ENRAF-NONIUS

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UPDATE 2013
INCLUDING 45 NEW PROTOCOLS

StatUS™ Therapy Guide

NEW in Physical Therapy: StatUS™ Therapy

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This paper is intended for professional practitioners in the health care services. Before using the therapeutic recommendations and applications, it is essential that the practitioner is aware of the risks associated with the various applications.
The instructions in the user manual of the relevant machine must be strictly followed at all times.

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1. Foreword

This abridged therapy book is primarily meant as a reference for the use of stationary ultrasound (StatUS™). StatUS™ stands for Stationary Ultra Sound. In other words: the application of ultrasound without moving the transducer (= stationary). StatUS™ therapy is an innovative way of applying ultrasound in a stationary (static) manner that was invented by Enraf-Nonius in collaboration with international institutes. This is a quite new, unique method within the area of physical therapy. Normally, ultrasound energy is applied by moving (“making circles with”) the transducer. This moving of the transducer (also called the dynamic or semi-stationary method) is necessary because some harmful effects occur both inside an ultrasound bundle as well as in the tissue that can result in tissue damage (so-called “hot spots”). For these reasons, treatment with a static transducer is almost never applied. In contrast, StatUS™ therapy is a new treatment method that turns the disadvantages of the static application of ultrasound into advantages for both therapist and patient.

StatUS™ therapy can be applied with the 6-series devices by Enraf-Nonius, provided that these are equipped with a StatUS™ module. Contact your local Enraf-Nonius dealer for more information about the 6-series devices and available modules. For general information regarding ultrasound therapy, please refer to the “Ultrasound” therapy book (article number 1482.762). This therapy book can also be ordered through your local Enraf-Nonius distributor.

2. Hands free in control, bridging health care and science

Over 60 years therapeutic ultrasound appears to be one of the most frequently applied modalities treating musculoskeletal and soft tissue disorders. Initially practised without unequivocal scientific proof, the introduction of evidence based medicine and the expansion of a scientific basis in physiotherapy contributed to substantial evidence of efficient and effective application of therapeutic ultrasound. To date, clinical physiotherapeutic evidence is based on solid scientific information as founded in clinical guidelines or original clinical studies. Initiation of such vital and robust information led to a turning point in the scientific platform and eventually in a justified choice of scientifically based clinical application of ultrasound therapy.

This transition appeared to be a valuable subject not unrecognised to rehabilitation industry. A revolutionary development of the therapeutic ultrasound application method. Where a dynamic application technique used to be inevitable in order to avoid possible tissue damage due to peak intensities, to date static ultrasound is a safe application opportunity. Changing the ultrasound intensity during treatment time prevents such undesirable intensity cumulation. Local ultrasound therapy by means of a vacuum pump mechanism using a non-liquid gel pad opens new possibilities applying therapeutic ultrasound on a specific and restricted treatment area.

This so called StatUS™ therapy (Static Ultra Sound) represents an innovative method to apply therapeutic ultrasound in a standardised, stationary (static) manner. Developed by Enraf-Nonius it appears to be less labour intensive and physically aggravating, and, moreover, treatment parameters are highly reproducible. The constant perpendicular position of the fixed ultrasound transducer – without dosage variation as in dynamic ultrasound – ensures clinical effectiveness and patient safety.

This booklet provides a reference framework using StatUS™ successfully and based on scientific evidence; thus bridging the essential liaison between health care and science. In conclusion, StatUS™ makes a significant difference for the contemporary professional health care provider.

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3. Introduction

Ultrasound is one of the most well-known and applied forms of therapy in physical technology [35, 37, 38]. The energy is transmitted to the tissue in the form of a sound wave by means of a “head” or transducer. The frequency with which this occurs is typically between 0.8 and 3 MHz. Not all tissue absorbs the ultrasound energy to the same degree. The effectiveness therefore strongly depends on the type of tissue that is being treated. The greatest effect of ultrasound occurs in that tissue where the energy is absorbed in an efficient manner. This is connective tissue (collagen) with a high degree of denseness such as ligaments, tendons, fascia, joint capsules and scar tissue.

Although ultrasound has an effect on other tissue (for example, muscle tissue), the effect of ultrasound on an acute muscle rupture is less pronounced than the effect on an acute ligament injury. Knowledge of the type of tissue that is affected is of essential importance for the clinical decision-making process [51, 45, 33, 16]. In a recent study no significant effects could be demonstrated in the treatment of very acute muscle contusions [53, 28] while positive effects were observed in the treatment of ligament injuries [42, 44].

3.1. Effects of Ultrasound

Ultrasound can be applied both in a thermal as well as in a non-thermal manner (see the table on page 10). A thermal effect is in place if a temperature of 40-45°C is reached in the tissue, which must continue for at least 5 minutes [36]. Excessive thermal effects, which could particularly occur at higher levels of intensity, could damage the tissue [13]. The non-thermal effects of ultrasound (including cavitation and acoustic microcirculation) would play a more important role than the thermal effects in the treatment of soft spot injuries. Cavitation occurs when gas-filled bubbles alternately swell and compress in tissue fluids under the influence of pressure differences (caused by ultrasound). This gives rise to a current movement in the tissue of the surrounding tissue [21]. Due to this microcirculation the cell structure and permeability changes, which is considered as an explanation of the fact that ultrasound has a positive effect on wound healing.

There are two forms of cavitation:
Stable (non-inertial) cavitation
Unstable (inertial) cavitation

Non-inertial cavitation is the occurrence of stable bubbles which shrink and grow approximately evenly during compression and expansion. It is assumed that stable cavitation has a positive effect on the affected tissue. The microbubbles can also be instable, however, which is called inertial cavitation. These bubbles implode rather quickly, which causes many effects such as extreme increase of pressure and temperature. Instable cavitation can result in tissue damage [52]. Instable cavitation should be prevented by using pulsed ultrasound with a very short pulse duration.

The thermal effect of ultrasound consists of heating the collagen tissue and is the easiest to reach through the use of continued ultrasound in combination with high intensity.

The non-thermal effects occur at lower energy levels and in pulsed mode and have cell "up" regulation as their objective. Non-thermal ultrasound is often used to speed up tissue recovery by optimizing the normal inflammation, proliferation and remodeling phase [32, 33, 51].

Treatment during the proliferative phase of wound healing results in improved recovery of the function [33].

Type of effect	Result
Thermal	• Increased tissue flexibility/elasticity • Improved circulation • Pain modulation • Triggers a mild inflammatory response • Decreased joint stiffness • Decreased muscle tension
Non-thermal	• Cavitation • Acoustic microcirculation • The combination could possibly result in stimulation of fibroblast activity, increased protein synthesis, improved circulation, tissue recovery and bone healing.

In order to speed up tissue recovery, ultrasound is applied very locally and in small doses. Use of low-intensity ultrasound is also referred to in the literature as LIUS (Low Intensity Ultra Sound) or LIPUS (Low Intensity Pulsed Ultra Sound).

Low-Intensity Ultrasound (LIUS or LIPUS).

Low-intensity ultrasound refers to the pulsed application of ultrasound with an average power of at most 0.1 W/cm^2 (100mW/cm^2). This in contrast to an intensity of 0.5-3.0 W/cm^2 as is customary for traditional ultrasound [49].

Table 1: Overview of various sorts of ultrasound and clinical application in humans

Type of ultrasound	Intensity	Mechanism of action	Clinical application

High intensity	5-300 W/cm^2	• Increase in temperature
		• Destruction
			• In surgery
			  • Fragmentation of calculi
			  • Excitation of tissue

Medium intensity	1 -3 W/cm^2	• Increase in temperature	• Decrease of joint stiffness, pain and muscle spasms • Increase of muscle mobility
Low intensity	1-50 mW/cm^2	• Not yet fully known • Very minimal increase in temperature (<<1°C) • Acoustic pressure differences and permeability changes of the cell membrane appear to play a role	• Non-invasive diagnostic of fetus, vital organs and bone • Promotion of healing and recovery of open wounds, acute/subcutaneous inflammations, tendons, nerves and bone

Source: Korstjens et al. Effecten van lage-intensiteit ultrageluid op bot. Ned. Tijdschrift Tandheelkunde 2002; 109: 485-489 (Korstjens et al. Effects of low-intensity ultrasound on bone. Dutch Journal of Dentistry 2002; 109: 485-489).

Low-intensity ultrasound (1-50 mW/cm^2) is primarily used in medicine for performing non-invasive diagnosis on a fetus or imaging vital organs or bone. In addition, low-intensity ultrasound also has a therapeutic effect. Tissue culture experiments as well as animal studies have shown that it has a clear stimulatory effect on bone growth. Furthermore, clinical studies have proven accelerated consolidation of fractures, among other things. In humans low-intensity ultrasound does not result in thermal and destructive effects [17, 18]. Low-intensity ultrasound also appears to speed up healing of open wounds as well as the recovery of tendons, nerves [6,7] and bones and promotes healing of acute and subcutaneous inflammations [31]. This theory is also supported by experimental research of the positive effect of low-intensity ultrasound on the healing of acute ligament injuries [44].
Recent research has shown that LIPUS has a positive effect on the recovery of connective tissue in general and on bone tissue in particular. Several RCTs (randomized controlled trials) have shown that low-intensity ultrasound can speed up the consolidation time of fractures of the tibia [18, 40], radius [25] and scaphoid [29] by about 30% to 38% (compared to treatment with placebo), which results in a significant gain in time [4].
In addition to a favorable influence on the healing process of acute bone fractures, low-intensity ultrasound has a facilitating effect on badly and non-consolidated fractures. In the group of non-consolidated fractures LIPUS still resulted in consolidation in 86% of the cases [30]. Although LIPUS certainly has the power to be used for treating total fractures, there is also much benefit to be gained from treating injuries in which tissue other than bone is affected. There are also indications that low-intensity ultrasound can be used for treating stress fractures [3].

The new StatUS™ devices by Enraf-Nonius are excellently suited to be used as LIPUS (see treatment example)

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5. General Characteristics of Ultrasound

In the last decade various new ultrasound therapy devices have appeared on the market. Moreover, the importance of ultrasound frequency is highly stressed. The penetration depth of ultrasound energy should increase with decreased frequency. A lower penetration depth is associated with a limited transmission of energy, fast absorption of energy and a marked heating effect in relatively superficial tissue structures [46]. In contrast, a high penetration depth ensures efficient transmission of energy with little absorption resulting in little tissue heating. The choice of the correct ultrasound frequency (0.8 to 3 MHz) thus needs to be based on the desired penetration depth and the thermal and acoustic characteristics of the tissue into which the ultrasound energy is transmitted.

