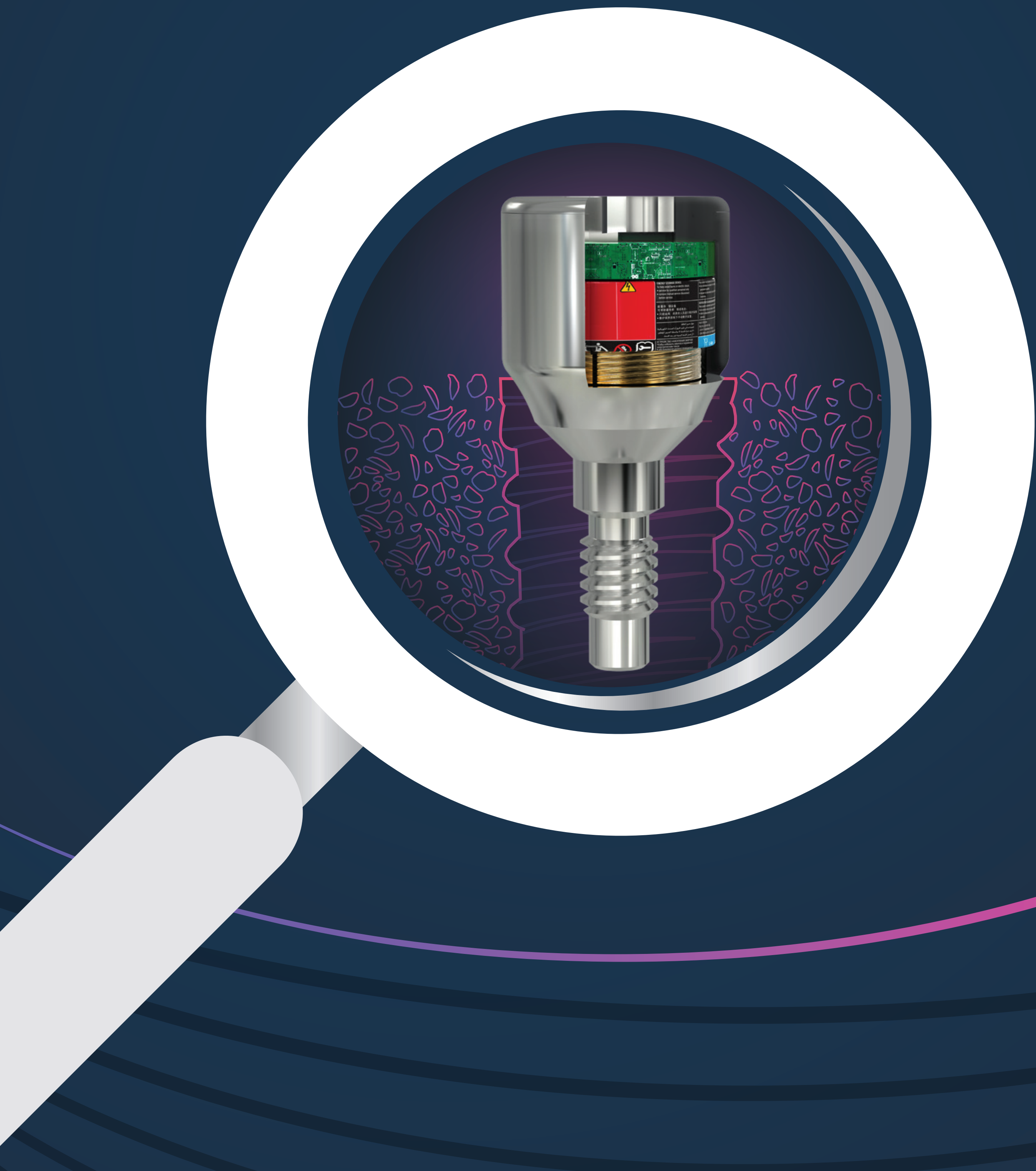
magdent

Magdent's Reseach



INTRODUCTION

Magdent has revolutionized the world of dental implants by utilizing pulse electromagnetic field (PEMF) technology to stimulate bone formation around dental implants. For the first time, dentists can actively shorten and improve the osseointegration process and reduce healing time.

Magdent has harnessed pulse electromagnetic fields (PEMF), a well-known and clinically proven treatment method commonly used in orthopedics to develop the Magdent-MED, a Miniaturized Electromagnetic Device, which is small enough to fit inside a dental implant and is shaped like a regular healing abutment.

Pulsed electromagnetic fields (PEMF) stimulate and enhance the formation of osteoblast cells, leading to regeneration of bone mass at a faster rate and with higher density.

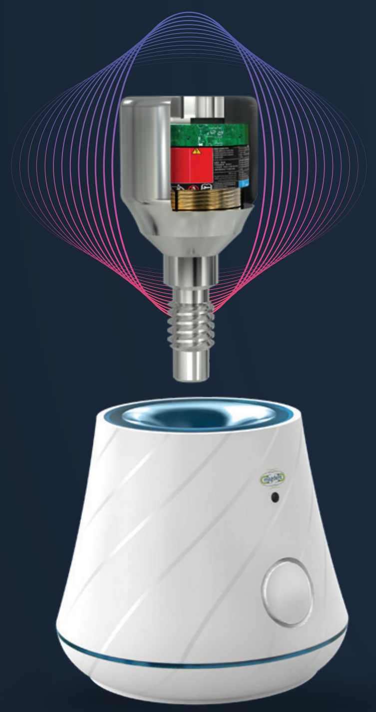
THE "Magdent-MED" DEVICE HAS BEEN CLINICALLY PROVEN TO:

X3
Acceleration of the healing process

48%
Increase in bone to implant contact

62%
Increase in trabecular bone volume density

✓
Proven success in inflammatory conditions



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MAGDENT PUBLICATIONS

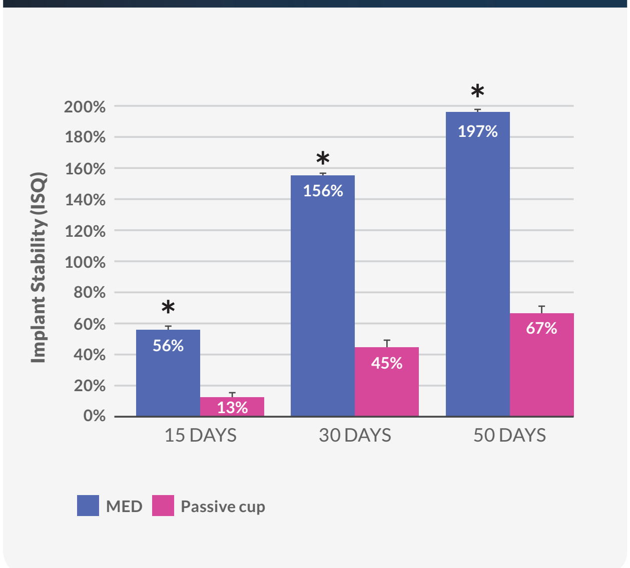
PEMF (Pulsed Electromagnetic Field) REVIEW PAPERS

Miniaturized Electromagnetic Device Abutment Improves Stability of Dental Implants

Barak S, Matalon S, Dolkart O, Zavan B, Mortellaro C, Piattelli A. J Craniofac Surg. 2018 Jul 27.

