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BMP7-Modified Polycaprolactone Nanofibrous Scaffolds Improve Osteoblast Activity

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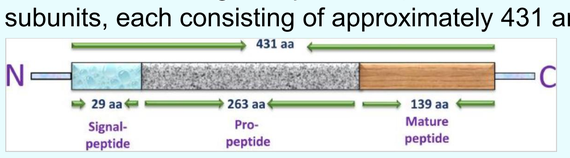
INTRODUCTION & AIM

- Effective biomaterial integration with host bone cells remains a significant problem in the field of regenerative medicine (1-3)
- Biomaterials that act as both biological stimulants and structural scaffolds are required for bone healing (1-3)
- The polymer polycaprolactone (PCL) is strong enough to maintain its structure on its own but lacks inherent osteo-inductive properties (1-3)
- One potential bioactive component for bone regeneration is Bone Morphogenetic Protein-7 (BMP7).
- BMP7, also termed osteogenic protein 1, is a homodimer protein composed of 2 identical subunits, each consisting of approximately 431 amino acids (4).



- Holds a pivotal role in diverse biological processes, including embryogenesis, tissue development, and maintenance of homeostasis and is known to regulate osteoblast activity (4).

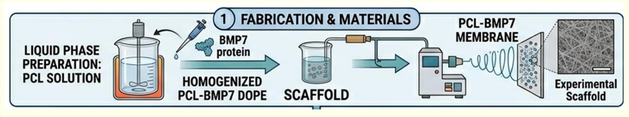
Aim

- To create BMP7-integrated PCL scaffold/membrane (PCL-BMP7) and evaluate their biological effects on MC3T3-E1 osteoblast cells.

METHOD

1. Scaffold (membrane) Fabrication:

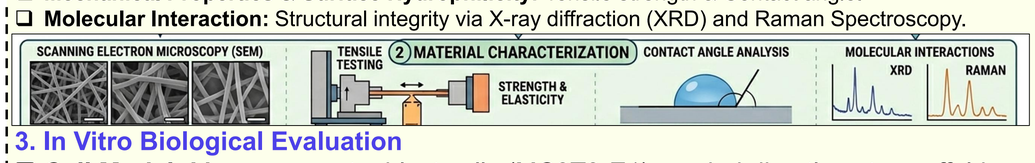
- Polymer Solution: 11wt% Polycaprolactone (PCL) dissolved in an organic solvent (DMSO & Chloroform)-10ml
- Bio-modification: Recombinant human BMP7 protein (20ug) added into the liquid PCL solution-10ml



Groups:
Control Group: PCL dissolved in organic solvent **(PCL-Ct)**
Experimental Group: PCL dissolved in organic solvent with BMP7 **(PCL-BMP7)**

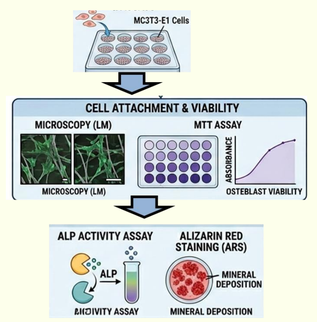
2. Material Characterization

- **Morphology & elemental mapping:** Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray Spectroscopy (EDS)
- **Mechanical Properties & Surface Hydrophilicity:** Tensile strength & Contact angle.
- **Molecular Interaction:** Structural integrity via X-ray diffraction (XRD) and Raman Spectroscopy.