However, there are several variables that determine the ultrasound dose:

- Wavelength
- Intensity
- Amplitude
- Effective Radiation Area (ERA)
- Beam Non-uniformity Ratio (BNR)
- Mode: continuous or pulsed
- Contact medium
- Tissue composition
- Movement and angle of the ultrasound transducer
- Frequency and duration of the treatment

The intensity peaks that occur at both 1 MHz and (although to a lesser degree) at 3 MHz can cause thermal and mechanical tissue damage. The highest intensity is measured in the middle of the ultrasound bundle (see chapter 3).

By moving the transducer in a calm manner the intensity peaks always occur at a different location. Moving the transducer – also called the *dynamic or semi-stationary method* – makes it possible to treat the area as evenly as possible. In addition, the chance of the occurrence of “hot spots” decreases considerably. Hot spots can be defined as local, relatively small areas that are excessively heated as a result of interference and reflection.

Based on the above-mentioned phenomena, treatment with a non-moving transducer (also called the *static or stationary method*) has almost never been used until now.

In contrast, StatUS™ therapy is a new treatment method that turns the disadvantages of the static application of ultrasound into advantages for both therapist and patient.

6. Characteristics of an Ultrasound Bundle

The aim of moving the transducer (the *dynamic or semi-stationary method*) is to decrease the chance of so-called "hot spots" from occurring. Treatment with a non-moving transducer (called the *static or stationary method*) could result in local, relatively small areas being heated excessively. These "hot spots" are the result of primarily two phenomena that occur both inside the ultrasound bundle as well as outside of it – in the tissue: *interference* and *reflection*.

6.1. Interference

There are two distinguishable zones in an ultrasound bundle (see figure 2):

- The near field: the Fresnel zone
- The far field: the Fraunhofer zone.

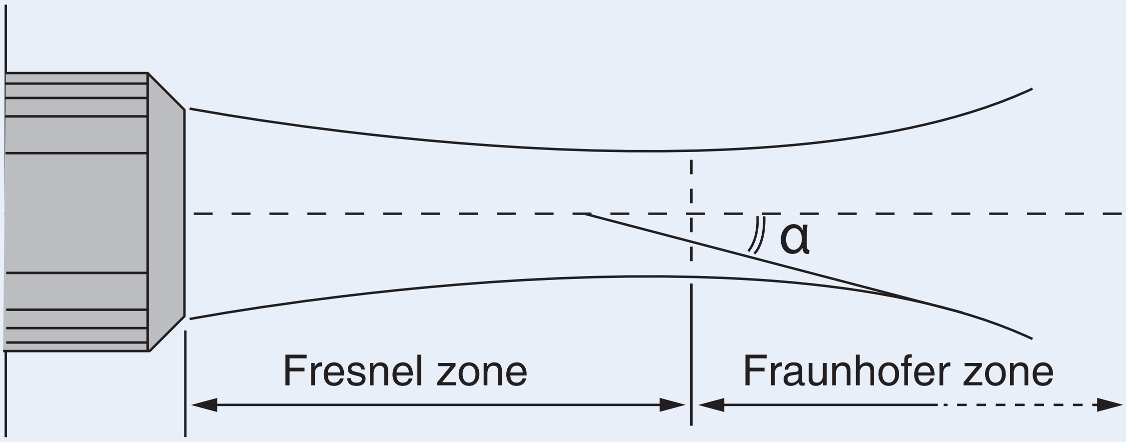

Figure 2: Lengthwise section of the ultrasound bundle

The near field (Fresnel zone) is characterized by:

- Interference in the ultrasound bundle through which strong variations in intensity can occur (see figure 3)
- The lack of divergence (in reality there is slight convergence).

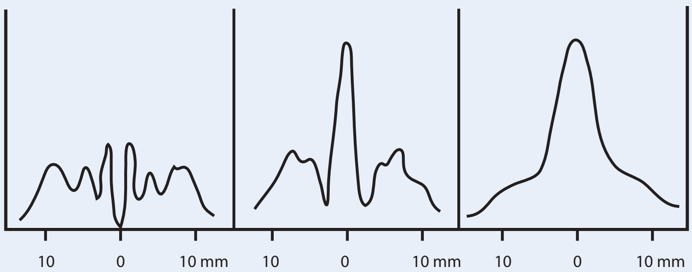

Figure 3: Cross-section of the ultrasound bundle

The far field (Fraunhofer zone) is characterized by:

- The almost total lack of interference signals, due to which the sound bundle is even and the intensity gradually decreases as the distance to the contact area of the transducer increases
- A larger cross-section of the ultrasound bundle
- A larger distribution of the sound energy, both by divergence as well (as because the intensity distribution becomes increasingly more bell-shaped) perpendicular to the longitudinal axis of the sound bundle.

The length of the near field depends on the diameter of the transducer and on the wavelength. With the usual transducer of 5 cm^2 the near field becomes about 10 cm long. With a transducer of 1 cm^2 the near field is about 2 cm long (at 1 MHz).

At 3 MHz the near field is 3 times as long, given that the wavelength becomes proportionally shorter. Because the depth effect of ultrasound is limited, the therapeutic effects primarily take place in the near field. Here one must realize that the ultrasound bundle exhibits interference signals in the Fresnel zone, which results in a non-homogeneous sound bundle (see figure 4). These interference signals can result in intensity peaks that are 5-10 times (or in some cases even 30 times) higher than the set value.

The non-homogeneous behavior of the sound bundle is reflected by the variable Beam Non-Uniformity Ratio (BNR).

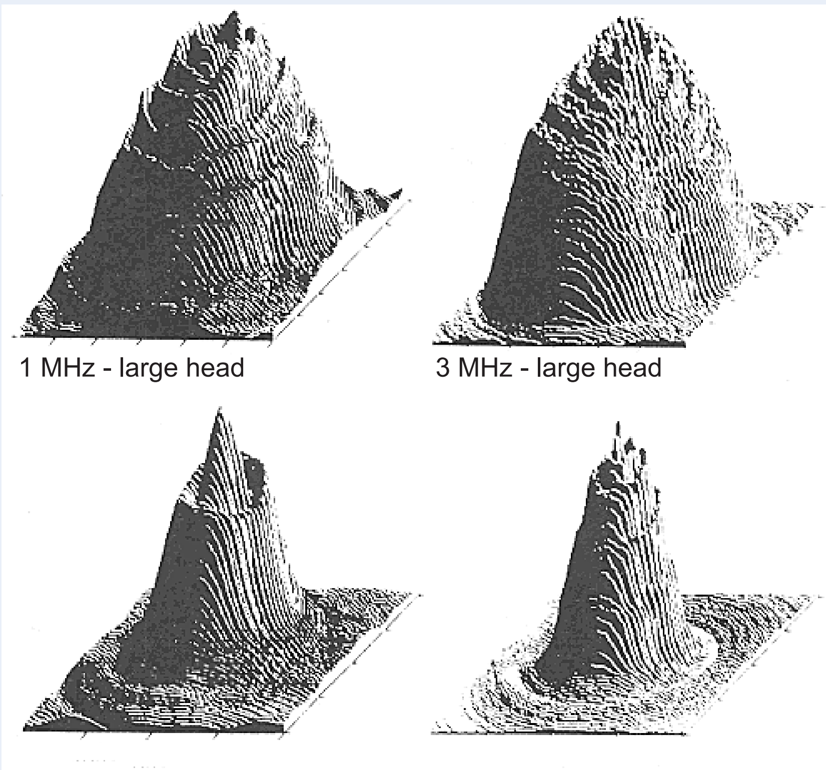

Figure 4: Bundle diagrams (1MHz and 3MHz ultrasound transducers)

In theory the BNR value cannot be smaller than 4, in other words you must always take into account intensity peaks of at least 4 times the set value. With well-designed transducers the BNR is between 5 and 6.

For safe treatment, the traditional ultrasound transducer must always be moved about so that the ultrasound energy is reasonably distributed. Rotating the transducer at one location is discouraged.

7.2. Reflection

The effects of ultrasound are twofold: a mechanical effect (micromassage) and a thermal effect (heat).

The heating effect is a direct result of the micromassage of tissue. The quantity of heat that is created is unequal for the various tissues.

The heat particularly occurs at locations where the sound vibrations are reflected (such as with transitions from one tissue to the other).

When ultrasound enters the body, diffusion occurs: the ultrasound bundle will spread into directions other than the lengthwise direction of the sound bundle, initially through reflection but also through divergence in the far field (see figure 5). Reflection of some significance (approx. 30-35%) only occurs with tissue transitions to bone tissue.

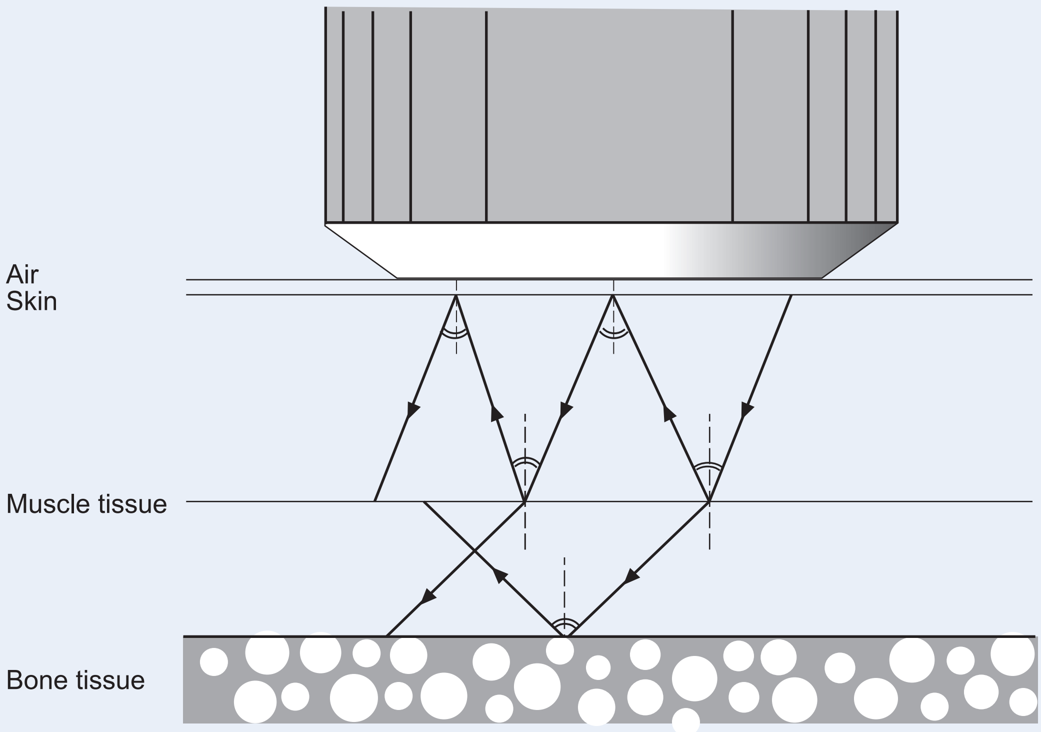

Figure 5: Dispersion of the ultrasound bundle through reflection

The entering and reflected ultrasound bundles can overlap each other, which creates two wave motions that can strengthen (interference) or weaken each other. Only in the case of strengthening through interference does this result in increased intensity of the sound bundle (see figure 6).

