THE USE OF SCAFFOLDS IN DENTAL REGENERATIVE MEDICINE

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Background:

Scaffolds are defined as three-dimension porous solid biomaterials designed to perform some or all of the following functions:

- promote cell-biomaterial interactions, cell adhesion, and extracellular matrix (ECM) deposition
- permit sufficient transport of gases, nutrients, and regulatory factors to allow cell survival, proliferation, and differentiation
- biodegrade at a controllable rate that approximates the rate of tissue regeneration under the culture conditions of interest, and
- provoke a minimal degree of inflammation or toxicity in vivo.

Scaffolds can be used as replacements for diseased or damaged tissues.
Their role is to provide support for delivering cells and/or growth factors to the proposed site of tissue regeneration.

THE AIM of this review was to describe the current types of scaffolds and evaluate their use in combination with stem cells for tissue engineering applications.

Methods and materials:

We searched for published studies, clinical trials and review papers, reported from 2008. to 2014. in PubMed by using keywords: scaffold, regenerative medicine, stem cells, tissue engineering, signaling molecules.

Results:

Tissue engineering aims to restore, maintain, or improve tissue functions that are defective or have been lost by different pathological conditions, either by developing biological substitutes or by reconstructing tissues. The general strategies adopted by tissue engineering can be classified into three groups:

1. implantation of isolated cells or cell substitutes into the organism
2. delivering of tissue-inducing substances (such as growth factors), and
3. placing cells on or within different matrices

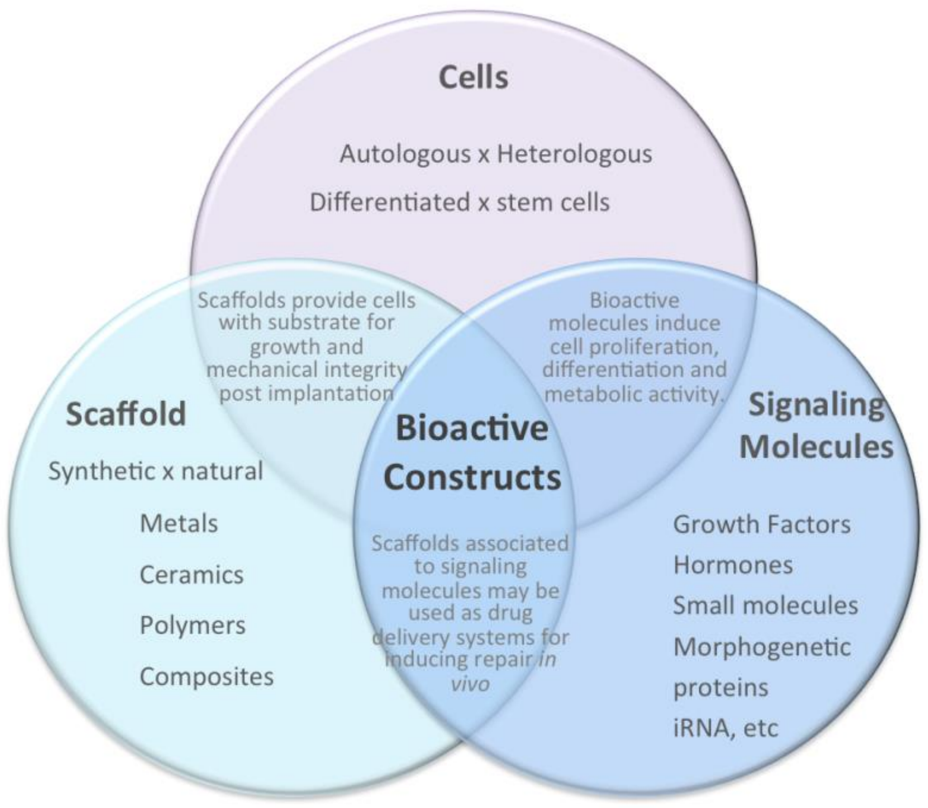
The best scaffold for an engineered tissue should be the ECM of the target tissue in its native state.

Functions of extracellular matrix (ECM) in native tissues and of scaffolds in engineered tissues

Functions of ECM in native tissues	Functions of scaffolds in engineered tissues
1) Provides structural support for cells to reside	1) Provides structural support for exogenously applied cells to attach, grow, migrate and differentiate in vitro and in vivo
2) Contributes to the mechanical properties of tissues	2) Provides the shape and mechanical stability to the tissue defect and gives the rigidity and stiffness to the engineered tissues
3) Provides bioactive cues for cells to respond to their microenvironment	3) Interacts with cells actively to facilitate activities such as proliferation and differentiation
4) Acts as the reservoirs of growth factors and potentiates their actions	4) Serves as delivery vehicle and reservoir for exogenously applied growth-stimulating factors
5) Provides a flexible physical environment to allow remodeling in response to tissue dynamic processes such as wound healing	5) Provides a void volume for vascularization and new tissue formation during remodeling

Currently proposed scaffolds include those made of inorganic materials, organic or synthetic polymers, or of mixed materials (composite scaffolds).
These materials include natural polymers (collagen, chitin, alginate), synthetic polymers (Polyglycolic acid (PGA), Poly (lactic-co-glycolic acid) (PLGA), Poly (lactic acid) (PLA)), metals (titanium, nitinol), and ceramics such as calcium phosphates (hydroxyapatite, tricalcium phosphate), calcium sulphates, and biological glass.

