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Can Static Magnetic Field and Gingerol Improve Osteogenic Property?

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ABSTRACT

INTRODUCTION

Static magnetic fields (SMF), which have a constant magnetic field strength and direction, have a long history. Numerous studies show that exposure to mild SMF (1 mT) can boost bone density and mass. In recent years, researchers have been investigating alternative approaches to enhance bone formation and promote osteogenic properties. Osteoporosis and bone-related disorders pose significant health challenges worldwide, leading to fractures, impaired mobility, and reduced quality of life. Promoting osteogenesis, the process of bone formation is of great importance in developing strategies for bone tissue engineering and regenerative medicine. Gingerol is a bioactive compound found in ginger and is responsible for its characteristic flavor and aroma. Like ginger, gingerol has been studied for its potential effects on various aspects of health, including bone formation. Gingerol has been shown to increase the expression of genes related to osteoblast differentiation and mineralization, suggesting a potential role in promoting bone formation.

AIM AND OBJECTIVE

To study whether static magnetic field and gingerol in combination have a positive effect on the osteogenic property of human osteoblastic cells under in vitro

MATERIALS AND METHODS

Human MG63 cells were procured from NCCS Pune, India. The cells were maintained under normal culture conditions with 5% carbon dioxide and 10% FBS containing DMEL medium. The cells were trypsinized and passaged for further use. The viability and cell morphology were assessed to check the cell viability.

Treatment protocol:

The cells were exposed to 25 millitesla of static magnetic field by using neodymium magnets and simultaneously exposed to gingerol of 2.5 millimolar concentration for a period Again, for specific time points.

RESULT

This study shows that static magnetic fields and gingerol in combination improves the osteogenic property

CONCLUSION

Assessing the clinical applicability of static magnetic fields and gingerol in patients with compromised skeletal health, such as osteoporosis or bone fractures, is an important future direction. Conducting well-designed clinical trials with appropriate patient populations and outcome measures will help determine the therapeutic potential of these interventions.

KEYWORD

Static magnetic field, Gingerol, Ginger extract, Osteogenesis, Bone formation, Bone regeneration

INTRODUCTION

Static magnetic fields (SMF), which have a constant magnetic field strength and direction, have a long history. (1)These magnetic fields have shown potential in enhancing bone healing and promoting osteogenesis in both in vitro and in vivo models. (2)Static magnetic fields have been reported to influence cellular behaviors, including proliferation, differentiation, and mineralization, in various cell types, including osteoblasts and mesenchymal stem cells (MSCs). (3)These magnetic fields have shown potential in enhancing bone healing and promoting osteogenesis in both in vitro and in vivo models. Numerous studies show that exposure to mild SMF (1 mT) can boost bone density and mass. In recent years, researchers have been investigating alternative approaches to enhance bone formation and promote osteogenic properties.Static magnetic fields have been reported to influence cellular behaviors, including proliferation, differentiation, and mineralization, in various cell types, including osteoblasts and mesenchymal stem cells (MSCs). These magnetic fields have shown potential in enhancing bone healing and promoting osteogenesis in both in vitro and in vivo

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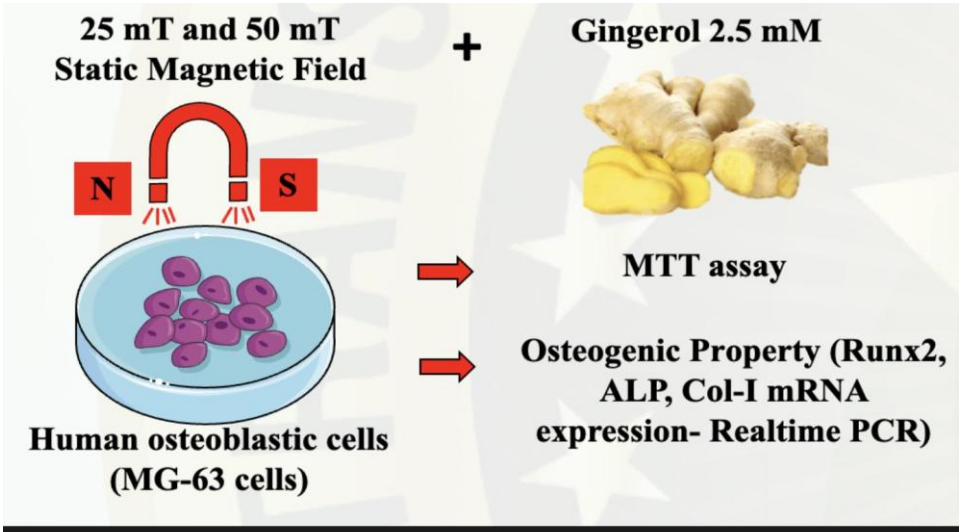
models. (2)However, further investigation is needed to understand the underlying mechanisms and optimize their application in bone tissue engineering.(2,4)

