The Development of PCL/Graphene 3D Scaffold for Enhancing Osteoinductive

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1. ABSTRACT

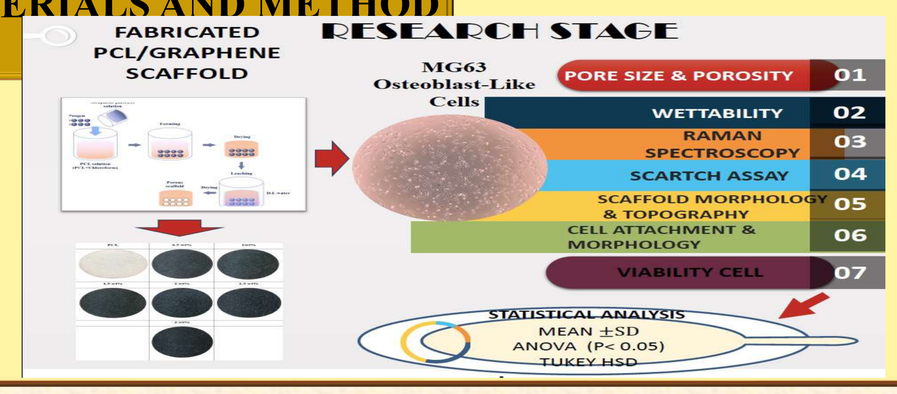
Introduction
Scaffolds provided a surface on which cells could attach, proliferate, and differentiate. Due to the osteogenic and regenerative capabilities of PCL/graphene, it could be used to produce bone tissue engineering scaffolds. The purpose of this study was to investigate the ability of PCL/graphene to enhance the osteoinductive mechanism.
Materials and Methods
The PCL/graphene scaffold was developed utilizing a particulate-leaching process and cultured with MG63 cell-like osteoblast cell lines at 0.5, 1.5, and 2.5 wt% of graphene. We evaluated the porosity, pore size, wettability, scaffold morphology and topography, chemical characteristics, migratory cells, viability cells, cell attachment, and morphology of the scaffold.
Results and Discussions
Graphene enhanced the biocompatibility of the scaffolds, and 2.5 wt% of graphene exhibited good characteristics over other concentrations.
Conclusion
This finding suggests that PCL/graphene composites may have potential applications in bone engineering.

