



OCCLUSION IN IMPLANT-AT A GLANCE

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ABSTRACT

Objectives: Occlusion is a critical and very important component for the clinical success and longevity of dental implants. This review article focuses on the various aspects of implant protective occlusion. Our scientific literature regarding implant occlusion, particularly in implant-supported fixed dental prostheses remains controversial.

Materials and methods: A search strategy was performed in MEDLINE/PubMed, Scopus and Google Scholar with keywords – ‘implants’ and ‘occlusion’, ‘implants’ and ‘fixed prosthesis’, ‘implants’ and ‘fixed dental prostheses’, ‘implants’ and ‘partial edentulism’, ‘implants’ and ‘complications’, ‘implants’ and ‘failures’, ‘implants’ and ‘cantilever’, ‘implants’ and ‘occlusal load’.

Results: 135 articles were retrieved. After hand search a total of 290 articles were identified. Ultimately, 30 articles were selected and summarized and discussed as they met the selection criteria.

Conclusion: Most of the available clinical data are controversial. Implant-protected occlusion can be accomplished by decreasing the width of the occlusal table and improving the direction of force. By doing these things, we can minimize overload on bone-implant interfaces and implant prostheses, to maintain an implant load within the physiological limits of individualized occlusion, and ultimately provide long-term stability of implants and implant prostheses. Current clinical practices rely heavily on principles extracted from the natural dentition or removable dental prostheses on complete edentulous patients and on expert opinions.

KEYWORDS: Dental implants, Dental occlusion, Fixed partial denture, Implant-supported dental prosthesis, Review.

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INTRODUCTION

Determining an occlusal scheme for the restoration of implants requires careful consideration. This stems from the fact that after

osseointegration, mechanical stresses beyond the physical limits of hard tissues have been suggested as the primary cause of initial and long-term bone loss around implants[1,2].

This review discusses the implant-protected occlusion for implant longevity and to provide clinical guidelines for optimal implant occlusion based on the currently available literature.

STUDY SELECTION

This review was based on articles searched through the MEDLINE/PubMed, Scopus and google Scholar databases. The search was augmented by hand search of the relevant journals unavailable through electronic database and the list of references of the included studies. The main keywords keywords – ‘implants’ and ‘occlusion’, ‘implants’ and ‘fixed prosthesis’, ‘implants’ and ‘fixed dental prostheses’, ‘implants’ and ‘partial edentulism’, ‘implants’ and ‘complications’, ‘implants’ and ‘failures’, ‘implants’ and ‘cantilever’, ‘implants’ and ‘occlusal load’ were used.

Total of 135 articles were retrieved. After hand search a total of 290 articles were identified. Ultimately, 30 articles were selected and summarized and discussed as they met the selection criteria.

INCLUSION CRITERIA

1. Peer reviewed articles in English only.
2. Full text articles-Reviews, reports and studies.

EXCLUSION CRITERIA

1. Abstracts only on the Databases searched.
2. Unpublished reports or abstracts or case reports as well as reports that did not cover both conventional and digital impression techniques.

Occlusal overload is often regarded as one of the main causes of peri-implant bone loss and implant prosthesis failure because it can cause crestal bone loss, thus increasing the anaerobic sulcus

depth and peri-implant disease states [3,4]. I.Naert et al concluded in his study that the location of the fixtures, the occlusal design and fixed prostheses in both jaws influence prosthetic and implant complications [5]. The choice of occlusal scheme for implant-supported prosthesis is broad and often controversial.

Judith L. Gartner conducted a pilot study on effect of osseointegrated implants on the coordination of masticatory muscles in which he concluded Patients with implant-supported prostheses appeared to be well adapted to perform habitual masticatory functions. The results of this study suggest that habitual masticatory function can be restored with osseointegrated implant-supported

prostheses, despite the lack of the periodontal ligament as an integral component of the neuromuscular coordination. However, an eccentric function, such as maximal occluding force, could potentially induce abnormal muscle reaction in the implant patients. According to him, occlusal concepts developed from the natural dentition can be implemented to implant support systems without any modifications, because mandibular movement, velocity, and chewing patterns are the same for patients with natural teeth and implants [6].

