Hard- and Soft Tissue Reactions to Dental Implants

Bilal Al-Nawas, Marc Klein
Oral- and Maxillofacial Surgery
High Success Rates

- 5 y: 95 – 100 %
- 10 y: 85 – 95 %

Is there a need for an antimicrobial surface in implant dentistry?
Implant Material

- Aluminiumoxid ceramic
- Titaniumalloy
- Cp(pure-)Titanium
- Zirconiumoxide ceramic

ASMA Mainz
Implant Material

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Hard Tissue - Osseointegration

Al-Nawas et al. 2007
Model of Osseointegration

Blood Components (Albumine, Fibrin) => Biofilm

Bone

Material-debris

Proteins

Proteins

Biomaterial
Model of Osseointegration

Migration, Adhesion, Proliferation of Leucocytes

Bone

Proteins

Material-debris

Thrombo-Leuko-Fibrocytes

Proteins

Biomaterial
Model of Osseointegration

Signaling proteins (IL-1, IGF)

Bone

Osteoblasts: Adhesion, Proliferation, Differentiation

Proteins

Material debris

Thrombo-Leuko-Fibrocytes

Cytokine

Osteoblasts

Biomaterial
Titanium Roughness and Hydrophilicity

**Cellular Morphology:** vital Staining via Transfection

PT  | SLA  | modSLA

Klein et al. submitted
Monitoring Cell Adhesion

- Monitoring der Zelladhäsion
- Kontrolle vs. Kollagen vs. Fibronectin

Klein et al. submitted
Osteocalcin – late cellular differentiation

Klein et al. submitted
Model of Osseointegration

Adhesion – Proliferation – Differentiation – Matrix / Calcification

Bone

Bone Maturing / Remodelling

Thrombo-Leuko-Fibrocytes

Material-debris

Cytokine

Proteins

Proteins

Osteoblasts

Biomaterial
SLActive vs. SLA

Buser et al. 2004
Surface roughness

smooth

blasted

ITI SLA

TiUnite

TiOblast

Osseotite

Al-Nawas et al. 2003
Clinical Goals

Reduced unloaded healing times

Avoid Augmentations

Long term Stability
Interaction Hard- and Softtissue
Bone reaction
Biologic width

Hermann et al 2003
Transmucosal part

similar roughness

mashined

0.1 to 10 µm

Grimm et al. 2003
Soft tissue and different surfaces

Glauser et al. CIDRR 2005
Soft tissue and different surfaces

- Machined
- Etched
- Oxidized

[Diagram showing the dimensions of different surfaces with labels for Epithel and Bindegewebe]
Surface ↔ Mucosa

- $\uparrow$ Roughness $\Rightarrow$ $\uparrow$ Plaque / Bacteria
  (Bollen et al. 1996)

- $\downarrow$ roughness $\Rightarrow$ $\downarrow$ epithelial Attachment
  (Bollen et al. 1996, Glauser et al. 2005)

- Dimension of Implant-Mucosa *biologic Width*
  (Hermann et al. 2000, Lindhe et al. 1998)

- Hemidesmosomes

- exact Mechanism of Attachment *unknown*. 
Isolated complication cause? loading?
10 year Implant survival

Fig. 1. Kaplan–Meier estimate of survival rates of implants, placed in patients with or without a history of periodontitis, as a function of time since insertion. Group A: patients with a history of periodontitis; group B: patients without a history of periodontitis.

Karoussis et al 2003
## Periimplantitis Prevalence

<table>
<thead>
<tr>
<th>Patienten</th>
<th>Bleeding</th>
<th>PA pathogens</th>
<th>Pockets ≥ 5 mm</th>
<th>Per-implantitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edentulous (n = 47)</td>
<td>57%</td>
<td>15%</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td>Remaining teeth (n = 53)</td>
<td>53%</td>
<td>34%</td>
<td>43%</td>
<td>36%</td>
</tr>
</tbody>
</table>
Cumulative Interceptive Supportive Therapy CIST
(Mombelli und Lang 1998)

- Mechanical scaling
- Local antiseptic therapy
- Antibiotic therapy
- Chirurgical therapy
Plaque control
CIST: Scaling and Antiseptics
Molecular biology

- leading bacteria
- mostly semiquantitative
- central processing
- Resistance testing (β-Lactamase!)

<table>
<thead>
<tr>
<th>Aggregatibacter actinomycetemcomitans</th>
<th>Peptostreptococcus micros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinomyces naeslundii</td>
<td>Porphyromonas gingivalis</td>
</tr>
<tr>
<td>Tanerella forsythiensis</td>
<td>Prevotella intermedia</td>
</tr>
<tr>
<td>Camphylobacter rectus</td>
<td>Selenomonas sputigena</td>
</tr>
<tr>
<td>Eikenella corrodens</td>
<td>Streptococcus intermedius</td>
</tr>
<tr>
<td>Eubacterium spp.</td>
<td>Treponema denticola</td>
</tr>
<tr>
<td>Fusobacterium nucleatum</td>
<td></td>
</tr>
</tbody>
</table>

Haffajee et Socransky 1994
Local (Topical) Antiinfectives

- **Atridox**  Doxycyclin Polymer 44 mg (8.8%)
- **Elyzol Gel**  Metronidazol 250 mg/g
- **Arestin**  Minocyclin (Polymer) Pulver 1mg
- **Periochip**  Chlorexidine (Gelatine)

![Graph showing concentrations of minocycline in gingival crevicular fluid (GCF) at site of administration.](image)
Future strategies?

Anti-Bioadhesion Coatings

- Alteration of cristaline structure of Ti (crystalline anatase) decreases bacterial adhesion (Del Curto et al. 2005)
- “dry processes” modification with alumina reduce bioadhesion (Yoshinari et al. 2001); fluorine reduces proliferation (Yoshinari et al. 2001)
- => yet not well documented
Future strategies?

Covalent Modification

- **Vancomycin** remains active > 1 Mon in vitro (Jose et al. 2005)
- Active in a rat model (Antoci et al. 2007)
- => Future indication for acute infections?
Future strategies?

Antibiotic release coatings

- Good clinical documentation in orthopedics (Gentamycin)
- Limited duration of activity!
- => Indication in osteomyelitis
Future strategies?

Photocatalytic surfaces
• Thin films / coatings become bactericidal under near ultraviolet light (Xu et al. 2006)
• => yet not well documented

Ag/Zn Modified Surfaces
• Seems not to alter osseointegration or soft tissue integration
In vivo Testing

• Dental Splint (Schwarz et al. 2005)
The Abutment – a Medical (!) Device!
Conclusions

• Soft tissue reactions are not well understood

• Good models for testing new materials are available

• There is a clear need for antimicrobial biomaterials in the mouth
Partners

- Applied Structure and Microanalysis (ASMA)– (Prof. Duschner, H. Götz)
- Dep. Of Traumatology (Dr. Kuhn)
- Fachhochschule Gelsenkirchen (Prof. Veith, M. Gorbhan)
- Max Planck Institute für Polymerforschung (Dr. Förch, Dr. Köper)