treatment as the number of shocks and intensity of energy-flux-density to get the best results in revitalization of the osteochondral damage for this study was only performed in a prefixed schedule. The results of this study will be revealed in the lecture.

As extracorporeal shockwave therapy seems to be a treatment with minimal side effects, it is understandable that we look out for new indications to be treated with shockwaves.

The Osteochondritis Dissecans is only to be treated effectively by surgical intervention and the results presented in publications are not encouraging for patients and doctors as the disease will lead to an osteoarthritis of the joint. The conservative treatment is based on the hope for a spontaneous healing supported by the reduction of physical strain for long period.

The extracorporeal shockwave therapy therefore might be a casual therapy for an still unsolved indication and further investigations on the mechanism of effectiveness will lead us to better statements to indications that will gain from this method. In our experience we later have case reports about the effectiveness of the shockwave therapy even in states of the Osteochondritis so as state three. This may lead us to the possibility of treating osteoarthritis successfully by shockwaves. We even found very good results in the treatment of acute posttraumatic osteochondral lesions (controlled by arthroscopy).

Antibacterial effects of extracorporeal shock waves

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Despite considerable knowledge about effects of extracorporeal shock wave therapy (ESWT) on eukaryotic tissues, only little data are available concerning their effect on prokaryotic micro organisms. The objective of the present study was to determine the bactericidal activity as a function of energy flux density and shock wave impulse number. Standardised suspensions of *Staphylococcus aureus* ATCC 25923 and other clinical relevant species were exposed to different impulse numbers of shock waves with an energy flux density (ED) up to 0.96 mJ mm⁻² (2 Hz). Subsequently, viable bacteria were quantified by culture and compared with an untreated control. After applying 4000 impulses, a significant bactericidal effect was observed with a threshold ED of 0.59 mJ mm⁻² ($P < 0.05$). A threshold impulse number of more than 1000 impulses was necessary to reduce bacterial growth ($P < 0.05$). Further elevation of energy and impulse number exponentially increased bacterial killing. ESWT proved to exert significant antibacterial effect in an energy-dependent manner. Certain types of difficult-to-treat infections could offer new applications for ESWT.