Pulsed Electromagnetic Field Therapy:
an integrative treatment modality

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Our Wild Neighbors

Volunteer veterinarian

What is PEMF therapy?

Pulsed
Electro-
Magnetic
Field

therapy

Time for a little physics...

Electromagnetic energy is radiation

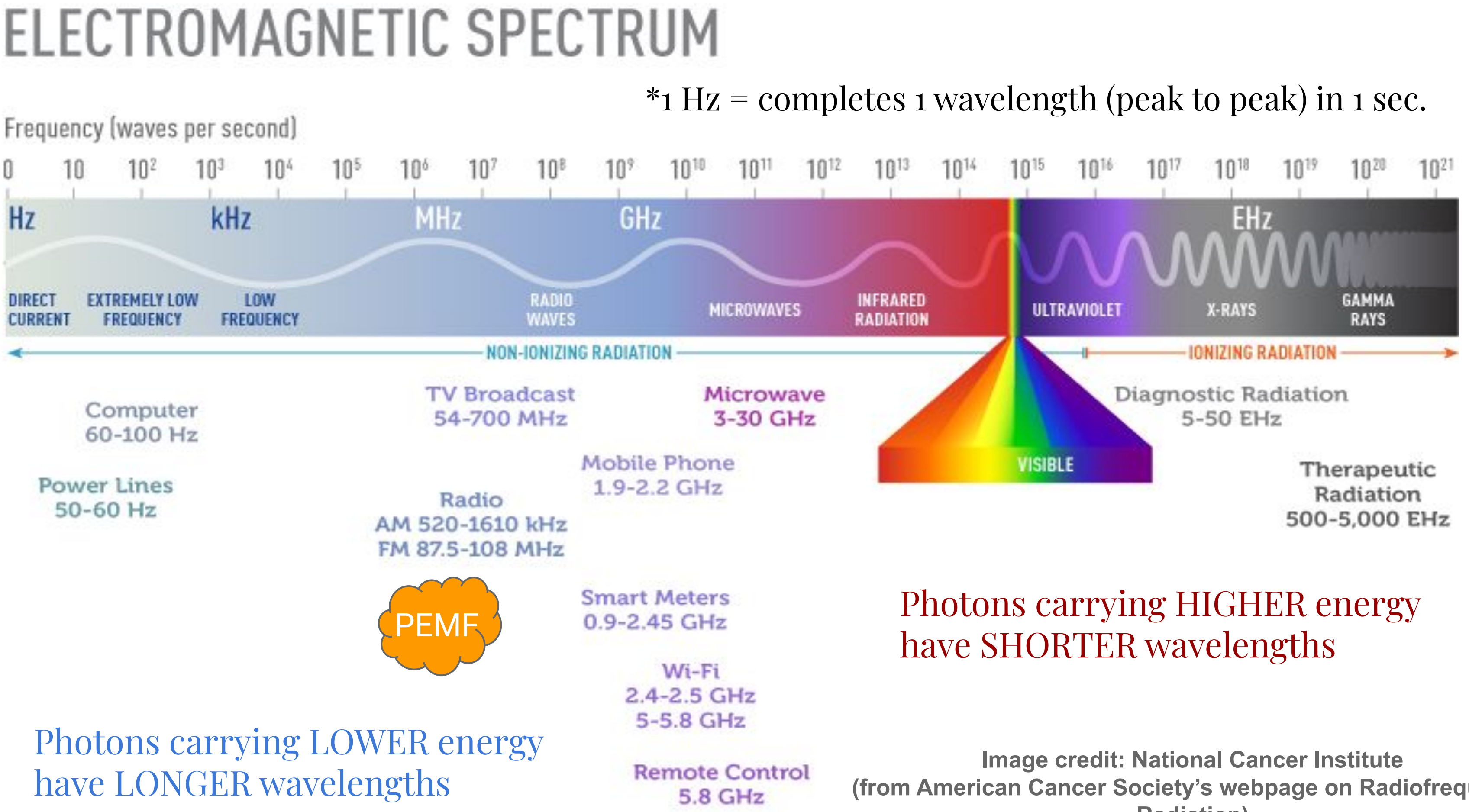
-photon = smallest unit of this energy

-travels in the form of waves

-Electromagnetic Spectrum is the range of all the types of electromagnetic energy.