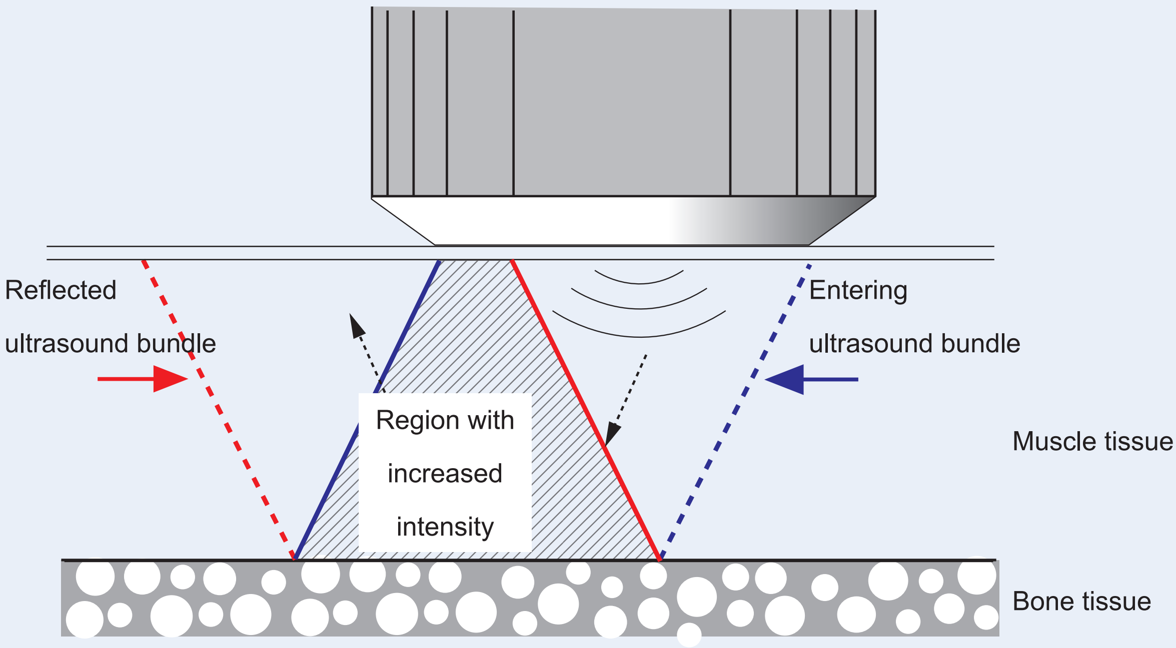

Figure 6: Interference through reflection

In practice, a problem only occurs if the tissue layer is thin up to the bone tissue or absorbs little ultrasound energy. This is the case, for example, with treatments around the wrist, the ankles and the patella.

Especially with continued application of ultrasound, this phenomenon leads to periosteal tingling in the form of heat sensation and/or pain. This once again proves the importance of moving the transducer. In addition, by applying the ultrasound energy in a pulsed format, the thermal effect can be reduced and the risk of periosteal tingling also decreases.

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8. StatUS™ (Stationary Ultrasound) in detail

Normally, ultrasound energy is applied by moving the transducer (*dynamic or semi-stationary method*). This is required in connection with the phenomena that can lead to tissue damage (“hot spots”). In addition, dynamic ultrasound application is time-consuming and labor-intensive. StatUS™ therapy, in contrast, is a new method of applying ultrasound *without moving the transducer* (= stationary). The therapist no longer even needs to hold the transducer. Such a “handsfree” treatment frees up a lot of time and makes treatments less cumbersome.

Figure 7: StatUS™ therapy in practice

8.1. StatUS™ Therapy Devices

In order for stationary ultrasound to be applied, the transducer needs to be fixated in one manner or another. Because the StatUS™ ultrasound transducer is built in to a special suction cup (the StatUS™ applicator), the transducer can be placed on the body quickly and easily. The vacuum pressure can be adjusted as desired. The ATUS controller (Air-To-Ultrasound), where the ultrasound and vacuum come together, forms the connection between the Status™ transducer and the StatUS™ therapy device (see figure 8).

Figure 8: StatUS™ applicator and ATUS controller

To create good transfer of the ultrasound energy, a special gel pad is placed on the transducer (ordinary gel cannot be used because it is sucked in by the vacuum pump). The gel pad is kept in place by means of a fixation ring. Due to the vacuum pressure the transducer and gel pad perfectly connect on the body surface (see figures 9 and 10).

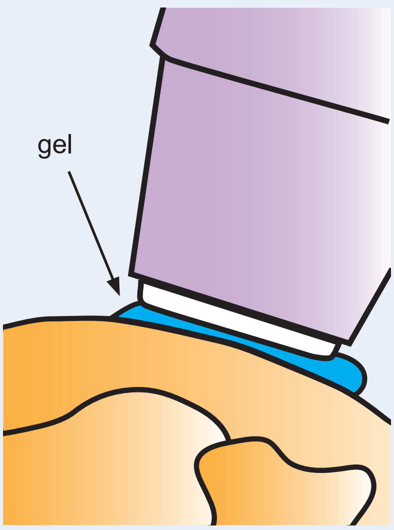


Figure 9: Contact surface when applying a traditional applicator and normal gel

Figure 10: Contact surface when applying a StatUS™ applicator and the special gel pad

SONOPULS STATUS™

StatUS™ therapy is possible with 3 new 6-series devices:

1. Sonopuls 690 S (S = StatUS™)
2. Sonopuls 692 S
3. Sonopuls 692V S

An individual StatUS™ module is also available. This can be built in to existing 6-series devices in case these units already have an ultrasound module. The StatUS™ module only works in conjunction with an ultrasound module. The transducer in the StatUS™ applicator has an effective surface of 5 cm^2. The frequency for the ultrasound must be set to either 1MHz or 3MHz.

Sonopuls 690 S

Sonopuls 692 S

Sonopuls 692V S

8.2. The Principle of StatUS™ Therapy

StatUS™ treatment is a relatively simple treatment. The parameters that need to be set do not differ significantly from the known parameters for applying regular ultrasound treatment.

The parameters can be quickly and easily set from the operating menu of Sonopuls StatUS™ devices. StatUS™ therapy can be directly activated from the main menu (see figure 11), after which the parameter screen is accessed in 2 steps (see figure 12). This screen has many similarities with the "traditional" ultrasound therapy screen.

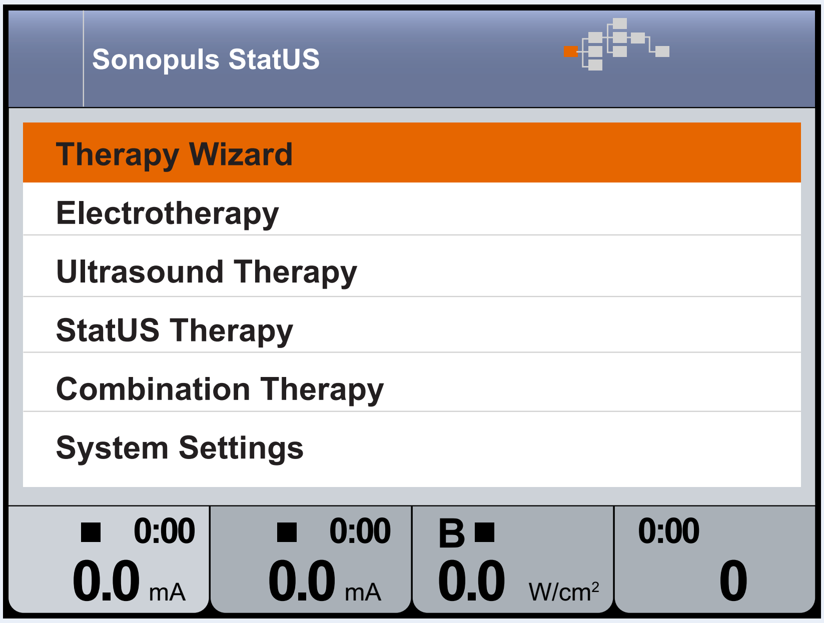


Figure 11: Main menu (Sonopuls 692 S) with StatUS™ therapy option

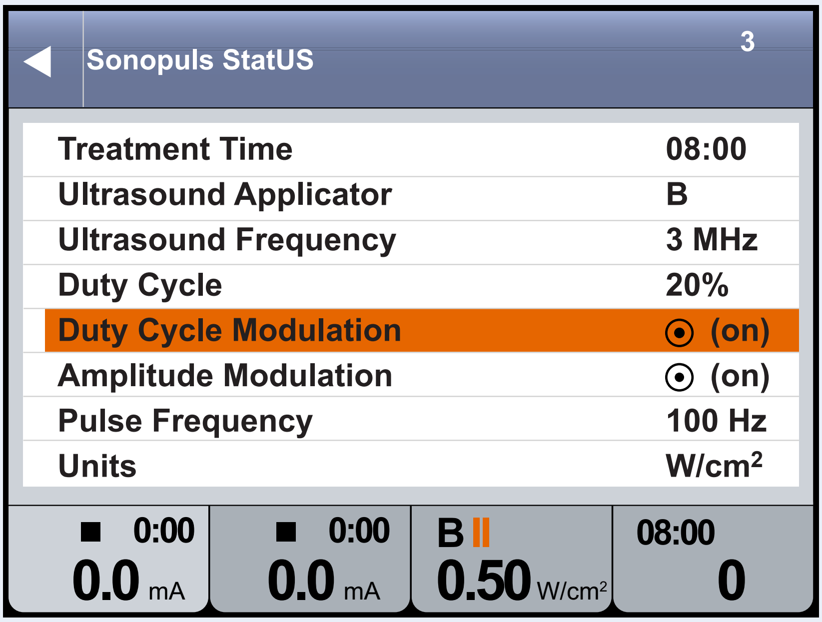


Figure 12: Parameter screen for StatUS™ therapy

The parameters for a StatUS™ ultrasound treatment differ fr om a “traditional” ultrasound treatment by the addition of 2 (patented) modulation forms:

1. Duty cycle modulation
2. Amplitude modulation

These modulation forms ensure that the intensity peaks in the ultrasound bundle are greatly reduced, that the chance of cavitation decreases and that the occurrence of “hot spots” is combated. Modulation occurs automatically in a certain rhythm – which is partially determined beforehand (see § 4.2.1 and § 4.2.2).