Gingerol is a bioactive compound found in ginger and is responsible for its characteristic flavor and aroma.In addition to physical interventions, natural compounds with potential therapeutic properties have gained attention in the field of bone regeneration. Similar to ginger, gingerol has been studied for its potential effects on various aspects of health, including bone formation.(1,5) Some research suggests that gingerol may have positive effects on bone formation and bone health. (6)It has been found to stimulate osteoblast activity,which are the cells responsible for bone formation.Gingerol has been shown to increase the expression of genes related to osteoblast differentiation and mineralization, suggesting a potential role in promoting bone formation.(1,5,7)Gingerol(Zingiber officinale), has been reported to exhibit multiple pharmacological effects, including anti-inflammatory, antioxidant, and anticancer activities. Emerging evidence suggests that gingerol may also have osteogenic potential, stimulating osteoblast differentiation and mineralization. (8)However, the effects of gingerol on osteogenic properties, particularly in combination with physical interventions like static magnetic fields, have not been extensively studied(9).

Osteoporosis and bone-related disorders pose significant health challenges worldwide, leading to fractures, impaired mobility, and reduced quality of life(10). Promoting osteogenesis, the process of bone formation, is of great importance in developing strategies for bone tissue engineering and regenerative medicine. Recent studies have shown that physical and chemical interventions can modulate the osteogenic potential of cells, providing avenues for enhancing bone formation.(11)(12)The findings from this study may contribute to the development of novel approaches for enhancing bone formation and provide insights into the mechanisms underlying the osteogenic effects of static magnetic fields and gingerol.(9).
Our aim is to study whether static magnetic field and gingerol in combination have positive effect on the osteogenic property of human osteoblastic cells under in vitro.

MATERIALS AND METHODS



Overall methodology followed in the study

Human MG63 cells were procured from NCCS Pune, India. The cells were maintained under normal culture conditions with 5% carbon dioxide and 10% FBS containing DMEL medium. The cells were trypsinized and passaged for further use. The viability and cell morphology was assessed to check the cell viability.
Treatment protocol:
The cells were exposed to 25 millitesla of static magnetic field by using neodymium magnets and simultaneously exposed to gingerol of 2.5 millimolar concentration for a period Again, for specific time point

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RESULT

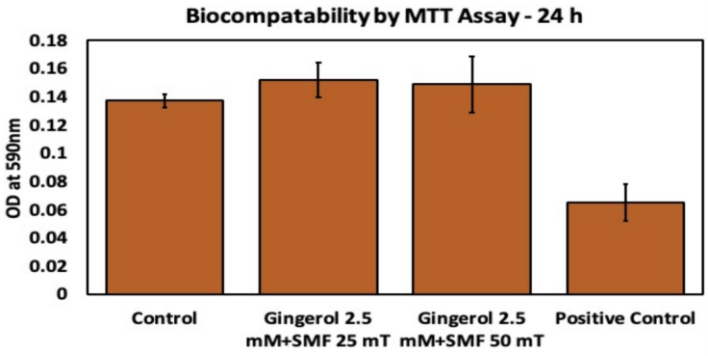

FIGURE 1: represents the biocompatibility for MTTassay for 24 hours.The x - axis represents the control group and the concentrations of Gingerol 2.5mM+SMF 25 mT,Gingerol 2.5mM+SMF 50 mT,Positive Control and the y- axis represents the OD at 590nm.

Initially, we wanted to assess the biocompatibility of gingerol and SMF treatment on osteoblastic cells. So we exposed human osteoblast to 2.5 millimolar of gingerol and 25 and 50 millitesla of static magnetic field for a period of 24 hours and MTT assay was performed. The results are presented in figure 1. Figure 1 clearly depicts that there were no significant toxicity or reduction in cell viability observed in the treatment groups. This indicates that both gingerol and SMF treatment are completely safe for the cells.

FIGURE 2: represents the changes in Runx2 expression .The x - axis represents the control group and the concentrations of Gingerol 2.5mM+SMF 25 mT,Gingerol 2.5mM+SMF 50 mT and the y- axis represents the fold changes.

Next we wanted to assess whether the treatment modality has any change in the osteogenic activity of human osteoblastic cells.

So we exposed the cells to gingerol and static magnetic fields of 25 mT and 50 mT concentration and we assessed the Runx2 expression. The Runx2 expression real-time RT-PCR analysis was carried out and the Runx2 expression is clearly depicted in figure 2.