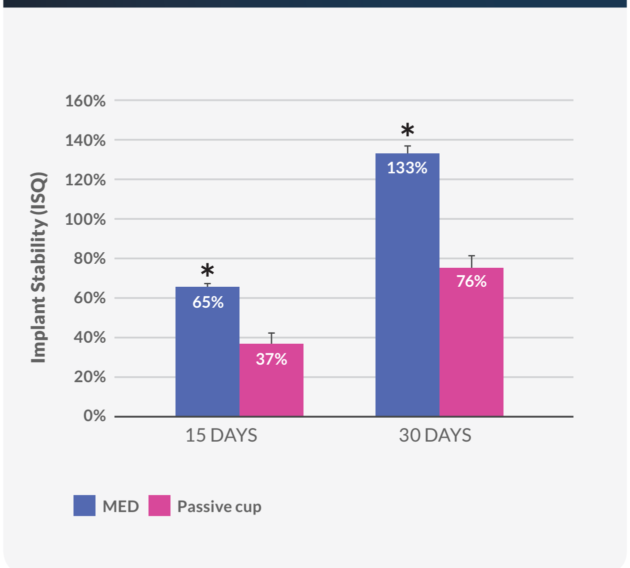
BACKGROUND: The overall success and predictability of dental implant treatment hinge on the primary stability, direct bone-to implant contact formation, and quantity and/or quality of residual bone. A pulsed electromagnetic field has been reported to increase bone regeneration in various clinical situations. Therefore, it was hypothesized that a device which can locally generate a pulsed electromagnetic field would stimulate bone healing and increase bone density surrounding implants.
OBJECTIVE: To retrospectively assess the effects of the miniaturized electromagnetic device (MED) on implant stability for the first time in human subjects, in a prospective case controlled series.
METHODS: Twelve patients (28 implants) were included in the study.Twelve MED healing caps and 16 regular control healing caps were inserted. Resonance frequency analysis (RFA) was performed at implant placement and abutment connection and an implant stability quotient value was attributed to each implant.
RESULTS: Maxillary implant stability was significantly higher with MED healing cups compared to controls at 15 days postimplantation (66.2 vs. 62.1, p. = .0008). Resonance frequency analysis test performed at 30 days postimplantation demonstrated significantly increased stability in MED as compared to the controls 73.5 ± 3.2 vs. 66.7 ± 4.8 in mandibular implants and 74 ± 1.7 vs. 65 ± 2.3 in maxillary implants. At the 50 days postimplantation, RFA tests revealed markedly higher stability of the maxillary implants with MED active healing caps compared to nonactive 75.4 ± 5.1 vs. 68.5 ± 8.5, respectively.
CONCLUSIONS: MED-abutment implants demonstrated a superior stability during the early phase of healing as compared to standard implants.

Evaluation of the maxillary implant stability quotient: MED vs. Passive healing cups.



The implant stability quotients were calculated at 15, 30 and 50 days of healing before conventional loading. Results are expressed as the percentage change from the baseline to the loading time point ± SD.

Evaluation of the maxillary implant stability quotient: MED vs. Passive healing cups.



The implant stability quotients were calculated at 15 and 30 days of healing before conventional loading. Results are expressed as the percentage change from the baseline to the loading time point ± SD.

A new device for improving dental implant anchorage: a histological and microcomputed tomography study in the rabbit

Barak S, Neuman M, Iezzi G, Piattelli A, Perrotti V, Gabet Y. Clinical Oral Implants Res. 2016 Aug;27(8):935-42.

OBJECTIVE: In the present study, a new healing cap that generates a pulsed electromagnetic field (PEMF) around titanium implants to stimulate peri-implant osteogenesis was tested in a rabbit model.

MATERIALS AND METHODS: A total of 22 implants were inserted in the proximal tibial metaphysis of 22 rabbits. A healing cap containing the active device was inserted in half of the implants (11 test implants); an "empty" healing cap was inserted in the other ones (11 control implants). The animals were euthanized after 2 and 4 weeks, and the samples were processed for micro-computed tomography and histology. The peri-implant volume was divided into coronal (where the PEMF was the strongest) and apical regions.

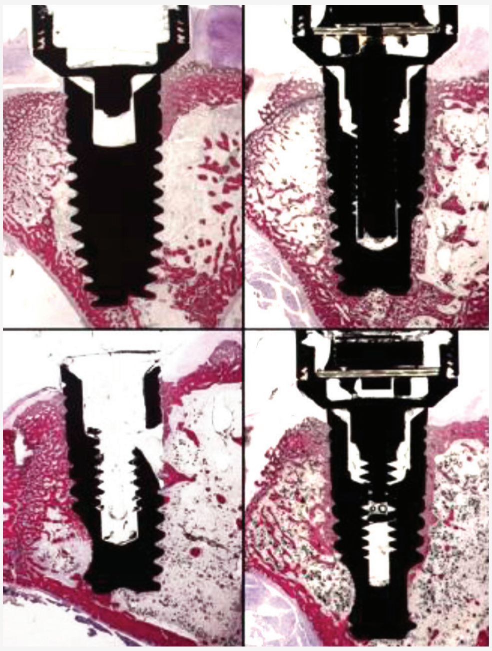
RESULTS: Most of the effects of the device were confined to the coronal region. Two weeks post-implantation, test implants showed a significant 56% higher trabecular bone fraction (BV/TV), associated with enhanced trabecular number (Tb.N, +37%) and connectivity density (Conn.D, +73%) as compared to the control group; at 4 weeks, the PEMF induced a 69% increase in BV/TV and 34% increase of Tb.N. There was no difference in the trabecular thickness (Tb.Th) at either time point. Furthermore, we observed a 48% higher bone-to-implant contact (BIC) in the test implants vs. controls after 2 weeks; this increase tended to remain stable until the fourth week. Mature trabecular and woven bone were observed in direct contact with the implant surface with no gaps or connective tissue at the bone-implant interface.

CONCLUSIONS: These results indicate that the PEMF device stimulated early bone formation around dental implants resulting in higher peri-implant BIC and bone mass as early as 2 weeks post-implantation which suggests an acceleration of the osseointegration process by more than three fold.