10.2.1. Duty Cycle Modulation

The duty cycle can be described as the relationship between the pulse duration and the pause duration. The duty cycle is expressed in a percentage (%). If the duty cycle is 100%, then the device works in continuous mode.

Duty cycle modulation means that the duty cycle is automatically varied in a fixed rhythmic pattern. The modulation is characterized by a fixed duration of 12 seconds in total, during which the (previously) set duty cycle goes to 5% and then back again. So, if a duty cycle of 50% has been set, then it will gradually decrease from 50% to 5% in 6 seconds in order to then again increase from 5% to 50% in 6 seconds. In fact, this modulation ensures that the pulse duration is automatically decreased and then increased.

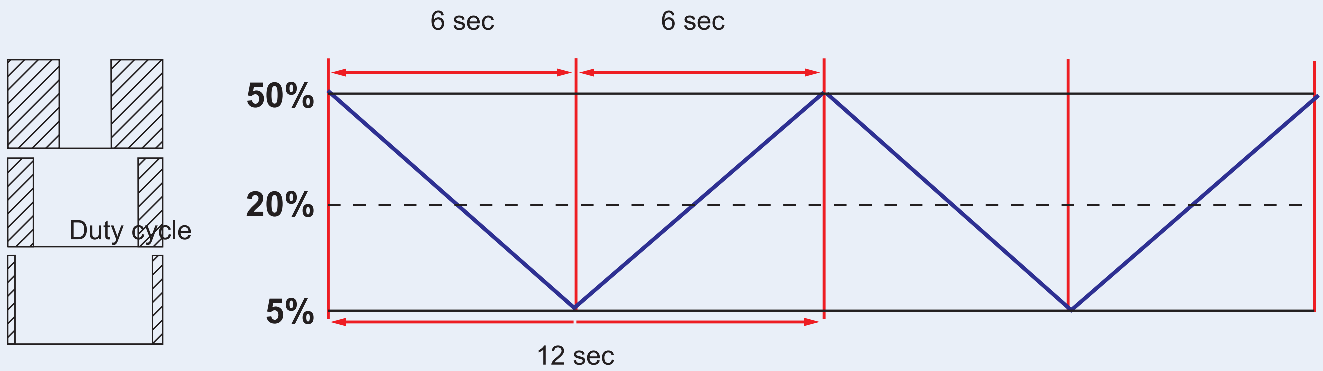


Figure 13: Duty cycle modulation (example of modulation at a selected duty cycle of 50%)

10.1.2. Amplitude Modulation

Amplitude modulation is the varying of the ultrasound intensity. This form of modulation is also characterized by a rhythmic period of 12 seconds. The set intensity (W/cm^2) equals 100%. In the first 6 seconds the intensity decreases from 100% to 85% in order to return to 100% in the following 6 seconds. Amplitude modulation has a fixed pattern and cannot be changed. This is in contrast to duty cycle modulation, where the duty cycle must be set to 5, 10, 20, 50, 80 or 100%.

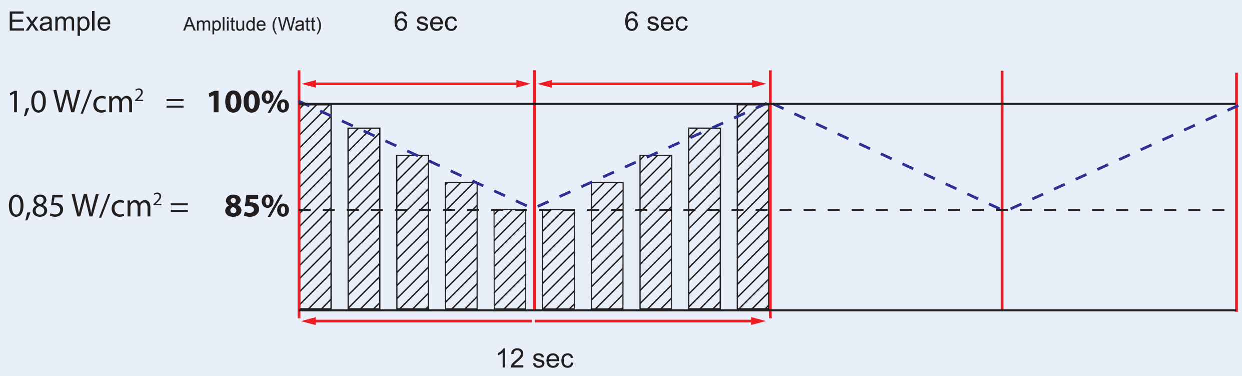


Figure 14: Amplitude modulation (example of modulation at a set intensity of 1.0 W/cm^2)

Both forms of modulation can be activated and deactivated independent of each other. This (de)activation takes place by selecting the desired function in the parameter screen (see figure 12). The (factory) default setting for both modulation forms is “modulation on.”

When both modulations are activated, these run synchronously (in phase) and start “from high to low.” This way the difference between the minimum and maximum of the effective capacity is the biggest.

11. Advantages of StatUS™ Therapy

StatUS™ ultrasound therapy is the newest development in the area of therapy and treatment comfort. The advantage of Sonopuls StatUS™ devices by Enraf-Nonius is that you can apply ultrasound both in a stationary as well as a dynamic manner. And – depending on the set parameters – you can work thermally and non-thermally. Ultrasound therapy is highly suitable for successfully treating injuries to connective tissue (collagen) that is very dense (such as ligaments, tendons, fascia, joint capsules and scar tissue).

Dynamic application with a traditional transducer

Stationary application with the StatUS™ applicator

StatUS™ therapy is also the best way to treat injuries where (delayed) tissue regeneration and restore of functions are in the foreground. StatUS™ especially offers unprecedented advantages when it comes to treatments where the treatment time can be up to 20 minutes. Just as in the case when low-intensity ultrasound is used in order to speed up the consolidation time of fractures. Normally, such dynamic ultrasound application is time-consuming and labor-intensive. The StatUS™ takes this work out of your hands without it impacting effectiveness and/or efficiency! With StatUS™ you work faster, smarter and more efficiently. In short:

Quick and easy	StatUS™ therapy can be directly accessed and is easy to set up.
Saves time	With StatUS™ as a "hands-free" form of therapy the therapist has his or her hands free during treatment, which results in a significant gain in time.
Less labor-intensive	Because the therapist no longer needs to hold the transducer, StatUS™ is the ideal therapy form for long(er)-term treatments.
More ease-of-use	More comfort for both the patient as well as the therapist.
Less cumbersome	Because the therapist no longer needs to hold the transducer the treatment is not cumbersome for the therapist.
Efficient	The transducer is always at the correct angle. The special gel pad forms to the body's contours. This combination ensures even and constant transmission of energy over the entire surface of the transducer.
Effective	The set treatment time is also the effective treatment time. The set capacity is effectively applied at that sites in the tissue.
Safe	Special modulation forms ensure that undesired intensity peaks in the ultrasound bundle are greatly reduced, that the chance of cavitation decreases and that the occurrence of "hot spots" is combated.

12. Indications and Contraindications

The greatest effect of ultrasound occurs in that tissue where the energy is absorbed in an efficient manner. This is connective tissue (collagen) with a high degree of denseness such as ligaments, tendons, fascia, joint capsules and scar tissue.

The heat that is created in the tissue can make a positive contribution to decreasing pain and muscle tension and combating contracture.

In low doses, ultrasound also appears to be able to speed up the recovery of nerves [6, 7] and bone.

Ultrasound therapy is primarily applied in (sport) physical therapy, orthopedics, rehabilitation and veterinary medicine.

12.1. Indications

- Arthrosis/arthritis (in a non-active stage)
- Bursitis
- Capsulitis
- Tendinitis
- (Acute) ligament injuries
- Post-traumatic conditions after contusion, distortion, dislocation, fracture
- Scar tissue
- Peripheral nerve injuries: neuropathy, hernia of the nuclear pulp, phantom pain
- Raynaud's syndrome, Bürger's disease, Sudeckse dystrophy
- Dupuytren's contracture

Indications for LIPUS

- Fractures (e.g. tibia, radius and wrist fractures)
- Delayed bone healing
- Stress fractures

16.2. Contraindications

- Contraindications such as they apply to heat therapy
- Epiphyseal discs (patient under 18 years of age)
- Area with a (malign) tumor
- Heart
- Brain
- Eyes
- Facial sinus
- Pregnancy (abdomen)
- Testicles
- Thorax (patients with a pacemaker)
- Diabetes mellitus
- Areas exhibiting decreased sensitivity
- Thrombophlebitis and varices
- Septic inflammations
- Close to metal implants and endoprostheses (LIPUS is possible here)
- Thyroid and lymph nodes in the neck

