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Scaffolds and Tissue Engineering

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Introduction

Scaffold is a commonly used term for a supporting structure. Similarly scaffolds biologically are extra cellular matrix that support and keep the cells viable by nutritional supply, receptor stimulation and signaling pathways. National foundation in 1998 has coined the term tissue engineering. Tissue engineering is concerned with the development of various biological tissues as an alternative functioning to the normal tissues. Accordingly tissue engineering may be defined as the development of scaffolds or materials with in the cells for the repair of damaged organs or tissue. Tissue engineering assists for the development of structures like vessels, bladder, liver, pancreas skin and muscle etc. Scaffolds are either biodegradable or bio stable. Bio degradable scaffolds highly porous and acts as base or seeding of cells and for growth of tissues and vessels. 3D bio degradable scaffolds are preferable than 2D as the earlier mimics natural environment and a steady state like that of tissues organs. However vascular tissues like bone and cartilage are also developed by tissue engineering.

Tissue engineering and stem cells

Bone marrows contain adult stem cells haemopoitic stem cells (Hscs) and mesenchymal stem cells (Mscs). Hscs have shown the ability to give rise to haemopotic cell lineage like red blood cells. Mesenchymal cells provide all connective tissue lineage including bone, cartilage, muscle, tendon, fat, and dermls [1].

The human embryonic stem cells was definitely influenced by scaffolds under culture conditions and growth factor such as retinoic acid (RA), transforming growth factor (TGF β) activin A, and insulin like growth factor (IGF-1). Retinoic acid supplementation leads to neural tissue, TGF beta cartilage, activin A liver and IGF liver tissue. This holds promise for the growth of human tissue in vitro through use of human embryonic stem cells (h ESC) and biodegradable polymeric scaffolds [2]. Blood vessels are seen in the interval structure of scaffold. Park et al. [3] reported the use of PGA fibrous scaffolds as a carrier for mesenchymal stem cells and implanted into evolving infracted cavities of mouse brains. Neuronal differentiation and neuronal out growth occurred in damaged neural tissue. This offers a promise for the repair neural damaged tissue during stroke or Parkinson's disease. Mesenchymal stem cells in biodegradable material the phenyl ester of hyaluronan in the presence of TGF beta resulted in cartilaginous like tissue. lisignoll et al. [4] processed silk such as silk fibrin has been investigated as scaffolding material using h MSCs and estrogenic response was seen Kim et al. [5].

Ovine bone marrows derived mesenchymal stem cells aspirated from sternum of adult sheep have been seeded on to a PGA/ poly 4 hydroxy butyrate (p4ha) composite scaffold to generate heart valves [6]. 3D scaffolds acts as extra cellular matrix minimickins micro environment and signal transduction and gene regulation.

A bladder fabricated from polyglycolic acids coated with polylactic co-glycolic acid (PLGA) was used as a structural template [7] bladder urothelial and smooth muscle cells harvested from canine subjects were seeded on to 3D scaffolds and then cultured in vitro the same is transplanted after removal of the bladder in the animal and it has a good functional capacity. Similarly clinical application was done a composite collagen and poly glycolic acid 3D scaffold added with patients over urothelial and smooth muscle cells was successfully implanted into seven patients with a 4 years follow up [8]. Decellularised donor tissue can also be used as a scaffold instead of synthetic material [9] and recellularised with a autologous stem cells and used in clinical transplantation of air ways in patients with long segmental congenital tracheal stenosis [10-12]. Clinical application of a scaffolds guided tissue engineering vascular construct was reported in 2001 for patients with single ventricle [13]. Tissue engineered conduits are used in 25 patients in a low pressure environment with only two late cardiac failure and deaths. These conduits were used as extra cardiac cavo pulmonary connections [14,15].

3D scaffolds advantages over 2D are that 3D are more relevant cell model, better simulation of conditions in a living organisms with integrations of flow and good interaction of

various types of cells. MSCS are also present in muscles [16] adipose tissue [17], scalp [18], and olfactory mucosd tissue [19]. Commonly used materials are polyglycolide (PGA) [20,21] polylactide (PLA) [22,23] and polglycolide (PLGA) [24,25] and polycaproactone (PCL) [26,27]. Naturally occurring polymers useful in tissue engineering are collagen [28,29] gelatin [30,31] fibrin [32] and algininate [33] Hard tissue engineering scaffolds needs the material like β tricalcium phosphate (TCP) and hydroxy apatite (HAP) [34] for bone formation.

It is now evident that cell seeded on 3d scaffolds emerge as a vehicle for improved oxygen support and also to deliver relevant therapeutic agents to facilitate tissue function and to regenerated damaged or otherwise compromised tissue function [35,36].

Conclusion

Future prospective studies on tissue engineering creating appropriate scaffolds and good micro environment with culture and growth factors with the development of novel methods are the hope for therapeutic applications. The pliability of 3D scaffolds can active signaling pathways than 2D scaffolds. Novel methods like increasing the oxygen supply with fluorinated molecules and calcium peroxide increases the oxygen delivery into the scaffolds and cells. Newer methods of acceleration of perfusion and cellular integration for effective drug delivery may be the future hope for excellent clinical results.

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