REGENERATIVE MEDICINE'S CURRENT STATE OF AFFAIRS

Prof. Dr. Hemant Kumar Halwai
Chief Editor, JUCMS
HOD, Department of Orthodontics and
Dentofacial Orthopedics

The basic concept behind tissue engineering is to recreate existing surgical or mechanical device-related procedures, even if those procedures greatly reduced the rate of untimely death. The phrase "Tissue Engineering" (TE), coined in 1933 by Langer and Vacanti, refers to the time-on-demand of available organ donors and suitable complementary biological habitats.[1]

TE is the multifaceted product of researchers that have significantly modified and recreated the in vivo biological niche using a combination of synthetic biomaterials, cells of interest, and biochemical components, which are crucial for tissue growth. The disciplines of regenerative medicine have been transformed by the new generation of biomaterials, and the advancement of 3D architecture may allow us to replicate the perfect in vivo tissue organoid.[2] The porosity, biodegradability, biocompatibility, and excellent carrier of the therapeutic compounds immobilized on the matrixes are additional crucial characteristics of the supporting scaffolds. Both synthetic and natural materials have been researched to create the three-dimensional support structure because of their inherent biological qualities, but the requirements for microbiological resistance, genotoxicity, and mechanical strength are still up for debate. The well-known naturally occurring, biocompatible and biodegradable polymers collagen, gelatin, hyaluronic acid, alginate, guar gum, chitosan, and polyhydroxyalkanoates have been used as bio-mimicking matrixes in the creation of artificial three-dimensional structures, but their mechanical and hydrophilicity properties have limited their special applications. The advent of biosynthetic technology greatly reduces the downside. Specifically, the discovery of carbon molecules like carbon nanotubes and nanoparticles of graphene oxide, Tissue engineering has undergone a revolution thanks to nanoparticles and other technologies.[3] To create the bioimitating 3D construct, other properties of these compounds are taken into account, including biocompatibility, antibacterial activity, and mechanical stability. Additionally, the creation of the optimal scaffold involves the use of synthetic materials like poly (ethylene glycol) and poly (lactidecoglycolide).[3]

Impact of naturally sourced biomaterials on cell-cell cross-talk

a) Collagen as base material and its derivatives
b) Hyaluronic acid as base material and its derivative
c) Gelatin as base material and its derivative
d) Sodium alginate as base material and its derivatives
e) Chitosan as base material and its derivatives
f) Silk as base material and its derivatives

Effect of growth factors on cell-matrix interaction

In vitro and in vivo tissue production experiments that showed the phenomena of adhesion, proliferation, and cell differentiation have undergone extensive studies on the interaction between cellular and bio-mimetic 3D matrices. However, the majority of the research falls short of the requirements for a successful therapeutic application because insufficient amounts of the protein molecules necessary for the cross-talk between cell-cell and cell matrix signaling are secreted. Growth factors are well-known tiny proteins that stimulate cell division, proliferation, and differentiation as well as control angiogenesis. Based on their utility in tissue engineering, the reported adaptability of various growth factors associated to the reported mediated repair of injured tissue tends to fall into several groups.[3]

Interleukins, EGFs, NGFs, IGFs, FGFs, PDGFs, and so on are the group of growth factors that are mostly known to be involved in the actin-cytoskeleton and cell–cell medicated trafficking of proliferation in the process of living tissue regeneration.[4]

The secret of cell–cell and cell–matrix interaction that enables healing in an artificial tissue environment, such as native tissue repair processes, has been revealed thanks to an understanding of the mechanism and fundamental criteria of tissue regeneration.[5,6,7] In fact, in order to biologically mimic the signaling cascade that initiates cellular activities, the biocompatibility of any manufactured 3D architecture plays an important role in adhesion, proliferation, migration, and differentiation of the cells of interest.[8] Several studies have demonstrated that porous and mechanically stable 3D structures made of natural and synthetic materials improved integrin ligand-mediated differentiation and tailored actin-cytoskeletal cell morphology.[8,9,10] The various growth factor-mediated signaling pathways and the active function of the ECM components influenced the cells' biological and biochemical performances, according to the studies.[11]

REFERENCES

1. Langer R, Vacanti JP. Tissue Engineering. Science. 1993; 260:920- 926.

2. Vacanti JP, Langer R. Tissue engineering: the design and fabrication of living replacement devices for surgical reconstruction and transplantation. Lancet. 1999 l; 354; 1: SI32-4.

3. Current Scenario of Regenerative Medicine: Role of Cell, Scaffold and Growth Factor.

https://doi.org/10.3126/jucms.v10i02.51395

4. Lee SW, Ji Ryu JH, Do MJ, Namkoong E, Lee H, Par K. NiCHE Platform: Nature-Inspired CatecholConjugated Hyaluronic Acid Environment Platform for Salivary Gland Tissue Engineering. ACS Applied Materials & Interfaces. 2020; 12(4): 4285-4294.

5. Song K, Compaan AM, Chai W, Huang Y. Injectable Gelatin MicrogelBased Composite Ink for 3D Bioprinting in Air. ACS Appl. Mater. Interfaces. 2020; 12: 22453 −22466.

6. Sheikholeslam M, Wright MEE, Cheng N, Oh HH, Wang Y, Datu AK, Santerre JP, Amini-Nik S, Jeschke MG, Electrospun Polyurethane−Gelatin Composite: A New Tissue- Engineered Scaffold for Application in Skin Regeneration and Repair of Complex Wounds, ACS Biomater. Sci. Eng. 2020; 6: 505−516.

7. Kim S, Cui ZK, Koo B, Zheng J, Aghaloo T, Lee M. Chitosan-Lysozyme Conjugates for Enzyme-Triggered Hydrogel Degradation in Tissue Engineering Applications. ACS Appl. Mater. Interfaces. 2018; 10: 48, 41138-41145.

8. Bhowmick A, Banerjee SL, Pramanik N, Jana P, Mitra T, Gnanamani A, Das M, Kundu PP. Organically modified clay supported chitosan/hydroxyapatite-zinc oxide nanocomposites with enhanced mechanical and biological properties for the application in bone tissue engineering, International journal of biological macromolecules. 2018; 106: 11-19.

9. Mahanta A K, Patel DK, Maiti P. Nanohybrid Scaffold of Chitosan and Functionalized Graphene Oxide for Controlled Drug Delivery and Bone Regeneration. ACS Biomater. Sci. Eng. 2019; 5: 5139−5149.

10. Zhao C, Qazvini N T, Sadati M, Zeng et al. A pH-Triggered, Self-Assembled, and Bioprintable Hybrid Hydrogel Scaffold for Mesenchymal Stem Cell Based Bone Tissue Engineering. ACS Applied Materials & Interfaces. 2019; 11(9):, 8749-8762.

11. Zhao Y, Liang Y, Ding S, Zhang K, Mao H, Yang Y. Application of conductive PPy/SF composite scaffold and electrical stimulation for neural tissue engineering. Biomaterials. 2020; 255: 120164.