Tissue Engineering and Regeneration in Dentistry

Basics of tissue engineering and regeneration, implementation possibilities, and the classification of the applicable materials

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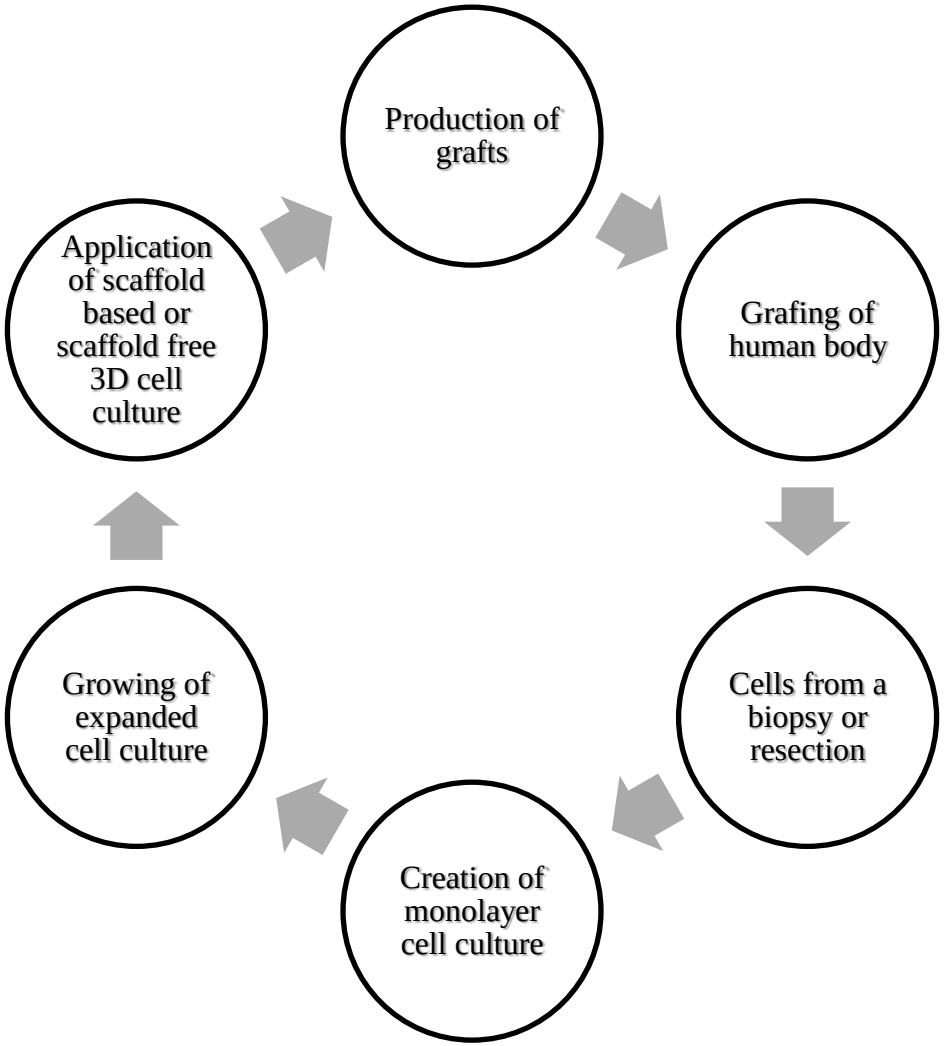
Basic principles of tissue engineering



Three dimensional tissue cultures and tissue engineering, by Dr Domokos Bartis and Dr Judit Pongrácz (2011)

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3D tissue cultures

Difficulties of

3D tissue cultures:

The thickness is a critical point

For Healthy tissues

Diffusion of the nutrients

and the oxiges is needed

If the thickness is too big

At the center the diffusion is not satisfactory

Apoptotic cells appearing

Secondary necrosis

Necrotic tissues will be developed

Three dimensioEFOP-3.4.3-16-2016-00021 Tiss eng es Szovettervezes eloadasoknal tissue cultures and tissue engineering, by Dr Domokos Bartis and Dr Judit Pongrácz (2011)