-PEMF devices use radio wave signals in bursts (pulses) to provide non-thermal, non-invasive therapeutic benefits

NASA's Imagine the Universe website has a great review: https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html



*1 Hz = completes 1 wavelength (peak to peak) in 1 sec.

Photons carrying HIGHER energy have SHORTER wavelengths

Photons carrying LOWER energy have LONGER wavelengths

Image credit: National Cancer Institute (from American Cancer Society's webpage on Radiofrequency Radiation)

How does this electromagnetic energy produce biologic effects?

By activating the body's own anti-inflammatory and repair responses!

Mechanisms at play:

1. Nitric oxide production
2. Heat shock protein induction
3. Increased cell membrane adenosine receptor expression
4. Likely more that have not been discovered…

Nitric Oxide (NO) signalling

1. PEMF stimulates more calcium release INSIDE the cells

2. Calcium binds with calmodulin

3. This complex activates nitric oxide synthase to produce NO

What does Nitrous Oxide (a signalling molecule in the body) do?

1. decreases inflammation
2. increases blood flow
3. increases growth factors

This translates to decreased pain and swelling and faster healing times in our patients!

For those visual learners……

PEMF

↓

Ca + CaM ↣ Ca-CaM

Ca-CaM + cNOS ↣ NO

NO

Through cellular processes involving Nitrous Oxide:

1. Anti-inflammatory response activated
2. Blood flow enhanced.
3. Growth factors for tissue repair produced.

****ONLY IN INJURED TISSUE! (likely a reason for no known side effects of treatment.)**

Heat Shock Protein (HSP) induction

-PEMF treatment increases these inducible proteins
-HSP are produced in stress conditions. AKA "stress" proteins

- provide cell-protective effects
- associated with anti-apoptotic effects.

HSP exist in all organisms, allowing PEMF to benefit multiple species.

Think of HSP as the "EMS crew" for the cells of the body during pathological conditions....

Cell membrane adenosine receptor expression

-when exposed to PEMF, certain adenosine receptors are increased in various cells and tissues.
-when they are activated by adenosine, these receptors are associated with...

- reduction in prostaglandins
- reduction of inflammatory cytokines

More reasons for decreased pain and inflammation in our patients!

Proposed mechanism of anti-inflammatory effect of PEMFs through the up-regulation of A2A and A3ARs.

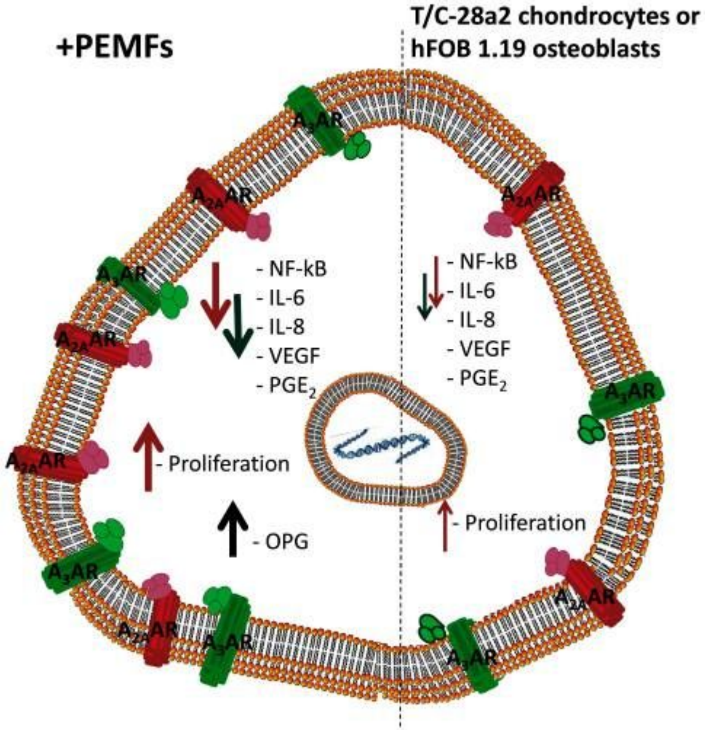


Image courtesy of Boopalan, P R J V C et al.