CONTROL **TEST**

2 WEEKS

4 WEEKS



Statistically significant results - CT-15µ

Active vs. Control:

Trabecural bone volume density:

2 weeks post-implantation - **56% increase**

4 weeks post-implantation - **62% increase**

Trabecular number

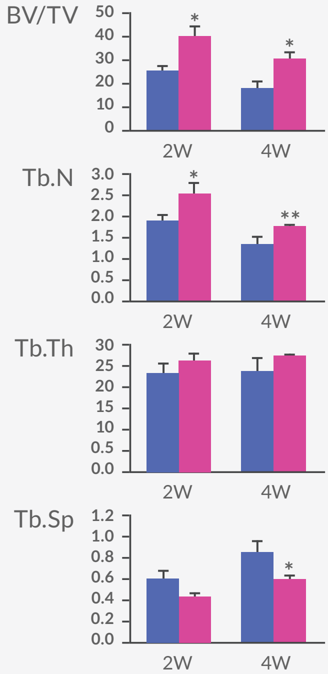
2 weeks & 4 weeks post-implantation - **44% increase**

Trabecular thickness

No effect

Trabecular spacing

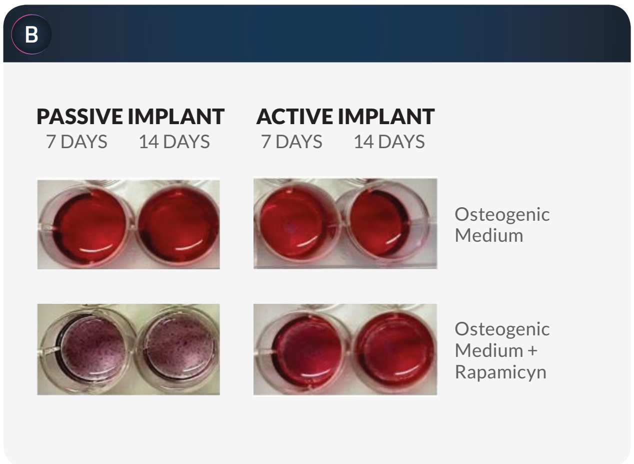
32% decrease

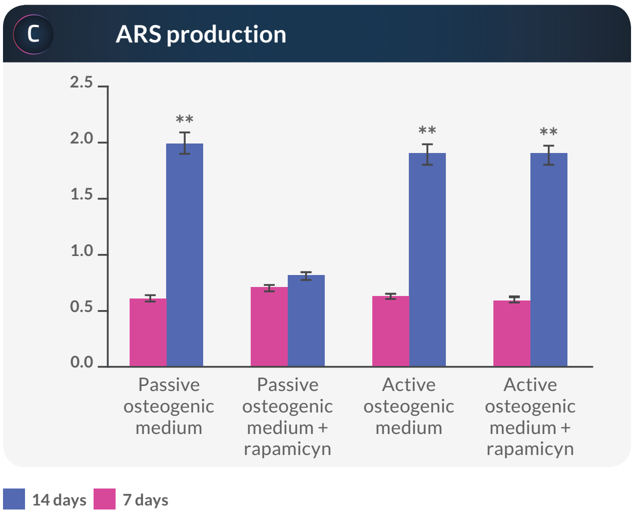


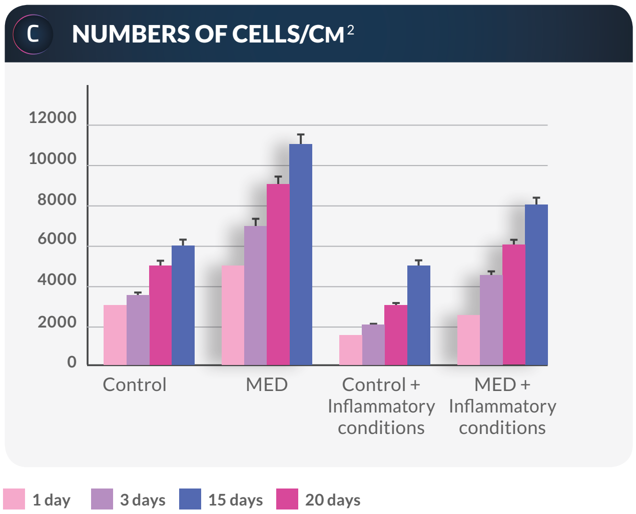
Pulsed electromagnetic fields increase osteogenetic commitment of MSCs via the mTOR pathway in TNF-α mediated inflammatory conditions: an *in-vitro* study.

Ferroni L[1], Gardin C[1], Dolkart O[2], Salai M[3], Barak S[4], Piattelli A[5], Amir-Barak H[6], Zavan B[1]. Sci Rep.
2018 Mar 23;8(1):5108.

Pulsed electromagnetic fields (PEMFs) have been considered a potential treatment modality for fracture healing; however, their action mechanism remains unclear. Mammalian targets of rapamycin (mTOR) signaling may affect osteoblast proliferation and differentiation. This study assessed the osteogenic differentiation of mesenchymal stem cells (MSCs) under PEMF stimulation and the potential involvement of the mTOR signaling pathway in this process. PEMFs were generated by a novel miniaturized electromagnetic device. Potential changes in the expression of mTOR pathway components, including receptors, ligands and nuclear target genes, and their correlation with osteogenic markers and transcription factors were analyzed. Involvement of the mTOR pathway in osteogenesis was also studied in the presence of proinflammatory mediators. PEMF exposure increased cell proliferation and adhesion and the osteogenic commitment of MSCs even in inflammatory conditions. Osteogenic-related genes were over-expressed following PEMF treatment. Our results confirm that PEMFs contribute to activation of the mTOR pathway via upregulation of the proteins AKT, MAPP kinase, and RRAGA, suggesting that activation of the mTOR pathway is required for PEMF-stimulated osteogenic differentiation. Our findings provide insights into how PEMFs influence osteogenic differentiation in normal and inflammatory environments.







Antimicrobial effects of pulsed electromagnetic field: *an in-vitro* polymicrobial periodontal subgingival biofilm model

S. Barak, O. Dolkart, M. Faveri, B. Bueno-Silva, G.M. Soares, M. Feres, J.A. Shibli
https://onlinelibrary.wiley.com/doi/full/10.1111/jcpe.166_12914

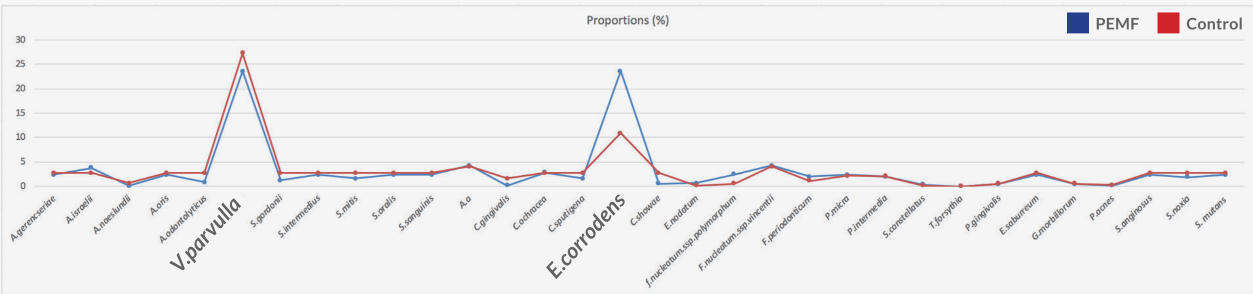
BACKGROUND & AIM: Periodontitis is an infectious disease that causes the inflammatory destruction of the tooth supporting tissues. It is caused by polymicrobial biofilm communities growing on the tooth surface. Treatment primarily involves the mechanical disruption of subgingival biofilms and may include adjunctive systemic antibiotic therapy. The aim of this in-vitro study was to evaluate the antibacterial effects of a pulsed electromagnetic field (PEMF), device that may be incorporated into healing abutments using a unique polymicrobial subgingival biofilm model.

