The patented original PST® technology

PST® – Pulsed Signal Therapy
for the treatment of musculoskeletal disorders

Lower Back  Knee  Elbow
The patented original PST® technology

The PST® Signal: its Mechanism of Action
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Targeted area of PST® treatment

Knee
PST® helps relieve pain and stimulates progressive regeneration of cartilage
Areas of application

- Neck
- Spine
- Hand
- Hip
- Elbow
- Wrist
- Shoulder
- Knee
- Foot and heel
- Ankle
The principal indications

1) Degenerative diseases
   - Gonarthrosis, coxarthrosis, Rhizomelic arthrosis of the thumb
   - Tendonitis / tendinopathy (Ex: Epicondylitis)
   - Lumbago, discopathy, osteochondrosis
   - Calcaneal spur
   - Deforming arthrosis of the hands

2) Traumatic lesions
   - Indicated as a post operative treatment to sustain healing and to improve functional rehabilitation
   - Ligament lesions
   - Soft tissue lesions

3) Inflammatory Arthropathy
   PST® offers a decrease in the pain felt and an improvement in terms of mobility.

4) Pain related to musculoskeletal system deformities
   Spine (Ex: Scoliosis)
   Feet (Ex: Hallux Valgus, Pes Planus)

Contra-indications

In general, patients with pacemakers, tumours and/or bacterial infections, epilepsy, angina pectoris, arrhythmias, as well as pregnant women and children under the age of 10, should seek advice from their PST® doctor, as certain indications may be treated upon medical advice.

Note: For the comprehensive indications and contra-indications list, please refer to product specific literature (example: the instruction manual).
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The PST® signal
What is so special about the PST® signal?

The essential differences between Pulsed Signal Therapy® (PST®) and traditional magnetic field therapy, such as the Kraus-Lechner-coil (alternating current oriented magnetic field) are clearly visible in the illustrations and graphics on page 9.

Clarification

The starting point is that PST® stimulates higher chondrocyte activity. To actually activate such a situation, it is necessary to:
1. Work with changing stimuli, as a permanently repeated similar impulse or stimulus of the cells is quickly perceived as inadequate;
2. Cover the whole sensitivity range of the chondrocytes by an appropriate stimuli pattern.

Besides the main physical parameters examined here - wave form, field strength and frequency - there are other important characteristic features, such as energy carriers, work cycle, impulse frequency, implementation etc. which are fundamentally different in these three therapy methods.
1. Kraus-Lechner System Coil

This system coil delivers an alternating current magnetic field that generates a sinusoidal waveform. This signal does not conform to what normally takes place in the body because electric activities in all living organisms follow only direct current oriented processes.

2. PEMF - Pulsed electromagnetic field

PEMF, which works with pulsed electromagnetic fields, utilizes a direct-current-oriented constantly repeated signal. It is transmitted at a specific intensity and a particular frequency and it remains constant during the treatment. Work and research on PEMF, including in vitro studies with cell cultures, constituted the essential foundation for the development of the PST® technology by Dr. Dr. Richard Markoll.

3. PST® - Pulsed Signal Therapy®

PST® should be seen as the logical evolution of PEMF technology. In contrast to PEMF, PST® generates a pure magnetic field output signal that employs direct current with unidirectional biological frequencies. The “waveform” is quasi-rectangular. PST® delivers changing pulsed electromagnetic signals in an alternating fashion. The intensity of impulses lies predominantly in the range between 10 and 30 Hertz. PST® therefore functions at a relatively low frequency, and in a low energetic range of field strength.
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**Pulsed Signal Therapy supports regeneration and repair of bone and cartilage tissues**

1. **Healthy joint - streaming potentials**
   - Movements generate fine electric currents in the joint
   - Electrical field of the joint
   - Control of the constant preservation and regeneration of the cartilage and connective tissues (tendons, ligaments, etc.)

2. **Disturbed electrical field**
   - Alteration of the electrical field by osteoarthritis or injuries
   - Perturbation in the continued cartilage regeneration

3. **PST® treatment - formation of the electrical field**
   - Activation of streaming potentials by PST®
   - This signal stimulates the regeneration process in cartilage, tendons and ligaments

Bone and cartilage tissues have electromagnetic natural bio-potentials which are of crucial importance to the formation and the dynamic functional adaptation of the tissue. Various factors, including electric stimuli such as pulsed electromagnetic fields, can activate the regeneration process. The combined energy parameters of Pulsed Signal Therapy, PST®, belong to the range also observed in the connective tissue.