Stem cell types

Stem cells:

Ferilized oocyte (egg) — Totipotent

8 cell embryo

Blastocyte — Pluripotent

Cultured stem cells

Neural or Blood cells directions

Multipotent cells — e.g.: from Brain neural cells

from Bone marrow Blood cells

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Types of stem cell replications

The fate of stem cells depends on the effect of the microenvironment

the increasing number of divisions, the proliferation capacity of stem cells is decreasing favouring differentiated phenotypes

Proliferation capacity vs. Differentiation capacity

to replicate:
From parental stem cells
Assimetirc replicating differentiating divisioi
Self-renewal

Daugther cell
Symmetric replicating/differentiating divisior

continuous proliferation signals can lead to depletion of stem cell sources

Epiblast stem cells

ethical debate is ongoing, but researches are continous for the repair

of damaged tissues, or to grow new organs for therapy or for drug testing

IPS cells

Opportunity for Dedifferentiton and reprogramming

recently discovered, that rodent stem cells in a special stage can resemble for human embryonic stem cells same properties making it possible to use rather than human cells in some research.

Adult or somatic stem cells

The microenvronment where stem cells live are called

STEM CELL NICHES

ensure the regenerative potential

Isolation procedures of ASCs

Adipose tissue derived stem cells easily isolated

multipotent,

immunophenotype is consistent

easily manipulated by genetic engineering

can differentiate into cardio-myocytes, skeletal myocytes, chondrocytes

osteoblasts, neuronal, endodermal and ectodermal lineages

Application of ESCs and ASCs

From

Endoderm

Ectoderm

Mesoderm

for the effectively engineered tissues, cells must be easily procured and readily available

Main types of bioreactors

Spinner flask bioreactors

mix the oxygen and nutrients

scaffolds are suspended at the end of needles a magnetic stirrer mixes the media

the scaffolds are fixed in place

fluid transport to the centre of the scaffold is thought to be enhanced

spinner flasks are around 120 ml in volume (although much larger flasks of up to 8 liters have also been used)

efficiency of the enhancement of mass transport is indicated that cartilage constructs have been grown in spinner flasks

to thicknesses of 0.5 mm compared to that of 100 μm in static cultures

Main types of bioreactors II

Rotating wall bioreactors

Cartilage tissue of 5 mm thickness has

been grown in this type of bioreactor after

seven months of culture.

Main types of bioreactors III

Flow perfusion bioreactors

Using a calcium phosphate scaffold, abundant extracellular matrix (ECM) with nodules of calcium phosphate was noted after 19 days in steady flow culture

expression levels of bone differentiation markers (namely Alkaline Phosphatase, Osteocalcin and the transcription factor Runx2) proved to be consistently higher in flow perfusion reactors than in any other type of bioreactors. Additionally, the mineralization of the scaffolds is also higher

Natural biomaterials

Proteins	Polysacharydes
Collagen	Agarose
Fibrin	Alginate
Silk	Hyaluronic acid
Glutamic acid	Chitosan

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Synthetic biomaterials

Organic polymers	Inorganic
PGA, PLA, PLGA	Ceramic
PEG	Metal
Peptides	Hydroxyapathite
PCL	B-trikalcium-phosphate

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Methods for scaffold construction

Solvent casting & particulate leaching (SCPL)

