Occlusal considerations in implant therapy: clinical guidelines with biomechanical rationale

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Key words: dental implant, implant longevity, implant occlusion, overloading

Abstract: Due to lack of the periodontal ligament, osseointegrated implants, unlike natural teeth, react biomechanically in a different fashion to occlusal force. It is therefore believed that dental implants may be more prone to occlusal overloading, which is often regarded as one of the potential causes for peri-implant bone loss and failure of the implant/implant prosthesis. Overloading factors that may negatively influence on implant longevity include large cantilevers, parafunctions, improper occlusal designs, and premature contacts. Hence, it is important to control implant occlusion within physiologic limit and thus provide optimal implant load to ensure a long-term implant success. The purposes of this paper are to discuss the importance of implant occlusion for implant longevity and to provide clinical guidelines of optimal implant occlusion and possible solutions managing complications related to implant occlusion. It must be emphasized that currently there is no evidence-based, implant-specific concept of occlusion. Future studies in this area are needed to clarify the relationship between occlusion and implant success.

Occlusal overload is often regarded as one of the main causes for peri-implant bone loss and implant/implant prosthesis failure. Studies have suggested that occlusal overload may contribute to implant bone loss and/or loss of osseointegration of successfully integrated implants (Adell et al. 1981; Rosenberg et al. 1991; Quirynen et al. 1992; Rangert et al. 1995; Isidor 1996, 1997; Miyata et al. 2000). In contrast, others believed that peri-implant bone loss and/or deosseointegration are primarily associated with biological complications such as peri-implant infection [Tonetti & Schmid 1994; Lang et al. 2000]. They questioned the causality of occlusal overloading for peri-implant tissue loss due to insufficient scientific evidence. However, it needs to be stressed that occlusal overload can cause mechanical complications on dental implants and implant prostheses such as screw loosening and/or fracture, prosthesis fracture, and implant fracture, eventually leading to compromised implant longevity (Schwarz 2000).

Unlike natural teeth, osseointegrated implants are ankylosed to surrounding bone without the periodontal ligament (PDL), which provides mechanoreceptors as well as shock-absorbing function [Schulte 1995]. Moreover, the crestal bone around dental implants may act as a fulcrum point for lever action when a force (bending moment) is applied, indicating that peri-implant tissues could be more susceptible to crestal bone loss by applying force. Literature has reported that the clinical success and longevity of dental implants can be achieved by biomechanically controlled occlusion (Rangert et al. 1989, 1997; Adell et al. 1990; Misch 1995).
Table 1 shows the comparison between tooth and implant.

<table>
<thead>
<tr>
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<tr>
<td>Proprioception</td>
<td>Tooth: Periodontal mechanoreceptors</td>
<td>Implant: Osseoperception</td>
</tr>
<tr>
<td>Tactile sensitivity</td>
<td>Tooth: High</td>
<td>Implant: Low</td>
</tr>
<tr>
<td>Axial mobility</td>
<td>Tooth: 25–100 μm</td>
<td>Implant: 3–5 μm</td>
</tr>
<tr>
<td>Movement phases</td>
<td>Tooth: Two phases (primary: non-linear and complex, secondary: linear and elastic)</td>
<td>Implant: One phase (linear and elastic)</td>
</tr>
<tr>
<td>Movement patterns</td>
<td>Tooth: Primary: immediate movement, secondary: gradual movement</td>
<td>Implant: Gradual movement</td>
</tr>
<tr>
<td>Fulcrum to lateral force</td>
<td>Tooth: Apical third of root (Parfitt 1960)</td>
<td>Implant: Crestal bone (Sekine et al. 1986)</td>
</tr>
<tr>
<td>Load-bearing characteristics</td>
<td>Tooth: Shock absorbing function, stress distribution</td>
<td>Implant: Stress concentration at crestal bone (Sekine et al. 1986)</td>
</tr>
<tr>
<td>Signs of overloading</td>
<td>Tooth: PDL thickening, mobility, wear facets, fremitus, pain</td>
<td>Implant: Screw loosening or fracture, abutment or prosthesis fracture, bone loss, implant fracture (Zarb &amp; Schmitt 1990)</td>
</tr>
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</table>

It is essential for clinicians to understand inherent differences between teeth and implants and how force, either normal or excessive force, may influence on implants under occlusal loading.

