PRESENTATION

Pulsed Signal Therapy

Range of Application and Active Principles

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It is well-known from experience that under physiological conditions, the healthy joint-cartilage retains wear-free functionality over a whole lifetime, whereas under non-physiological loads, through incorrect positioning, instabilities and trauma, progressive wear of the joint leads to osteoarthritis with extensive erosive destruction of the cartilage surfaces.
Inactivity too, e.g. through immobilization, but also changes in synovial composition which occur during bacterial and non-bacterial inflammation or e.g. in hemophiliac joints, lead to cartilage destruction.

Cartilage physiology must be taken into account if one wishes to intervene in this pathological process.
The extra-cellular matrix of the cartilage contains 60-80% water.
The dry matter consists almost entirely of collagen, proteoglycan and glycosaminoglycan proteins, which represent the synthesis products of the chondrocytes.
The collagen forms a web which determines the tensile strength and elasticity of the cartilage.
The proteoglycan and glycosaminoglycan proteins are deposited and fixed in this web. The proteoglycans form hydrous gels through which nutrients reach the chondrocytes by diffusion.

The proteoglycan play a decisive role in the active mechanism of Pulsed Signal Therapy.

These are macromolecules, which consist of a protein core, to which several glycosaminoglycan chains are bound.
The main proteoglycan occurring in the hyaline cartilage is in aggrecane form, together with glycosaminoglycans, chondroitin sulfate and keratan sulfate.
The glycosaminoglycan's constituents are disaccharides with sulfate (SO_2-) and carboxyl (COO-) groups carrying negative charges, which determine the extracellular cartilage matrix. I.E. the Donnan effect explains that the density of the fixed charges determines the concentration of the counter ion.

These negative charges on the glycosaminoglycans influence the composition of the electrolyte, the interstitial fluid.
The fixed negative charges lead to a reduction in anions and a higher concentration of cations compared with the surrounding organs, such as e.g. the joint capsule.

The threshold pressure depends directly on pressure and voltage in the matrix, since negative charge density depends on the water's volume ratio and thus on matrix expansion.

Ion concentration changes under pressure, which leads to increase osmotic pressure and threshold pressure as well as to lowered pH value.

These changes in physio-chemical conditions modify the tissue's mechanical properties such as hydraulic permeability and compressive strength.

The chondrocytes' biosynthetic output depends on extra cellular osmolarity, which is why one assumes that the combination of mechanical and physio-chemical conditions is an important prerequisite for signal transmission in combination with the applied load.

These physio-chemical processes in the matrix also explain the conversion of mechanical stimuli into electrical phenomena which occur in the cartilage. Through the negative charge in the matrix, cartilage deformation lead to gradients in fluid pressure and ion composition.
Displacement of interstitial fluid and ions take place, together with electro-kinetic phenomena such as potential flows and electrical currents.

These phenomena result from the movement of mobile cations and anions relative to the negative charges of the glycosaminoglycans, which are fixed to the collagen fibers due to their size and physio-chemical binding to the rigid matrix.
These potential flows in the cartilage can be modified through a reduction in proteoglycan content, e.g. via enzymatic breakdown or via modulation of chondrocyte metabolism.

Thus, changes in the extra cellular matrix must also lead to modification of the electrical phenomena, so that the chondrocyte receives altered signals, which effect its synthesis output.

Histological and nuclear spin investigations in cadavers have demonstrated that cartilage compressibility change with degeneration. Whereas an increase in height reduction through cartilage edema is observed during the first stage, compressibility is regularly reduced in stages 2 to 4.
The associated loss of water and proteoglycans also leads to loss of electric signals, which depend on an intact extra cellular matrix. (R. Andresen et al)

This is where Pulsed Signal Therapy intervenes. Investigations with PEMF signals, using pulse duration of 30 ms, frequency of 1.5 Hz and pulse-rise within 230 ms on cartilage explant cultures have shown that consistent proteoglycan composition is retained, without the molecular structure and function being affected.