METHODS: Healing abutments with (test group) and without (control group) active PEMF devices were placed in a multispecies biofilm with 31 different periodontal microorganisms. The composition of the biofilm as well as the total bacterial counts (x106) were analyzed by checkerboard DNA-DNA hybridization after 96 h.

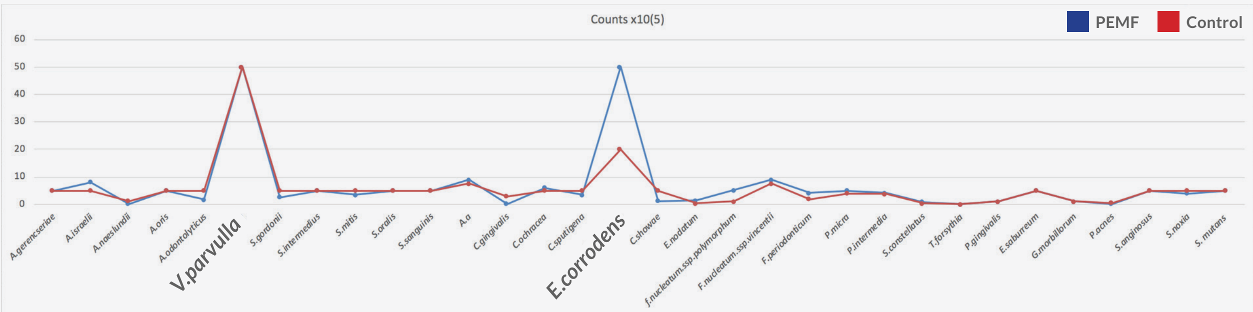
RESULTS: After 96 h, the mean levels and proportions of 4 out of the 31 bacterial species evaluated were lower in the test group than in the control group (without PEMF) ($p < 0.05$): Actinomyces odontolyticus, Fusobacterium nucleatum sp polymorphum, Campylobacter showae and Capnocytophaga gingivalis. The total microbial count was not influenced by PEMF ($p > 0.05$).

CONCLUSION: This preliminary in-vitro data suggest that PEMF exerts antimicrobial effects on a few subgingival species after 96 h of exposure. Further evaluation of the PEMF effects on this multispecies biofilm model at different time intervals may provide more insights into the underlying antimicrobial mechanisms.

PROPORTIONS (%)



COUNTS X10 (S)



Effect of pulsed electromagnetic field on healing of mandibular fractures: a preliminary clinical study

Abdelrahim A, Hassanein HR, Dahaba M. J Oral Maxillofac Surg. 2011 Jun;69(6):1708-17

PATIENTS AND METHODS: A total of 12 patients with mandibular fractures were selected for the present study. Each patient was treated by closed reduction using maxillomandibular fixation (MMF) and was assigned to 1 of 2 equal groups. The fracture sites of group A only were exposed to pulsed electromagnetic fields (PEMF) 2 hours daily for 12 days, 2 weeks postoperatively to MMF removal. For group B (control group), the MMF was removed 4 weeks postoperatively. The effectiveness of the 2 treatment modalities was evaluated clinically and radiographically using computerized densitometry.
RESULTS: After releasing the MMF, a bimanual mobility test of the fractured segments showed stability of the segments in all cases. There was no significant difference between the mean bone density values of the 2 groups for any of the study intervals. In contrast, the percentage of changes in bone density of the 2 groups revealed that group A had non-significant decreases at the 15th postoperative day and a significant increase 30 days postoperatively compared to group B.
CONCLUSIONS: PEMF stimulation may have a beneficial effect on the healing of mandibular fractures treated with closed reduction. However, additional research, using randomized controlled trials, should be conducted to ascertain its effectiveness compared to other treatment modalities.

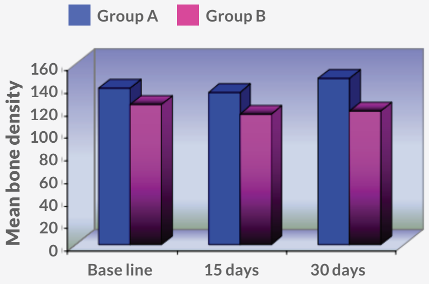


Fig. 7 Mean bone density values of the 2 groups at each study interval

Abdelrabim, Hassanein, and Dababa. Pulsed Electromagnetic Field and Manndibular Fracture. J Oral Maxillofac Surg 2011.

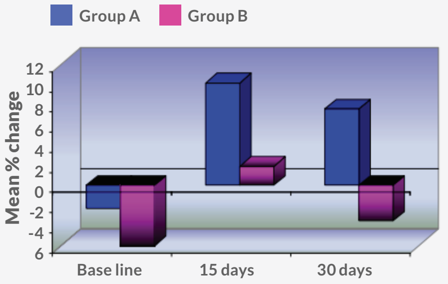


Fig. 8 Percentage changes in bone density in the 2 groups.

Abdelrabim, Hassanein, and Dababa. Pulsed Electromagnetic Field and Manndibular Fracture. J Oral Maxillofac Surg 2011.

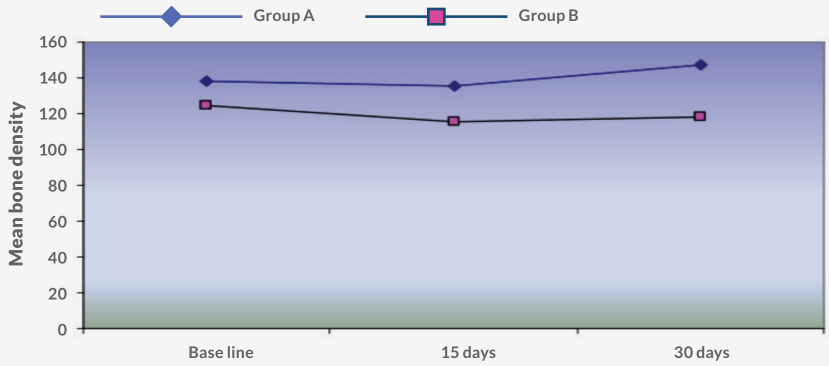


Fig. 9 Changes in mean bone density as a function of time within each group.

The Application of Pulsed Electromagnetic Fields (PEMFs) for Bone Fracture Repair: Past and Prospective Findings

Daish C, Blanchard R, Fox K, Pivonka P, Pirogova E. Ann Biomed Eng. 2018 Apr;46(4):525-542.

Bone fractures are one of the most commonly occurring injuries of the musculoskeletal system. A highly complex physiological process, fracture healing has been studied extensively. Data from in-vivo, in-vitro and clinical studies, have shown pulsed electromagnetic fields(PEMFs) to be highly influential in the fracture repair process. Although the underlying mechanisms acting to either inhibit or advance the physiological processes are yet to be defined conclusively, several non-invasive point of use devices have been developed for the clinical treatment of fractures. Given the complexity of the repair process, involving many components acting at different time steps, it has been a challenge to determine which PEMF exposure parameters (i.e., frequency of field, intensity of field and dose) will produce the most optimal repair. In addition, the development of an evidence-backed device comes with challenges of its own, since many elements (including process of exposure, construct materials and tissue densities) impact the field exposed. The objective of this review is to provide a broad assessment of the applications of PEMFs in bone fracture repair and to then show what is further required for enhanced therapeutic outcomes.

