The exciting future of regenerative dentistry

Tissue engineering and regenerative medicine (TERM) is a highly multidisciplinary field in which bioengineering and medicine merge. Integrative approaches using scaffolds, cells, growth factors or gene therapy are developed to overcome today’s limitations in augmentation procedures.

Patients with defects due to congenital disorders, trauma or tumor removal often suffer from serious functional and aesthetic deficiencies that strongly compromise their social lives. Current therapy options are highly invasive, associated with severe morbidity or are simply unavailable. However, the progress in technology has enabled advances. Promising techniques are now being studied that may shift the frontiers in regenerative dentistry and medicine. TERM techniques include:

› Injecting cells into the damaged tissue, either with or without a degradable scaffold.

› Growing a complete three-dimensional tissue to maturity in the laboratory and then implanting it into a patient.

› Implanting a scaffold directly into the injured tissue and stimulating the body’s own cells to regenerate the tissue.

› Introducing a gene encoding a therapeutic protein into cells, which can then express the target protein.

3D printing may help to shift the frontiers in regeneration.

Cells + scaffold + growth factors

Three components are needed for successful tissue engineering: cells (such as stem cells), scaffold or matrix (which provides a degradable physical base for cell growth), and growth factors. Simply put, the cells grow along a physical scaffold, and specific growth factors stimulate cell activity and differentiation into the desired tissue.
One of the first tissues to be engineered and used clinically is bone. Engineered bones may one day eliminate the need for more invasive therapy.

**Stem cells**

Reconstruction of craniofacial and dental defects using mesenchymal stem cells avoids many of the limitations of both auto- and allografting. Clinical studies are underway using stem cells for alveolar ridge regeneration as well as long-bone defects.2 Dental stem cells from the pulp, periodontal ligament, and associated healthy tooth structure have shown promise in treating a number of diseases.

**3D scaffolds**

A scaffold is necessary to enable cell growth. It should contain growth factors such as Bone Morphogenic Protein (BMP), fibroblast growth factors, and endothelial growth factors to aid in stem cell proliferation and differentiation. Furthermore, it should provide nutrients promoting cell survival and growth. The scaffolds studied have included natural or synthetic, biodegradable or permanent materials.

**3D printing of tissue**

Technological advances in biomaterials, printer technology and computer-aided design allow replacement tissues and organs to be “printed”. The idea is to use patient data, such as from a CT scan, to first create a computer model of the organ. This model is used to guide the printer as it prints layer-by-layer a three-dimensional structure made up of cells and the biomaterials to hold the cells together. This printer is unique in that it can use biomaterial gels as well as rigid polymers – so that any three-dimensional shape can be created. In addition, it can print proteins, growth factors and other liquids into the structure to help promote regeneration once the device is implanted. This device is still experimental and is being explored for organs such as the kidney and structured tissue such as the ear.

**Challenge: vascularisation**

Many challenges remain, however. For example, if an engineered tissue is placed into the body, it has to be vascularised quickly or the tissue will die. This presents a greater challenge in larger engineered tissues. The timing and appropriate doses of growth factors are still under investigation.

**Next evolution**

Researchers are also developing engineered skin, which will help treat massive burns, chronic wounds and missing soft tissue in the oral cavity. Skin and cartilage substitutes are available through regenerative medical techniques, and laboratory-grown tracheas, blood vessels and other tissues have been implanted into patients. Other tissues that are at the early stages of engineering include heart valves as well as bladders. In fact, a whole bladder has been engineered and transplanted in a dog.1 The bladder appeared to be normal and demonstrated normal function. Nearly every body tissue is being engineered for future applications in medicine. As we continue on this exciting journey of exploration, thus expanding the frontiers of tissue regeneration, we should keep the words of Christopher Columbus in mind:

“**You can never cross the ocean unless you have the courage to lose sight of the shore**”.

Christopher Columbus

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**References**