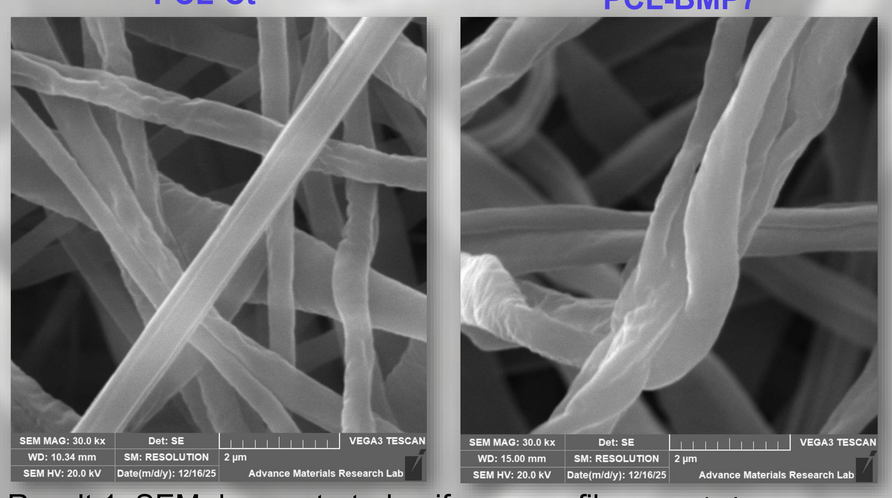
3. In Vitro Biological Evaluation

- **Cell Model:** Mouse pre-osteoblast cells (MC3T3-E1) seeded directly onto scaffolds.
- **Biocompatibility Assays:**
  - ✓ **Attachment:** Visualized via SEM and light microscopy.
  - ✓ **Viability:** Quantified via 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT Assay) 24, 72hrs
- **Osteogenic Differentiation Assays: ALP and Alizarin red staining.**
- **Statistical Analysis**
  - ✓ Data analyzed using One-Way ANOVA followed by Tukey's post-hoc tests ($p < 0.05$ considered significant).



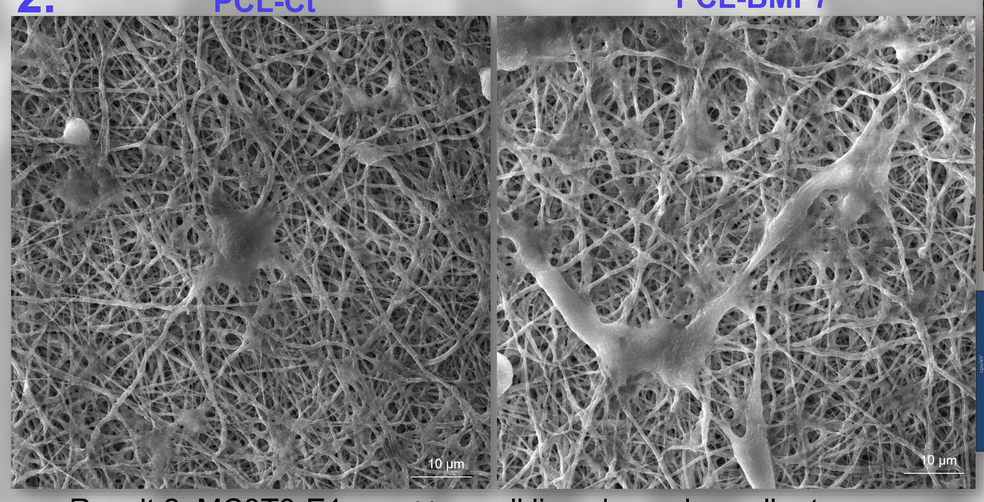
RESULTS & DISCUSSION

1. PCL-Ct | PCL-BMP7



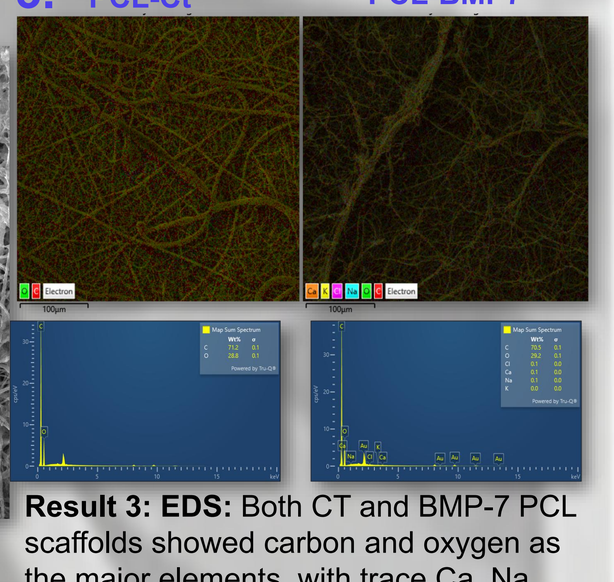
Result 1: SEM demonstrated uniform nanofiber morphology