Different types of PEMF devices exist

-strength of magnetic and electric fields generated can depend on:

1. Shape and strength of waveforms
2. Size/shape of antenna
3. How long and often treatments applied.

1930's: The idea of "pausing" continuous electromagnetic waveforms for therapeutic effects was first introduced

1980's: FDA approval for first PEMF devices (bone growth stimulators).

2008: FDA approval for a veterinary device for reducing pain and inflammation.

FDA approval in human medicine include:

- post-operative pain/inflammation
- urinary incontinence
- muscle stimulation
- cervical fusion
- anxiety/depression
- migraine headaches
- brain cancer

What exactly does the research say?

Search for "PEMF" on pubmed....768 results.

Overall, beneficial therapy!

Dipping into a few:

1. Human studies (what luck! Animals have gotten humans as "their guinea pigs" this time)
2. Studies in creatures similar to those rehabbers see.
3. What about research in reptiles and birds?

Pulsed Electromagnetic Fields Reduce Postoperative Interleukin-1β, Pain, and Inflammation: A Double-Blind, Placebo-Controlled Study in TRAM Flap Breast Reconstruction Patients

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Background: Pulsed electromagnetic fields have been shown to reduce postoperative pain, inflammation, and narcotic requirements after breast reduction and augmentation surgical procedures. This study examined whether pulsed electromagnetic field therapy could produce similar results in patients undergoing unilateral transverse rectus abdominis myocutaneous (TRAM) flap breast reconstruction, a significantly more complex and painful surgical procedure.

Methods: In this double-blind, placebo-controlled, randomized study, 32 patients undergoing unilateral TRAM flap breast reconstruction received active or sham pulsed electromagnetic field therapy. Pain levels were measured by using a visual analogue scale; narcotic use and wound exudate volume were recorded starting 1 hour postoperatively. Wound exudates were analyzed for interleukin-1β.

Results: Mean visual analogue scale pain scores were 2-fold higher in the sham cohort at 5 hours and 4-fold higher at 72 hours ($p < 0.01$), along with a concomitant 2-fold increase in narcotic use in sham patients ($p < 0.01$). Wound exudate volume was 2-fold higher in the sham cohort at 24 hours ($p < 0.01$), and mean interleukin-1β concentration in wound exudates of sham patients was 5-fold higher at 24 hours ($p < 0.001$).

Conclusions: Pulsed electromagnetic field therapy significantly reduced postoperative pain, inflammation, and narcotic use following TRAM flap breast reconstruction, paralleling its effect in breast reduction patients. Both studies also report a significant reduction of interleukin-1β in the wound exudate, supporting a mechanism involving a pulsed electromagnetic field effect on nitric oxide/cyclic guanosine monophosphate signaling, which modulates the body's antiinflammatory pathways. Adjunctive pulsed electromagnetic field therapy could impact the speed and quality of wound repair in many surgical procedures. (*Plast. Reconstr. Surg.* 135: 808e, 2015.)

CLINICAL QUESTION/ LEVEL OF EVIDENCE: Therapeutic, I.

THERAPEUTIC

Noninvasive nonthermal pulsed electromagnetic fields have been used successfully as adjunctive therapy to accelerate the repair of delayed and nonunion fractures and chronic wounds, and the reduction of pain and inflammation.[1–5] Recent double-blind, randomized clinical