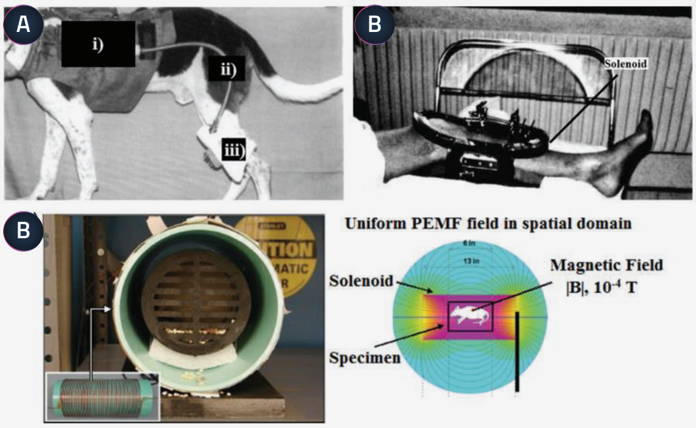


Fig. 7 Clinical and *in-vivo* experimental setups modified from Inoue *et al.*, Hisenkamp *et al.* and Androjna *et al.* showing (a) PEMF stimulation system applied to a dog to induce osteotomies in canines showing (i) signal generato, (ii) tubing to connect generator to coil and (iii) coil [56]; (b) Double coil setup of the system used to treat fresh tibial fractures in humans [54] and (c) solenoid setup and mapping field for PEMF treatment of osteoporotic fractures in rats[4].

TABLE 5. Summary of the most conclusive studies applying EMF treatment to tibial non-union fractures.

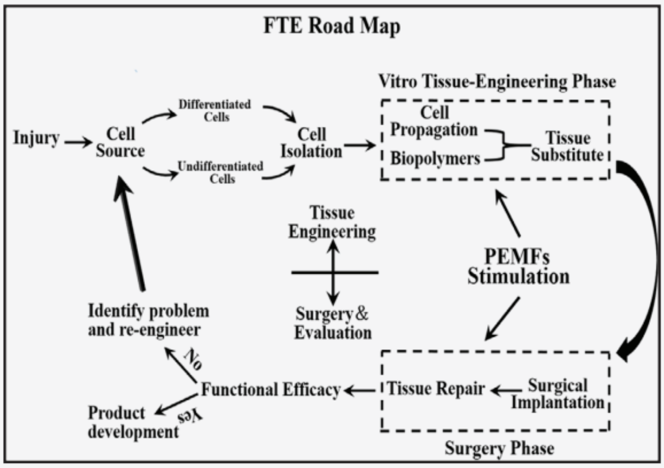
Clinical design	Number of tibial fractures	Duration of treatment	Union rate	Authors
Prospective, non-randomized	17	20 h/Day, 24 Weeks	88%	De Haas *et al.* [50]
Prospective, non-randomized	127	10 h/Day, 5 Months	87%	Bassett *et al.* [14]
Prospective, non-randomized	30	12-16 h/Day, 6 Months	87%	Sharrard *et al.* [92]
Prospective, randomized, double-blind	16	24 Weeks	77%	Barker *et al.* [9]
Prospective, non-randomized	56	-	84%	De Haas *et al.* [34]
Prospective, randomized, double-blind	15	27 Weeks	60%	Scott and King [91]
Prospective, randomized, double-blind	34	6 Months	60%	Simonis *et al.* [97]
Prospective, non-randomized	45	8 Weeks	85%	Gupta *et al.* [48]
Multicenter, randomized, double-blind	259	6 h/Day,	-	Adie *et al.* [1]
Prospective, non-randomize	44	3 h/Day, 29 Weeks	77%	Assiotis *et al.* [5]
Prospective, randomized	58	8 h/Day, 3 Months	77.4%	Shi *et al.* [94]

Underlying Signaling Pathways and Therapeutic Applications of Pulsed Electromagnetic Fields in Bone Repair

Yuan J, Xin F, Jiang W. Cell Physiol Biochem. 2018;46(4):1581-1594

Pulsed electromagnetic field (PEMF) stimulation, as a prospective, noninvasive, and safe physical therapy strategy to accelerate bone repair has received tremendous attention in recent decades. Physical PEMF stimulation initiates the signaling cascades, which effectively promote osteogenesis and angiogenesis in an orchestrated spatiotemporal manner and ultimately enhance the self-repair capability of bone tissues. Considerable research progress has been made in exploring the underlying cellular and subcellular mechanisms of the PEMF promotion effect in bone repair. Moreover, the promotion effect has shown strikingly positive benefits in the treatment of various skeletal diseases. However, many preclinical and clinical efficacy evaluation studies are still needed to make PEMFs more effective and extensive in clinical application. In this review, we briefly introduce the basics of PEMFs on bone repair, systematically elaborate on the several key signaling pathways involved in PEMF-induced bone repair, and then discuss the therapeutic applications of PEMFs alone or in combination with other available therapies for bone repair, and evaluate the treatment effects by analyzing and summarizing recent literature.

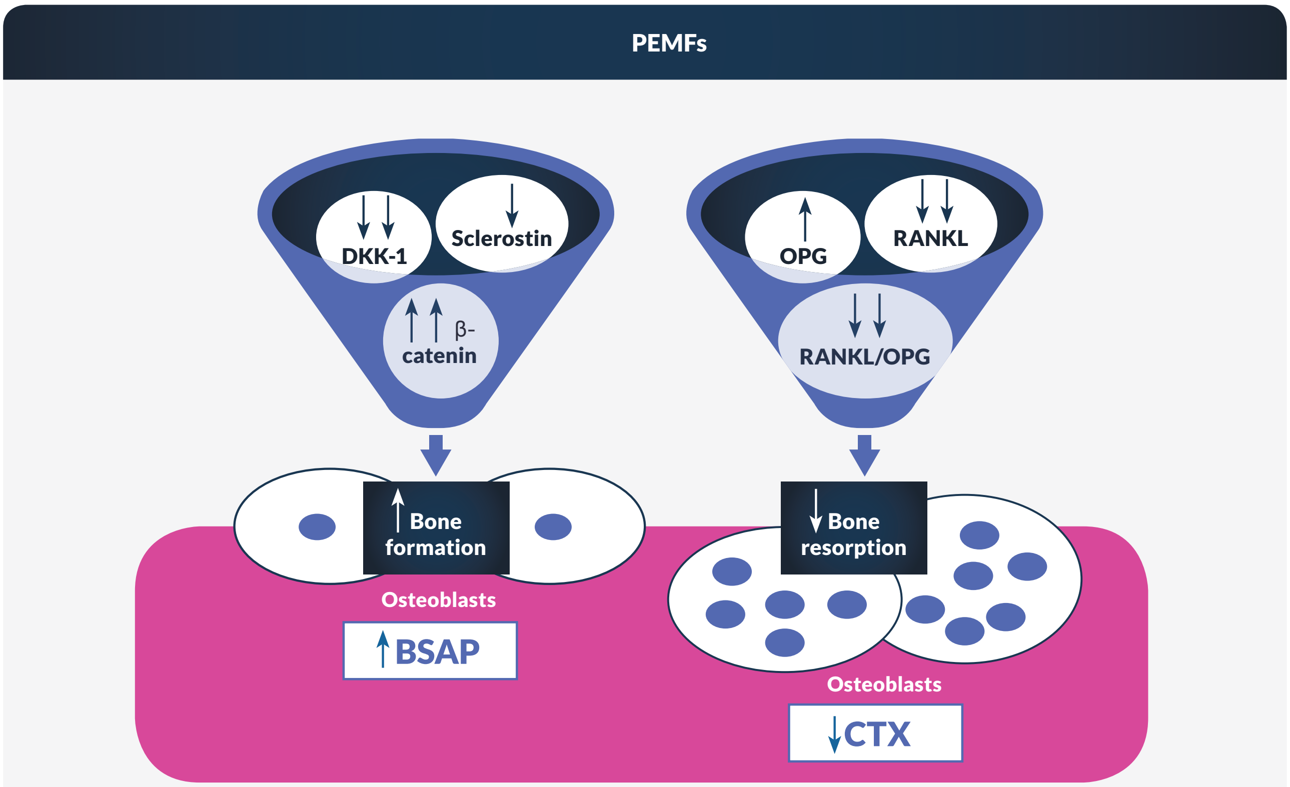
Signaling pathway	Role of PEMF stimulation
Ca^{2+}	Active
Wmt/β-catenin	Active
MAPK	Active
FGF	Active
VEGF	Active
TGF-β/BMP	Active
IGF	Active
Notch	Active
cAMP/PKA	Active