PST® has a specific signal pattern:
   - Constant changes in intensity, duration and frequency (frequency 1-30 Hz, field strength 0.5-1.5 mT, 5-15 Gauss)
   - The signals correspond with the natural physiological body signals
   - They activate the self healing process of the body
The patent “electromagnetic stimulation of cartilage tissue” with original PST® energy parameters was issued under US patent number 6,524,233 and European patent 1,119,393. Inventor: Richard Markoll. In fact, the Global Medical Device Nomenclature (GMDN) Agency has recognized PST® as a unique technology and therefore created a new classification only for PST® products (GMDN GENERAL CODE 47584).

During a one-hour therapy session, the joint is treated in an enclosed coil. A treatment course consists of 9-12 hourly sessions conducted on consecutive days. If necessary, only one interruption of less than 2 days (48 hours) is authorized after completion of at least 3 treatment sessions. PST® treatment is non-invasive, pain-free and has no known side effects.

In addition to the treatment of osteoarthritis, PST® has been increasingly used as a therapy for injuries such as stress fractures and/or tendinopathies. PST® has increasingly gained importance in the conservative therapy of professional and amateur athletes.

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**The regeneration process**

PST® impulses → PST® signal pattern → Chondrocytes → Proteoglycan → Extracellular matrix (ECM) → Collagen

PST® stimulates the chondrocytes. Observation: more production of proteoglycan and collagen (building blocks for the extracellular matrix)
The patented Original PST® technology intervenes here in the treatment of the affected joint cartilage. The unhealthy tissue is treated with impulses that constantly change in intensity and duration. Another effect of the pulsed electromagnetic fields method is that PST® stimulates the natural regeneration of the cartilage cells and the bone tissue with changing rectangular impulses.

The PST® therapy concept supports natural processes and can be applied as a pain free, non-invasive method without known side effects.
**How does PST® work? (extract)**

Various studies indicate that the capacity of the cartilaginous tissue to withstand compressive stresses is linked to the level of proteoglycans in the intercellular substance; the sulphated glycosaminoglycan chains have an increased concentration of negative electrical charges which give considerable rigidity to the system by their reciprocal repulsion and hold bound a large part of the cartilaginous water in states of rest. Once the destructive process has begun, similarly to the operation of factors which stimulate the chondrocytes to produce harmful substance in pathological quantities, the same cells initiate an attempt at regeneration of the cartilage by increasing the synthesis of glycosaminoglycans. However, they are not capable of supporting such hyperactivity for long so the glycosaminoglycan content is reduced with a more marked reduction in the chondroitin sulphates and an increase in the keratan sulphate/chondroitin sulphate ratio.

The reduction in the proteoglycans, the breaking up of the proteoglycan aggregates, their increased extractibility and the change in tissue hydration cause a reduction of the resistance of the amorphous substance and the collagen fibrils are subjected to intolerable mechanical pressure. There have been numerous studies showing that the process is reversible initially; if maintenance of an adequate concentration of GAG is successful, the cartilage damage can be hindered or slowed and use of chondroprotective drugs and also of PST® is based on this assumption.

Pulsed Signal Therapy (PST®) is based on a patent developed by the American doctor and biophysicist of German origin, Richard Markoll. This is a therapeutic method which differs from the so-called magnetic field therapy used for many years for slowly consolidating fractures. PST®, while it can be used in bone tissue also, finds its main indication in the treatment of cartilage and of soft and connective tissues. To understand the effect of PST®, it must be remembered that when a joint is subjected to compressive stress, there is a displacement of the water present in the matrix accompanied by sodium ions, leaving the negative charges of the proteoglycan molecules unneutralised. By a mechanism of mechanical-electrical transduction, the mechanical stimulus is transformed into a weak electric current (potential streaming) which is thought to represent the main signal for the cartilage cells to increase the synthesis of proteoglycans and collagen.

If the potential streaming is the signal for chondrocytes to produce new matrix, the same effect can be obtained by exposing the joint to an electromagnetic field, producing currents which simulate those of the organism. Administration in this way of low strength pulsed signals at a frequency similar to the biological one is capable of creating an electrical field in the joint, promoting the regeneration of the cartilaginous tissue, and thus conferring physical chondroprotection.