Currently, scientific evidence with regard to implant occlusion is insufficient, limited to mainly in vitro, animal, and retrospective studies [Taylor et al. 2000]. Therefore, the purposes of this paper are to discuss the importance of implant occlusion for implant longevity and to provide clinical guidelines of optimal implant occlusion based on the currently available literature. In addition, possible solutions managing complications related to implant occlusion are proposed.
et al. [1995] in which the mean threshold value of tactile perception for implants (100.6 g) was 8.75 times higher than that of natural teeth (11.5 g). From the results of the above studies, it can be speculated that osseointegrated implants without periodontal receptors would be more susceptible to occlusal overloading because the load-sharing ability, adaptation to occlusal force, and mechanoreception are significantly reduced in dental implants.

**Overloading factors of implant occlusion**

A large cantilever of an implant prosthesis can generate overloading, possibly resulting in peri-implant bone loss and prosthetic failures [Lindquist et al. 1988; Quirynen et al. 1992; Shackleton et al. 1994]. Duyck et al. [2000] reported that the loading position on fixed full-arch implant-supported prostheses could affect the resulting force on each of supporting implants. When a biting force was applied to the distal cantilever, the highest axial forces and bending moments were recorded on the distal implants, which were more pronounced in the prostheses supported by only three implants as compared with prostheses with five or six implants. In a series of studies, it was found that closing and chewing forces increased distally along the cantilever beams when occluding with complete denture and decreased distally when occluding with fixed partial dentures [Falk et al. 1989, 1990; Lundgren et al. 1989]. The displacement of complete denture during function might create heavy occlusal contacts on the posterior cantilever segment. This finding suggested that simultaneous occlusal contacts along the prosthesis were significant, and the number and distribution of occlusal contacts on cantilever segments should be controlled carefully with the opposing complete denture. Interestingly, Lindquist et al. [1988] noted more peri-implant bone loss at the anterior implants in patients treated with mandibular fixed implant-supported prostheses with distal cantilevers. Later, the same group reported that peri-implant bone loss was mainly correlated with poor oral hygiene and smoking, not with occlusal overload [Lindquist et al. 1996, 1997]. Currently, the correlation between implant bone loss and overloading induced by cantilevers remains unanswered. However, it cannot be disregarded that a cantilever, especially a long cantilever, may introduce a larger force on the implant prosthesis, depending on the position and direction of force, which may result in overloading on supporting implants. Regarding a cantilever length, a clinical study demonstrated that long cantilevers (≥ 15 mm) induced more implant-prosthesis failures as compared with cantilevers shorter than 15 mm [Shackleton et al. 1994]. The results of the above studies indicated that a shorter cantilever length is more favorable for the success of mandibular fixed implant-supported prostheses, particularly critical for the prosthesis supported by less number of implants.