Pulsed electromagnetic fields modulate bone metabolism via RANKL/OPG and Wnt/β-catenin pathways in women with postmenopausal osteoporosis: A pilot study

Catalano A, Loddo S, Bellone F, Pecora C, Lasco A, Morabito N. Bone. 2018 Jul 16;116:42-46.

Pulsed electromagnetic fields (PEMFs) have been proven to enhance in-vitro and in-vivo osteogenesis but the mechanism remains unknown. This study explored whether RANKL/OPG and Wnt/β-Catenin pathways could be involved in bone response to PEMFs in postmenopausal osteoporotic women. Forty-three women (mean age 62.8 ± 4.5 yr.) were randomized into two groups. The PEMF group received PEMF treatment (50 min treatment session/day, 6 treatment sessions/week, for a total of 25 times), by wearing a custom gilet applied to the trunk and connected to the electromagnetic device (Biosalus, by HSD Srl, Serravalle RSM), whereas women assigned to the control group wore sham PEMFs with the same device. BSAP as bone formation and CTX as bone resorption markers, RANKL, OPG, β-Catenin, DKK-1 and sclerostin were obtained at baseline, after 30 and 60 days. In PEMFs group, BSAP levels increased significantly after 30 and 60 days while CTX concentrations decreased at day 60. RANKL levels decreased significantly after 60 days. OPG did not change significantly, but the RANKL/OPG ratio decreased significantly at day 30. DKK-1 levels decreased, whereas β-catenin concentrations increased after 30 and 60 days ($P < 0.05$). No significant changes in calcium, phosphorus, creatinine or sclerostin were detected. In the PEMFs group, at day 30, Δsclerostin was associated with ΔRANKL/OPG ratio ($r = -0.5$, $p. = 0.03$) and ΔDKK-1 was associated with Δβ-Catenin ($r = -0.47$, $p. = 0.02$). In women with postmenopausal osteoporosis, our data provide evidence of a PEMFs modulation of RANKL/OPG and Wnt/β-Catenin signaling pathways that may account for the metabolic effects of PEMFs on bone.



Arrows indicate the direction of modifications not statistical significance

Pulsed electromagnetic field stimulation may improve fusion rates in cervical arthrodesis in high-risk populations

Coric D, Bullard DE, Patel VV, Ryaby JT, Atkinson BL, He D, Guyer RD. Bone Joint Res. 2018 Feb;7(2):124-130.

OBJECTIVES: Pulsed electromagnetic field (PEMF) stimulation was evaluated after anterior cervical discectomy and fusion (ACDF) procedures in a randomized, controlled clinical study performed for United States Food and Drug Administration (FDA) approval. PEMF significantly increased fusion rates at six months, but 12-month fusion outcomes for subjects at elevated risk for pseudoarthrosis were not thoroughly reported. The objective of the current study was to evaluate the effect of PEMF treatment on subjects at increased risk for pseudoarthrosis after ACDF procedures.
METHODS: Two evaluations were performed that compared fusion rates between PEMF stimulation and a historical control (160 subjects) from the FDA investigational device exemption (IDE) study: a post hoc (PH) analysis of high-risk subjects from the FDA study (PH PEMF), and a multicenter, open-label (OL) study consisting of 274 subjects treated with PEMF (OL PEMF). Fisher's exact test and multivariate logistic regression were used to compare fusion rates between PEMF-treated subjects and the historical controls.
RESULTS: In separate comparisons of the PH PEMF and OL PEMF groups to the historical control group, PEMF treatment significantly ($p < 0.05$, Fisher's exact test) increased the fusion rate at six and 12 months for certain high-risk subjects who had at least one clinical risk; namely, age >50 or>65, a nicotine user, osteoporotic, or diabetic and for those with at least one clinical risk factor who had at least a two- or three-level arthrodesis.
CONCLUSION: Adjunctive PEMF treatment can be recommended for patients who are at high risk for pseudoarthrosis. Pulsed electromagnetic field stimulation may improve fusion rates in cervical arthrodesis in high-risk populations.

Table II. Fusion rates bby risk factor (nicotine use, osteoporosis, diabetes, and either age > 65 or > 50 years)

	6 months			12 months		
	OL PEMF	PH PEMF	Control	OL PEMF	PH PEMF	Control
Clinical risk factors, n (%)						
At least 1 RF4 (>65 yrs)	92/118 (78.0)*	61/70 (87.1)*	50/57 (65.8)	125/132 (94.7)*	67/69 (97.1)*	64/78 (82.1)
p-value	0.069	0.0033	N/A	0.0043	0.0033	N/A
At least 1 RF4 (>50 yrs)	151/200 (75.5)*	73/88 (83.0)*	57/90 (63.3)	201/217 (92.6)*	83/88 (94.3)*	76/92 (82.6)
p-value	0.036	0.0040	N/A	0.013	0.019	N/A
Number of levels, n (%)						
At least 1 RF4 (>65 yrs) and at least 2 levels	84/108 (77.8)*	37/44 (84.1)*	29/51 (56.9)	114/120 (95.0)*	41/41 (100)*	38/50 (76.0)
p-value	0.0088	0.0068	N/A	0.0006	0.0004	N/A
At least 1 RF4 (>65 yrs) and at least 3 levels	55/68 (80.9)*	7/12 (58.3)	3/10 (30.0)	73/75 (97.3)*	11/11 (100)*	50/11 (45.5)
p-value	0.0021	0.23	N/A	< 0.0001	0.012	N/A
At least 1 RF4 (>50 yrs) and at least 2 levels	141/185 (76.2)*	49/62 (79.0)*	36/65 (55.4)	186/200 (93.0)*	57/60 (95.0)*	50/64 (78.1)
p-value	0.0024	0.0051	N/A	0.0018	0.0081	N/A
At least 1 RF4 (>50 yrs) and at least 3 levels	87/114 (76.3)*	9/19 (47.4)	31/14 (21.4)	117/123 (95.1)*	17/19 (89.5)*	6/13 (46.2)
p-value	< 0.0001	0.16	N/A	< 0.0001	0.15	N/A

*Significant difference compared to the control group ($p<0.05$ Fisher's exact test)
*Marginally significant difference compared to the control group ($0.05 < p < 0.10$ Fisher's exact test)
OL, open-label; PEMD, pulsed electromagnetic field; PH, post hoc; RF4, risk factors (nicotine user, osteoporosis, diabetes, age > 65 years or > 50 years); N/A, not applicable

The effect of pulsed electromagnetic field exposure on osteoinduction of human mesenchymal stem cells cultured on nano-TiO_2 surfaces.

