Outline

- History of Dental Implants
- Types
- Materials Used
- Procedures for Implantation
Outline

- Osseointegration
- Forces and Loading
- Problems/Disadvantages
- Future Developments
History

- Replace damaged or missing teeth
- Ancient Aztecs and Egyptians
- Dentures; around for 50 years
- Integrated dental implants; around for 25-30 years
Types of Dental Implants

- Intramucosal Inserts
  - AKA dentures
  - Attached to gum
  - Reduces chewing ability 40-80%
  - Lowest cost
Types of Dental Implants

- Subperiosteal
  - Attached on top of bone
  - Used with limited bone
  - Up to 90% chewing ability
  - High cost
Types of Dental Implants

- Endosteal
  - Attached to bone
  - Up to 100% chewing ability
  - High cost
Types of Dental Implants

- Implant-Borne Bridgework
  - Many adjacent missing teeth
  - Bridge between several implants
  - Up to 70% chewing ability
  - Medium cost
Materials

- 3 Main Components:
  - Crown
  - Abutment
  - Implant
Materials

- Crown
  - Mimic teeth properties
  - Porcelain (ceramic)
  - Porcelain-fused-to-metal
  - Gold
Materials

- Implant root
  - Titanium or titanium alloy
  - Corrosion resistant
  - Highly biocompatible

*Figure 7.1: Different types of threaded implants.*
Materials

- **Implant root**
  - Ideal length: 10mm
  - Ideal width: 3-5mm
  - Porous surface
    - Shot blasting
    - Hydroxyapatite coating
Implantation

- Two stage technique
  - Implant inserted into jawbone
  - Totally recovered by gingival tissue
  - Tissue reopened
  - Desire 40 N of torsion
  - Abutment and crown attached
Two stage technique
Two stage technique
Implantation

- One stage technique
  - Implant inserted into jawbone
  - Only 1 surgery
  - Protrudes through gums
  - Desire 40 N of torsion
One stage technique
Osseointegration

- Occurs when an implant is inserted into living bone
- Connection/bond forms between living bone and implant
- Key for long-term implant stability
Osseointegration

Factors affecting osseointegration

- Material
- Surface composition and structure
- Heat
- Initial stability
- Bone quality
Forces

- Mainly vertical and transversal
- Compression, tension, shear, and bending moments
- Mastication and bruxism
Forces

- Inclined surface of crown → angled force
- Axial and lateral components
Forces

- Human bite force: 250-1200N (molars), 80-400N (frontal)
- Lateral components of bite force: 20N
- Maximum contact stress on teeth: 20 MPa
- Bending moments: 10-50N⋅cm
## Material Stiffness

<table>
<thead>
<tr>
<th>Material</th>
<th>Young’s Modulus (GPa)</th>
<th>Poisson’s Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortical bone</td>
<td>13.7</td>
<td>0.30</td>
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<tr>
<td>Cancellous bone</td>
<td>7.93</td>
<td>0.30</td>
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<tr>
<td>Titanium</td>
<td>120</td>
<td>0.35</td>
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<tr>
<td>Type III dental gold alloy</td>
<td>96.6</td>
<td>0.35</td>
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<tr>
<td>Feldspathic procelain</td>
<td>82.8</td>
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<tr>
<td>Enamel</td>
<td>48</td>
<td>0.33</td>
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<tr>
<td>Dentin</td>
<td>13</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Material Strength

- Titanium yield stress: 225 MPa
- Cortical bone yield stress: 130 MPa
- Cancellous bone: even lower elastic modulus and strength
- Bone or bone-titanium bond will fail before the titanium
Osseointegrated Implant

- Bone heals around implant in the absence of loading
- Interlocking/in growth of bone into asperities of titanium implant
- Transmit shear stress directly into bone
- Misalignment results in internal stresses and reduces loading capacity
Loading

- Bone-titanium interface moves as unit; no relative motion of titanium in bone
- Inclined faces of screw thread transmit load to surrounding bone
Loading

Factors affecting load bearing capacity of implants:
- Type of loading
- Shape and dimension of implant
- Implant surface
- Implant structure/material
- Quality of bond to bone
Finite Element Method

- Study stress and strain in teeth
- Complex physical system divided into large number of discrete elements
- Individual elements are easy to analyze
Fig. 1. A 3D FE model of an implant/bone system constructed for analysis in this study. (a) 8mm fixture, (b) 13mm fixture, (c) abutment, (d) abutment screw
Forces

- Axial loading; maximum strain around implant base
- Lateral loading; maximum strain around implant neck
Moments

- Crown larger than diameter of implant
- Larger crown and higher cuspal inclinations lead to higher moments
- FEM study: narrow crown stress of 64 MPa; wide crown, 84 MPa
Loading

- Bare dental implant modeled as spring $K$
- Mass $(M)$ with velocity $(v)$ impacts
- High peak force
Loading

- Dental implant with abutment and crown modeled by softer spring $K_1$ and dashpot $\mu$
- Lower modulus of elasticity provides internal damping
- Impulse same, lower peak force
Problems

- Immediate loading may induce implant failure to osseointegrate
- Fibrous layer forms around an implant
- Any motion or abrasion of the implant will lead to degradation of surrounding bone

![Diagram showing osseointegrated and non-integrated bone structures](image)
Disadvantages

- Regular teeth are mobile → roots surrounded by periodontal ligament
- Pressure from ligament dissolves bone, reforms behind → orthodontics
- Dental implants rigid
Future Developments

- Dental implants very advanced (85-100% success)
- Minor research into artificial root membranes
- Major development in computer tomography of jawbone, simulations, stints
References


Questions?