Implant Occlusion

Dora Kompotiai
Boris Stein
David Wilson
“Currently, there is no evidence-based, implant-specific concept of occlusion”

“Future studies are needed to clarify the relationship between occlusion and implant longevity”
Since Implants lack PDL, it is believed that they are more prone to occlusal overloading, which is often regarded as one of the reasons for peri-implant bone-loss and failure of the implant/implant prosthesis.

Teeth intrude 25-100 microns

Implants intrude 3-5 microns

Occlusal Overload

The lack of PDL makes a large difference in detecting early phase of occlusal force between teeth and implants

Natural teeth can perceive an interference at approx 20microns, vs implants (48microns)

Occlusal Overload

Implants lack periodontal receptors and are more susceptible to occlusal overloading because:

- lack of load-sharing ability
- adaptation to occlusal force
- reduced mechanoreceptors

Opposing Arch

Complete implant fixed prosthesis do not have proprioception

Patients bite with 4x more force than with natural teeth
Overloading factors

Large cantilevers

Parafuction

Improper occlusal scheme (ej excessive lateral load)

Premature contacts
Overloading factors

6 monkeys with implant prosthesis delivered in supra-occlusion, and would displace the mandible in a lateral direction

Implants brushed 1x/wk, and cleaned sub-g 1x/mo

Of 6 implants in occlusal overload:
- 2 lost osseointegration
- 2 osseointegrated in apical part only
- 2 had 1.8-1.9mm bone loss

14 studies were included for review
11/14 were animal experimental studies
Humans: case reports and retrospective studies
Animal studies:
- Complete loss of osseointegration or marginal bone loss has been shown in few animal studies. Inconclusive results.
- Consistently shown that functional load increases remodeling activities around implants which can increase BIC and bone density.
• Human studies

- Repeatedly shown marginal bone loss and possible lack of osseointegration of implants with increased occlusal load

- However, these are retrospective studies and other factors can be considered
Occlusal Overload Prevention

Even distribution of occlusal contacts avoiding occlusal interferences and increasing number of implants may significantly reduce occlusal overload on implants and implant prosthesis.

Poor bone quality may be more vulnerable to occlusal overloading, which can be reduced by extending healing time and carefully monitored loading (progressive or delayed loading).

<table>
<thead>
<tr>
<th></th>
<th>Tooth</th>
<th>Implant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connection</td>
<td>Periodontal ligament (PDL)</td>
<td>Osseointegration (Bränemark et al. 1977), functional ankylosis (Schroeder et al. 1976)</td>
</tr>
<tr>
<td>Proprioception</td>
<td>Periodontal mechanoreceptors</td>
<td>Osseoperception</td>
</tr>
<tr>
<td>Tactile sensitivity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>(Mericske-Stern et al. 1995)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Axial mobility</td>
<td>25–100 μm</td>
<td>3–5 μm</td>
</tr>
<tr>
<td>(Sekine et al. 1986; Schulte 1995)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement phases</td>
<td>Two phases</td>
<td>One phase</td>
</tr>
<tr>
<td>(Sekine et al. 1986)</td>
<td>Primary: non-linear and complex</td>
<td>Linear and elastic</td>
</tr>
<tr>
<td></td>
<td>Secondary: linear and elastic</td>
<td></td>
</tr>
<tr>
<td>Movement patterns</td>
<td>Primary: immediate movement</td>
<td>Gradual movement</td>
</tr>
<tr>
<td>(Schulte 1995)</td>
<td>Secondary: gradual movement</td>
<td></td>
</tr>
<tr>
<td>Fulcrum to lateral force</td>
<td>Apical third of root (Parfitt 1960)</td>
<td>Crestal bone (Sekine et al. 1986)</td>
</tr>
<tr>
<td>Load-bearing characteristics</td>
<td>Shock absorbing function</td>
<td>Stress concentration at crestal bone (Sekine et al. 1986)</td>
</tr>
<tr>
<td></td>
<td>Stress distribution</td>
<td></td>
</tr>
<tr>
<td>Signs of overloading</td>
<td>PDL thickening, mobility, wear facets, fremitus, pain</td>
<td>Screw loosening or fracture, abutment or prosthesis fracture, bone loss, implant fracture (Zarb &amp; Schmitt 1990)</td>
</tr>
</tbody>
</table>
Overextended cantilever
- > 15 mm in the mandible
  (Shackleton et al. 1994)
- > 10-12 mm in the maxilla
  (Rangert et al. 1989; Taylor 1991)