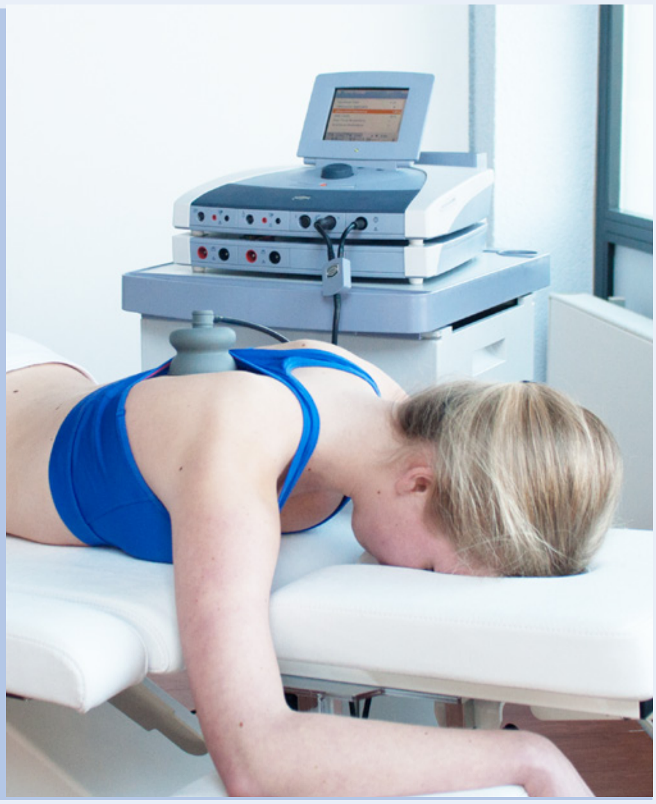
17. Protocols

PROTOCOL 1: HYPERTONIC TRAPEZIUS MUSCLE, UPPER PART

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,00 - 1,50 W/cm^2
Time:	10 min.
Literature:	23, 29, 35, 47, 74, 81, 94, 105, 121

PROTOCOL 2: TRIGGERPOINTS IN RHOMBOID MUSCLE, UPPER AND LOWER PART

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	off
Intensity:	1,00 - 1,75 W/cm^2
Time:	1 - 3 min. per TP
Literature:	66, 67, 95, 96



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PROTOCOL 3: CERVICAL MYOFASCIAL PAIN SYNDROME

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	3 - 1 MHz
Duty Cycle:	20 - 10 %
Modulations:	on
Intensity:	1,00 - 1,50 W/cm^2
Time:	4 min. (2x paraverte-bral)
Literature:	19, 66, 67, 95, 96, 106, 107

PROTOCOL 4: DEGENERATIVE DISC DISEASE

Tissue type:	Joint/Disc
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	50 - 20%
Modulations:	on
Intensity:	1,25 - 1,75 W/cm^2
Time:	5 min. (2x paraverte-bral)
Literature:	37, 51, 52

Precise localization is pathology dependent

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PROTOCOL 5: SUBACROMIAL BURSITIS

Tissue type:	Bursae
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,25 W/cm^2
Time:	6 min.
Literature:	72, 73

PROTOCOL 6: SUBDELTOID BURSITIS

Tissue type:	Bursae
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,00 - 1,50 W/cm^2
Time:	5 min.
Literature:	72, 73

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PROTOCOL 7: BICEPS BRACHII TENDINITIS, CAPUT LONGUM

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,00 - 1,50 W/cm^2
Time:	8 min.
Literature:	23, 29, 35, 47, 74, 81, 94, 105, 121

PROTOCOL 8: BICEPS BRACHII MUSCLE CALCIFICATION, CAPUT LONGUM

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	off
Intensity:	1,50 - 2,00 W/cm^2
Time:	8 min.
Literature:	23, 34, 54

Precise localization is pathology dependent

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PROTOCOL 9: PRONATOR TERES MUSCLE SYNDROME

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,50 - W/cm^2
Time:	10 min.
Literature:	51, 52, 81, 88

PROTOCOL 10: MEDIAL EPICONDYLITIS HUMERI

Tissue type:	Tendon/Periost
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,50 - W/cm^2
Time:	5 min.
Literature:	81

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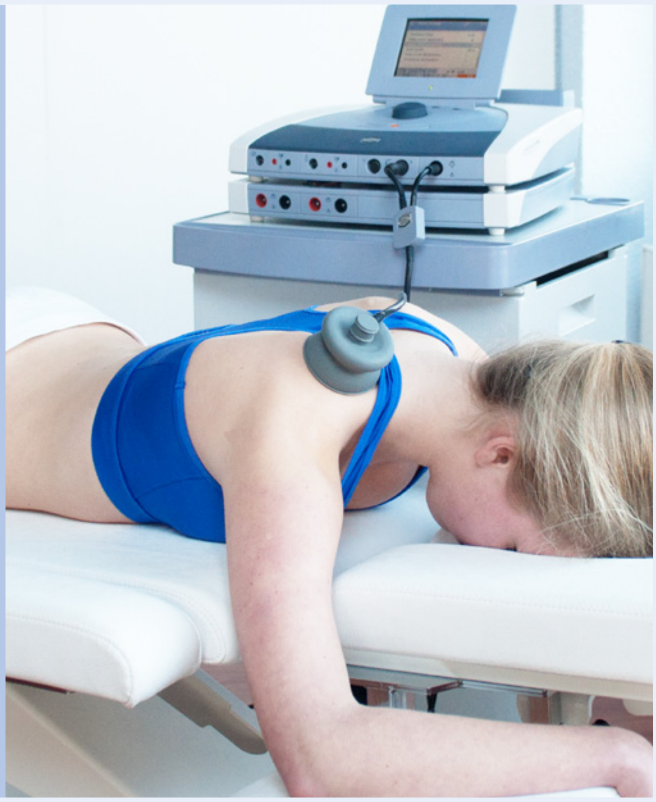
ENRAF NONIUS
Partner for Life

PROTOCOL 11: SUPRASPINATUS TENDINITIS

Tissue type:	Tendon
ERA:	5 cm²
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,20 - 0,50 W/cm²
Time:	5 min.
Literature:	29, 35, 47, 74, 81, 94, 105, 121

PROTOCOL 12: TRIGGERPOINTS SUPRASPINATUS MUSCLE

Tissue type:	Muscle
ERA:	5 cm²
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	off
Intensity:	0,75 - 1,00 W/cm²
Time:	3 min. pro TP
Literature:	66, 67, 95, 96, 106, 107



Precise localization is pathology dependent

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PROTOCOL 13: PIRIFORMIS MUSCLE SYNDROME, ENTRAPMENT NEUROPATHY

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,50 - 2,00 W/cm^2
Time:	8 min.
Literature:	10, 12

PROTOCOL 14: TROCHANTOR MAJOR BURSITIS

Tissue type:	Bursae
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	50 - 20%
Modulations:	on
Intensity:	0,25 - 0,75 W/cm^2
Time:	5 min.
Literature:	72, 73

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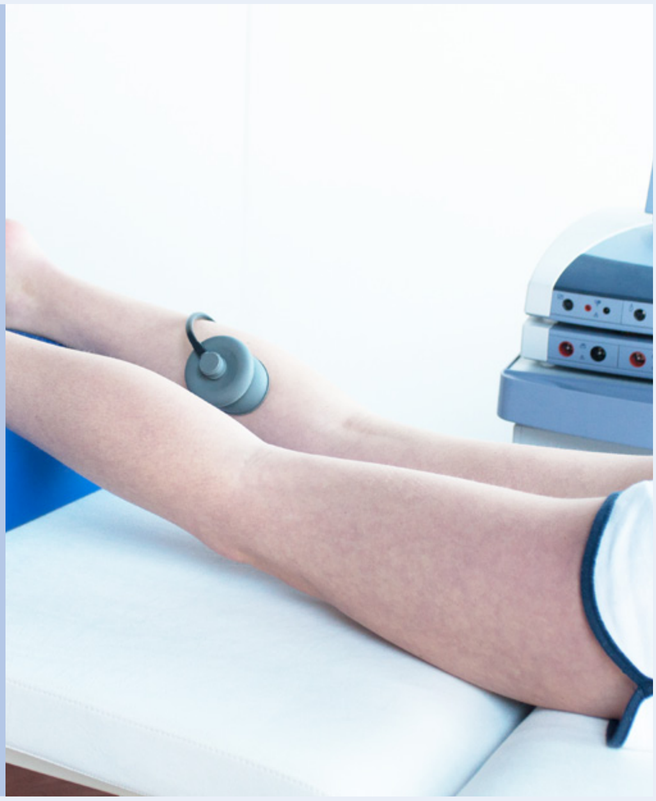
PROTOCOL 15: PARTIAL RUPTURE GASTROCNEMIUS MUSCLE, MEDIAL PART

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,50 W/cm^2
Time:	10 min.
Literature:	51, 52, 81, 88, 97



Precise localization is pathology dependent

PROTOCOL 16: COLLATERAL LIGAMENT STRAIN INJURY, LATERAL / MEDIAL

Tissue type:	Ligament
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,25 - 0,75 W/cm^2
Time:	7 min.
Literature:	99, 102, 118

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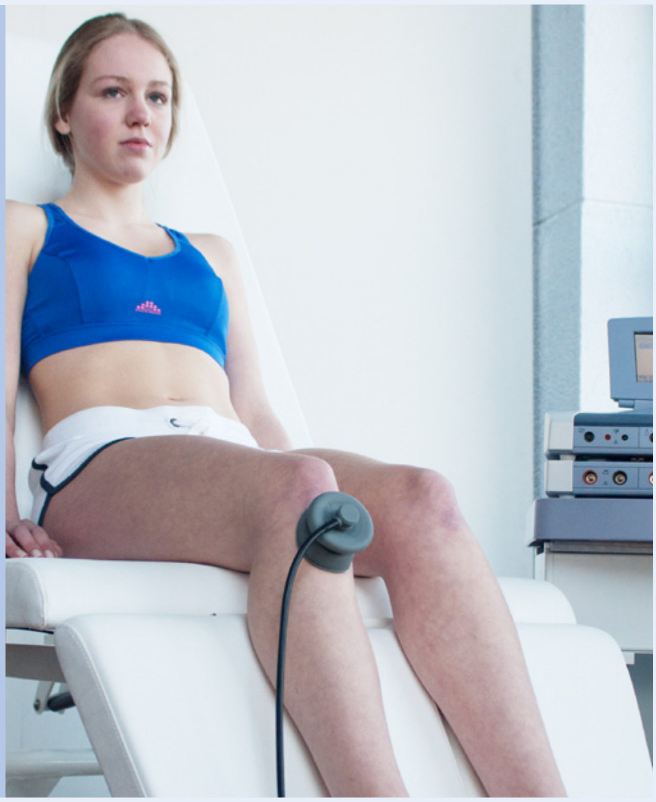
PROTOCOL 17: CORPUS HOFFA INFLAMMATION (HOFFITIS)

Tissue type:	Fat tissue
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,50 - 0,75 W/cm^2
Time:	8 min.
Literature:	72, 73

PROTOCOL 18: PATELLA TENDINITIS

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,25 - 0,50 W/cm^2
Time:	7 min.
Literature:	29, 35, 47, 74, 81, 94, 105, 121