Keywords: PCL, Graphene, Scaffold, Particulate-leaching method, Biocompatibility

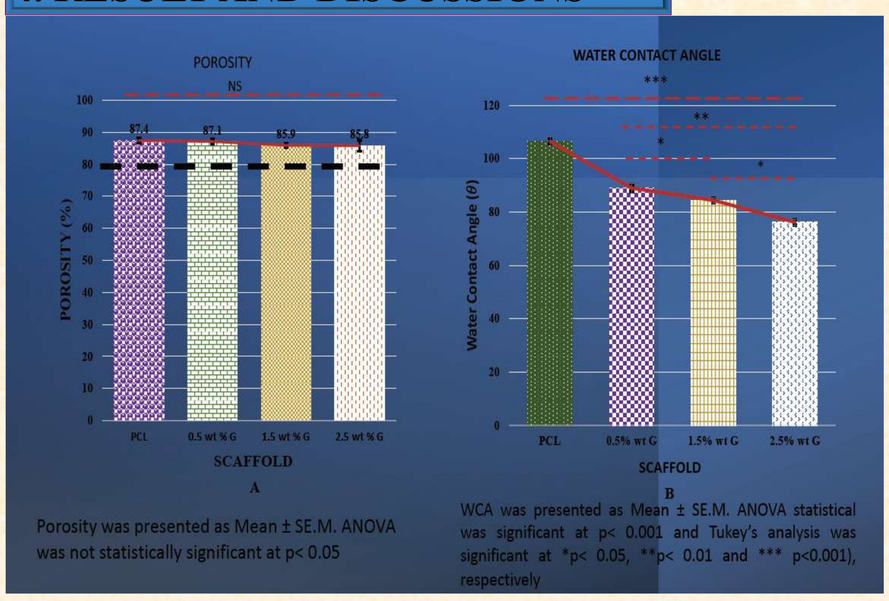
2. INTRODUCTION

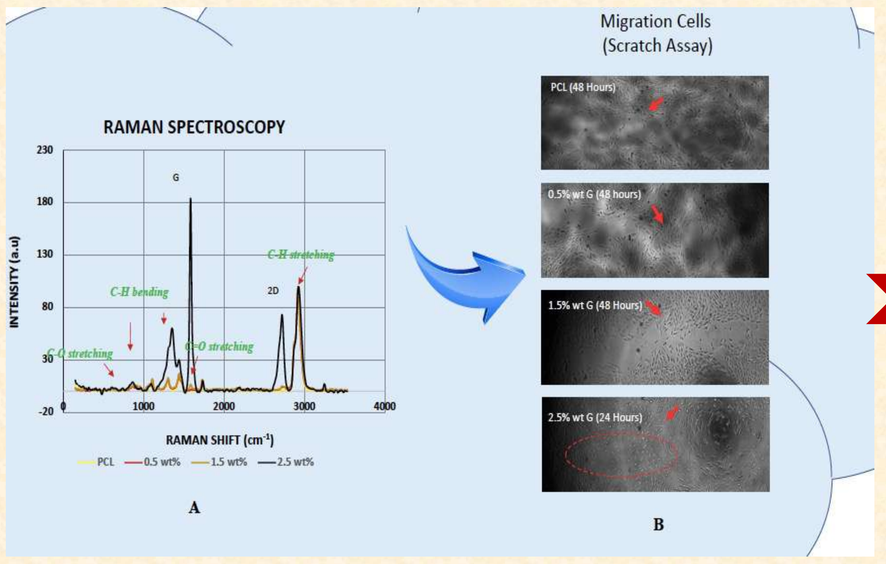
Bone reconstruction or regeneration often requires a biodegradable scaffold with a porous structure, as a scaffold generally controls the growth of cells that have migrated from surrounding tissue or were seeded within the scaffold's porous structure. Wherever cells adhere and proliferate, they are influenced by a variety of elements, including their physical and chemical properties. According to previous studies, graphene can enhance the mechanical and electrical properties of biomaterials while increasing cellular attachment and growth on the surface of biomaterials. It's because adding graphene to another biodegradable material such as PCL can stimulate cell growth via electrical signaling from graphene.
Objective: This work examined the effects of various graphene concentrations (0.5, 1.5, and 2.5% wt G) on the physical, chemical, and biological properties of a PCL/graphene biomedical scaffold.(1,2)