Occlusion is the critical process for implant longevity because of the nature of the attachment of the bone to the implant surface. In 1954, Beyron put forward characteristics of functionally

TABLE 1: OCCLUSAL OVERLOAD COMPARISON OF NATURAL TEETH VS. DENTAL IMPLANTS

| | NATURAL TEETH | DENTAL IMPLANTS |
|-------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Interface | Periodontal membrane | Direct bone |
| Junctional Epithelium | Hemidesmosomes and basal lamina (lamina lucida and lamina densa zones) | Hemidesmosomes and basal lamina (lamina lucida, lamina densa and sublamina lucida zones) |
| Connective Tissue | 12 groups: six insert perpendicular to tooth surfaces ↓ collagen, ↑ fibroblasts | Only two groups: parallel and circular fibers; no attachment to the implant surface ↑ collagen, ↓ fibroblasts |
| Biomechanical Design | Cross section related to direction and magnitude of stress | Round cross section mainly designed for surgical placement |
| Vascularity | Greater; suprapariosteal and periodontal ligament | Less; mainly periosteal |
| Biologic Width | 2.04-2.91 mm | 3.08 mm |
| Proprioception | Periodontal mechanoreceptors | Osseoperception |
| Mobility | + | - |
| Pain | +/- (tooth may be hyperemic) | - |
| Attrition | + Wear facets, abfraction, fremitus | - (-porcelain fracture, possible screw loosening) |
| Radiographic Changes | + Increased radiopacity and thickness of cribriform plate | Crestal bone loss |
| Interference Awareness | + (Proprioception) | - (Osseoperception) |
| Non-Vertical Forces | Relatively tolerated | Results in bone loss |
| Force-Related Movement: | Primary: Movement of PDL Secondary: Osseous movement | Primary: Osseous movement |
| Lateral Force | Apical 1/3 of root surface | Crestal bone |
| Lateral Movement ² | 56-108 µm | 10-50 µm |
| Apical Movement ³ | 25-100 µm | 3-5 µm |
| Tactile Sensitivity | High | Low |
| Signs of Overloading | PDL thickening, fremitus, mobility, wear facets, pain | Screw loosening, screw fracture, abutment fracture, implant body fracture, bone loss |

optimal occlusion and principles of occlusal rehabilitation and he emphasized about the concept of therapeutic occlusion. **THERAPEUTIC OCCLUSION** is one in which arrangement of teeth and their opposing occlusal surfaces satisfies function and esthetic requirements while distributing the forces of **occlusion** over as many teeth during functions of mandible [7].

Occlusal goals for implant supported restorations:

1. bilateral simultaneous contacts and equal distribution of occlusal forces [7]
2. no occlusal prematurities [8]
3. Smooth, even lateral excursive movements with no non-working interferences [9]

Difference between natural tooth and implant supported prosthesis

Kim et al. [10] and Misch [11], compared natural teeth and implants and main differences between these two structures:

Occlusal Design and morphology consideration :

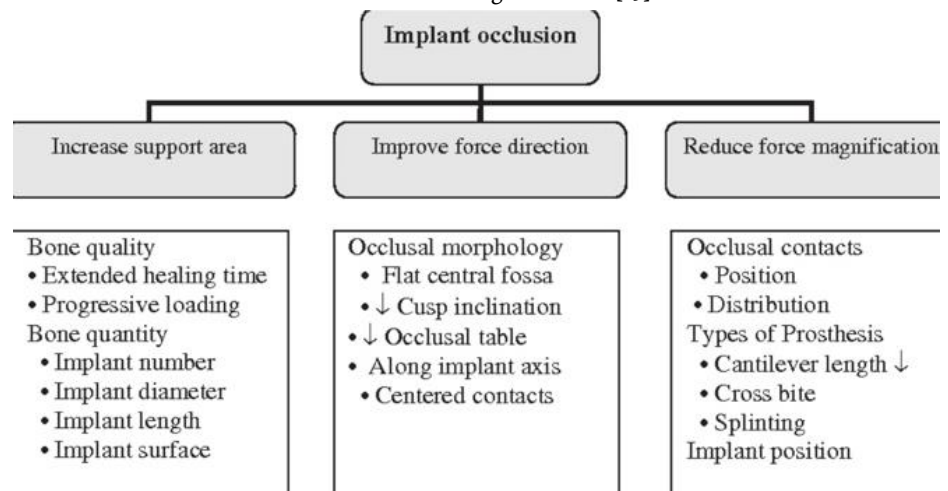
Iven Klineberg in a study named the bases for using a particular occlusal design in tooth and implant-borne reconstructions and complete denture, within the limits of contemporary clinical outcome studies, based on their design and population size, data suggested that long-term clinical outcome studies on implant-supported fixed partial dentures in the mandible have indicated that (a) the association of

occlusal loading and occlusal scheme design was of minor or no importance to marginal bone loss, and (b) the key confounding variables were smoking and poor plaque control, which were directly associated with marginal bone loss. Best practice guidelines for implant superstructure design have been developed by extrapolation from (a) biomechanical studies on implant cantilevers and (b) design features used for tooth-supported superstructures that

movement in single unit implant-supported prostheses [16,17,18]