Figure 2 indicates that there was significant increase in the expression level of Runx2 following gingerol and SMF treatment. The expression was further enhanced when the SMF, the static magnetic field, the SMF was increased to 50 millitesla when compared to the control.

So this indicates that both gingerol as well as SMF have an osteogenic role on osteoblastic cells.

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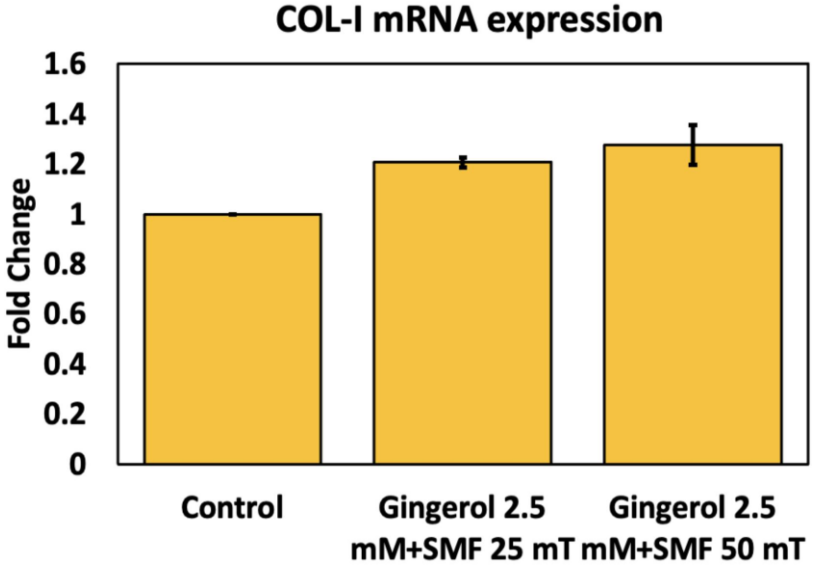

FIGURE 3: represents the COL-1 mRNA gene expression. The x - axis represents the control group and the concentrations of Gingerol 2.5mM+SMF 25 mT,Gingerol 2.5mM+SMF 50 mT and the y- axis represents the fold changes. We assess the collagen 1 mRNA and alkaline phosphatase mRNA.Both the collagen followed the same trend as compared to Runx2.

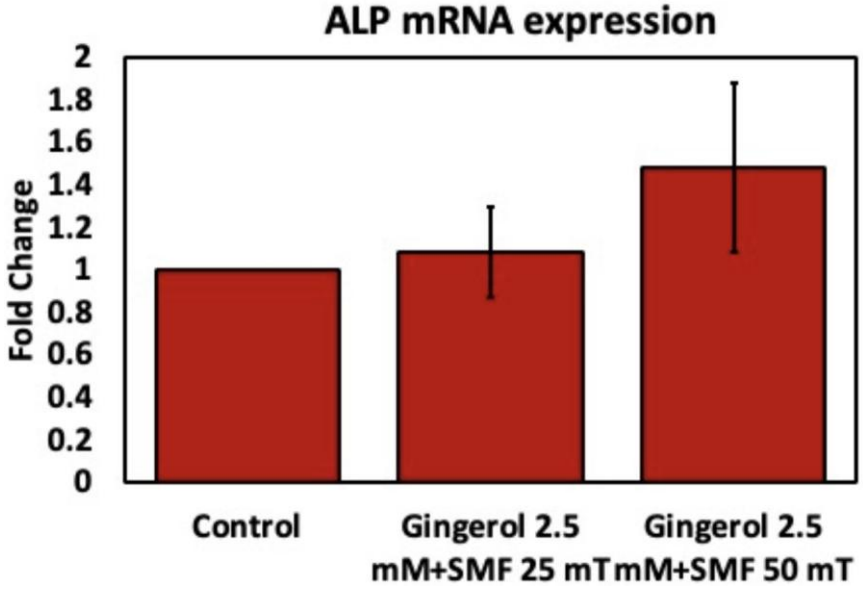

FIGURE 4 : represents the ALP mRNA gene expression. The x - axis represents the control group and the concentrations of Gingerol 2.5mM+SMF 25 mT,Gingerol 2.5mM+SMF 50 mT and the y- axis represents the fold changes.It was noted that the on increasing the concentration of gingerol and static magnetic field improves the osteogenic property.
In case of ALP, there was no significant change in 25 millitesla of static magnetic field. Whereas, there was significant increase in the expression of ALB by increasing the static magnetic field of 50 millitesla.