Several studies have reported that parafunctional activities [bruxism, clenching, etc.] and improper occlusal designs are correlated with implant bone loss/failure, implant fractures, and prosthesis failures [Falk et al. 1989, 1990; Naert et al. 1992; Quirynen et al. 1992, Rangert et al. 1995]. Naert et al. [1992] speculated that overload from parafunctional habits seemed to be the most probable cause of implant loss and marginal bone loss after loading. They also emphasized that the frequent occurrence of distal implant loss, eight out of 12 cases evaluated, might reflect the necessity of optimal spreading of implants, short cantilevers, and a proper occlusal design. Rangert et al. [1995] evaluated 39 fractured implant cases. Most of implant fractures, 35 out of 39 (90%), occurred in the posterior area, and most of prostheses, 30 out of 39, were supported by one or two implants with cantilever in association with heavy occlusal forces such as bruxism. In this study, in-line placement, leverage factors (cantilever), and bruxism or heavy occlusal force were suggested as the possible causes of implant fracture. Quirynen et al. [1992] reported that excessive marginal bone loss and/or implant loss were found in patients with lack of anterior contacts, the presence of parafunctional activities, and full-fixed implant-supported prostheses in both jaws. The retrospective study suggested a correlation between occlusal overloading resulting from those factors and severe marginal bone loss and/or loss of osseointegration. In contrast, in a prospective 15-year follow-up study, no notable correlation was found between implant marginal bone loss and load-related factors, such as bite force and cantilever length [Lindquist et al. 1996].

The different results between the above studies might have been attributed to individual variability of the patients and prosthetic condition and differences in occlusal designs. Falk et al. [1990] reported that the occlusal design (the number and distribution of occlusal contacts) had a major influence on the different force distribution between a cantilever segment and implant-supported area, increasing local forces significantly on the cantilever unit. In summary, it is implied that heavy occlusal force and undesirable distribution of occlusal contacts may be factors of overloading, thus possibly leading to higher susceptibility to implant bone loss, implant fractures/loss, and prosthesis failures.

Loss of osseointegration and excessive marginal bone loss from excessive lateral load provided with premature occlusal contacts were demonstrated in several animal studies [Isidor 1996, 1997; Miyata et al. 2000]. In non-human primate studies, it was observed that five out of eight implants lost osseointegration due to excessive occlusal overloading after 4.5–15.5 months of loading [Isidor 1996, 1997]. Among the three remaining implants, one showed severe crestal bone loss and the other two showed the highest bone-implant contact and density. The results suggested that implant loading might have significantly affected the responses of peri-implant osseous structures. However, it should be noted that the loss of osseointegration observed might have been attributed to the unrealistically high-occlusion overload used in the study. Similar studies were performed in monkeys with different heights of hyperocclusion, 100, 180, and 250 μm [Miyata et al. 1998, 2000]. After 4 weeks of loading, bone loss was observed in 180 and 250 μm group, not in the 100 μm group. The results of these studies suggested that there would be a critical height of premature occlusal contacts on implant prostheses for crestal bone loss. Hoshaw et al. [1994] applied an excessive controlled cyclic load (330 N, 500 cycles, 5 days) on implants in canine tibia. Significant bone resorption and less mineralized bone percentage were observed in loading group compared with non-loading group. Another study demonstrated that excessive dynamic loading (73.5 N/cm bending moment and total 2520 cycles for 2 weeks) on implants placed in rabbit tibia caused...
crater-like bone defects lateral to implants [Duyck et al. 2001]. Contradictory to the findings from the above studies, some studies have demonstrated that overloading did not increase marginal bone loss [Asikainen et al. 1997; Hürzeler et al. 1998]. The difference observed between the studies may be attributed to different magnitude and duration of applied force. Also, it should be noted that direct application of the findings from the animal studies to humans requires caution. Nonetheless, it can be speculated that occlusal overload may act as one of the factors causing marginal bone loss and implant failure.

Bone quality has been considered the most critical factor for implant success at both surgical and functional stages, and it is therefore suggested that occlusal overload in poor-quality bone can be a clinical concern for implant longevity [Lekholm & Zarb 1985; Misch 1990a]. In human studies, higher failures of implants were observed in bone with poor quality [Engquist et al. 1988; Jaffin & Berman 1991; Becktor et al. 2002]. Jaffin & Berman [1991] reported that 35% of implants placed in poor bone quality (i.e. posterior maxilla) failed at the second-stage surgery. However, it should be noted that all of the implants evaluated were Bränemark implants with a smooth pure-titanium surface, which is considered less favorable for poor quality bone (Cochran 1999). Some studies reported that higher implant failures in maxillary overdentures were attributed to poor bone quality of the maxilla [Engquist et al. 1988; Quirynen et al. 1992; Hutton et al. 1995]. In addition to poor bone quality, unfavorable load direction may have contributed to higher failure rates in the maxilla [Jemt & Lekholm 1995; Blomqvist et al. 1996; Raghoebar et al. 2001; Becktor et al. 2002]. Esposito et al. [1997] found that late failure of implants did not show any infectious factor in histological evaluation. The combination of poor bone quality and overload was considered to be the leading cause for the late implant failure.