Parafunctional habits/Heavy bite force
Excessive premature contacts
- > 180 μm in monkey studies
  (Miyata et al. 2000)
- > 100 μm in human
  (Falk et al. 1990)

Large occlusal table
Steep cusp inclination
Poor bone density/quality
Inadequate number of implants
Principles of Implant Occlusion

Bilateral stability in centric (habitual) occlusion

Evenly distributed occlusal contacts and force

No interferences between retruded position and centric

Narrow occlusal table (30-40% more narrow): reduces offset loading and increases axial loading
Principles of Implant Occlusion

Wide freedom in centric occlusion

Anterior guidance whenever possible

Smooth, even, lateral excursive movements w/o working/non-working interferences

Place posterior implant crowns in crossbite if necessary to create axial loading

Principles of Implant Occlusion

Occlusal adjustments could be performed by elimination of mobility difference between implants and teeth under heavy bites. This evenly distributes loads between implants and teeth.

Over time, teeth change position in vertical and mesial directions, while implants do not change position. Also, enamel wears faster than porcelain. Therefore, periodic occlusal adjustments are imperative.
## Principles of Implant Occlusion

<table>
<thead>
<tr>
<th>Clinical situations</th>
<th>Occlusal principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-arch fixed prosthesis</td>
<td>- Bilateral balanced occlusion with opposing complete denture</td>
</tr>
<tr>
<td></td>
<td>- Group function occlusion or mutually protected occlusion with shallow anterior guidance when opposing natural dentition</td>
</tr>
<tr>
<td></td>
<td>- No working and balancing contact on cantilever</td>
</tr>
<tr>
<td></td>
<td>- Infraocclusion in cantilever segment (100 µm)</td>
</tr>
<tr>
<td></td>
<td>- Freedom in centric (1–1.5 mm)</td>
</tr>
<tr>
<td>Overdenture</td>
<td>- Bilateral balanced occlusion using lingualized occlusion</td>
</tr>
<tr>
<td></td>
<td>- Monoplane occlusion on a severely resorbed ridge</td>
</tr>
</tbody>
</table>
## Principles of Implant Occlusion

<table>
<thead>
<tr>
<th>Posterior fixed prosthesis</th>
<th>Single implant prosthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Anterior guidance with natural dentition</td>
<td>• Anterior or lateral guidance with natural dentition</td>
</tr>
<tr>
<td>• Group function occlusion with compromised canines</td>
<td>• Light contact at heavy bite and no contact at light bite</td>
</tr>
<tr>
<td>• Centered contacts, narrow occlusal tables, flat cusps, minimized cantilever</td>
<td>• Centered contacts (1–1.5 mm flat area)</td>
</tr>
<tr>
<td>• Cross bite posterior occlusion when necessary</td>
<td>• No offset contacts</td>
</tr>
<tr>
<td>• Natural tooth connection with rigid attachment when compromised support</td>
<td>• Increased proximal contact</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor quality of bone/Grafted bone</td>
<td></td>
</tr>
<tr>
<td>• Longer healing time</td>
<td>• Progressive loading by staging diet and occlusal contacts/materials</td>
</tr>
<tr>
<td>• Progressive loading by staging diet and occlusal contacts/materials</td>
<td></td>
</tr>
</tbody>
</table>
Principles of Implant Occlusion

- **Increase support area**
  - Bone quality
    - Extended healing time
    - Progressive loading
  - Bone quantity
    - Implant number
    - Implant diameter
    - Implant length
    - Implant surface

- **Improve force direction**
  - Occlusal morphology
    - Flat central fossa
    - Cusp inclination
    - Occlusal table
    - Along implant axis
    - Centered contacts

- **Reduce force magnification**
  - Occlusal contacts
    - Position
    - Distribution
  - Types of Prosthesis
    - Cantilever length
    - Cross bite
    - Splinting
  - Implant position

Teeth designed for long-axis loads
Natural roots perpendicular to curves of Wilson + Spee
Contact during mastication $\rightarrow$ forces along long-axis of roots

Implants designed for long-axis loads
Generates less overall stress
↑ Proportion of compressive stress compared to angled forces

Implant body should be perpendicular to curves of Wilson + Spee
Implant Body Orientation

Finite element analysis

All designs sustained stress contours concentrated at the crestal region of the implant.