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This study is registered under the name "Use of Pulsed Electromagnetic Fields (PEMF) After Breast Reconstruction Surgery," ClinicalTrials.gov identification number NCT01262599 (http://clinicaltrials.gov/show/NCT01262599).
Preliminary results from this study were presented at the American Society of Plastic Surgeons Annual Meeting, in New Orleans, Louisiana, October 26 through 30, 2012; and the 31st Annual Meeting of the Northeastern Society of Plastic Surgeons, in Providence, Rhode Island, September 12 through 14, 2014.
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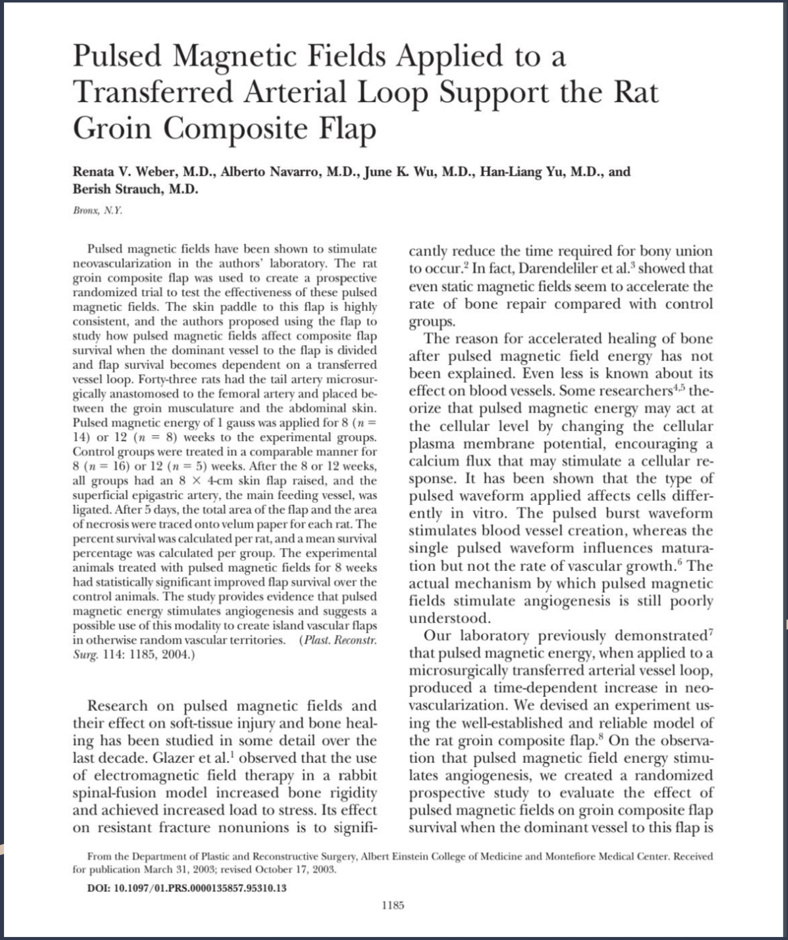
Disclosure: *Dr. Rohde received a research grant from Ivivi Health Sciences, LLC, for this study. Dr. Pilla receives compensation as a senior scientific advisor to Ivivi Health Sciences and had no contact with patients in this study. Drs. Taylor and Ascherman and Ms. Alonso and Ms. Hardy have no financial interest with Ivivi Health Sciences and no financial interests or sources of support to disclose.*

This study used a human device that is similar to the FDA-approved veterinary device most commonly used.

- Pain scores were 2-fold higher in sham cohort at 5-hours post-op and 4-fold higher in sham cohort 72 hours post-op

- sham cohort required 2 times as more narcotics by 3 hours and 6 times more narcotics between 48-72 hours.

- wound exudate amount was 2 times higher in sham cohort and contained 4-fold higher levels of interleukin-1β than treatment cohort.



Pulsed Magnetic Fields Applied to a Transferred Arterial Loop Support the Rat Groin Composite Flap