5. The reduced cuspal inclination can decrease the bending moment, increase the axial loading force of implants, and reduce stress on the implant and the implant/abutment interface [19]

Kim Y et al in Occlusal considerations in implant therapy has put forward implant occlusion guidelines: [13]



have been found to be effective to minimise effects of loading and achieving desirable patient outcomes [12]. In addition, occlusal scheme design has minor or no importance to marginal bone loss of implant-supported prostheses [13].

Recommendation for occlusal morphology:

1. shallow occlusal anatomy, a narrow occlusal table, and reduced cuspal inclination[14]
2. flat fossa and grooves for wide freedom in centric [15]
3. size of the occlusal table be 30% to 40% smaller for molars [16,17,18]
4. Widths greater than the implant diameters may generate cantilever effects and some bending

Implant-protected occlusion has been suggested for implant-supported prostheses [2]. Earlier in the literature bilateral balanced occlusion for complete denture fabrication [20], group-function occlusion, and mutually protected occlusion for the natural dentition with and without fixed prostheses [21,22] have been mentioned and are holding the great importance till day.

Implant Protected Occlusion

Occlusal design is a primary requirement for the success of long term survival of implant.

Implant-protective occlusion (IPO) is an occlusal scheme suggested to decrease overload on the implant

| Clinical situations | Occlusal principles |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Full-arch fixed prosthesis | <ul style="list-style-type: none"> • Bilateral balanced occlusion with opposing complete denture • Group function occlusion or mutually protected occlusion with shallow anterior guidance when opposing natural dentition • No working and balancing contact on cantilever • Infraocclusion in cantilever segment (100 µm) • Freedom in centric (1–1.5 mm) |
| Overdenture | <ul style="list-style-type: none"> • Bilateral balanced occlusion using lingulized occlusion • Monoplane occlusion on a severely resorbed ridge |
| Posterior fixed prosthesis | <ul style="list-style-type: none"> • Anterior guidance with natural dentition • Group function occlusion with compromised canines • Centered contacts, narrow occlusal tables, flat cusps, minimized cantilever • Cross bite posterior occlusion when necessary • Natural tooth connection with rigid attachment when compromised support |
| Single implant prosthesis | <ul style="list-style-type: none"> • Anterior or lateral guidance with natural dentition • Light contact at heavy bite and no contact at light bite • Centered contacts (1–1.5 mm flat area) • No offset contacts • Increased proximal contact |
| Poor quality of bone/Grafted bone | <ul style="list-style-type: none"> • Longer healing time • Progressive loading by staging diet and occlusal contacts/materials |

supported prosthesis and enable its successful functioning in the oral set-up. The IPO concept addresses several conditions to decrease stress to the implant interface.

Misch has put forward in Occlusal considerations for implant-supported prosthesis factors affecting implant protected occlusion [2]

- No premature occlusal contacts or interferences: timing of occlusal contacts
- Influence of surface area
- Mutually protected articulation
- Implant body angle to occlusal load
- Cusp angle of crowns (cuspal inclination)
- Cantilever or offset distance (horizontal offset)
- Crown height (vertical offset)
- Occlusal contact positions
- Implant crown contour
- Protect the weakest component
- Occlusal materials

Jamie A. Kaukinen in 1996 conducted a study on The influence of occlusal design on simulated masticatory forces transferred to implant-retained prostheses and supporting bone [23].

This pilot study used a method to apply quantified vertical forces to a food substance and record the forces and strain transmitted through cusped 33-degree and cusplless 0-degree occlusal design specimens to a simulated implant-retained prosthesis and the supporting bone. The data were analyzed to compare the forces required to cause initial breakage of the food, the maximum breakage forces applied before cycle termination, and the maximum strain registered by strain gauges at the bone level. The following conclusions were drawn within the limits of this pilot study. 1. The initial breakage force for the 33-degree cusped occlusal design specimen was greater

than the initial breakage force for the 0-degree cusplless occlusal design specimen. 2. No significant differences were demonstrated in maximum breakage forces or maximum strains between the 33-degree cusped and the 0-degree cusplless occlusal design specimens. 3. The occlusal configuration and cusp angulation of implant-retained prostheses played a significant role in force transmission and the stress-strain relationship in bone.