Bloise N, Petecchia L, Ceccarelli G, Fassina L, Usai C, Bertoglio F, Balli M, Vassalli M, Cusella De Angelis MG , Gavazzo P, Imbriani M, Visai L. PLoS One. 2018 Jun 14;13(6):e0199046.

Human bone marrow-derived mesenchymal stem cells (hBM-MSCs) are considered to hold great promise for bone repair and regeneration. Numerous efforts have been devoted to uncovering the best strategy to promote stem cells osteogenic differentiation. In previous studies, hBM-MSCs exposed to physical stimuli such as pulsed electromagnetic fields (PEMFs) or directly seeded on nanostructured titanium surfaces (TiO_2) were shown to improve their differentiation to osteoblasts in osteogenic conditions. In the present study, the effect of daily PEMF-exposure on osteogenic differentiation of hBM-MSCs seeded onto nanostructured TiO_2 (with clusters under 100 nm of dimension) was investigated. TiO_2-seeded cells were exposed to PEMF (magnetic field intensity: 2 mT; intensity of induced electric field: 5 mV; frequency: 75 Hz) and examined in terms of cell physiology modifications and osteogenic differentiation. Results showed that PEMF exposure affected TiO_2-seeded cell, osteogenesis by interfering with selective calcium-related osteogenic pathways, and greatly enhanced hBM-MSC osteogenic features such as the expression of early/late osteogenic genes and protein production (e.g., ALP, COL-I, osteocalcin and osteopontin) and ALP activity. Finally, PEMF-treated cells secreted higher amounts of BMP-2, DCN and COL-I into the conditional media than untreated cell cultures. These findings further confirm the osteoinductive potential of PEMF, suggesting that its combination with TiO_2 nanostructured surface might be a viable candidate for bone tissue engineering applications.

Osteogenic markers

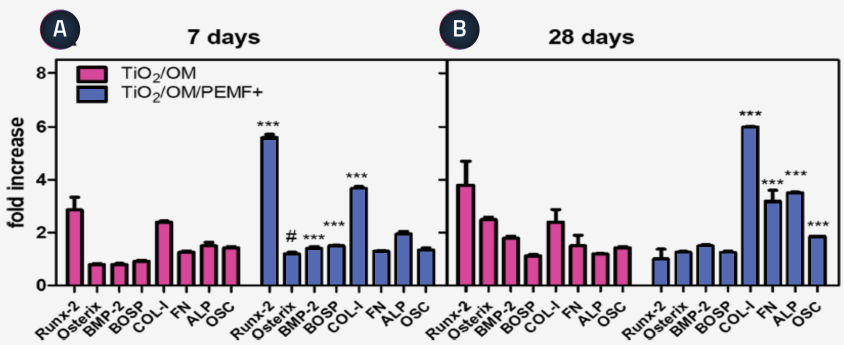


Fig 2. Gene expression of bone-specific markers as determined by qRT-PCR. hBM-MSCs were seeded and cultured in osteogenic medium on TiO2 nanostructured surface with/without PEMF stimulation 7 (A) and 28 (B) days, respectively. Abbreviations: *** p < 0.001 and # p < 0.05.

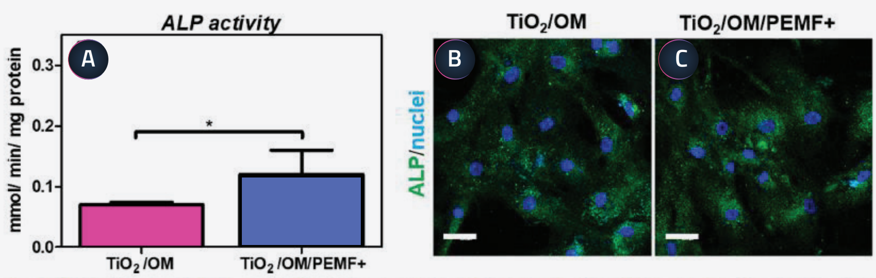


Fig 4. ALP activity (A) and immunolocalization (B) of hBM-MSCs cultured for 28 days onto TiO2 with/without PEMF stimulation. A) ALP activity detemined colorimetrically, corrected for the protein content measured with the BCA Protein Assay Kit and expressed as millimoles of *p*-nitrophenol produced per min per mg of protein. Bars express the mean values ± SEM of results from three measurements in two separate experiments (* p < 0.05). C). Immunolocalization of ALP followed with Hoechst 33342. Magnification 40X; the scale bar respresents 50 µm.

Effects of PEMF and glucocorticoids on proliferation and differentiation of osteoblasts.

Esmail MY, Sun L, Yu L, Xu H, Shi L, Zhang J. Electromagn Biol Med. 2012 Dec;31(4):375-81.

Pulsed electromagnetic fields (PEMF) can promote bone healing, whereas the use of dexamethasone induces bone loss and osteoporosis. There are no studies on the combined effects of PEMF and dexamethasone on the activity of osteoblasts. Here, we investigated the effects of PEMF and dexamethasone on the proliferation and differentiation of MC3T3-E1 osteoblasts. Our results showed that PEMF and dexamethasone respectively increased and decreased the proliferation of MC3T3-E1 osteoblasts, and that PEMF eliminated the effect of dexamethasone on MC3T3-E1 osteoblasts. Moreover, dexamethasone combined with PEMF upregulated the mRNA expression of IGF-1 at the early stage after the stimulation of PEMF and enhanced the decrease of COX-2 mRNA expression induced by dexamethasone in the late stage after the stimulation of PEMF. PEMF may be beneficial to remedying dexamethasone-induced bone loss and osteoporosis.