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Pulsed magnetic fields have been shown to stimulate neovascularization in the authors' laboratory. The rat groin composite flap was used to create a prospective randomized trial to test the effectiveness of these pulsed magnetic fields. The skin paddle to this flap is highly consistent, and the authors proposed using the flap to study how pulsed magnetic fields affect composite flap survival when the dominant vessel to the flap is divided and flap survival becomes dependent on a transferred vessel loop. Forty-three rats had the tail artery microsurgically anastomosed to the femoral artery and placed between the groin musculature and the abdominal skin. Pulsed magnetic energy of 1 gauss was applied for 8 (n = 14) or 12 (n = 8) weeks to the experimental groups. Control groups were treated in a comparable manner for 8 (n = 16) or 12 (n = 5) weeks. After the 8 or 12 weeks, all groups had an 8 × 4-cm skin flap raised, and the superficial epigastric artery, the main feeding vessel, was ligated. After 5 days, the total area of the flap and the area of necrosis were traced onto velum paper for each rat. The percent survival was calculated per rat, and a mean survival percentage was calculated per group. The experimental animals treated with pulsed magnetic fields for 8 weeks had statistically significant improved flap survival over the control animals. The study provides evidence that pulsed magnetic energy stimulates angiogenesis and suggests a possible use of this modality to create island vascular flaps in otherwise random vascular territories. (*Plast. Reconstr. Surg.* 114: 1185, 2004.)

Research on pulsed magnetic fields and their effect on soft-tissue injury and bone healing has been studied in some detail over the last decade. Glazer et al.[1] observed that the use of electromagnetic field therapy in a rabbit spinal-fusion model increased bone rigidity and achieved increased load to stress. Its effect on resistant fracture nonunions is to significantly reduce the time required for bony union to occur.[2] In fact, Darendeliler et al.[3] showed that even static magnetic fields seem to accelerate the rate of bone repair compared with control groups.

The reason for accelerated healing of bone after pulsed magnetic field energy has not been explained. Even less is known about its effect on blood vessels. Some researchers[4,5] theorize that pulsed magnetic energy may act at the cellular level by changing the cellular plasma membrane potential, encouraging a calcium flux that may stimulate a cellular response. It has been shown that the type of pulsed waveform applied affects cells differently in vitro. The pulsed burst waveform stimulates blood vessel creation, whereas the single pulsed waveform influences maturation but not the rate of vascular growth.[6] The actual mechanism by which pulsed magnetic fields stimulate angiogenesis is still poorly understood.

Our laboratory previously demonstrated[7] that pulsed magnetic energy, when applied to a microsurgically transferred arterial vessel loop, produced a time-dependent increase in neovascularization. We devised an experiment using the well-established and reliable model of the rat groin composite flap.[8] On the observation that pulsed magnetic field energy stimulates angiogenesis, we created a randomized prospective study to evaluate the effect of pulsed magnetic fields on groin composite flap survival when the dominant vessel to this flap is

From the Department of Plastic and Reconstructive Surgery, Albert Einstein College of Medicine and Montefiore Medical Center. Received for publication March 31, 2003; revised October 17, 2003.

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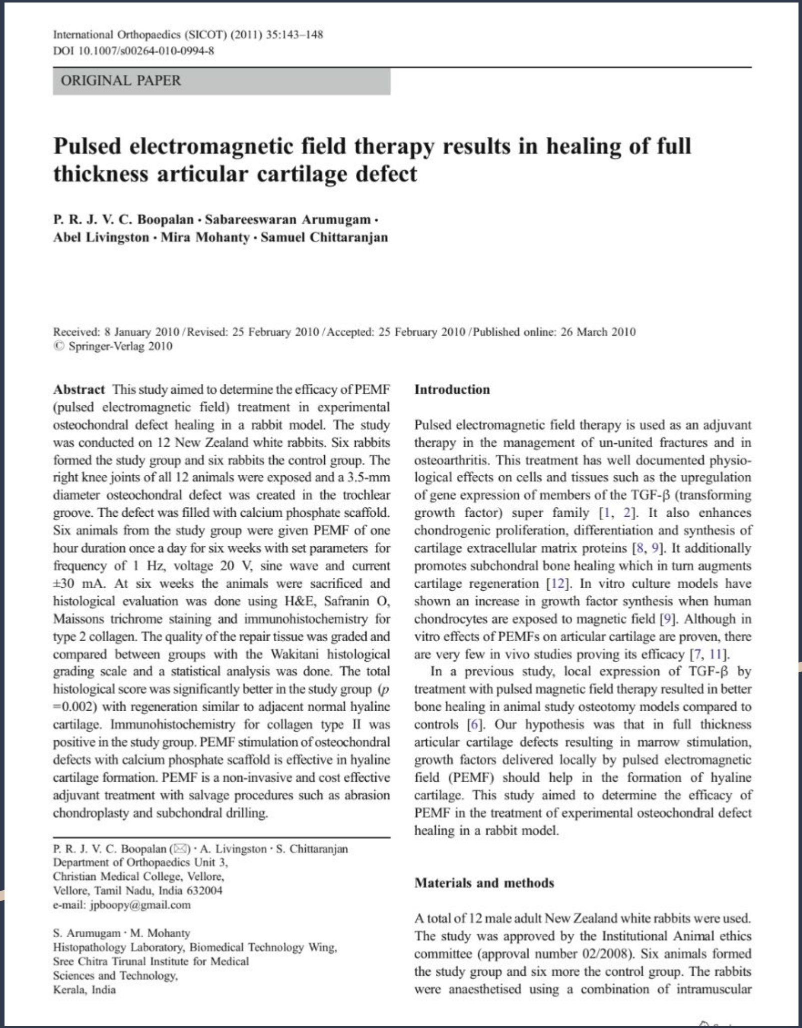
While squirrels are not the highest funded species in studies, their cousins, rats, are often models for research.