M. Cossu, N. Portale - Niguarda Hospital, Milan (1998)

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**Supported by clinical studies and laboratory research**

- Early improvement of the joint function (mobility and flexibility) by the removal of muscular tension, with normalized joint kinematics and reduced pain
- Acceleration of the healing process in injuries to joint-related structures
- Stimulation of the chondrocyte activity on streaming potentials with regeneration of the cartilage tissue
- Stimulation of the osteoblast activity through piezoelectric potentials with stabilisation of the bone thickness
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The PST® signal parameters fall within the biologically efficient window

The biologically efficient window defines the area of action for metabolic processes in the connective tissue. These processes stimulate cartilage regeneration. PST® operates within these parameters.

PST® differs from other magnetic field therapies through its physical parameters as well as the treatment duration. The physical parameters of PST® are based on experimentally obtained clinical results and correspond with those innate in by the body.

Pulsed Signal Therapy® is a non-invasive method which generates physiological signals in order to support or to restore physiological synthesis processes.

### Device parameters
- Energy form:
- Wave form:
- Frequency:
- Frequency source:
- Energy carrier:
- Treatment duration:

### Magnetic field therapy
- alternative current
- sinusoidal
- 0.2 - 20 Hz – 100 kHz
- continuous
- fixed
- tension control
- 4 - 12 weeks

### PST®
- direct current
- quasi-rectangular
- 1 – 30 Hz
- modulated impulse
- 6 frequency sources
- pulsed direct current
- 9 – 12 days
- 1 hour daily

Physical properties of the magnetic field therapy and Pulsed Signal Therapy®
PST® has a comprehensive library of scientific literature

The PST® scientific CD contains scientific articles and studies which have been published and presented in prestigious medical journals and congresses. The following pages provide the table of contents and some extracts from the scientific CD.

The information on the CD is organized in several folders.

Table of contents:
1. Studies (clinical, In vitro)
2. Information on new applications
3. Information for physicians
4. Scientific Information
5. Vet applications
I - STUDIES

CLINICAL PATIENT STUDIES (PRESENTED IN CHRONOLOGICAL ORDER)

1. DB*: A double-blind trial of the Clinical Effects of Pulsed Electromagnetic Fields in OA* of the Knee - Yale University School of Medicine Teaching Hospital Waterbury Connecticut/USA 1991

2. DB*: A double-blind trial of the clinical effects of Pulsed Electromagnetic Fields in OA* - Yale University School of Medicine Teaching Hospital Waterbury Connecticut/USA 1991


4. DB*: The effect of pulsed electromagnetic fields in the treatment of OA* of the knee and cervical spine - Three trial centers: Waterbury, Danbury, Melville/USA 1993

5.-7. Prospective studies using extremely low frequency electromagnetic induction therapy in the treatment of patients with inflammatory and non-inflammatory arthritis - 3 Yale University Clinical Centers Yale University School of Medicine Teaching Hospital/USA 1993


9. DB*: Efficacy of pulsed electromagnetic therapy (PST®) in painful knee OA* - Cochin Hospital Paris/France 1998

10. PST®: A proposal for a chondro-protection with physical methods - Niguarda Hospital Milan / Italy 1998

11. Long-term results achieved by PST® - Niguarda Hospital Milan/Italy 1999

12. The use of PST® in the treatment of arthrosis of the hand - Niguarda Hospital Milan/Italy 2000

13. The use of PST® in OA* of the knee - Niguarda Hospital/Milan 2001

14. Preliminary results of the treatment with Pulsed Signal Therapy (PST®) of osteochondral knee injuries - Catania Univ./Italy 2001

15. Prospective clinical verification study of PST® in Gonarthrosis, Coxaarthrosis and degenerative LWS changes - PST® Center Munich/Germany 1998


17. Permanent prospective study VITAL - Ludwig Maximilian Univ. Munich/Germany Thru Mar 2001


19. Pulsed Signal Therapy in degenerative articular pathology: our experience - Tor Vergata Rome /Italy 2005

20. Use of Pulsed Signal Therapy for the treatment of pain and functional limitation in the context of arthritic degenerative pathology - Tor Vergata Rome/Italy 2007

IN VITRO STUDIES (PRESENTED IN CHRONOLOGICAL ORDER)

1. The stimulation of chondrocyte metabolism by pulsed magnetic fields - North Shore Univ. Hospital/USA 1992

2. Biochemical and morphological study of human articular chondrocytes cultivated in the presence of PST® - Siena Univ./Italy 2000