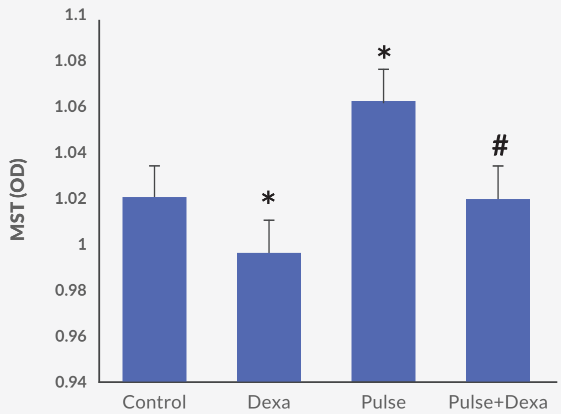


Fig 1. Combined effects of PEMF and dexamethasone on proliferation of MC3T3-E1 osteoblasts. Control, Dex, Pulde, and Pulde + Dexa, respectively, indicates the control group, dexamethasone (1μM) group, PEMF (15 Hz, 4 mT) stimulation group, and dexamethasone combined with PEMF stimulation group. Abbreviations: * indicates p. < 0.05 vs. control group and # indicates p. < 0.05

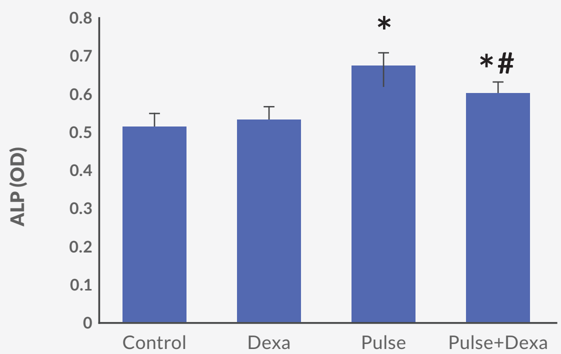
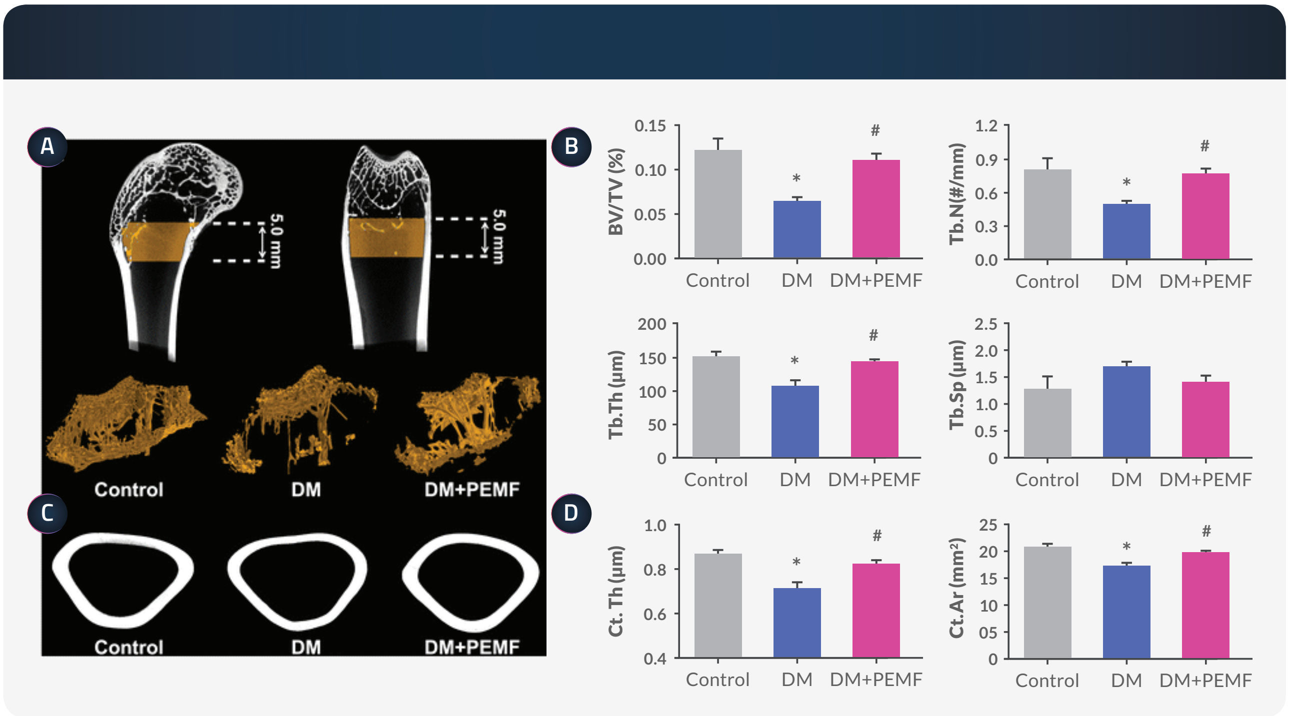


Fig 2. Combined effects of PEMF and dexamethasone on differentiation of MC3T3-E1 osteoblasts. Control, Dex, Pulde, and Pulde + Dexa, respectively, indicates the control group, dexamethasone (1μM) group, PEMF (15 Hz, 4 mT) stimulation group, and dexamethasone combined with PEMF stimulation group. * p. < 0.05 vs. control group and # indicates p. < 0.05 vs. Dexa group (n = 8).

Pulsed electromagnetic fields preserve bone architecture and mechanical properties and stimulate porous implant osseointegration by promoting bone anabolism in type 1 diabetic rabbits

Cai J, Li W, Sun T, Li X, Luo E, Jing D. Osteoporos Int. 2018 May;29(5):1177-1191.

The effects of exogenous pulsed electromagnetic field (PEMF) stimulation on T1DM-associated osteopathy were investigated in alloxan-treated rabbits. We found that PEMF improved bone architecture, mechanical properties, and porous titanium (pTi) osseointegration by promoting bone anabolism through a canonical Wnt/β-catenin signaling-associated mechanism, and revealed the clinical potential of PEMF stimulation for the treatment of T1DM-associated bone complications.
INTRODUCTION: Type 1 diabetes mellitus (T1DM) is associated with deteriorating bone architecture and impaired osseous healing potential; nonetheless, but effective methods for resisting T1DM-associated osteopenia/osteoporosis and promoting bone defect/fracture healing are still lacking. PEMF, as a safe and noninvasive method, has proven to be effective for promoting osteogenesis, whereas the potential effects of PEMF on T1DM osteopathy remain poorly understood.
METHODS: We investigated the effects of PEMF stimulation on bone architecture, mechanical properties, bone turnover, and its potential molecular mechanisms in alloxan-treated diabetic rabbits. We also developed novel nontoxic Ti2448 pTi implants with an elastic modulus closer to natural bone and investigated the impacts of PEMF on pTi osseointegration for T1DM bone-defect repair.
RESULTS: The deteriorations of cancellous and cortical bone architecture and tissue-level mechanical strength were attenuated by 8-week PEMF stimulation. PEMF also promoted osseointegration and stimulated more adequate bone ingrowths into the pore spaces of pTi in T1DM long-bone defects. Moreover, T1DM-associated reduction of bone formation was significantly attenuated by PEMF, whereas PEMF had no impacts on bone resorption. We also found PEMF-induced activation of osteoblastogenesis-related Wnt/β-catenin signaling in T1DM skeletons, but PEMF did not alter osteoclastogenesis-associated RANKL/RANK signaling gene expression.
CONCLUSION: PEMF improved bone architecture, mechanical properties, and pTi osseointegration by promoting bone anabolism through a canonical Wnt/β-catenin signaling-associated mechanism. This study enriches our basic knowledge of skeletal sensitivity in response to external electromagnetic signals, and also paves the way for new treatment alternatives for T1DM-associated osteopenia/osteoporosis and osseous defects in an easy and highly efficient manner.



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