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Pulsed electromagnetic fields increase osteogenic commitment of Mesenchymal stem cells via the mTOR pathway: an in-vitro study

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Background and Aim: Pulsed electromagnetic fields (PEMFs) have been considered a potential treatment modality for fracture healing. As bone fracture healing and osseointegration share the same biological events, the application of PEMF stimulation in order to facilitate the osseointegration process of dental implants has been suggested. However, the mechanism of their action remains unclear. Mammalian target of rapamycin (mTOR) signaling may affect osteoblast proliferation and differentiation. This study aimed to assess the osteogenic differentiation of mesenchymal stem cells (MSCs) under PEMF stimulation and the potential involvement of mTOR signaling pathway in this process.

Methods: PEMFs were generated by a novel miniaturized electromagnetic device (MED). 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.

Results: PEMF exposure increased cell proliferation and adhesion and the osteogenic commitment of MSCs even in inflammatory conditions. Osteogenic-related genes were overexpressed 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.

Conclusion: In summary, the findings of the present study revealed that MED-generated PEMFs stimulate osteogenic differentiation and the maturation of the adipose tissue-derived MSCs via activation of the mTOR pathways. Even though further research is required to determine an optimal stimulation timing and flux density both in vitro and in vivo, this study results may serve a source for an adjuvant therapy to improve a dental implant stability and longevity.

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Pulsed electromagnetic fields increase osteogenic commitment of mesenchymal stem cells in inflammatory conditions: an in-vitro study

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Background and Aim: The osteointegration process begins with an inflammatory stage followed by the migration of MSCs. One of the major goals of dental, orthopedic and maxillofacial surgery is to achieve good and rapid osteointegration between implants and bone. The main research strategies to reduce implant failure aim at improving biomaterial characteristics, or stimulating bone endogenous repair. Pulsed electromagnetic field (PEMF) is a non-invasive and safe treatment modality that stimulates biophysically an osseointegration process. To the best of our knowledge, no previous study had assessed the influence of PEMF irradiation on the production of cytokines in MSC cultures.

Methods: MSCs were seeded in an osteogenic medium and exposed to continuous PEMF treatment for different experimental times. PEMFs were generated by a novel miniaturized electromagnetic device (MED). Cell proliferation, adhesion and osteogenic commitment in normal and inflammatory conditions were assessed. Furthermore, we examined the influence of the PEMF on the aforementioned MSCs properties.

Results: MED generated PEMF induced a significant increase of in vitro expression of IL-10 (that exerts anti-inflammatory activity). Conversely, there was a reduction of expression of pro-inflammatory cytokines, such as IL-1, following PEMF treatment. There was no significant difference in expression of the other selected cytokines.

Conclusion: We demonstrated that PEMF exposure increased cell proliferation, adhesion and the osteogenic commitment of MSCs, even in inflammatory conditions. We showed that PEMFs increased the expression of anti-inflammatory cytokines, such as IL-10, and reduced the expression of the pro-inflammatory cytokine IL-1. In the presence of PEMF, MSCs provided not only cell sources for connective tissues, but also had a significant influence on the immune response. Clinical studies to elucidate the effects of MED generated PEMF on the dental implants stability and longevity are warranted.

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Role of bone window repositioning in lateral sinus floor elevation: comparative evaluation based on the preliminary results of an ongoing randomized, controlled trial

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Background and Aim: Application of resorbable membranes for lateral bony window coverage delivers favourable results in sinus floor elevation. The piezoelectric approach allows repositioning of the sinus bony wall. Our aim was to present preliminary clinical results of an ongoing prospective, randomized, controlled trial on sinus bony wall repositioning compared to rotary window preparation with membrane coverage.

Methods: 39 patients with at least one missing maxillary premolar/molar were treated by lateral maxillary sinus floor augmentation. Patients were randomized to Test (14 patients): piezoelectric window preparation (NSK Variosurg 3), bony wall repositioning. Control (15 patients) rotary window preparation, resorbable collagen membrane coverage (Botiss Collprotect). A particulate xenograft (Botiss Cerabone) was utilized in both groups. Following parameters were registered: duration of surgery, bony window, sinus mucosa preparation; percentage of sinus perforations; postoperative patient complaints by visual analogue scale (VAS); number of non-steroid inflammatory drugs (NSAID) taken.

Results: Duration of surgery was 44 ± 11 min in test compared to 49 ± 11 min in control. Duration of window preparation was 4.59 ± 1.37 min in test compared to 6.22 ± 3.66 min in control. Duration of mucosa elevation was 5.0 ± 1.97 min in test compared to 6.56 ± 3.2 min in control. Percentage of sinus perforations was 17% in test compared to 33% in control. Postoperative patient complaints subjectively evaluated by VAS demonstrated lower morbidity in test compared to control.