Misch [1990b] proposed that progressive bone loading can permit development time for load-bearing bone at bone-to-implant interface and provide bone with adaptability to loading via a gradual increase of loading. He further described that the progressive bone loading could be attained by the practice of increasing occlusal load over a time period of 6 months. Appleton et al. [1997] also noted that progressively loaded implants had increased bone density as well as reduced amounts of crestal bone loss. These findings suggest that extended healing time and carefully monitored loading may be needed in poor quality bone.

From the above studies, it can be speculated that (1) the amount of stress and the quality of the bone are related to implant longevity, (2) occlusal overloading, possibly resulting from large cantilevers, excessive premature contacts, parafunctional activities, improper occlusal designs, and/or osseointegrated full fixed prostheses in both jaws, can be a limiting factor for implant longevity [Table 2]; (3) Even distribution of occlusal contacts avoiding occlusal interferences and increasing number of implants may significantly reduce occlusal overload on implants and implant prostheses; and (4) poor quality bone may be more vulnerable to occlusal overloading, which can be reduced by extended healing time and carefully monitored loading (e.g. progressive or delayed loading).

**Types and principles of implant occlusion**

The types and basic principles of implant occlusion have largely been derived from occlusal principles in tooth restoration. Three occlusal concepts (balanced, group-function, and mutually protected occlusion) have been established throughout clinical trials and conceptual theories [Pameijer 1983; Santos 1985; Hobo et al. 1989]. All of the concepts may have maximum intercuspation (MIP) during habitual and/or centric occlusion. First of all, bilateral balanced occlusion has all teeth contacting during all excursions. It is primarily used in complete denture fabrication [Stuart 1955]. In group-function occlusion, posterior teeth contact on the working side during lateral movements, without balancing side contacts. This occlusion is used primarily with compromised canines in order to share lateral pressures to posterior teeth instead of the canine (Schuyler 1959). Mutually protected occlusion has posterior teeth protection in habitual and/or centric occlusion via posterior contacts in MIP while light contacts on anterior teeth and anterior guidance during all excursions. This occlusal scheme is based on the concept that the canine is a key element of occlusion avoiding heavy lateral pressures on posterior teeth [D’Amico 1958]. It has been considered a convenient and reasonable type of occlusal scheme for prosthetic rehabilitation, even though scientific evidence does not yet provide its clinical advantages [Pameijer 1983]. These occlusal concepts (i.e. balanced, group-function, and mutually protected occlusion) have been successfully adopted with modifications for implant-supported prostheses [Adell et al. 1981; Chapman 1989; Hobo et al. 1989; Naert et al. 1992; Lundgren & Laurell 1994; Wismeijer et al. 1995; Misch 1999a]. Furthermore, implant-protected occlusion has been proposed strictly for implant prostheses [Misch & Bidez 1994]. This concept is designed to reduce occlusal force on implant prostheses and thus to protect implants. For this, several modifications from conventional occlusal concepts have been proposed, which include providing load sharing occlusal contacts, modifications of the occlusal table anatomy and occlusal force distribution during all excursions.