No premature occlusal contact

Premature contacts are defined as occlusal contacts that divert the mandible from a normal path of closure, interfere with normal, smooth, gliding mandibular movement, and/or deflect the position of the condyle, teeth, or prosthesis. Several animal studies demonstrated that excessive lateral forces from premature occlusal contact can cause excessive marginal bone loss or even osseointegration failure[24].

Occlusal prematurity between maximum intercuspation and centric relation occlusion should be taken into consideration especially on an implant supported prostheses. This is because, non-mobile implants bear the entire load of the prosthesis when it comes in contact with the mobile natural teeth, hence during the occlusal adjustment between implants and natural teeth, premature occlusal contacts on the implants can occur as the natural teeth can move away from the centric during function [1].

Occlusal adjustment can be done by using a thin articulating paper which is less than 25 µm to evaluate the centric relation of the occlusal contact. This is done to relieve the implant crown which leads to heavier contact on the

adjacent natural tooth. A greater occlusal force is then applied to the articulating paper, establishing equal contact regions on both the implant-supported crowns and natural teeth. Tooth might not return to its original position for several hours after application of a heavy occlusal force. Following this, light forces on adjacent natural teeth are first equilibrated. Occlusal adjustment of implants and teeth in the opposing arch should also be compensated for the primary tooth movement [1].

Cusp inclination

Kaukinen et al. [23] determined the difference of the force transmission between 33° and 0° cusps. The mean initial breakage force of 33°-cusped specimens was 3.846 kg, while the corresponding value of the 0° cusplless occlusal designed specimens was 1.938 kg. So they suggested that the cusp inclination affects the magnitude of forces transmitted to implanted prostheses.

Weinberg and Kruger [25] evaluated the torque of a gold screw, abutment screw, and implant and concluded that cuspal inclination produces the most torque, followed by maxillary horizontal implant offset, while implant inclination and apical implant offset produce minimal torque.

Weinberg [15] also claimed that cusp inclination is 1 of the most significant factors in producing bending moments. Because the angle of force to the implanted body may be influenced by cusp inclination, a reduction in cusp inclination can decrease the resultant bending moment with a lever-arm reduction and improvement of the axial loading force. Therefore a reduced cusp inclination, shallow occlusal anatomy,

and wide grooves and fossae may be beneficial when constructing implanted prostheses due to the axial loading induced. It is especially critical when the intensity and duration of the force increase.

Influence of surface area

Sufficient surface area is required to withstand the load transmitted to the prosthesis therefore when an implant of decreased surface area, subjected to increased load in magnitude, direction or duration, the stress and strain in the interfacial tissue will increase. This can be minimized by placing additional implants in the region of concern, ridge augmentation, reduce crown height or by increasing the implant width [26]. Bidez et al have reported a study showing that, forces distributed over 3 abutments results in less stress on the crestal bone compared to 2 abutments [27].

Anterior guidance

According to Weinberg and Kruger[25], with every 10° change in the angle of disclusion, there is a 30% difference in load. They suggested that the anterior guidance of implantsupported prostheses should be as shallow as possible to avoid greater forces on the anterior implants by steeper incisal guiding angles.

Anterior bite force measurements and electromyographic studies also reported that the stomatognathic system elicits significantly less force when the posterior segments are not in contact in the lateral mandibular position[28,29].

Crown height

Implant crown height is often greater than the natural anatomical crown. As the implant crown height becomes greater, the crestal moment with any lateral component of force also becomes greater [30]. Therefore any harmful effect of any feebly selected cusp angle, angled implant body, or angled load to the crown will be magnified by the crown height measurements.

CONCLUSION

Occlusal overload is regarded as one of the main causes for peri-implant bone loss and implant/implant prosthesis failure. Many clinical complications may be attributed to implant overload. Most of the available clinical data are controversial. Implant-protected occlusion can be accomplished by decreasing the width of the occlusal table and improving the direction of force. By doing these things, we can minimize overload on bone-implant interfaces and implant prostheses, to maintain an implant load within the physiological limits of individualized occlusion, and ultimately provide long-term stability of implants and implant prostheses. Current clinical practices rely heavily on principles extracted from the natural dentition or removable dental prostheses on complete edentulous patients and on expert opinions.

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