This study used a different human device (same 27.12MHz carrier wave, but different pulse duration and rate)

➳Mean skin flap tissue survival for control group was 10% compared to 94% in the group treated with PEMF.

➳supports PEMF as a modality that increases angiogenesis (new blood vessel formation from existing vessels)

➳no adverse effects noted


International Orthopaedics (SICOT) (2011) 35:143–148
DOI 10.1007/s00264-010-0994-8

ORIGINAL PAPER

Pulsed electromagnetic field therapy results in healing of full thickness articular cartilage defect

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Abstract This study aimed to determine the efficacy of PEMF (pulsed electromagnetic field) treatment in experimental osteochondral defect healing in a rabbit model. The study was conducted on 12 New Zealand white rabbits. Six rabbits formed the study group and six rabbits the control group. The right knee joints of all 12 animals were exposed and a 3.5-mm diameter osteochondral defect was created in the trochlear groove. The defect was filled with calcium phosphate scaffold. Six animals from the study group were given PEMF of one hour duration once a day for six weeks with set parameters for frequency of 1 Hz, voltage 20 V, sine wave and current ±30 mA. At six weeks the animals were sacrificed and histological evaluation was done using H&E, Safranin O, Maissons trichrome staining and immunohistochemistry for type 2 collagen. The quality of the repair tissue was graded and compared between groups with the Wakitani histological grading scale and a statistical analysis was done. The total histological score was significantly better in the study group (*p* =0.002) with regeneration similar to adjacent normal hyaline cartilage. Immunohistochemistry for collagen type II was positive in the study group. PEMF stimulation of osteochondral defects with calcium phosphate scaffold is effective in hyaline cartilage formation. PEMF is a non-invasive and cost effective adjuvant treatment with salvage procedures such as abrasion chondroplasty and subchondral drilling.

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Introduction

Pulsed electromagnetic field therapy is used as an adjuvant therapy in the management of un-united fractures and in osteoarthritis. This treatment has well documented physiological effects on cells and tissues such as the upregulation of gene expression of members of the TGF-β (transforming growth factor) super family [1, 2]. It also enhances chondrogenic proliferation, differentiation and synthesis of cartilage extracellular matrix proteins [8, 9]. It additionally promotes subchondral bone healing which in turn augments cartilage regeneration [12]. In vitro culture models have shown an increase in growth factor synthesis when human chondrocytes are exposed to magnetic field [9]. Although in vitro effects of PEMFs on articular cartilage are proven, there are very few in vivo studies proving its efficacy [7, 11].

In a previous study, local expression of TGF-β by treatment with pulsed magnetic field therapy resulted in better bone healing in animal study osteotomy models compared to controls [6]. Our hypothesis was that in full thickness articular cartilage defects resulting in marrow stimulation, growth factors delivered locally by pulsed electromagnetic field (PEMF) should help in the formation of hyaline cartilage. This study aimed to determine the efficacy of PEMF in the treatment of experimental osteochondral defect healing in a rabbit model.