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**Table 2. Possible overloading factors**

<table>
<thead>
<tr>
<th>Overextended cantilever</th>
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<tr>
<td>&gt;15 mm in the mandible (Shackleton et al. 1994)</td>
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<tr>
<td>&gt;10–12 mm in the maxilla (Rangert et al. 1989; Taylor 1991)</td>
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<table>
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<tr>
<th>Parafonctional habits/Heavy bite force</th>
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<tr>
<td>Excessive premature contacts</td>
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<tr>
<td>&gt;180 µm in monkey studies (Miyata et al. 2000)</td>
</tr>
<tr>
<td>&gt;100 µm in human (Falk et al. 1990)</td>
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</table>

| Large occlusal table |
| Steep cusp inclination |
| Poor bone density/quality |
| Inadequate number of implants |
occlusal contacts and force, [3] no interferences between retruded position and centric (habitual) position, [4] wide freedom in centric (habitual) occlusion, [5] anterior guidance whenever possible, and [6] smooth, even, lateral excursive movements without working/non-working interferences. Along with evenly distributed occlusal contacts, bilateral occlusal stability provides stability of the masticatory system and a proper force distribution (Beyron 1969). This can reduce the possibility of premature contacts and decrease force concentration on individual implants. In addition, wide freedom in centric can accomplish more favorable vertical lines of force and thus minimize premature contacts during function. Weinberg [1998] recommended continuous 1.5 mm flat fossa area for wide freedom in centric in the prosthesis based on his clinical experience. In addition, Gibbs et al. [1981] found that anterior or canine guidance decreased chewing force compared with posterior guidance. Quirynen et al. [1992] reported that lack of anterior contacts in an implant-supported cross-arch bridge created excessive marginal bone loss in posterior implants. The anterior or canine guidance could minimize potentially destructive forces in posterior implants. In addition to the advantage of the anterior guidance, smooth and even lateral working contacts without cantilever contacts in the posterior region may be preferred to provide proper force distribution and to protect the anterior region (Chapman 1989; Engelman 1996). It was suggested that working-side contacts should be placed as anteriorly as possible to minimize the bending moment [Lundgren & Laurell 1994].

Hobkirk & Brouziotou-Davas [1996] evaluated masticatory force patterns of two occlusal schemes (balanced occlusion and group-function occlusion) with various foods in mandibular implant-supported prostheses. The mean peak masticatory force and load rate were lowest when eating bread and highest when chewing nuts, and the values of the mean peak masticatory force and load rate were lower with balanced occlusion compared with group-function occlusion upon chewing nuts and carrots. The study suggested that balanced occlusion might be more protective than group-function occlusion. However, Wennerberg et al. [2001] observed that occlusal factors in mandibular implant-supported prostheses opposing complete dentures did not influence patient satisfaction and treatment outcomes. It is implied that occlusal schemes may be less crucial factors of implant overloading than the number and position of occlusal contacts on implant prostheses.

Developing tooth morphology to induce axial loading is an important factor to consider when constructing implant prostheses. The axial loading on thread-type implants can be distributed well along the implant–bone interface, and the cortical bone can resist the compressive stress favorably [Reilly & Burstein 1975; Misch 1993; Rangert et al. 1997]. A flat area around centric contacts can direct the occlusal force in an apical direction. Weinberg [1998] claimed that cusp inclination is one of the most significant factors in the production of bending moment. The reduction of cusp inclination can decrease the resultant bending moment with a lever-arm reduction and improvement of axial loading force. Kaukinen et al. [1996] investigated the difference of force transmission between 33° and 0° cusps. The mean initial breakout force of the 33° cusped specimens was 3.846 kg while the corresponding value of the 0° cuspless occlusal design specimens was 1.938 kg. This result suggests that the cusp inclination affected the magnitude of forces transmitted to implant prostheses. In summary, a reduced cusp inclination, shallow occlusal anatomy, and wide grooves and fossae could be beneficial for implant prostheses.

