

# Pulsed Signal Therapy (PST) Stimulates Mitosis of Human Chondrocytes in Culture

H. Gierse<sup>+</sup>, R. Breul<sup>\*</sup>, M. Faensen<sup>#</sup>, and R. Markoll<sup>»</sup>

<sup>+</sup> Praxis für Orthopädie und Sporttraumatologie Cologne, Germany

<sup>\*</sup> Anatomische Anstalt der Ludwig-Maximilians-Universität Munich, Germany

<sup>#</sup> Abteilung für Allgemein-, Unfall- und Wiederherstellungschirurgie des Städtischen Wenckebach-Krankenhaus Berlin, Germany

<sup>»</sup> BMTS Inc., Boca Raton, FL, USA and Munich, Germany

## Introduction

Over 70,000 patients suffering from osteoarthritic pain have now been treated with Pulsed Signal Therapy (PST), which utilizes an electromagnetic field with specific parameters. PST has evolved from two decades of basic science research designed to reproduce the normal streaming potentials that stimulate chondrocyte activity as a result of pressure on bone during normal daily activities. The long term efficacy and safety of PST was initially established in randomized, double blind, placebo controlled clinical trials [1,2] that have been validated by data from more recent controlled studies [3].

The glycosaminoglycans (GAG) of proteoglycans that aggregate in cartilage contain charged sulfate ( $\text{SO}_3^-$ ) and carboxyl ( $\text{COO}^-$ ) groups that have profound effects on tissue hydration because of their influence on ionic flux across the cell membrane [4]. Cartilage acts as a bio-mechanical signal transducer to generate the streaming potential required to maintain bone integrity through anabolic actions that counteract the constant breakdown of bone during normal metabolic activities. This is accomplished via networks of collagen and charged proteoglycan aggregates that influence intracellular and extracellular electrolyte concentrations. When bone is placed under pressure, cartilage acts as a biologic transducer to generate the streaming potential responsible for the synthesis of proteoglycan [5] and collagen. Although this sequence of events is impaired in cartilage damaged by osteoarthritis or trauma, we believe it can be reproduced by the administration of Pulsed Signal Therapy.

## Objective

The purpose of this study was to explore this hypothesis by determining whether human articular chondrocyte cultures exposed to PST demonstrate greater rates of mitosis compared to untreated chondrocyte cultures.

## Materials and Methods

Chondrocytes were obtained from the femoral condyles of six patients undergoing reconstructive surgery for osteoarthritis. This was performed according to the method outlined by Brittberg, [6] in which excised cartilage is cut into small pieces, washed in saline solution and digested by clostridial collagenase. After centrifugation and filtration the derived cell-suspension of chondrocytes of each patient was cultivated at 37°C in a glass-tube with a flat bottom. Initially the cells were cultivated in human and subsequently in bovine serum. The cell-suspensions were equally divided into two groups exposed to one hour of PST daily for 5 respectively 9 consecutive days and in into two untreated control groups (5 respectively 9 days). To prevent infections of the cell-cultures antibiotics were added to the cell-suspensions. At baseline, after five and after nine days an increased count of all cell-cultures was noted by light microscopy and a Neubauer chamber [6]. After attaining a confluence but before doing the five, respective nine day counts, the cultures were dissected with trypsin and carefully removed from the glass tubes by washing with water.

The PST treatment device consisted of a magnetic field generator, an electronic interface, and a system of toroid coils. This produces unidirectional

DC elliptical magnetic fields of 10 - 15 Gauss with varying frequencies between 10 and 30 Hertz.

## Results

The increase of cell numbers of each group was transformed into a percentage of the mean of the baseline cell number = 100%. The results of this in vitro experiment are summarized in Fig. 1. After five days, the control group culture demonstrated a 130% increase in mitosis compared to 192% in the treated group. After nine days the control group culture demonstrated an increase of 207% compared to 393% in the treated group. In summary, it can be stated that the cell-cultures of chondrocytes exposed to PST demonstrated mitosis rates nearly twice that of the control group.

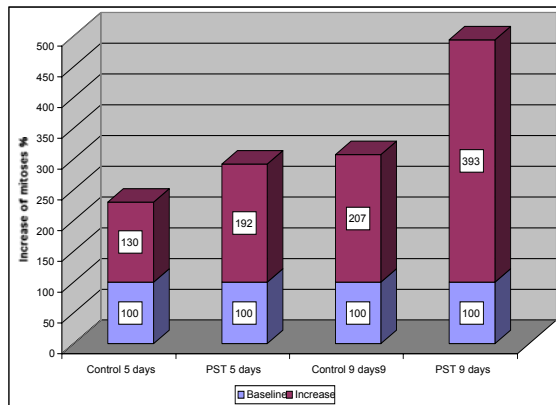


Fig 1: This histogram shows as a mean (n=6) the increased mitosis in percentage after five and nine days of exposure to PST compared to the control groups. The baseline represents the initial cell count.

## Discussion

This experiment clearly demonstrated that human chondrocyte cell cultures exposed to the specific electromagnetic fields generated by PST attained statistically significant higher mitosis-rates than chondrocytes in untreated cultures. This in vitro finding confirms the positive results of over twenty prospective clinical studies of patients suffering from osteoarthritis and supports one of the proposed mechanisms of action that may be responsible for these benefits.

PST is a noninvasive, potent treatment not associated with any adverse side or long term effects and represents a novel and very cost-effective modality for providing sustained pain relief and improved mobility in patients suffering from osteoarthritis.

## Literature

- 1 Trock DH, Bollet AJ, Dyer RH Jr, Fielding LP, Miner WK, Markoll R. A double-blind trial of the clinical effects of pulsed electromagnetic fields in osteo-arthritis. *J Rheumat.* 1993; 20(3):456-460.
- 2 Trock DH, Bollet AJ, Markoll R. The effect of pulsed electro-magnetic fields in the treatment of osteoarthritis of the knee and cervical spine. *J Rheumat* 1994; 21: 1903-11.
- 3 Breul R, Faensen M. Multi-Center-Studie zum Wirksamkeitsnachweis der PST Pulsierende Signal Therapie bei der Behandlung von Gonarthrosen. 2000: In preparation

- 4 Mow VC, Athesian GA. Lubrication and wear of the diarthrodial joints. In Mow VC, Hayes WC, EDS. *Basic Orthopaedic Biomechanics.* Philadelphia, PA: Lippincott-Raven Publishers 1997: 275 –315.
- 5 Nerucci A, Marcolongo R, Markoll R. Pulsed Signal Therapy (PST) enhances proteoglycans concentration in human chondrocytes cultures. Abstract Book, Twenty-Second Annual Meeting of The Bioelectromagnetics Society, Munich 2000: 48
- 6 Brittberg M, Lindahl A, Nilsson A, Ohlsson C, Isaksson O, Petersen L. Treatment of deep cartilage defects in the knee with autologous chondrocyt transplantation. *N Engl J of Med* 1994: 889 - 895