Pour the polymer solution to the porogen containing MOLD

Evaporate the solvent

Dissolve the porogen

Obtain a Porous structure

Methods for scaffold construction

Electrospinning

Pour the polymer solution into a syringe

Metallic needle is necessary

High-voltage power supply ensure the electric field

Electrified jet will be created

On the collector pile up the NANOFIBERS

Critical points

Taylor-cone

Slow Acceleration phase

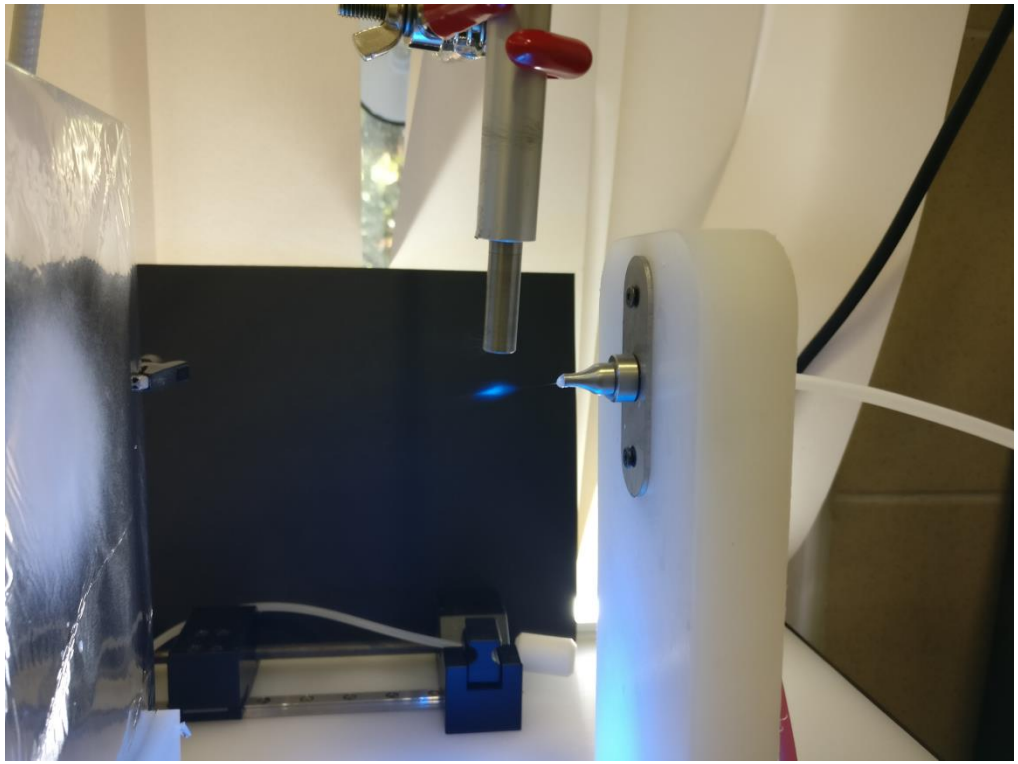
(Geometry of the cone is governed bythe ratio of surface tension to electrostatic repulsion

Rapid Acceleration phase

(Zone of transition between liqiud and solid)

During the flying

Zone of solidification



Crosslinked nanofibers creation

Two pump and common needle

Reactive electrospinning technique.

Hyaluronic acid - dithio-bis-(propion-dihidrazin) modified hyaluronic acid (HA-DTPH) nanofiber scaffold creation.

Different complex scaffold structure can design with this methode

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Electrospinning products

Direct electrospinning methode for preparation of **wound healing material** , guiding-electrode and airblowing for the better controlled reaction.

Posteriorly UV-treated electropinning produced PVA/AgNO3 net covered fiber

Electrospinning technique used for hemoglobin és myoglobin crosslinked material preparation from 2,2,3-trifluoro-ethanol solution.

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Cell attachments

Effects of the different scaffold structures to the cell attachment possibilities:

Micropore scaffold

- Cells only spread into the pores

Microfiber scaffold

- Cells grow to the thick fibers

Nanofiber scaffold

- Cells attach to the high number of fibers

Dent Mater. 2010 Apr;26(4):275-87.

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Concepts for tooth bioengineering (mice)

epithelium and mesenchyme differentiate into ameloblasts, which later become enamel and odontoblasts which will form dentin

mesenchyme also differentiates into the dental pulp and into periodontal tissues, which will become cementum, alveolar bone, and periodontal ligament

THANK YOU FOR YOUR ATTENTION!

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