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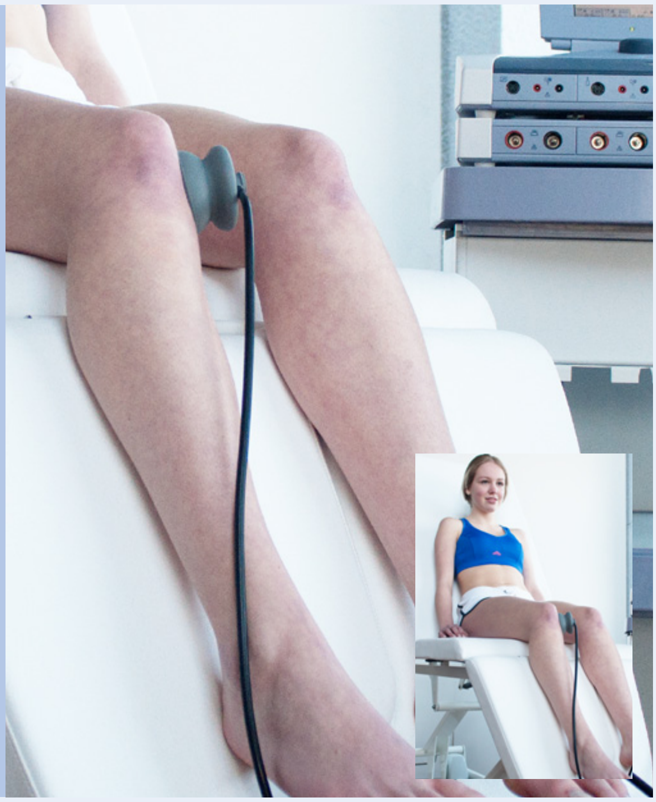
PROTOCOL 19: SCIATIC NEURALGIA (RADICULAIR ORIGIN)

Tissue type:	Nerve
ERA:	5 cm^2
Frequency:	3 - 1 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,75 - 1,75 W/cm^2
Time:	5 min.
Literature:	10, 12

Precise localization is pathology dependent

PROTOCOL 20: MENISCUS LESION

Tissue type:	Connective tissue
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,75 W/cm^2
Time:	7 min.
Literature:	49



Precise localization is pathology dependent

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ENRAF NONIUS
Partner for Life

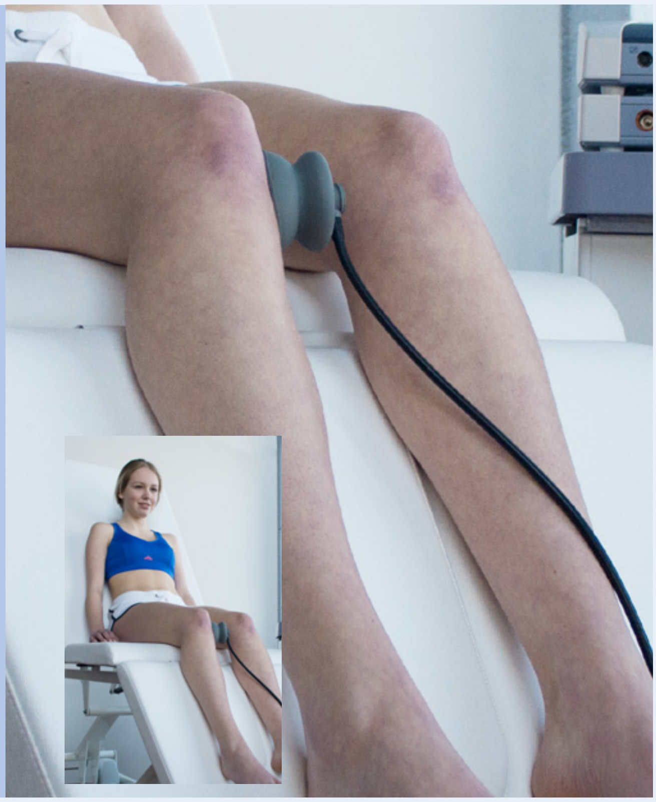
PROTOCOL 21: KNEE OSTEOARTHRITIS

Tissue type:	Joint
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,20 - 1,00 W/cm^2
Time:	10 min.
Literature:	15, 32, 43, 58, 62, 63, 64, 65, 79, 80, 91, 103, 120, 122

Precise localization is pathology dependent

PROTOCOL 22: KNEE SYNOVITIS / CAPSULITIS

Tissue type:	Joint
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,20 - 1,00 W/cm^2
Time:	10 min.
Literature:	72, 73



Precise localization is pathology dependent

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PROTOCOL 23: PES ANSERINUS, INSERTION TENDINITIS

Tissue type:	Tendon/periost
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,50 - 0,75 W/cm^2
Time:	7 min.
Literature:	99, 102

PROTOCOL 24: BAKER'S CYST

Tissue type:	Bursae
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,00 W/cm^2
Time:	10 min.
Literature:	72, 73

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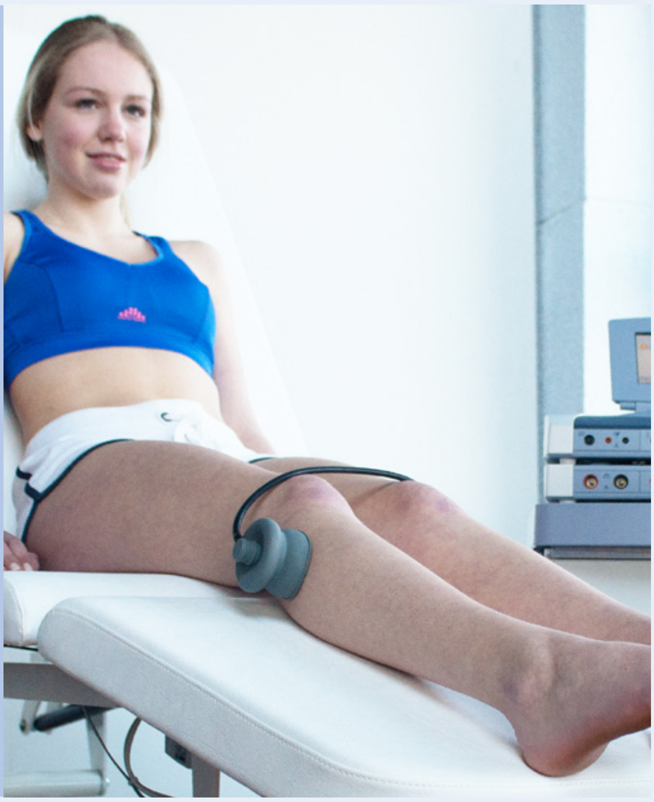
PROTOCOL 25: ILIOTIBIAL BAND SYNDROME

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,25 - 0,50 W/cm^2
Time:	7 min.
Literature:	35, 94, 99, 102



PROTOCOL 26: TENSOR FASCIAE LATA SYNDROME

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,25 W/cm^2
Time:	10 min.
Literature:	99, 102

Precise localization is pathology dependent

PROTOCOL 27: TIBIAL STRESSFRACTURE (LIPUS*)

BONE HEALING (LIPUS) – STRESS FRACTURE OF THE TIBIA (POSTERIOR)

A stress fracture occurs from repeated high doses of stress. Half of all stress fractures resulting from playing sports (tennis, football, volleyball, basketball, running) occur in the tibia. In addition, the foot (25%-35%) and the hip are also sensitive to stress fractures. The cause of the symptoms small fractures (hairline tears) of the bone tissue. This can lead to a real fracture later in the process. With fragile bones, such as with osteoporosis, these processes occur earlier. Due to the small tears, stress fractures are difficult to see on X-rays. Only when the fracture heals can you see that there is a fracture from the new bone formation. This often makes diagnosis of this injury difficult. With a stress fracture a tolerable, vague pain is initially felt that occurs gradually and primarily at the beginning of a sports activity. Due to this athletes often walk around for quite some time with these symptoms before a stress fracture is ascertained. In the second stage the pain becomes sharper and worse. In the third stage there is even pain when the body is at rest and in some cases there is swelling at the site of the pain. The pain symptoms can manifest themselves in various locations; in the tibia this occurs on the interior, while in the foot this occurs in the forefoot and in the hip in the groin.

PROTOCOL 27: TIBIAL STRESSFRACTURE (LIPUS*)

Tissue type:	Bone
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	50 - 10 %
Modulations:	on
Intensity:	0,05 - W/cm^2
Time:	20 min. (daily)
Literature:	18, 26, 39, 101, 108

Precise localization is pathology dependent

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PROTOCOL 28: PLANTAR FASCIITIS

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,50 - 1,25 W/cm^2
Time:	8 min.
Literature:	29, 35, 47, 74, 81, 94, 105, 121

PROTOCOL 29: MORTON'S NEURALGIA

Tissue type:	Nerve
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,25 - 0,50 W/cm^2
Time:	8 min.
Literature:	10,12

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PROTOCOL 30: ANKLE JOINT STRAIN INJURY (TALOFIBULAR ANTERIOR LIGAMENT)

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,20 - 0,75 W/cm^2
Time:	6 min. (bi malleolair)
Literature:	99, 102, 118

PROTOCOL 31: TALO CRURAL ARTHROSIS

Tissue type:	Joint
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,00 - 1,50 W/cm^2
Time:	10 min.
Literature:	15, 32, 43, 58, 62, 63, 64, 65, 79, 80, 91, 103, 120,122

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PROTOCOL 32: SUBTALAR ARTHROSIS

Tissue type:	Joint
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,00 - 1,50 W/cm^2
Time:	10 min.
Literature:	15, 32, 43, 58, 62, 63, 64, 65, 79, 80, 91, 103, 120,122

PROTOCOL 33: CARPAL TUNNEL SYNDROME

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	1 - 3 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,50 - 0,80 W/cm^2
Time:	10 min.
Literature:	2, 4, 6, 10, 12, 13, 16, 24, 44, 60, 83, 89

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PROTOCOL 34: WRIST FRACTURE

Tissue type:	Bone
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	30 mW/cm^2
Time:	20 min.
Literature:	3, 11, 39, 59, 71

PROTOCOL 35: DUPUYTREN'S CONTRACTURE (GRADES 1. 2.)