Materials and methods

A total of 12 male adult New Zealand white rabbits were used. The study was approved by the Institutional Animal ethics committee (approval number 02/2008). Six animals formed the study group and six more the control group. The rabbits were anaesthetised using a combination of intramuscular

Here, rabbits are the study participants.

The experimental device in this study used a frequency of 1Hz, but for longer duration (1 hour) Pulse duration and rate were not specified.

»The surface of the cartilage in the PEMF-treated group was visibly more smooth and normally contoured compared to the control group

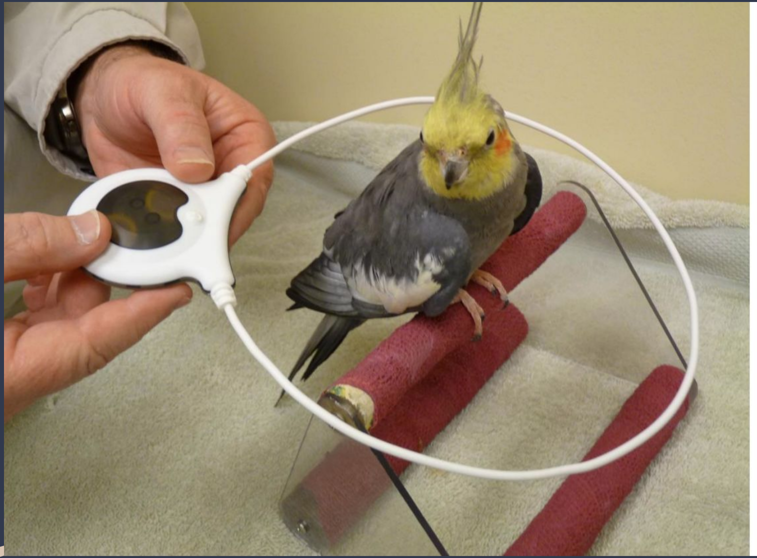
»Microscopically, the cartilage was ⅔ thicker in the PEMF-treated group, as well as had more pronounced subchondral bone regeneration

»no adverse effects noted

Patient spotlight:

assisianimalhealth.com

April 15,2015



https://assisianimalhealth.com/blog/cockatiel-regains-ability-to-fly-after-using-the-assisi-loop/

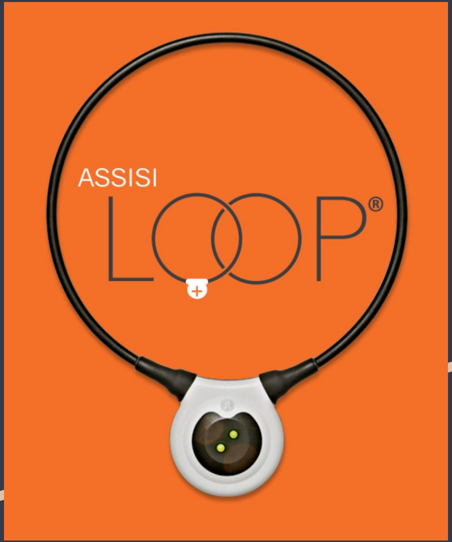
Case report:

Daji, 30-year-old cockatiel, diagnosed with arthritis and inflammation on pads of left foot.

Previous treatment with pain medication and laser therapy were only minimally effective.

- A few days after starting twice daily PEMF therapy, his foot inflammation improved
- A bonus: his energy level and mood improved, as well as his arthritis–he flew again–something he hadn't done for years.

What FDA-approved veterinary device is available?



https://assisianimalhealth.com/

Advantages:

-Specific targeted PEMF field (tPEMF)
Designed to specifically *target* the binding of calcium to calmodulin and accelerate the NO cascade

-FDA-approved

-Short treatment period (15min) compared to other devices.

