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Perspective

Electromagnetic Field Treatment in Mesenchymal Stem Cells under Osteogenic Induction

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DESCRIPTION

Osteoporosis is a disease which means porous bone in which the density and quality of bone are reduced. Worldwide, millions of people suffer from osteoporosis, with postmenopausal women making up the majority of these patients. It is characterised by decreased bone mass and microstructural bone tissue deterioration, which increases bone fragility and raises the risk of fracture. Dietary and lifestyle adjustments, as well as pharmaceutical medicines including teriparatide, denosumab, and bisphosphonates, are common treatments for osteoporosis; however, these interventions are constrained by a number of adverse effects, a high price tag, and low patient compliance. Though the exact pathophysiology of osteoporosis is unknown, there is mounting evidence that structural abnormalities in osteoporosis bones are mostly caused by dysplasia of Bone Marrow Stromal Cells (BMSCs). After being cultured with the proper hormone inducers or growth factors under the right circumstances, BMSCs are self-renewable, multipotent stem cells that can be differentiated into multiple lineages of chondrocytes, osteoblasts, adipocytes, and other mesenchymal tissues. Osteoporosis results from the decoupling of osteoblast and osteoclast activity as well as the imbalance between BMSCs' osteogenic differentiation and adipogenic differentiation.

In recent decades, Electromagnetic Field (EMF) therapies have gained popularity as a clinically secure, efficient, and noninvasive treatment. EMF therapy is frequently utilised in the field of orthopaedics to treat musculoskeletal conditions like osteoarthritis and rheumatoid arthritis as well as bone fractures. The Food and Drug Administration in the USA authorised pulsed EMF therapy as a secure and efficient procedure for treating fractures with delayed union or nonunion based on pre-clinical investigations and prospective clinical trials. EMFs have been widely documented in recent years to have a good impact on the balance of mesenchymal stem cells' differentiation into osteoblasts and adipocytes as well as the balance between bone creation and bone resorption, both of which are essential elements in the emergence of osteoporosis. These studies suggested that EMFs could be utilised to treat osteoporosis. The osteogenic development of BMSCs was directly triggered or accelerated by EMF treatment, according to earlier investigations. However, it is still unclear exactly how EMFs cause or quicken MSC differentiation into osteoblasts.

As soluble substances that are released into the cellular matrix in response to mechanical stimuli, extracellular nucleotides like ATP and UTP signal in an autocrine or paracrine way by specifically binding cell surface P2 receptors. Extracellular nucleotides are increasingly being shown to be crucial to bone metabolism. P2 purinergic receptors in mammalian cells can be divided into two groups based on their molecular makeup and signal pathway activation. There are seven P2X subtypes and eight P2Y subtypes.

In particular, mechanical transduction and bone remodelling are tightly related to the purinergic receptor P2X7, a ligand-gated ion channel. When P2X7 is knocked out, long bones develop less periosteal bone, but there are no appreciable differences in bone length or trabecular bone resorption. This results in an osteopenic phenotype. Additional *in-vivo* loading studies revealed that these animals have decreased skeletal responses to mechanical stress and lower long bone appositional development. Since then, research conducted *in vitro* has shown that shockwaves promote osteogenic differentiation of human mesenchymal stem cells by releasing ATP and activating P2X7. Mesenchymal stem cells generated from postmenopausal bone marrow are supported in osteogenesis and mineralization by membrane blebbing brought on by P2X7.

CONCLUSION

EMF exposure and P2X7 expression in MSCs undergoing osteogenic differentiation have not yet been linked, nevertheless. The expression of P2X7 increased following EMF exposure. Additionally, the Akt/GSK3/-catenin axis was involved in the enhanced P2X7 expression's contribution to MSC osteogenic differentiation. P2X7 agonists were used to enhance the therapeutic effects of EMF in osteoporosis.

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