3. Pulsed Signal Therapy (PST®) stimulates mitosis of human chondrocytes in culture - Germany 2000

4. Effects of Pulsed Signal Therapy on 3 - dimensional chondrocyte culture - Charité, Humboldt Univ. Berlin/Germany 2001

5. Reference list on Chondrocyte Stimulation

II - INFORMATION ON NEW APPLICATIONS

1. New medical applications


4. Marbux Tinnitus - A pilot study - ENT Medical Center 2000


III – INFORMATION FOR PHYSICIANS

1. PST® Studies List

2. PST® - an overview - APLAR 2003

3. PST® for musculoskeletal conditions - APLAR 2004

4. PST® Status in the treatment of arthritis

5. PST® for bone & cartilage - Pub 2004

6. PST® in refractory neuropathic pain - Pub 2004

7. Pain management chapter 57

8. Database representative overview

9. PST® Active principles

10. Comparison PST® ethical checklist

11. Graphics

12. Comparison PST® to Magnetic Field Therapy

13. Why is treating two joints simultaneously disallowed?

14. Indications & contra-indications List

15. Certificates

16. PST® medical devices

IV – SCIENTIFIC INFORMATION

1. PST® Presentations List

2. PST® Publications List

3. PST® Posters

4. Electrophysiology of the joint

5. PST® possible mechanism of action

6. Ion cyclotron resonance concept

7. Phys. factors in bone remodeling

8. Article Osteoarthritis & cartilage

9. PST® patents

V – VET APPLICATIONS

1. Info for pet owner

2. PST® questions & answers

3. PST® Vet medical benefits at a glance

4. Comparison PST® – others therapies

*OA = Osteoarthritis

* DB = double-blind
Use of Pulsed Signal Therapy for the treatment of pain and functional limitation in the context of arthritic degenerative pathology

University of Rome “Tor Vergata”, Italy
Physiopathology and Pain Management Centre

135 patients underwent PST® treatment between January 2006 and March 2007. 86 patients suffered from gonarthritis and 49 patients suffered from coxarthrosis. The protocol prescribed that the patients would be questioned with the WOMAC questionnaire (Western Ontario and McMaster Universities Osteoarthritis) before the start of the treatment (T0), at the end of treatment (T1), one week later (T2), six months later (T3) and one year after the end of the PST® treatment (T4). During the control visits planned in the protocol, the evaluation of pain and mobility was performed using the V.A.S. (Visual Analog Scale).

**Figure 1 Gonarthrosis**

<table>
<thead>
<tr>
<th>V.A.S.</th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.76</td>
<td>4.03</td>
<td>3.06</td>
<td>2.73</td>
<td>2.38</td>
</tr>
</tbody>
</table>

T0 = before the start of the treatment
T1 = at the end of treatment
T2 = one week later
T3 = six months later
T4 = one year after the end of the PST® treatment

**Figure 2 Coxarthrosis**

<table>
<thead>
<tr>
<th>V.A.S.</th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.31</td>
<td>4.41</td>
<td>3.69</td>
<td>3.91</td>
<td>2.23</td>
</tr>
</tbody>
</table>

T0 = before the start of the treatment
T1 = at the end of treatment
T2 = one week later
T3 = six months later
T4 = one year after the end of the PST® treatment
Pain management: patient examples

Example 1
Arthritis of the right hand
Age: 66 years
Device: PST® H-200
9 treatment sessions

Example 2
Tendinitis
Age: 56 years
Device: PST® H-100
9 treatment sessions

Example 3
Entire spine (cervicals, lumbars, hips)
Age: 48 years
Device: PST® H-300
12 treatment sessions
Pulsed Signal Therapy (PST®) enhances proteoglycan concentration in human chondrocyte cultures

Institute of Rheumatology, University of Siena, Italy

A study on effects of PST® stimulation on the morphology and metabolism of in vitro human chondrocytes in the presence or the absence of Interleukin IL-1β - a cytokine involved in cartilage degradation processes.

**Figure 1** Proteoglycan concentration (ng/μg DNA)

A – cultured cells at baseline conditions
B – cultured cells in the presence of IL-1β (5ng/ml)
C – cells cultured in basal condition and submitted to PST® stimulation
D – cells cultured in the presence of IL-1β and submitted to PST® stimulation

**Figure 2** Transmission Electron Microscopy (TEM)

**Figure 3** Scanning Electron Microscope (SEM)
1. Utilizzo della Terapia a Segnali Pulsanti nel trattamento del dolore e della limitazione funzionale nella patologia degenerativa artrosica.
(The use of Pulsed Signal Therapy for the treatment of pain and functional limitation in the context of arthritic degenerative pathology).
De Polo C.; Trenca I.; Frasca M.G.; Rocconi F.; Zorbo S.; Santucci M.; Caraccio V.; Ceccobelli M.; Lazzari M.J. Università degli Studi Roma “Tor Vergata” dipartimento di Medicina Critica, Medicina del Dolo e delle Scienze Anestesiologiche [Dr. Prof. A. F. Sabato] Servizio di Fisioterapia e Terapia del Dolore Azienda Ospedaliera Universitaria Policlinico Tor Vergata, Italy (Resp. Prof. A. Gatti), 2007