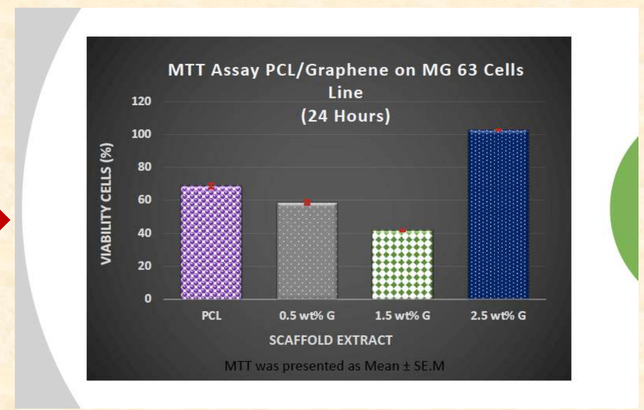
3. MATERIALS AND METHOD



4. RESULT AND DISCUSSIONS







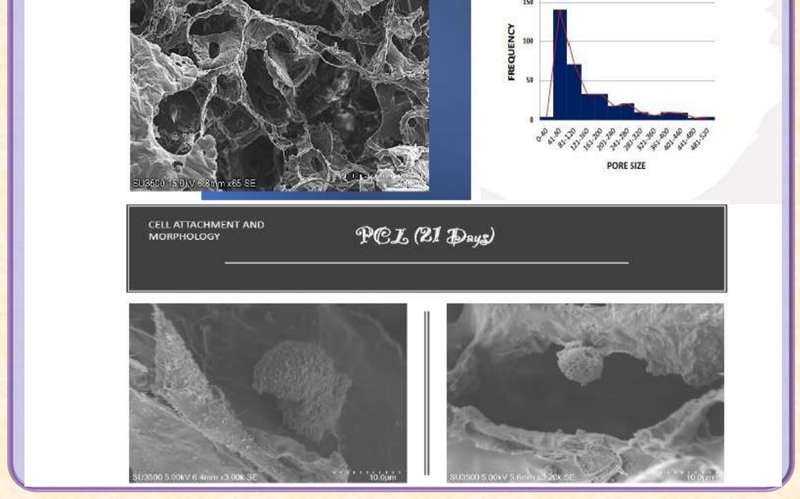
In this study, the total porosity of the scaffolds was determined using a liquid displacement method. The structures had a total porosity of more than 85%. When compared to the cancellous scaffolds (average porosity 79.3%), the porosity of the scaffolds is ideal (A).(2,3)

By adding graphene to PCL, the hydrophilicity of the scaffold was increased by lowering the water contact angle. Because it facilitated cell adherence to the scaffolds' surface, hydrophilicity was well-established as a critical element influencing cell response. Cell adhesion was strongest between contact angles of 60 and 80 degrees (B).(1,4)

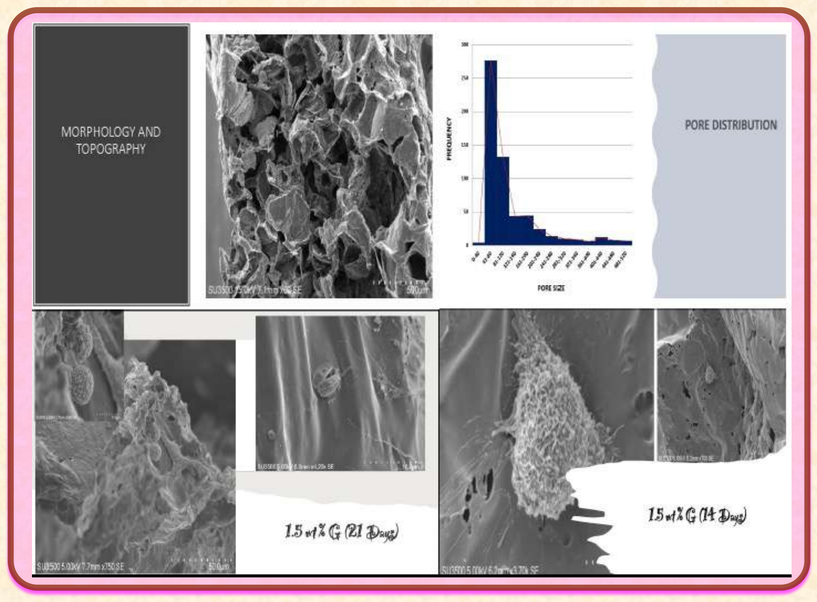
With increasing graphene content, the PCL peaks become less apparent as the intensity of the graphene's characteristic D (1350 cm^{-1}) and G bands (1620 cm^{-1}) increases, leaving only the D and G band graphene peaks visible. The ratio of the graphene D and G band intensities (I_D/I_G) falls marginally with increasing graphene content. This is because the composite's crystalline size decreases as the graphene content increases (A)(5,6)