12° angled force
↑ force to the implant by 18.6%, 21 N
↑ shear force
Force Direction

15 degree axial implant ➔ load to facial bone ↑ 25.9%

30 degree axial implant ➔ load to facial bone ↑ 50%

Force Direction

Bone is strongest to compressive forces
30% weaker to tensile forces
65% weaker to shear forces

Force Direction

Bone strength is decreased under angled forces

↑ the angle of load → ↓ strength of bone

<table>
<thead>
<tr>
<th>Type</th>
<th>Strength (mPa)</th>
<th>Direction of Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>193</td>
<td>Longitudinal</td>
</tr>
<tr>
<td></td>
<td>173</td>
<td>30 degrees off axis</td>
</tr>
<tr>
<td></td>
<td>133</td>
<td>60 degrees off axis</td>
</tr>
<tr>
<td></td>
<td>133</td>
<td>Transverse</td>
</tr>
<tr>
<td>Tension</td>
<td>133</td>
<td>Longitudinal</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>30 degrees off axis</td>
</tr>
<tr>
<td></td>
<td>60.5</td>
<td>60 degrees off axis</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>Transverse</td>
</tr>
</tbody>
</table>

Force Direction

Axial Load → Lamellar Bone

Non-Axial Load → Woven Bone

Mineralized, organized

Less mineralized, unorganized

Force Direction

Non-axially loaded implants ➔

↑ Total force, ↑ Shear force

↑ Risk of crestal bone loss

↑ Risk of porcelain fracture under shear force

↑ Risk of loss of cement retention due to shear force

↑ Risk of abutment screw loosening and implant component fracture under shear loads

Angled abutments should **ONLY** be used:

- Improve path of insertion of prosthesis
- Improve final esthetic result
P: Analyze stresses generated with different angulations to the long axis of the implant, under axial and oblique loading by Finite Element Modelling and Analysis.

M+M:
Frontal region of maxilla modelled with a cortical layer 1.5 mm thick with an inner cancellous core
Implant: cylindrical, round ended, 4.1 x 13 mm.
Abutment: 7 mm height with a 5 degree occlusal taper.
Abutment angulations: 0°, 10°, 15° and 20°.
Loads used: 100, 125, 150, 175 and 200 N axially, and 50 N in oblique direction.

Evaluation of stress patterns in bone around dental implant for different abutment angulations under axial and oblique loading:

Rohit Bahuguna, Bhargavi Anand, Dheeraj Kumar, Himanshu Aker, Vishal Anand, Minkle Gulati

Table 4: Compressive stress and tensile stress under axial loading

<table>
<thead>
<tr>
<th>Angulation mode of abutment</th>
<th>0 deg. Axial (MPa)</th>
<th>100 N</th>
<th>125 N</th>
<th>150 N</th>
<th>175 N</th>
<th>200 N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. compressive stress</td>
<td>1.106</td>
<td>1.382</td>
<td>1.660</td>
<td>1.937</td>
<td>2.212</td>
<td></td>
</tr>
<tr>
<td>Max. tensile stress</td>
<td>1.410</td>
<td>1.762</td>
<td>2.115</td>
<td>2.467</td>
<td>2.820</td>
<td></td>
</tr>
<tr>
<td>Max. compressive stress</td>
<td>1.188</td>
<td>1.485</td>
<td>1.782</td>
<td>2.079</td>
<td>2.376</td>
<td></td>
</tr>
<tr>
<td>Max. tensile stress</td>
<td>2.513</td>
<td>3.141</td>
<td>3.770</td>
<td>4.398</td>
<td>5.026</td>
<td></td>
</tr>
<tr>
<td>Max. compressive stress</td>
<td>1.528</td>
<td>1.909</td>
<td>2.291</td>
<td>2.673</td>
<td>3.056</td>
<td></td>
</tr>
<tr>
<td>Max. tensile stress</td>
<td>2.854</td>
<td>3.568</td>
<td>4.282</td>
<td>4.995</td>
<td>5.708</td>
<td></td>
</tr>
<tr>
<td>Max. compressive stress</td>
<td>1.635</td>
<td>1.933</td>
<td>2.454</td>
<td>2.862</td>
<td>3.271</td>
<td></td>
</tr>
<tr>
<td>Max. tensile stress</td>
<td>3.417</td>
<td>3.733</td>
<td>5.125</td>
<td>5.979</td>
<td>6.833</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of stress patterns in bone around dental implant for different abutment angulations under axial and oblique loading:

Rohit Bahuguna, Bhargavi Anand¹, Dheeraj Kumar¹, Himanshu Aeran, Vishal Anand, Minkle Gulati

Table 5: Compressive stress and tensile stress for 50 N force under oblique loading

<table>
<thead>
<tr>
<th>Angulation mode of abutment</th>
<th>45 deg. Oblique (MPa)</th>
<th>50 N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>Max. Compressive stress</td>
<td>3.873</td>
</tr>
<tr>
<td></td>
<td>Max. Tensile stress</td>
<td>9.441</td>
</tr>
<tr>
<td>10°</td>
<td>Max. Compressive stress</td>
<td>4.128</td>
</tr>
<tr>
<td></td>
<td>Max. Tensile stress</td>
<td>11.367</td>
</tr>
<tr>
<td>15°</td>
<td>Max. Compressive stress</td>
<td>4.214</td>
</tr>
<tr>
<td></td>
<td>Max. Tensile stress</td>
<td>12.521</td>
</tr>
<tr>
<td>20°</td>
<td>Max. Compressive stress</td>
<td>4.306</td>
</tr>
<tr>
<td></td>
<td>Max. Tensile stress</td>
<td>13.555</td>
</tr>
</tbody>
</table>

As the abutment angulation ↑, there is an ↑ in both tensile and compressive stresses yet they are within the tolerance limits of the bone.

Increase observed in both the axial and oblique loading.

Care should be taken while planning a restoration to minimize the oblique component of force.

Solution to Angled Loads

A reduction in the force magnitude
Additional surface area of implant support is indicated

**Surgically:**
1. Additional implant next to most angled implant
2. ↑ Diameter of the angled implant
3. Select implant design with greatest surface area
Solution to Angled Loads

- A reduction in the force magnitude
- Additional surface area of implant support is indicated

Restoratively:
1. Splinting implants together
2. Reducing occlusal load on angled implants
3. Eliminating all lateral or horizontal forces on angled implants
Cantilevers

Cantilevers are **force magnifiers** on implants, abutment screws, cement or prosthesis screws, and implant-bone interface.

Class I Lever -  

\[
\text{effort arm} = \text{length of cantilever} \\
\text{resistance arm} \quad \text{distance b/w abutments}
\]
Cantilevers

Mechanical advantage = 20mm/10mm = 2

Force to cantilever → 2 x Force on furthest abutment
Sum of forces on fulcrum abutment

Cantilevers

Force on cantilever: compressive
Force on furthest abutment: tensile and shear
Force on closest abutment (fulcrum): compressive
Cantilevers

Exceptions when cantilevers maybe acceptable if low force factors and increased bone density:

**Cantilever the lateral incisor**

Edentulous mandible with insufficient bone in the posterior
Crown Height

- Implant is loaded in long axis → Crown height does NOT magnify force

- Lateral load, angled force, or cantilever applied → Crown height is a force magnifier (vertical cantilever)
  - Load applied to occlusal table → magnified by crown height

Crown Height

Crown height directly increases effect of angled force

100 N load at a 12° angle $\rightarrow$ 21 N of lateral/shear force

15mm Crown x 21N force = 315 N-mm moment force

P: Review on the consequences loading has on the bone surrounding already osseointegrated oral implants.

M+M: A search in the PubMed database performed with the terms oral implant/dental implant/implant and load/overload/force and bone. None of the 607 papers revealed were randomized controlled clinical studies or prospective cohort studies in respect to evaluating the influence of controlled forces on peri-implant bone. An expanded hand search was done, failed to reveal any randomized controlled clinical studies or prospective cohort studies. Mode of a narrative review was chosen.
D:
- Most clinical studies have only few patients and a small frequency of failed implants.
- Much of the knowledge in this field is derived from a relatively small number of experimental animal studies, and it may be difficult to draw definitive conclusions.
- Difficult clinically to quantify the magnitude and direction of naturally occurring occlusal forces.
- Difficult to discover a possible correlation between occlusal forces and implant failures.

Bone tissue reacts to strain. A given force may affect different bones or bone tissues differently, but mechanically loaded bones adapt to the load.

If the strain in the bone surrounding an oral implant is in the mild overload range (1500–3000 microstrain), apposition of bone seems to be the biological response. Strain in the bone beyond this range will at some point result in fatigue fracture and bone resorption.

Animal experimental studies have shown that occlusal load may result in increased marginal bone loss around oral implants.
D:

- Only one animal experimental study has shown that excessive occlusal load can cause complete loss of osseointegration.