Changi General Hospital, Singapore (Lim YW, Chong KC, Low CO), 2005

3. Impiego della PST® nell’artrosi del ginocchio.
(The use of PST® in osteoarthritis of the knee). Niguarda Hospital, Milan, Italy (M. Cossu, N. Sias, De Vito), 2001

4. Ergebnisse einer multizentrischen Untersuchung zur Wirksamkeit der PST® bei Arthrosen im Kniegelenk.
(Results of a multicenter study on PST® efficacy in gonarthritis). Ludwig-Maximilian-Universität Munich, Germany (R. Breul, M. Faensen), 2001

5. Die Wirkung der PST® auf eine dreidimensionale Chondrozytenkultur.

6. PST® enhances Proteoglycans Concentration in Human Chondrocyte Cultures.
Siena University, Italy (A. Nerucci, R. Marcolongo, R. Markoll), 2000

7. Impiego della PST® nell’artrosi della mano.
(The use of PST® (Pulsed Signal Therapy) in the treatment of arthritis of the hand). Niguarda Hospital, Milan, Italy (C. Leuci, N. Sias, M. Cossu), 2000

Vancouver PST® Clinic, Canada (C. Hershler, A. Sjaus), 1998

9. La PST®: Proposta di Condroprotezione con Metodiche Fisiche.
(PST®: a proposal for chondroprotection with physical methods). Niguarda Hospital, Milan, Italy (C. Leuci, N. Sias, M. Cossu), 1998

10. Étude de vérification de l’efficacité antalgique des champs électromagnétiques pulsés (PST®) dans la gonarthrose.
(Study on the analgetic efficacy of pulsed electromagnetic fields (PST®) in gonarthrosis). Cochin Hospital, Paris, France (C.-J. Menkès, S. Perrot), 1998

Yale University School of Medicine Teaching Hospital Melville, New York, USA (D. H. Trock, A. J. Bollet, R. Markoll), 1994

Overview

Treatment of musculoskeletal conditions, in particular osteoarthritis, tendinitis and sports type injuries

**Efficiency 70 - 80%**

**Pain-free**

**Non-invasive**

**No known side effects**

The treatment entails 9 to 12 sessions of 60 minutes each

Physiological signals stimulate cartilage growth and repair

The technology uses low frequencies and a low field strength

**More than 25 clinical** and in vitro studies, including the study at Tor Vergata University in Rome (Italy) in 2007; other studies are in progress

**More than 500 000 patients have been treated**

The technology was brought onto the market in 1996, it is since then commercialized in more than 20 countries

Hundreds of PST® centers were created worldwide

The technology is certified by a notified body and complies with **strict medical standards** (Medical Device Directive MDD 93/42/EEC, ISO norm 13485:2003)

**Unique GMDN Code** 47584

**More than 50 patents including Electromagnetic Stimulation of Cartilage Tissue** (US 6,524,233 and EP 1,119,393 B1)

**PST® devices**

GPM has a wide range of products and business models for individual practices, clinics and hospitals. Presented below are some models of our product line. More information is available on request.

**PST® H-300**

This device has been specifically developed to treat the spine, hips and the shoulder girdle. This PST® device can also be used to treat osteoporosis. PST® H-300 is equipped with a full body bed and a variable pitch coil. It has been designed in order to allow patients to be in the most relaxed position during the treatment sessions. The device is intended for treatment at the practitioner’s or in a clinic.

**PST® H-200**

This device is dedicated to the treatment of joint disorders in extremities, e.g., knees, ankles, hands, elbows, etc. This device is delivered with a full set of accessories allowing the patient to be treated in optimal conditions. The device is intended for treatment at the practitioner’s or in a clinic.

**PST® Mobile Clinical H-50**

This device has been developed in order to allow doctors to treat patients without requiring additional practice space. The PST® Mobile allows patients to treat themselves at home. It is very convenient for patients since they do not have to travel to the centre to complete their daily hour of treatment.

**PST® Personal Compact®**

This device has been developed specifically for consumer purchase and home use. It has been designed in order to respond to the needs of patients living far away from PST® centres or preferring to be treated in the convenience of their homes.