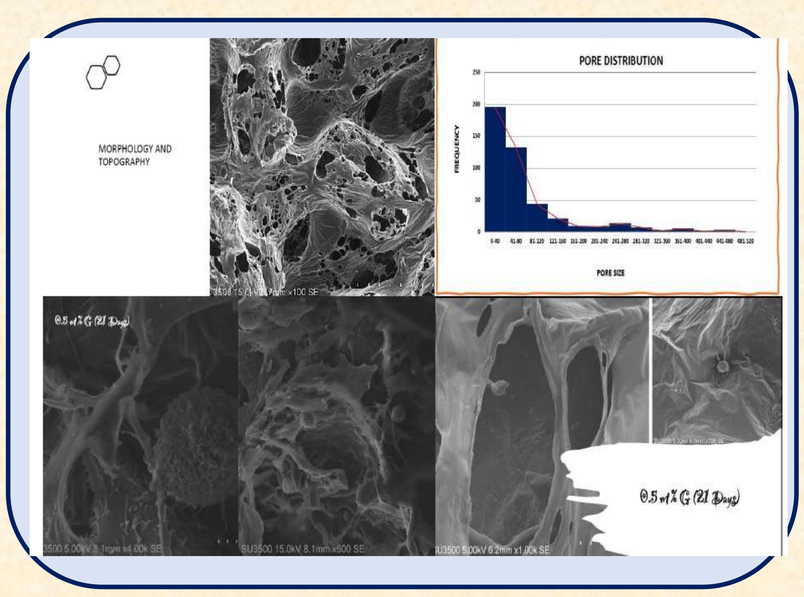
Cell migration and proliferation are required for a range of physiological and pathological processes, including wound healing, revascularization, cartilage regeneration, and bone regeneration. Cell migration can be induced by biochemical and biophysical cues such as the mechanical properties of matrix, peptides, and growth factors in an immobilized and free form, respectively, which are referred to as mechanotaxis, haptotaxis, and chemotaxis. Two types of biomaterials have been used to facilitate cell migration; one is scaffolds, which have a predetermined architecture, however cell infiltration is more difficult with scaffolds.(2,4)

We confirmed the biocompatibility of the PCL/graphene scaffold in this study by demonstrating that osteoblast-like MG63 cells can adhere to, survive on, and proliferate on it. The study indicated that increasing the concentration of graphene could result in an increase in cell viability.(1,5)



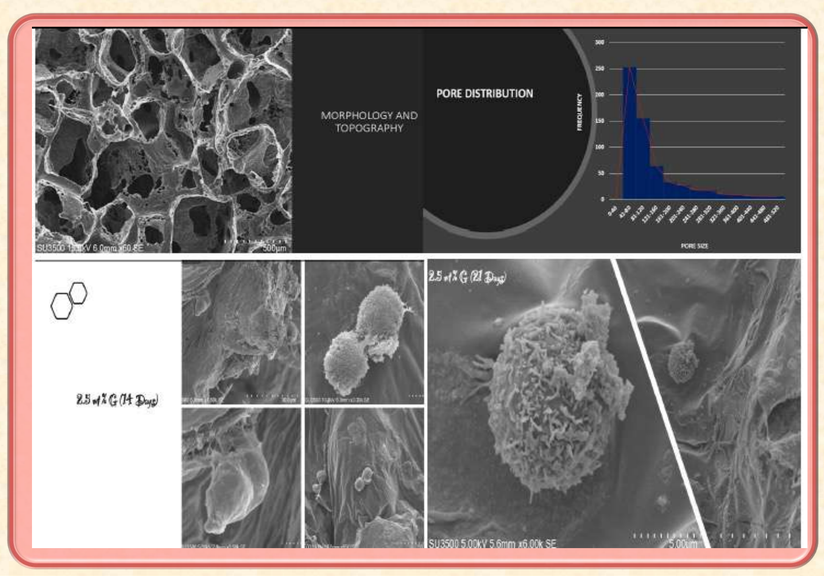
It is well established that the pore size of scaffolds has a critical role in cell adhesion, migration, ingrowth, and regeneration. In general, it has been reported that the large pore size or porosity of the scaffold enables efficient nutrition delivery, gas diffusion, and metabolic waste disposal but results in low cell attachment and intracellular signaling. While a small pore size or porosity can have the opposite effect of the foregoing, The ideal pore size is near to the diameter range (100-400 µm), which is regarded optimal for cell infiltration, new vessel formation, and appropriate nutrition, oxygen, and waste metabolism exchange.(4,7)





In fact, when graphene concentration grew, the total number of pores increased, and this approach revealed a wide range of pore diameters, ranging from 81 to 120 µm.(7)

It was sufficient for cell ingrowth because the pores needed to be large enough to allow for efficient nutrient supply and waste removal, both of which were required for optimal cell growth, yet small enough to establish a sufficiently large surface area for efficient cell attachment to the scaffold. However, when graphene was added, the surface area increased.(3,4,5)



5. CONCLUSIONS

PCL/graphene 3D scaffold is a promising candidate for guided bone regeneration due to its porosity, pore size, chemical properties, and biocompatibility, all of which encourage cell migration and ingrowth.

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