Magnetic Fields and Bone Growth:
Several investigations have explored the possible influence of EMFs on bones.Nevertheless, the evidence is inconsistent in that more researches may be required to make a definite linkage between the bones and magnetic fields.
Pulsed electromagnetic fields can be used through different devices for diverse therapeutic functions, such as ossification, and fissures reconstruction. However, these instruments are sometimes utilized in clinical settings, but the effectiveness is not accepted everywhere.

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Gingerol and Bone Health:
This bioactive compound is called gingerol and it is found in ginger. It has been shown to possess anti-inflammatory as well as antioxidative properties.
The beneficial properties of gingerol towards general well being and inflammation are known to exist. Some researchers believe there may be an inflammatory effect of ginger which would indirectly improve bone health.

DISCUSSION
SMF was varied and Gingerol concentration remained the same throughout the study and found to be non-toxic at all the tested SMF strengths in osteoblastic cells.(13)
SMF at 50mT significantly enhanced the expression of Runx2, Collagen-1 and ALP in osteoblasts under osteogenic conditions for a period of 3d. Previous studies indicate that the activities of the early marker ALP and the late markers matrix mineralization and calcium content, as well as osteoblast- and cementoblast-specific gene expression in osteoblasts, PDLCs, and cementoblasts were enhanced.(14) Gingerol is known up regulate the expression of osteoblast differentiation marker genes and mineralization process in vitro. (15)Our results were also aligned with the previous research works(16). We report that a combination of SMF and gingerol is more advantageous over the use of single regimens to improve bone formation.
This can be done carrying out standardized study protocols that will ultimately lead to the creation of the right guidelines for the use of static magnetic fields as a means of improving the osteogenic property. (17)
The combination of SMFs and gingerol may have synergistic effects on osteogenic characteristics. Gingerol may include other bioactive substances supporting bone health as SMFs might accelerate various cellular acts.(18) (19)However, the best operational parameters for SMFs (intensity, duration, ete.) as well as the proper concentration of gingerol supporting the osteogenesis requires further delineation.Interaction of SMFs with biological active substances like gingerol is complicated and might influence experimental conditions.(20)(21)More investigation into their combined effect on osteoblastic differentiation and bone mineralization is required. This would involve in vivo experiments followed by clinical trials.(16)
For example, the present study involves different kinds of static magnetic fields, various durations of exposure and a broad spectrum of gingerol concentrations resulting from heterogeneous Study Designs. Heterogeneity here makes it hard to come up with general statements and may explain variances in the outcomes.(17)
Limited Clinical Evidence: Notably, several clinical trials have taken place in vitro or animal models, yet they lack sufficient strong clinical trials to establish the effects of SMF's constituents or gingerol on human osteogenesis. Extensive clinical validation is necessitated by translations of findings from laboratory settings to real-world clinical trials. (22)Optimal Parameters Uncertainty: The right dose, span, and the appropriate frequency in cases of SMFs (optimal exposure parameters) are not that obvious. Such an absence of standardization hinders providing well defined prescriptions for everyday implementations.(22)
Gingerol Variability: The concentration of gingerols is dependent on the type of ginger as well as processing methodology. However, there is no uniform way of administering gingerol hence it is difficult to compare results in different studies.(23)
Long-Term Effects and Safety: Not many studies have been conducted on the long-term implications of gingerol intake and SMFs. Moreover, most researches focus on short-term impacts. Thorough investigations are required in safety profiles, side effects, as well as interactions with other drugs.(24)
Individual Variability: The response of different people to SMFs and gingerol will depend on some factors including the unique genes of each person, existence of other diseases or health problems. Coming up with specific approach aimed at tackling such a problem in individuals is not an easy task.(21,25)

CONCLUSION
Assessing the clinical applicability of static magnetic fields and gingerol in patients with compromised skeletal health, such as osteoporosis or bone fractures, is an important future direction. Conducting well-designed clinical trials with appropriate patient populations and outcome measures will help determine the therapeutic potential of these interventions. Lastly, there is a very intricate scenario behind the investigation of how SMF and gingerol affect osteogenic capacities. The existence of static magnetic fields is potentially capable of manipulating the behavior of osteoblasts however literature has various contradictions therefore more study needs to be carried out on optimized parameters for best effects and how they work.However, gingerol, an active substance formulated from gingers Moreover, its anti-inflammatory properties give some interesting perspectives about their potential as remedies related to the inflammation-derived bone loss. Still, these studies are still early phases regarding SFM's and gingerol's investigations. For example, a number of issues need more exploration like the long term consequences, clinical viability, and potential interactions with other approaches. Filling in these gaps will formulate a crucial path to transforming these findings into effective therapeutic approaches to improve bone health.

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