The diameter and distribution of implants and harmonization to natural teeth are important factors to consider when deciding the size of an occlusal table. Typically 30–40% reduction of occlusal table in a molar region has been suggested, but any dimension larger than the implant diameter can create cantilever effects and eventual bending moments in single-implant prosthesis (Misch 1993; Rangert et al. 1997). A narrow occlusal table reduces the chance of offset loading and increases axial loading, which eventually can decrease the bending moment (Rangert et al. 1997; Misch 1999a). Misch (1999a) described that a narrow occlusal table also improves oral hygiene and reduces risks of porcelain fracture. He further described that the posterior maxillary region with buccal bone resorption may enforce palatal placement of implants compared with the position of natural teeth. Normal occlusal contour on the palatally placed implant may create a significant buccal cantilever in a biomechanically poor environment [heavy bite, poor bone, and poor crown/implant ratio]. In this case, the utilization of cross-bite occlusion can avoid the buccal cantilever and increase the axial loading [Misch 1993; Weinberg 1998].

Force distribution between implants and natural teeth in a partially edentulous region can be accomplished with serial and gradient occlusal adjustments [Lundgren & Laurell 1994]. Due to the non-significant mobility during initial tooth movement [3–5 μm], implants may absorb all heavy biting force because natural teeth can be intruded [25–30 μm] easily with any occlusal force. Misch (1993, 1999a) proposed that occlusal adjustments could be performed by the elimination of mobility difference between implants and teeth under heavy bites. This approach may evenly distribute loads between implants and teeth. Over the years, natural teeth have positional changes in vertical and mesial direction while implants do not change their positions. In addition, enamel on the tooth wears more than porcelain on implant restorations. The positional changes of teeth may intensify the occlusal stress on implants. In order to prevent the potential overloading on implants from the positional changes, re-evaluation and periodic occlusal adjustments are imperative [Dario 1995; Rangert et al. 1997; Misch 1999a].

Clinical applications

Occlusion on full-arch fixed prostheses

For full-arch fixed implant prostheses, bilateral balanced occlusion has been successfully utilized for an opposing complete denture, while group-function occlusion has been widely adopted for opposing natural dentition. Mutually protected occlusion with a shallow anterior guidance was also recommended for opposing natural dentition (Chapman 1989; Hobo et al. 1989; Wismeijer et al. 1995). Bilateral and anterior–posterior simultaneous contacts in centric relation and MIP should be obtained to evenly distribute occlusal force during excursions regardless of the occlusal
Occlusion on overdentures

For the occlusion on overdentures, it has been suggested to use bilateral balanced occlusion with lingualized occlusion on a normal ridge. On the other hand, monoplane occlusion was recommended for a severely resorbed ridge (Lang & Razzouq 1992; Wismeijer et al. 1995; Mericske-Stern et al. 2000). Although there has been consensus that bilateral balanced occlusion can provide better stability of overdentures (Engelman 1996), there are no clinical studies which demonstrate the advantages of bilateral balanced occlusion for overdenture occlusion compared with other occlusal schemes. Recently, Peroz et al. [2003] performed a randomized, clinical trial comparing two occlusal schemes, balanced occlusion and canine guidance, in 22 patients with conventional complete dentures. The results of the assessment using a visual analog scale revealed that canine guidance was comparable to balanced occlusion in denture retention, esthetic appearance, and chewing ability.

Occlusion on posterior fixed prostheses

Anterior guidance in excursions and initial occlusal contact on natural dentition will reduce the potential lateral force on osseointegrated implants. Group-function occlusion should be utilized only when anterior teeth are periodontally compromised (Chapman 1989; Hobo et al. 1989; Misch & Bidez 1994). During lateral excursions, working and non-working interferences should be avoided in posterior restorations [Lundgren & Laurell 1994]. Moreover, reduced inclination of cusps, centrally oriented contacts with a 1–1.5 mm flat area, a narrowed occlusal table, and elimination of cantilevers have been proposed as key factors to control bend overload in posterior restorations [Weinberg 1998; Curtis et al. 2000]. In a recent in vivo study, it was reported that narrowing the bucco-lingual width of the occlusal surface by 30% and chewing soft food significantly reduced bending moments on the posterior three-unit fixed prosthesis [Morneburg & Pröschel 2003]. The study also suggested that soft diet and reduction of the buccolingual, occlusal surface need to be considered in unfavorable loading conditions, such as immediate loading, initial healing phase, and/or poor bone quality.