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	50 - 10 %
Modulations:	on
Intensity:	0,75 - 1,25 W/cm^2
Time:	10 min.
Literature:	29, 35, 45, 47, 74, 81, 94, 105, 121

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PROTOCOL 36: HAEMATOMA

Tissue type:	Subcutaneous / muscle
ERA:	5 cm^2
Frequency:	3 - 1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,75 W/cm^2
Time:	5 - 10 min.
Literature:	51, 52, 78, 81, 88

Precise localization is pathology dependent

PROTOCOL 37: TEMPOROMANDIBULAR DISORDER (TMD)

Tissue type:	Joint / Muscle
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,25 - 0,50 W/cm^2
Time:	10 min.
Literature:	5, 30, 36, 52, 123

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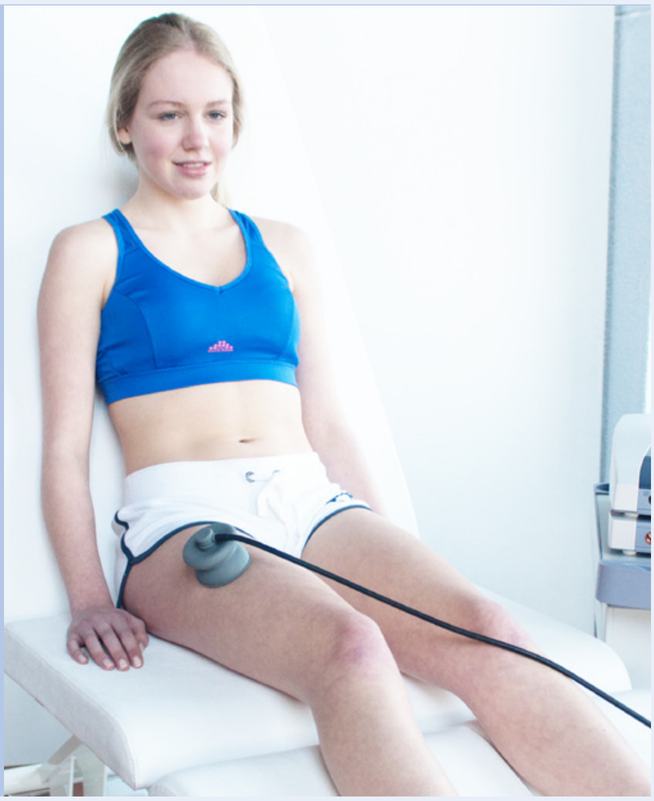
PROTOCOL 38: QUADRATUS LUMBORUM MUSCLE MYALGIA

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,50 - 2,00 W/cm^2
Time:	10 min.
Literature:	37, 81, 97

Precise localization is pathology dependent

PROTOCOL 39: QUADRICEPS FEMORIS MUSCLE CONTUSION

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,25 - 1,75 W/cm^2
Time:	10 min.
Literature:	69, 76, 81, 97, 100, 116



Precise localization is pathology dependent

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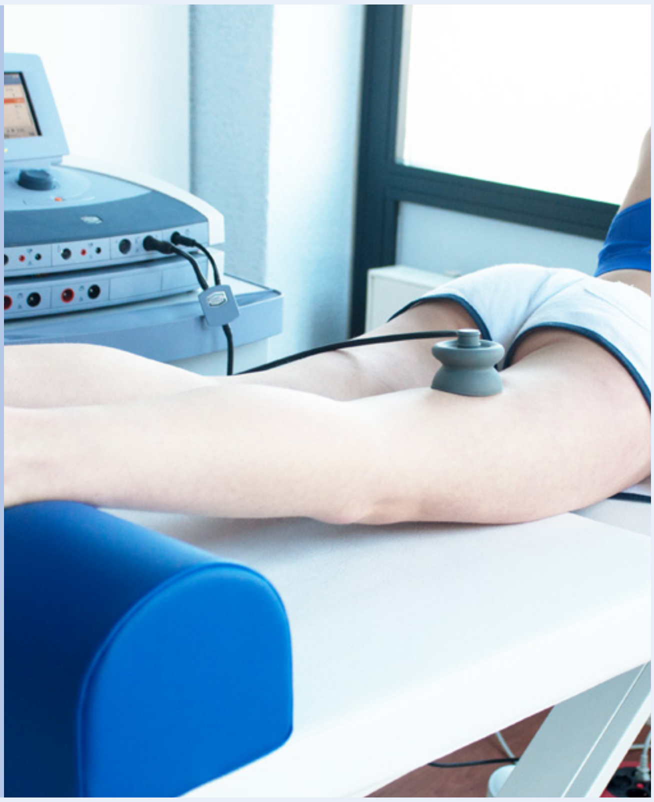
PROTOCOL 40: ADDUCTOR MUSCLE SYNDROME

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,25 - 1,75 W/cm^2
Time:	10 min.
Literature:	69, 76, 81, 97, 100, 116

PROTOCOL 41: HAMSTRING MUSCLES, PARTIAL RUPTURE

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,25 - 1,75 W/cm^2
Time:	10 min.
Literature:	69, 76, 81, 97, 100, 116



Precise localization is pathology dependent

PROTOCOL 42: ERECTOR SPINAE MUSCLE, STRAIN INJURY

Tissue type:	Muscle
ERA:	5 cm²
Frequency:	1 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	1,25 - 1,75 W/cm²
Time:	8 min.
Literature:	69, 76, 81, 97, 100, 116

Precise localization is pathology dependent

PROTOCOL 43: SHIN SPLINTS

Tissue type:	Tendon/periost
ERA:	5 cm²
Frequency:	3 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,25 - 0,75 W/cm²
Time:	10 min.
Literature:	72, 73

Precise localization is pathology dependent

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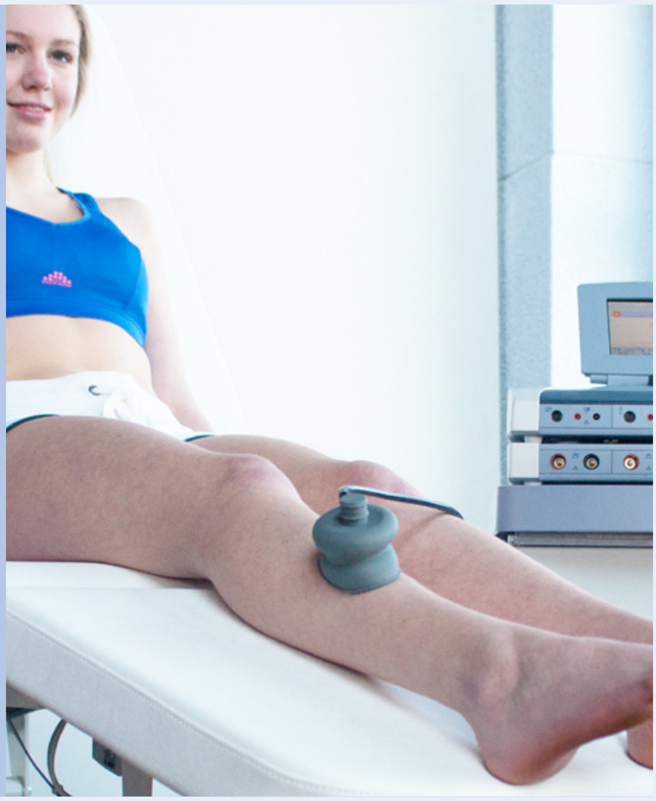
PROTOCOL 44: COMPARTMENT SYNDROME

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,25 W/cm^2
Time:	10 min.
Literature:	69, 76, 81, 97, 100, 116



Precise localization is pathology dependent

PROTOCOL 45: ABDOMINAL MUSCLE, PARTIAL RUPTURE

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 - 3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	1,50 - 1,75 W/cm^2
Time:	10 min.
Literature:	42, 61, 69, 76, 81, 97, 100, 116

Precise localization is pathology dependent

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PROTOCOL 46: MYOSITIS OSSIFICANS

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	100 - 80%
Modulations:	on
Intensity:	2,00 - W/cm^2
Time:	8 min.
Literature:	23, 34, 54

PROTOCOL 47 - 50: LATERAL EPICONDYLITIS

Stationary application of Ultrasound for Epicondylitis Lateralis Humeri

Etiology

A tennis elbow is an injury where pain is felt on and around the epicondylus lateralis humeri as a result of excessive use of the radial wrist extensors (synonyms: surménage, occupational overuse syndrome, repetitive strain injuries/RSI). Direct trauma of the elbow is rarely the cause of this injury. The symptoms occur as a result of partial ruptures of the extensor carpi radialis longus and brevis, often with a secon–dary reaction of the periost. The term tennis elbow was coined in view of the fact that this injury is seen in tennis players, although the symptomatology is also seen in people other than tennis players.

Tennis elbow typically occurs in people aged 30 to 60; the lesion is rare in people younger than 30. The injury is classified as a “self-limiting disease,” and has a recovery period of 8-13 months without any form of intervention.

Clinical Manifestation

The clinical picture is very typical. There is pressure pain at the site of the origin of the above-mentioned extensors and contraction against resistance (active supination and dorsal reflection of the wrist) causes major pain. The pain radiates from the forearm, sometimes the middle and ring fingers also hurt. Sometimes the pain radiates to proximal structures. There is no restriction in movement of the art. cubiti.

Type Classification

Although regarded by some as partly arbitrary, a classification into four types is employed. Such a classification offers more possibilities for determining an adequate dosing strategy of ultrasound applications than has often been assumed (see figure 15).

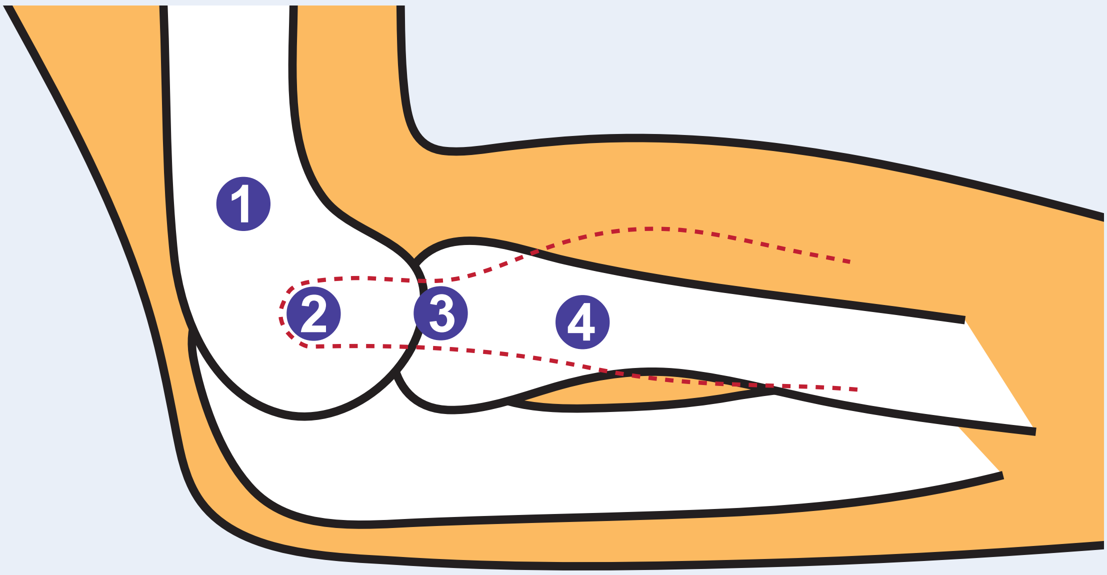

Figure 15: Classification into "types" with epicondylitis lateralis humeri

Type I Figure 15, position 1

Origin of the m. extensor carpi radialis longus (tenoperiosteal), proximal from the epicondylus lateralis and ventral from the humerus. During examination and treatment the elbow is positioned at 90-degree flexion and supination.