2. PCL-Ct | PCL-BMP7



Result 2: MC3T3-E1 osteoblast cell line showed excellent attachment and spreading on PCL-BMP7 scaffold

3. PCL-Ct | PCL-BMP7



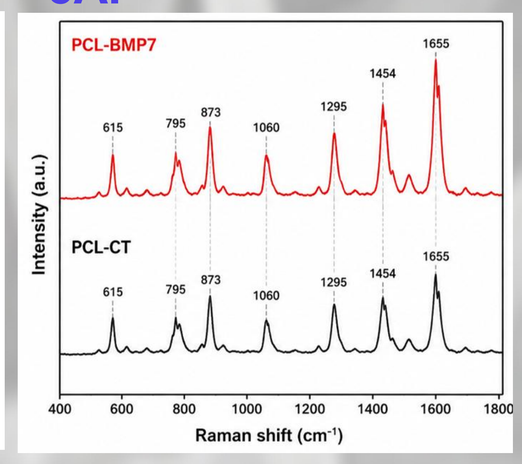
Result 3: EDS: Both CT and BMP-7 PCL scaffolds showed carbon and oxygen as the major elements, with trace Ca, Na, Cl, and K detected in the BMP-7 group.

4.

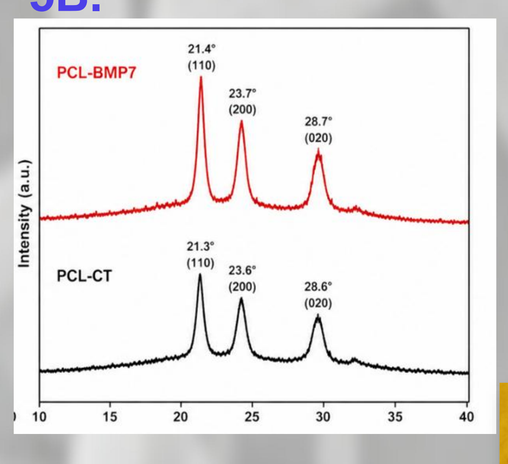
Time point	PCL-Ct (mean contact angle)	PCL-BMP7 (mean contact angle)
0 min	136.0 ± 0.5	124.0 ± 0.3
5 min	134.7 ± 0.5	120.8 ± 0.4
15 min	129.8 ± 0.7	109.6 ± 0.5*
35 min	118.2 ± 1.0	95.4 ± 0.6**

Result 4:Contact angle analysis showed that PCL-BMP7 scaffolds exhibited improved surface wettability compared with PCL. The contact angle decreased from 124.0° ± 0.3 to 95.4° ± 0.6 over 35 min, while PCL showed a smaller reduction from 136.0° ± 0.5 to 118.2° ± 1.0, indicating enhanced hydrophilicity after BMP7 modification

5A.



5B.



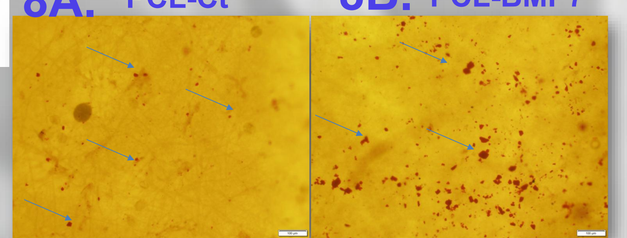
Result 5A.Raman spectra of PCL-BMP7 show enhanced peak intensities and slighter shift of peaks compared to PCL-Ct suggested stronger molecular interactions.
5B.XRD patterns of PCL-BMP7 also shows high peak intensities and sharper diffraction peaks suggesting increased crystallinity.