Wennerberg & Jenett [1999] described that additional implants in the maxilla could provide tripodism to reduce overload- ing and clinical complications. Also, axial positioning and reduced distance between posterior implants are important factors to decrease overloading [Belser et al. 2000]. The utilization of cross-bite occlusion with palatally placed posterior maxillary implants can reduce the buccal cantilever and improve the axial loading [Misch 1993; Weinberg 1998]. If the number, position, and axis of implants are questionable, natural tooth connection with a rigid attachment can be considered to provide additional support to implants [Rangert et al. 1991; Belser et al. 2000; Naert et al. 2001].

Occlusion on single implant prosthesis

The occlusion in a single implant should be designed to minimize occlusal force onto the implant and to maximize force distribution to adjacent natural teeth [Misch 1993; Lundgren & Laurell 1994; Engelman 1996]. To accomplish these objects, any anterior and lateral guidance should be obtained in natural dentition. In addition, working and non-working contacts should be avoided in a single restoration [Engelman 1996]. Light contacts at heavy bite and no contact at light bite in MIP are considered a reasonable approach to distribute the occlusal force on teeth and implants [Lundgren & Laurell 1994]. Like posterior fixed prostheses, reduced inclination of cusps, centrally oriented contacts with a 1–1.5 mm flat area, and a narrowed occlusal table can be utilized for the posterior single tooth implant restoration [Weinberg 1998; Curtis et al. 2000]. Wennerberg & Jenett [1999] claimed that centrally oriented occlusal contacts in single molar implants were critical to reduce bending moments attributable to mechanical problems and implant fractures. Increased proximal contacts in the posterior region may provide additional stability of restorations [Misch 1999b]. Two implants for a single molar have been utilized and demonstrated less screw loosening and higher success rates [Balshi et al. 1996]. However, the placement of two implants in a limited space is a challenging procedure, and difficulty in oral hygiene and prosthetic fabrication may develop. Instead of two implants in a single molar area, a wide-diameter implant with proper position and axis in a molar area could be a better option to reduce surgical and prosthetic difficulties and to improve oral hygiene and loading condition [Becker & Becker 1995; Chang et al. 2002]. The occlusal guidelines in various clinical situations are summarized in Table 3.
Table 3. Occlusal guidelines

<table>
<thead>
<tr>
<th>Clinical situations</th>
<th>Occlusal principles</th>
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<tr>
<td>Full-arch fixed prosthesis</td>
<td>- Bilateral balanced occlusion with opposing complete denture</td>
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<td></td>
<td>- Group function occlusion or mutually protected occlusion with shallow anterior guidance when opposing natural dentition</td>
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<td></td>
<td>- No working and balancing contact on cantilever</td>
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<td></td>
<td>- Infraocclusion in cantilever segment (100 μm)</td>
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<td>- Freedom in centric (1–1.5 mm)</td>
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<td>Overdenture</td>
<td>- Bilateral balanced occlusion using linguilized occlusion</td>
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<td></td>
<td>- Monoplane occlusion on a severely resorbed ridge</td>
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<tr>
<td>Posterior fixed prosthesis</td>
<td>- Anterior guidance with natural dentition</td>
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<tr>
<td></td>
<td>- Group function occlusion with compromised canines</td>
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<tr>
<td></td>
<td>- Centered contacts, narrow occlusal tables, flat cusps, minimized cantilever</td>
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<tr>
<td></td>
<td>- Cross bite posterior occlusion when necessary</td>
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<td></td>
<td>- Natural tooth connection with rigid attachment when compromised support</td>
</tr>
<tr>
<td>Single implant prosthesis</td>
<td>- Anterior or lateral guidance with natural dentition</td>
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<tr>
<td></td>
<td>- Light contact at heavy bite and no contact at light bite</td>
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<tr>
<td></td>
<td>- Centered contacts (1–1.5 mm flat area)</td>
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<td></td>
<td>- No offset contacts</td>
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<td></td>
<td>- Increased proximal contact</td>
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<tr>
<td>Poor quality of bone/Grafted bone</td>
<td>- Longer healing time</td>
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<td></td>
<td>- Progressive loading by staging diet and occlusal contacts/materials</td>
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Fig. 1. Factors to consider in implant occlusion.

