Cartilage Injury

- 6 million people each year in US
- As a result of
  - Trauma
  - Disease
  - Chronic mechanical loading imposed on joints with aging.
- Cartilage demonstrates very little capability for self-repair after injury.
Types of Cartilage

3 Types of Cartilage:

- Elastic Cartilage
  - Epiglottis/Eustachian tube
- Fibrocartilage
  - Fracture sites/major locations in the body
- **Hyaline Cartilage** – joints
Cartilage is made up of:
- Water 68-85%
- Collagen 10-20%
- Proteoglycans 5-10%
- Chondrocytes

Primary functions:
- Move as frictionless as possible
- Provide strength
How Cartilage Works in a Healthy Knee
Treatments for Articular Cartilage Defects

- Symptom management
- Allograft
- Autograft
- Autologous Chondrocyte Implantation (ACI)
- Implantation of biomaterials

However, all current techniques have limited long-term follow-up. Current clinical experience questions the durability of the repair.
Biomaterials available

- **Nondegradable**
  a) Poly (vinyl alcohol) PVA
  b) Polyacrylates pHEMA
  c) Polyethylene
- **Degradable** (favored)
  a) Porous polymer
  b) PGA, PLA
  c) Alginate, Collagen
Cartilage Replacement

- By Poly (vinyl alcohol) PVA
- Synthetic biomaterial
- Nondegradable

Structure of Vinyl Alcohol
PVA

- Relative biocompatible
- Can swell water content
- Can be molded to desired shape
- Incorporate with other bioactive material
PVA cont…

- Be able to withstand enormous loading
- Over millions of cycles
- Ration of PVA and water
- Higher molecular weight
- Better damping property than nature tissue
Disadvantages

- Not suitable to total joint replacement
- Tissue reaction
- Inflammatory reaction
- Difficult to obtain stable long-term fixation
Tissue engineered cartilage

- Tissue engineering inducing repair of host tissues by delivering repair cells, genes, or polypeptide stimulatory factors to the site of injury.
The module of scaffold

Differentiation factors

Embryonic stem cells, chondrocytes, MSCs

Cytokines/growth factors

Surface modifiers / peptides

SCAFFOLD
The module of scaffold

- Services as temporary structure

- Furthermore, the scaffold is gradually absorbed.
Properties of scaffold

- Good adhesion
- Good biocompatibility
- Biodegradability
- Non-toxicity
- Larger surface for cell-polymer interaction
Porous polymer

- Acts as a 3D carrier for seeding
- Exhibits viscosity
- Shows elastic characteristic
- Fragments will be bioactive
Molecule of material

- Biodegradable, insoluble (e.g., poly(lactic acid))
- Hydrophilic (e.g., poly(ethylene glycol))
- Linker
- Bioactive molecule
Cartilage Regeneration

- Porous polymer
TE cont...
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<th>Experiment</th>
<th>Acellular controls</th>
<th>Cellular constructs</th>
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<td></td>
<td>G' at day 1 [kPa]</td>
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* A reference G’ value for native articular cartilage at 1 Hz is 277 kPa
Example

- Only 2 weeks

- Cartilage re-grown in rabbit knee joint
Human septal cartilage was encapsulated with polyelectrolyte complex membranes and subcutaneously implanted on the back of nude mice.
Challenges for tissue engineering

- Getting a blood supply to the new tissue
- Manufacturing/processing of scaffolds with complex structures, gradients of materials, cell attachment/signalling molecules on surface, drug/growth factor delivery capabilities.
- New biomaterials for TE scaffolds
  - FDA approval of new biomaterials is difficult and expensive
Comparison

- Adhere well to tissue
- Incorporate to native tissue
- Biocompatible
- Mechanical property
- Desired degradable rate
- Regeneration VS. Replacement
References


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Reference cont…

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