-affordable (compared to the $4000-8000 range for a quality non-FDA approved or human device)

2022 retail costs:

- $299 for a disposable device with at least 150 treatments
- $799 for XS mat (called the Loop lounge) that guarantees at least 6000 treatments
- larger mat sizes available.

these are CLIENT costs. Devices are also available through prescription from veterinarian,

Assisi Loop in action

-do not use around large amounts of metal (it may disrupt signal and potentially decrease efficacy)

-metal bone implants are ok

Treatment Pearls

-Read the FAQs and call Assisi Animal Health with any questions…great customer service!

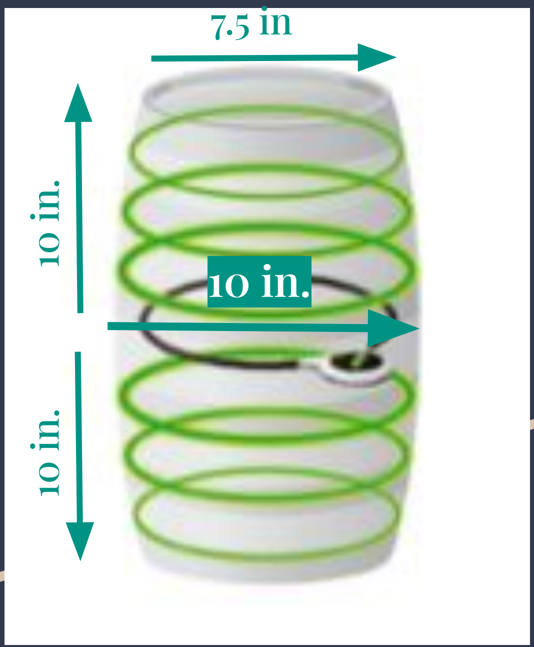
-printable tracking sheet is available on the Assisi Animal Health website

-Precautions for users with a pacemaker or other electrical implanted device

-Wait at least 2 hours between treatments

-Treat the patient, not the disease.
They often let you know when treatment is "finished"

Treatment Zone for the 20 cm (7.5in) LOOP



https://assisianimalhealth.com/faq/#vet-faq

Another turtle patient... great at posing!

Assisi Loop Lounge benefits

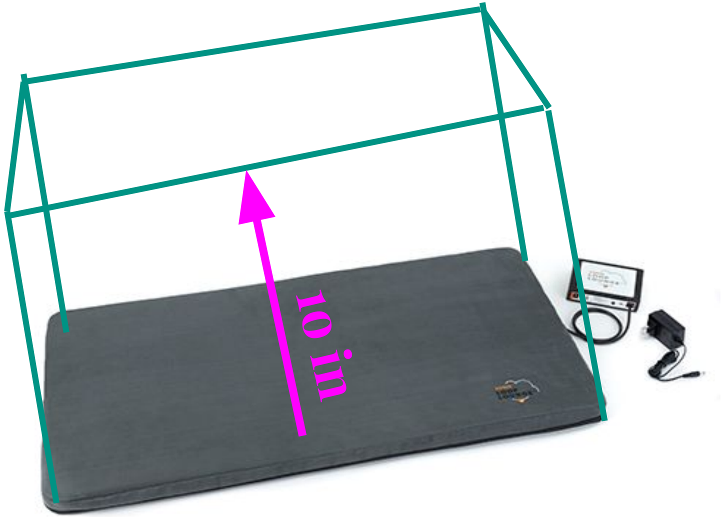
-can treat different patients consecutively, rather than waiting 2 hours for Loop to recharge

-more cost effective long-term

-guaranteed for 4 years.

Treatment Zone for the Loop Lounge

-extends full pad dimensions and 10 inches up from pad (no matter what the size of the pad)



Example: XS pad is 7.5in x 15in

Why use in wildlife species?

1. Hands-off treatment

2. No side effects or drug residues as with pharmaceuticals

3. Uses body's own healing mechanisms.

4. Potentially get patients back to their natural environments faster

Thank you!

Special thanks to…

*Mailisa Glickert with Assisi Animal Health
*Greg Levine NOAA Pacific Island Regional Office Contract Veterinarian
*Our Wild Neighbors staff

Questions?

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