6.

	Tensile strength (MPa)
PCL-Ct	32.8 ± 1.8
PCL-BMP7	22.2 ± 2.6

Result 6. The tensile strength was seen to be decreased in PCL-BMP7 compared to the PCL-Ct

8A. PCL-Ct **8B.** PCL-BMP7



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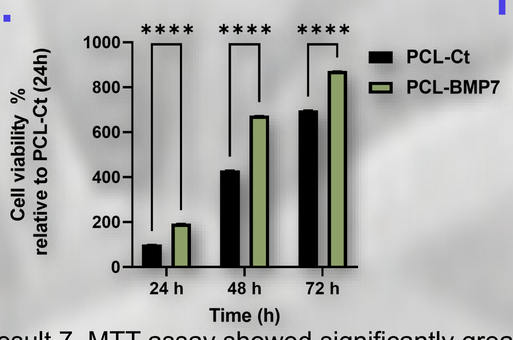
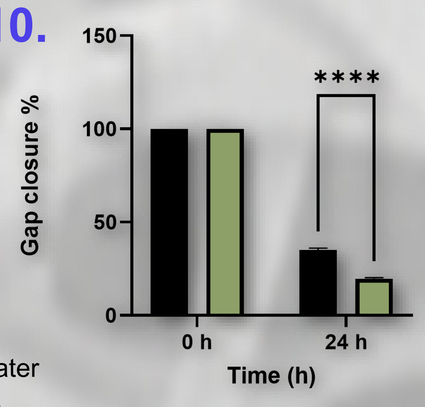


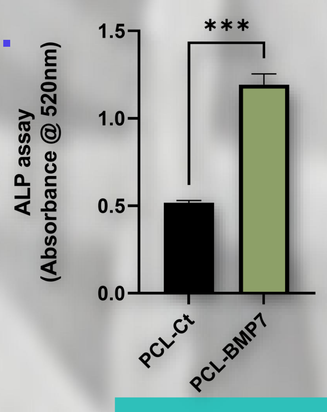
Result 7. MTT assay showed significantly greater cell viability on PCL-BMP7 at 24, 48 and 72 h.

10.



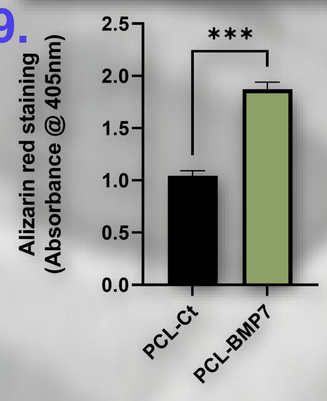
Result 10. Wound healing assay showed significantly greater wound closure of cells on PCL-BMP7 at 24h after wound.

11.



Result 11. Alp assay showing increase absorbance of cells cultured with differentiation media on PCL-BMP7 compared to PCL-Ct for 14 days.

9.



Result 8A and &8B showing Alizarin red staining after 21 days. The arrow shows the mineralized nodule. Result 9 is the quantification of the ARS staining PCL-BMP7 shows increased mineralization compared to PCL-Ct.

CONCLUSIONS

- ✓ BMP7-functionalized PCL nanofibrous scaffolds significantly improved osteoblast viability, migration and osteogenic activity.
- ✓ Enhanced hydrophilicity and cell–material interactions contributed to superior biological performance.
- ✓ PCL-BMP7 scaffolds show strong potential for regenerative dentistry and broader bone tissue engineering applications.

FUTURE WORK/ REFERENCES/ACKNOWLEDGMENT

Future work

- In vivo evaluation of bone regeneration efficacy.
- Translation toward dental and orthopedic regenerative therapies

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For References Scan me