The objectives of implant occlusion are to minimize overload on the bone–implant interface and implant prosthesis, to maintain implant load within the physiological limits of individualized occlusion, and finally to provide long-term stability of implants and implant prostheses. To accomplish these objectives, increased support area, improved force direction, and reduced force magnification are indispensable factors in implant occlusion (Fig. 1). In addition, systematic, individualized treatment plans and precise surgical/prosthodontic procedures based on biomechanical principles are prerequisites for optimal implant occlusion. Implant occlusion should be re-evaluated and adjusted, if needed, in a regular basis to prevent from developing potential overloading on dental implants, thus providing implant longevity. Currently, there is no evidence-based, implant-specific concept of occlusion. Future studies in this area are needed to clarify the relationship between occlusion and implant longevity.

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Résumé

Vu l’absence de ligament parodontal, les implants ostéointégrés, contrairement aux dents naturelles, réagissent biomécaniquement d’une manière différente aux forces occlusales. Les implants dentaires seraient alors plus aptes à supporter la surcharge occlusale qui est souvent considérée comme une des causes potentielles de la perte osseuse parodontoimplantaire et de l’échec des prothèses sur implants. Les facteurs de surcharge qui pourraient influencer négativement la longévité implantaire comprennent des porte-aux étendus, des parafonctions, des dessins occlusaux improprets et des contacts prématuroirs. Il est donc important au niveau des implants de contrôler l’occlusion dans une limite physiologique et donc d’apporter une charge implantaire optimalement qui permette un succès implantaire à long terme. Les buts de ce manuscript ont été de discuter l’importance de l’occlusion implantaire dans la longévité implantaire et d’apporter des guides cliniques de l’occlusion implantaire optimale et des solutions possibles pour arranger les complications en relation avec l’occlusion implantaire. Aucune étude basée sur l’évidence ayant un concept spécifique de l’occlusion au niveau des implants n’existe
Zusammenfassung


Resumen

Debido a la ausencia de ligamento periodontal, los implantes osteointegrados, al revés que los dientes naturales, reaccionan biomecánicamente de una forma diferente a la fuerza occlusal. Por ello se cree que los implantes dentales pueden ser mas propensos a sobrecarga occlusal, la cual es frecuentemente considerada como una de las causas potenciales de pérdida ósea periimplantaria y fracaso de la prótesis implante/implante. Los factores de sobrecarga que pueden influir negativamente en la longevidad del implante incluyen largas piezas en extensión, parafunciones, diseños oclusales inadecuados, y contactos prematuros. Por lo tanto, es importante controlar la oclusión del implante dentro de limites fisiológicos y por ello suministrar una carga del implante óptima para asegurar un éxito del implante a largo plazo. Los propósitos de este artículo son discutir la importancia de la oclusión del implante para la longevidad de este y suministrar una guía clínica para una oclusión óptima del implante y posibles soluciones para manejar las complicaciones relacionadas con la oclusión del implante. Se debe enfatizar que actualmente no existe un concepto específico de oclusión del implante basado en la evidencia. Son necesarios futuros estudios en esta área para clarificar la relación entre oclusión y éxito implantario.

References