Thus the effect of Pulsed Signal Therapy is that the chondrocyte, which no longer receives physiological signals due to pathological changes in the extra cellular matrix, is sent signals via a pulsed magnetic fields PST which generates electric currents in the matrix by induction; these signals are needed by the chondrocyte for physiological production, one which synthesises and breaks down aggrecanes in a coordinated way.

Thus, it is an electric signal (Streaming Potential) created through mechanical loading which effect cartilage maintenance, its regeneration after damage and its growth.
The effect of electric pulses is similar to that of growth hormones. Electric potentials and hormones act in synergy.

Other physical regulation methods such as static or dynamic loading, hydrostatic pressure or tensile loading are not capable of practical application and can only be used in limited fashion, locally and in combination with invasive techniques.

The effects and indications for the therapeutic application of pulsed signals (PST) can be derived from their active mechanism.

Normalization of the metabolism of connective tissue such as hyaline cartilage, fibrous cartilage, ligaments, tendons and joint capsules can also explain the clinical observation of a significant reduction of pain with this therapy.

Table 1

Device parameter	**Magnetic field therapy**	**PST**
Electromagnetic properties	Piezo-electric	Biological signal
Energy form	Alternating current	Direct current
Frequency	44 - 77 Hz	1 - 30 Hz
Waveform	Sinusoidal	Quasi-rectangular
Field strength	2 G	12.5 G
Energy driver	Voltage control	Pulsed DC
Duty cycle	< 50%	> 50%
Pulse frequency	Continuous	Pulse-modulated
Frequency source	Fixed frequency source	6 frequency sources
Implementation	Diode (biasing)	Free-wheeling diode

Reduction of cell detritus in the joint brings about normalization of the synovial fluid and reversal of the inflammatory changes in the synovia, with the release of pain-inducing prostaglandins.

The painful formation of exophytes can also be stopped. Painful Micro fractures of the subchondral spongiosa, are promoted by reduced elasticity of the cartilage and pain-conditioned atrophy.

Reduction in pain also leads to better mobility of the joints and the non-physiological, protective posture is given up. Hence, this mechanism too, brings about further normalization of joint function.

Ligaments and tendons display similar structural properties to those of cartilage. Fluid displacements, with water content being in the range 60-80%, are limited by the large proteoglycan molecules.

Here too, the negative charges contribute to important features that trigger electric phenomena similar to those in the cartilage. Here too, we have confirming results available from experimental investigations.

Therefore, the tried and tested indications for the application of Pulsed Signal Therapy are conditions of the Musculosketal apparatus such as e.g. arthritis, as long as hyaline joint cartilage is still present, meniscus damage, as long as it does not cause mechanical joint blockage, strain damage at the knee-joint's extending apparatus with retropatellar cartilage damage and altered senorium.

In the region of the upper extremities, impingement syndromes in the shoulder, anesthesopathy at the elbow-joint can be beneficially influenced. In the spine, these are degenerative changes in vertebral joints and in intervertebral discs.
Very positive experience with regard to pain elimination was demostrated with chronic polyarthritis and Morbus Becherev, naturally without eliminating the bony deformities or understanding the mechanism of action causative therapy on the underlying condition.

An interesting indication is the treatment of Sudeck Dystrophy. A large number of individual observations are available in this connection.

Absolute contraindications are not known however collagen Vascular deseases are not treated. Care must be observed in-patients with cardiac pacemakers and during pregnancy.
Tumors should not be treated with PST, since other therapies have priority in such conditions. The same goes for bacterial infections.
The wide spectrum of resulting conditions could often be beneficially treated with PST.
In order to avoid confusion with magnetic field therapy, the physical features of PST are contrasted here with the former (Tab. 1).
The physical parameters of PST based on scientific calculations rely on clinical results obtained experimentally, established empirically, and correspond to the physiological orders of magnitude occurring in the organism.
Thus, Pulsed Signal Therapy is a non-invasive procedure, which provides the physiological signals for maintaining or restoring physiological synthesis output, and therefore can be applied without side effects to all connective tissue in the mobility apparatus.