- In clinical studies increased bone loss has been observed in areas of relatively high stress, but a causative relationship with overload, has not been established.

- In clinical studies occlusal forces may be associated with loss of oral implants, a causative relationship has never been convincingly demonstrated.

**Loading Protocols**

*Immediate restoration*: A restoration inserted within 48hrs of implant placement but not in occlusion with the opposing dentition.

*Immediate loading*: A restoration placed in occlusion with the opposing dentition within 48hrs of implant placement.

*Early loading*: A restoration is in contact with the opposing dentition and placed at least 48hrs after implant placement but not later than 3 months.
**Conventional loading:** The prosthesis is attached in a second procedure after a healing period of 3-6 months.

**Delayed loading:** The prosthesis is attached in a second procedure that takes place later than the conventional healing period of 3-6 months.

Cochran et al. 2004
The decision to immediately load or restore dental implants is based on:

- Primary clinical stability of the implants
- Adequate implant splinting where appropriate
- Provisional restorations that promote splinting and reduce or control the mechanical load applied to implants
- Prevention of provisional restoration removal during the healing period

Morton et al, 2004
Risk factors for immediate restoration/loading

- High masticatory or parafunctional habits
- Poor bone quality
Restorative considerations for immediate loading

Biomechanical effects of the provisional restoration should be controlled by:

1) limiting and distributing occlusal contact in centric occlusion or maximum intercuspation
2) removing all excursive contacts from provisional restorations
3) limiting the effects of cantilevers and off-axial loading
4) author recommends splinting implants whenever possible

Morton et al 2004
Immediate loading recommendations

**Edentulous mandible** - Well documented procedure for:

4 implants with rigid bar fixation and overdenture or a fixed restoration that rigidly connects the implants

**Edentulous maxilla**: No routine procedure is recommended

**Partially dentate maxilla and mandible**: No routine procedure is recommended

Cochran et al, 2004
Occlusal Adjustment

No study demonstrates increase in parafunction after occlusal adjustment

Benefit: decrease risk of occlusal overload on particular teeth and added benefit of perhaps reducing parafunction

Almost every patient diagnosed with parafunction should undergo occlusal analysis and adjustment if necessary

Is bruxism a contraindication for implants?
• Bruxism is a complex disease of multifactorial origin for which treatment has been shown to be ineffective

• Dental implants should not be contraindicated any more than any other form of restorative dentistry as soon as the patient understands that his/her increased risk of oral destruction is not something that the dentist can control
Occlusal Guards

In partially edentulous patients, the maxillary nightguard can be relieved around the implant crowns so the remaining teeth bear the entire load.

A mandibular posterior cantilever on a full-arch implant prosthesis may also be taken out of occlusion with a maxillary night guard.

Soft reline material may be placed around the implant crowns to act as a stress relief element (or night guard may be made shorter, not including the cantilever).
Tongue Thrust

Definition: the unnatural force of the tongue against the teeth during swallowing

Although of lesser intensity than other parafunctional forces, it can increase stress at the site of the implant.

This is critical for 1-stage approaches

May contribute to incision line openings

Tongue Thrust

**Anterior tongue thrust:** hold lower lip down, squirt water into the mouth and ask patient to swallow. A person without a tongue thrust will use the tongue to create a vacuum and swallow. A patient with anterior tongue thrust cannot create the vacuum to swallow.

**Posterior tongue thrust:** retract one cheek at a time away from posterior teeth, inject water and ask patient to swallow. Visual evidence may be accompanied by pressure against the instrument and confirms a lateral force.

Treatment of malpositioned implants
Implant occlusal complications
Unfavorable Implant Position

• Lack of available bone for implant placement

• Pt’s unwillingness to undergo augmentation procedures

• Inadequate diagnosis and treatment planning with the restorative dentist
Esthetic complications of malpositioned implants
Mechanical Complications of Malpositioned Implants

- Ceramic fracture
- Screw loosening / fracture
- Implant fracture
Why porcelain keeps breaking on implant screw retained restorations?
Prevention of occlusion related ceramic fracture

- Create a coping that more closely reflects the final contour and volume of the final restoration

- Use a custom abutment that more closely reflects the shape of the final restoration
Splint or no splint multiple adjacent implants?

• No current scientific evidence
• Clinician must make the determination based on personal experience

Splinting- avoidance of adjusting multiple IPx contacts

No splinting- if complication occurs is limited to single complex
Thank you