Pulsed electromagnetic fields increase osteogenetic commitment of MSCs via the mTOR pathway – an in-vitro study

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Background: 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.

Aim/Hypothesis: 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.

Material and 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 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.

Conclusions and Clinical Implications: 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 as a source for an adjuvant therapy to improve a dental implant stability and longevity.