Surface configuration of Implant

Challenges in Implantology

- Reduce healing time
- Improve results in suboptimal bone
- Strengthen bone-implant interface
- More bone around implant

Improve Techniques
Improve Tools

Implants in market

- Revolutionary implant
- Nano-technology
- Accelerate osseointegration
- Promote osseointegration
- Speed up osseointegration
- Osteoconductive

The latest advancement in implant dentistry

Quality of dental implants

- Quality of dental implants
  - Substantial number of claims made by different manufacturers on alleged superiority due to design and characteristics are not based on sound and long-term clinical scientific research


Race for the surface

Surface Characteristics
Topography + Chemistry

- IONS
- POLYSACCHARIDES
- IMMUNOGLOBULIN
- PROTEINS
- FIBROBLASTS
- CHONDROBLASTS
- OSTEOBLASTS

Endosseous Healing
Surface Topography
Surface Chemistry
Biomimetic Approach
Mechanism of Endosseous healing

- Distance osteogenesis
- Contact osteogenesis

**Distance Osteogenesis**
- Bone approximating the implant surface
  - Cortical bone
  - Osseointegration of “Machined” implant

**Contact Osteogenesis**
- Bone apposition to the implant surface
  - In poor quality bone, Surface
  - Osteoconduction
  - De novo bone formation (Cement line matrix)

**Osteoconduction in Contact Osteogenesis**
- Blood cells

**Osteoconduction in Contact Osteogenesis**
- Fibrin: The transitory matrix

References:
- Park & Davies. COIR 2000;1:530-539
**De novo Bone Formation in Contact Osteogenesis**

- Bone implant interface
  - Interfacial matrix

**Macrostructure**

- Thread implant
  - Optimize initial contact
  - Improve initial stability
  - Favor dissipation of interfacial stress

**Microstructure – Evaluation**

- Methods of evaluation
  - Rough?
  - Smooth?
  - Quantitative Evaluation

- Mechanical Contact Profilometer
- Optical Profiling (Confocal Laser Scanning Microscopy)
- Scanning Probe Microscope

**Material/manufacturer**

<table>
<thead>
<tr>
<th>Material</th>
<th>$S_r$ (SD)</th>
<th>$S_a$ (SD)</th>
<th>$S_k$ (SD)</th>
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</thead>
<tbody>
<tr>
<td>Nobel Biocare (Göteborg, Sweden)</td>
<td>0.05 (0.01)</td>
<td>6.6 (1.7)</td>
<td>1.20 (0.2)</td>
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<tr>
<td>Valpy</td>
<td>6.6 (1.1)</td>
<td>4.66 (1.6)</td>
<td>1.17 (0.1)</td>
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<tr>
<td>Fit-K</td>
<td>7.27 (0.4)</td>
<td>1.20 (0.3)</td>
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</tr>
</tbody>
</table>

**Where to evaluate?**

- Flank
- Top
- Valley

Effect of Surface Roughness

**ALP**: early marker of OB diff  
Osteocalcin : late marker of OB diff  
Type I collagen : indicator of synthetic capacity  
Runx-2(Cbfα-1), Osterix

**Osteoblast response**

- Sandblasting (Al₂O₃)
- Acid etching (1%HF+30% Nitric Acid)

**Turned**

- Sa = 0.20 μm
- Blasted with 63-90μm particles  
  Sa = 0.72 μm
- Blasted with 106-180μm particles  
  Sa = 1.30 μm
- Blasted with 180-300μm particles  
  Sa = 1.38 μm


**CBFα1 UMR**


**OB/FB response**

- Rat Calvaria OB  
- Human Gingival FB

Kunzler et al. Biomaterials 2007;29:2175-2182
Chemically modified titanium oxides

Fluoride

Table 1: Percentage of Bone-to-Implant Contact, Mean ± SD

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage Bone-to-Implant Contact, Mean ± SD</th>
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<tbody>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Fluoride-modified</td>
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Fluoride-modified


Titanium Oxide Layer

- Corrosion Resistance
- Passivation ability
- Amorphous Homogenous
- Thickness ≈ Crystalline

IONS
POLYSACCHARIDES
IMMUNOGLOBULIN
PROTEINS
FIBROBLASTS
CHONDROBLASTS
OSTEOBLASTS

Fluoride

Control
Fluoride-modified

Table 2: Removal Torque and Shear Strength, Mean ± SD

<table>
<thead>
<tr>
<th>Group</th>
<th>Removal Torque</th>
<th>Shear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
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<tr>
<td>Fluoride-modified</td>
<td></td>
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</tbody>
</table>


Fluoride

Control
Fluoride-modified

Table 1: Mechanical Characterization of the Implants, Mean ± SD

<table>
<thead>
<tr>
<th>Trait</th>
<th>Control</th>
<th>Fluoride-modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal torque</td>
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<tr>
<td>Shear strength</td>
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</tbody>
</table>


Fluoride
Fluoride

Non-modified BIC % = 34.21%
Fluoride-modified BIC % = 55.45%

Cooper et al. Biomaterials 2006;27:926-936

Agents for Biomimetic Approach

BMP, RGD
Type I Collagen

Bioceramics

HOW to coat implant surface with Ca-P?

Plasma Spraying

Biomimetic Coating (Simulated Body Fluid)

Ca10PO4(OH)2

Bio–ACTIVE Implant for chemical BONDING


Closer structure to bone mineral than plasma sprayed HA coating


Biomimetic Coating of Ca-P

Modification of SBF → Different mineral phase
Solubility & Attachment of bone marrow stromal cell


Agents for Biomimetic Approach

Chitosan: glucosamine + N-acetyl glucosamin

Bioceramics

Bioceramics

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Bioactive Protein - BMP

HOW to immobilize BMPs on titanium surface?

Use Allyamine
Incorporation BMP into biomimetic Ca-P
Thin amorphous layer of Ca-P
Subsequent growth of thick crystalline lattice work

Ti6Al4V plate
SBF with Mg
Supersaturated Ca-P + BMP

Alkaline phosphatase activity
SYPRO Ruby protein blot staining


Comment

Implant in Suboptimal condition
Faster osseointegration
Stronger bone-implant interface
Surface roughness
Surface chemistry
Biomimetic approach