Type II Figure 15, position 2

Origin of the m. extensor carpi radialis brevis (tenoperiosteal), directly on the lateral epicondyle (so not on the lateral aspect of the epicondyle). During examination and treatment the elbow is positioned at 90-degree flexion and supination.

Type III Figure 15, position 3

Tendon of the m. extensor carpi radialis brevis (tendinous), just proximal from the caput radii. During examination and treatment the elbow is positioned at 45-degree flexion and pronation.

Type IV Figure 15, position 4

Muscle-tendon transition and proximal part of the m. extensor carpi radialis brevis (tendinomyogenous). During examination and treatment the elbow is positioned at 90-degree flexion and supination.

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Therapeutic Application of Ultrasound

Ultrasound therapy can be applied by means of two application methods:

- Dynamic
- Stationary (static)

Dynamic – or static application of ultrasound?

In the dynamic application technique, the ultrasound transducer is slowly moved over a relatively sizeable tissue surface while with stationary application the transducer is focused on a confined location. In the dynamic treatment moving the ultrasound transducer levels intensity peaks in the ultrasound bundle. In the static application method the set intensity (W/cm^2) is varied over a certain range, which prevents a dangerous peak intensity from building up. This enables localized ultrasound treatment whereby the transducer is fixated at one specific tissue position with the aid of a vacuum pump.

Reasons for choosing Ultrasound

A multitude of physical therapy treatment options is reported in the literature. Depending on the type, stage and topicality of the injury, one intervention is sometimes preferred over another. Especially due to the often subacute and chronic character of the injury, where pain as well as metabolic changes play a role, ultrasound treatment should be considered because, in addition to indirect pain alleviation, the local tissue metabolism is affected by ultrasound application.

Dosing Strategy

Because the difference in tissue classification and localization results in differences in absorption, penetration, distribution, breaking and reflection, targeted differentiation of ultrasound dosing is necessary. The dosing parameters in the table below provide insight into such a targeted dosing strategy.

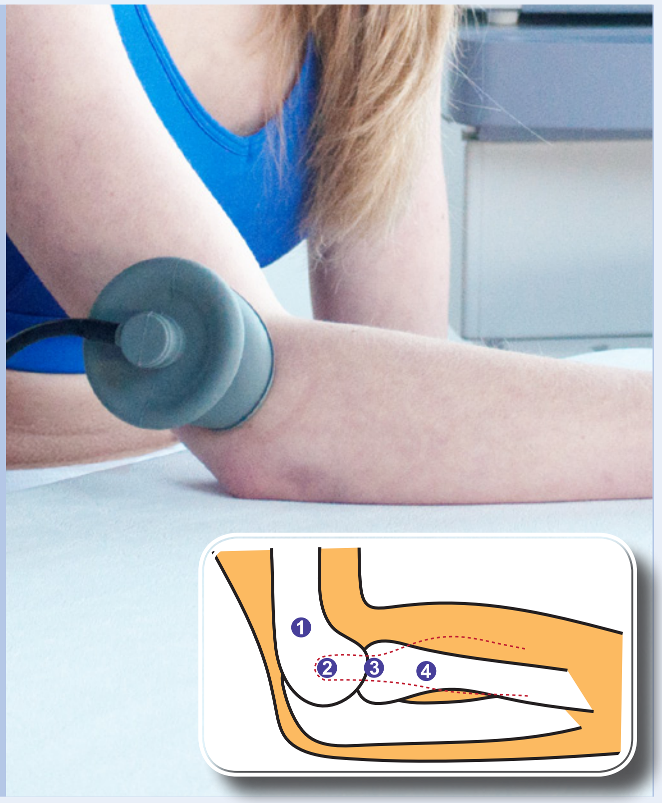
Epicondylitis Lat. Hum.	Type I	Type II	Type III	Type IV
Tissue type	tenoperiosteal	tenoperiosteal	Tendinous	Tendinomyogenous
ERA	5,0 cm^2	5,0 cm^2	5,0 cm^2	5,0 cm^2
Frequency	3 MHz	3 MHz	1 MHz	1 MHz
Duty Cycle	20%	20%	20%	20%
Modulations	on	on	on	on
Intensity	0,5 W/cm^2	0,5 W/cm^2	0,75 – 1,0 W/cm^2	1,0 – 1,5 W/cm^2
Time	5 min	5 min	8 min	12 min

Table 2: Differentiation of ultrasound dosing parameters for various tissue types in the case of epicondylitis lateralis humeri

SONOPULS STATUS™

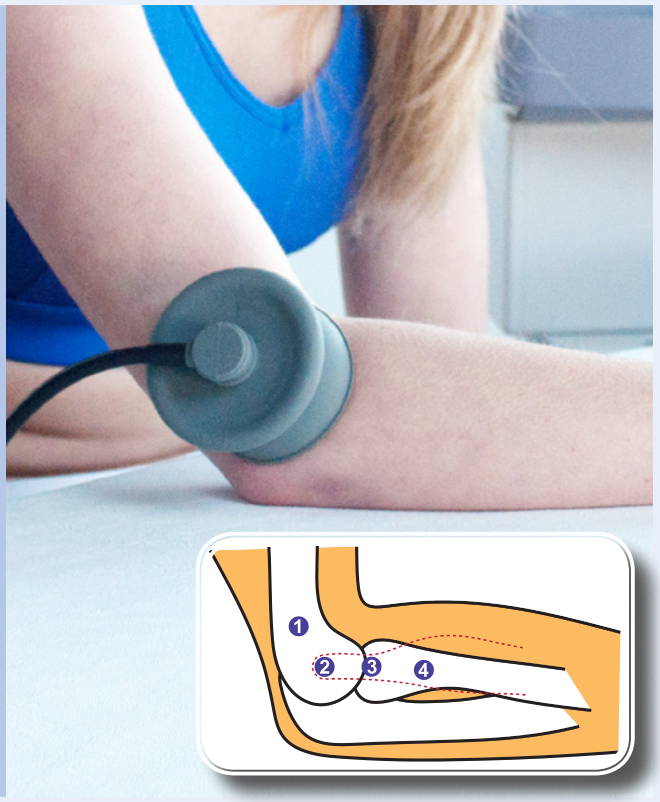
PROTOCOL 47: LATERAL EPICONDYLITIS, TYPE I

Tissue type:	Tenoperiostial
ERA:	5 cm²
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,50 - W/cm²
Time:	5 min.
Literature:	2, 31, 38, 81 98, 101, 105



PROTOCOL 48: LATERAL EPICONDYLITIS, TYPE II

Tissue type:	Tenoperiostial
ERA:	5 cm²
Frequency:	3 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,50 - W/cm²
Time:	5 min.
Literature:	2, 31, 38, 81 98, 101, 105

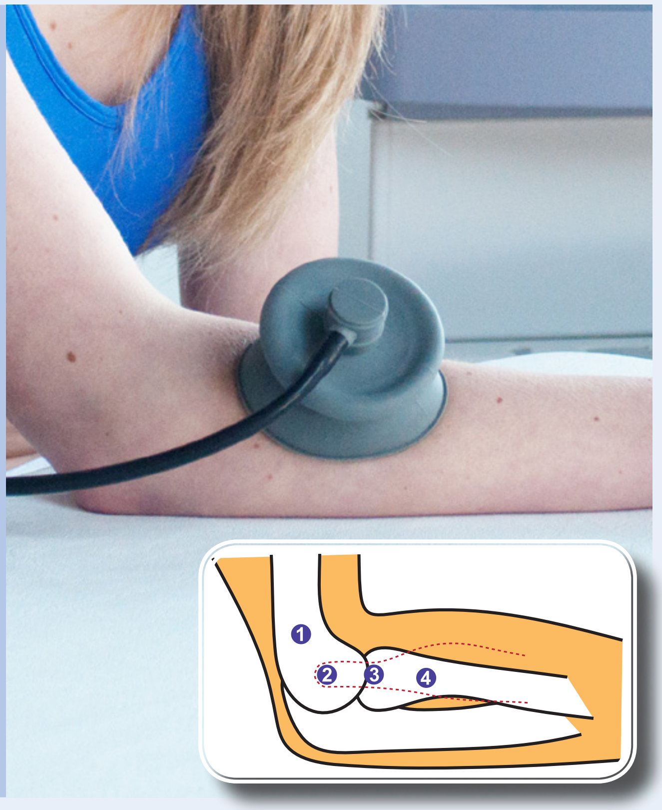


PROTOCOL 49: LATERAL EPICONDYLITIS, TYPE III

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,00 W/cm^2
Time:	8 min.
Literature:	2, 31, 38, 81 98, 101, 105

PROTOCOL 50: LATERAL EPICONDYLITIS, TYPE IV

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	80 - 50%
Modulations:	on
Intensity:	0,75 - 1,50 W/cm^2
Time:	8 min.
Literature:	2, 31, 38, 81 98, 101, 105



SONOPULS STATUS™

PROTOCOL 51: ACHILLES TENDON, PARTIAL RUPTURE

Tissue type:	Tendon
ERA:	5 cm^2
Frequency:	3 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	0,75 - 1,25 W/cm^2
Time:	10 min.
Literature:	29, 35, 47, 74, 81, 94, 105, 121

PROTOCOL 52: BICEPS BRACHII MUSCLE, RUPTURE

Tissue type:	Muscle
ERA:	5 cm^2
Frequency:	1 MHz
Duty Cycle:	50 - 20 %
Modulations:	on
Intensity:	1,25 - 1,50 W/cm^2
Time:	10 min.
Literature:	51, 52, 81,88, 97

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