

DEVELOPMENT AND EVALUATION OF SCAFFOLDS FOR BONE TISSUE ENGINEERING



THESIS SUBMITTED IN PARTIAL FULFILMENT FOR THE AWARD OF DEGREE

DOCTOR OF PHILOSOPHY

By

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PREFACE

Tissue engineering has emerged as a solid approach to bone tissue regeneration. It has helped in developing artificial bone substitutes that can overcome the limitations of existing bone disease therapies. Bone tissue-engineered constructs can completely reproduce the characteristics of a graft, hence ending the patient's discomfort. Tissue engineering of biological bone focuses on regenerating new functional tissue that successfully merges with the host without generating any adverse effects. In recent years, research in tissue regeneration has focused on developing biomaterials for replacing, regrowing, or restoring damaged cells or tissues. These biomaterials serve optimum support and act as a framework for cellular attachment, replacement and ingrowth of tissues. The literature review suggests that several materials are utilized for bone tissue restoration or regeneration, like natural and synthetic materials. Biomaterials with proteins have found primary utilization in various industries and areas like biosensors, food and agricultural industry, drug delivery mechanisms, pharmaceutical drugs, contact lenses, bone plates, etc. These biomaterials include natural materials like chitosan, gelatin, collagen, alginate, chondroitin sulfate, etc. which exhibit good biocompatibility and biodegradation properties. Similarly, synthetic materials are also there like polylactic acid, polyvinyl chloride, polyglycolic acid, etc. The synthetic materials possess good mechanical strength but there exist some limitations like poor cell cytocompatibility, poor degradation rate, etc. Therefore, both these biomaterials are used in composite forms to attain the desired properties in achieving good cell proliferation and physiochemical properties.

Chapter- 1 focuses on the introduction of tissue engineering and its significance, key challenges in bone tissue engineering and different strategies for bone tissue regeneration. It discusses porous scaffold fabrication and its need in current bone repair technology.

Chapter- 2 consists of a literature survey of bone, its types and the cells involved in its formation. It discussed the various scaffold fabrication techniques and the scaffold's properties. It also covers the requirement of bone tissue engineering in the current scenario.

Chapter- 3 represents the detailed experimental methods and materials involved in this research study. It also gives a detailed description of the instruments involved in this research.

Chapter- 4 discusses the development and evaluation of different scaffolds developed for Bone tissue regeneration. Their efficacy and properties are elaborated via various examinations and tests performed. It includes the chitosan and gelatin-based scaffold with the incorporation of different bioactive nanoparticles. Among all the developed scaffolds, it was observed that the best-optimized scaffold was graphene oxide and nanobioglass-based scaffold (Ch-G-NBG-60%GO) with the highest mechanical strength and enhanced biocompatibility among all the other scaffolds and also CN based Ch/G/nHAP/0.02%CN scaffold with good mechanical strength as well as cytocompatibility.

Chapter- 5 gives the conclusion and future perspective for the conducted research work in the area of Bone tissue engineering

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LIST OF ABBREVIATIONS

TE	Tissue engineering
BTE	Bone Tissue engineering
MSCs	Mesenchymal stem cells
ECM	Extracellular matrix
HAP	Hydroxyapatite
TCP	Tricalcium phosphate
3D	Three dimensional
PVA	Polyvinyl alcohol
HP	Hyperbranched polymer
ICP-OES	Inductively coupled plasma-optical emission spectrometry
PCL	Poly ϵ-caprolactone
PEG	Polyethylene glycol
GFs	Growth factors
PLGA	Poly (lactic-co-glycolic acid)
CL	Cellulose
NHS	N-hydroxysuccinimide
EDC	1-Ethyl-3-(3-dimethylaminopropyl)carbodiimide
rhBMP-2	Recombinant human bone morphogenetic protein
SBF	Simulated bodily fluids
Alg	Alginate
CS	Chondroitin sulfate
AA	Amino acid
SF	Silk fibroin
PD-RGO	Polydopamine-reduced graphene oxide
HA	Hyaluronic acid
Ch	Chitosan
Gel	Gelatin
Col	Collagen
VEGF	Vascular endothelial growth factor
BMPs	Bone morphogenetic proteins
TNF-alpha	Tumor necrosis factor-alpha
SLRPs	Small leucine-rich proteoglycans
MGO	Magnetic graphene oxide
PVA/SA/HAP	Polyvinyl alcohol/sodium alginate/hydroxyapatite
AM	Additive manufacturing
PMPV	Polyacrylamide/poly (vinyl alcohol)
HNTs	Halloysite nanotubes
BG	Bioactive glass
PADH	Polymer of acrylamide -Urethacrylate dextran
PLLA	Poly(L-lactic acid)

Dex-U	Urethacrylate dextran
PMMA	Polymer of acrylamide
PGA	Polyglycolic acid
PU	Polyurethane
PPF	Poly(propylene fumarate)
QDs	Quantum dots
rBMSC	Recombinant Bone marrow stromal cells
SMAD	Mothers against decapentaplegic
hASC	Human adult stromal cells
SBMs	Smart biomaterials
PVDF	Polyvinylidene fluoride
SAMs	Self-assembled monolayers
CNTs	Carbon nanotubes
f-MWCNT	Multiwalled Carbon Nanotubes
ERMs	Enzyme-responsive materials