Cells can be seeded onto the scaffold and culture in vitro to generate tissue before transplantation, or can be transplanted cell-free scaffolds with incorporated signaling molecules which induce the homing of stem cells residing in tissues and promote their differentiation.
Currently, the association of cells, scaffolds and signaling molecules, composing bioactive constructs, is proposed to be the best option for tissue engineering.

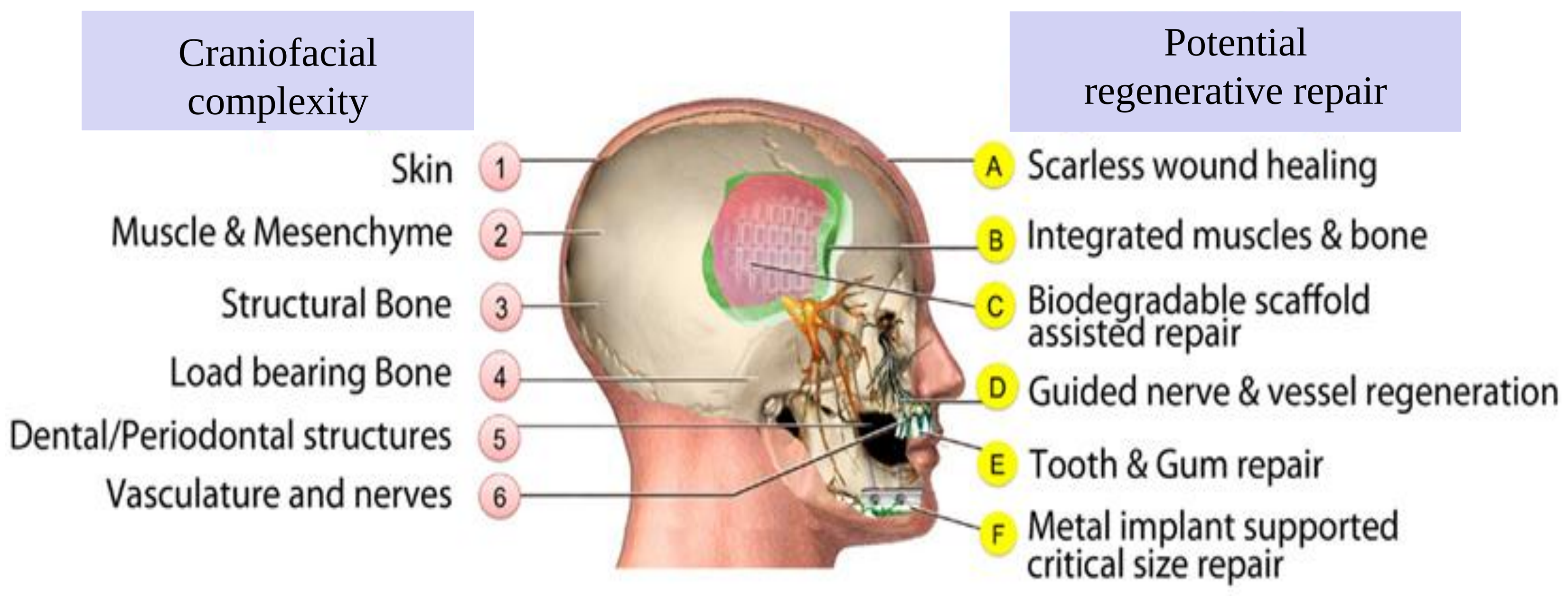


Juliana Lott Carvalho et al. (2013). Innovative Strategies for Tissue Engineering, Advances in Biomaterials Science and Biomedical Applications, ISBN: 978-953-51-1051-4.

Cells and tissue response to a scaffold depend upon the composition of the scaffold, its surface microstructure and three-dimensional architecture.
Scaffolds should have appropriate porosity and the mechanical properties that are appropriate for the cells and their macro- and microenvironments

The concept of tissue engineering is being applied for treatment of salivary gland disorders, regeneration of craniofacial tissues, oral mucose, periodontium, dentin and dental pulp.

Bio-oss ®, the most common natural biomaterial, is considered as the "gold standard" in bone tissue replacement in oral and maxillofacial surgery.
But, in recent years, there has been an increasing use of composite scaffolds with ceramic and polymer phases. Porous hydroxyapatite (pHAP) is often used for the ceramic phase, because of its excellent osteoconductivity and even osteoinductivity. For polymer phase, poly(lactic-co-glycolic) acid (PLGA) is approved as biodegradable, biocompatible and noncytotoxic, and may improve chemical and functional properties of different ceramic scaffold structures, which is important for cell adhesion and growth.



Sanchez-Lara P.A et al. Impact of stem cells in craniofacial regenerative medicine Front. Physiol, 21 June 2012, doi: 10.3389/fphys.2012.00188

Conclusion:

The impact of tissue engineering and potential applications of stem cells to reconstruct different dental, oral, and craniofacial tissues and structures extend well beyond craniofacial and dental practices.

The use of scaffolds can overcome the drawbacks of traditional bone graft materials and offer a novel way for bone repair and regeneration.

References:

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