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Implant protected occlusion: A comprehensive review

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ABSTRACT

Complexities in the study of occlusion have set tough challenges for both under graduate and post-graduate students and the introduction of osseointegrated implants has further complicated these challenges. The principles of occlusion are applied by dentists for the natural dentition directly to implant-supported and retained restorations. Although successful, this rationale at times may result in overly complex or simplified treatment protocols and outcomes. The focus of this review is mainly on currently available scientific literature involving dental implant occlusion. The authors reviewed the English peer-reviewed literature prior to 1996 in a comprehensive manner, and the material post 1996 was reviewed electronically using MEDLINE. Electronic searches of the literature were performed in MEDLINE using key words – cohort studies, complete denture occlusion, clinical trial, case studies, dental implant function, dental implant occlusion, dental implant occlusion research, dental implant functional loading, dental implants, dental occlusion, dental occlusion research, denture function, denture occlusion, dentures, implant function, implant functional loading, implant occlusion, occlusion, and removable partial denture occlusion – in various combinations to obtain potential references for review. A total of 4445 English language titles were obtained, many of which were duplicates due to multiple searches. Manual hand searching of the MEDLINE reference list was performed to identify any articles missed in the original search.

KEYWORDS: Dental implant, loading of implant, occlusion

Introduction

Occlusal overload is attributed to be 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.[1-5] Mechanical complications on dental implants and implant prostheses such as screw loosening and/or fracture, prosthesis fracture, and implant fracture can be caused by occlusal overload, eventually leading to compromised implant longevity.[6] Osseointegrated implants are ankylosed to surrounding bone without the periodontal ligament (PDL) (unlike natural teeth), providing mechanoreceptors as well as shock-absorbing function.[7] The peri-implant tissues could be more susceptible to crestal bone loss by applying force; this can be indicated when the crestal bone around dental implants acts as a fulcrum point for lever action when a force (bending moment) is applied. It has reported that biomechanically controlled occlusion can achieve the clinical success and longevity of dental implants.[8-10] Therefore, the inherent differences between teeth and implants and how forces (normal/excessive) may influence implants under occlusal loading is essential for clinicians to understand.

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The rationale of this paper is to illustrate the importance of implant protected occlusion for implant longevity and to provide clinical guidelines of optimal implant occlusion based on the currently available literature. Also, various possible solutions that are available for managing complications relating to implant occlusion have been proposed.

Search Method for Identification of Studies

A review of the dental literature concerning occlusion was undertaken. Material appearing in the literature prior to 1996 was reviewed in a comprehensive manner, and the material post 1996 was reviewed electronically. Electronic searches of the literature were performed as well.

Key words – case series, clinical trials, cohort studies, complete denture occlusion, dental implant function, dental implant occlusion, dental implant occlusion research, dental implant functional loading, dental implants, dental occlusion, dental occlusion research, denture function, denture occlusion, dentures, implant function, implant functional loading, implant occlusion, occlusion, and removable partial denture occlusion – were used in MEDLINE in various combinations to obtain potential references for review. A total of 4445 English language titles were obtained, many of which were duplicates due to multiple searches. The titles were reviewed and selected for closer examination.

If the article under review was a study of any type, manual hand searching of the MEDLINE reference list was performed to identify any articles missed in the original search. Only articles that provided experimentally derived, objective information regarding occlusion were included. Completely empirical or anecdotal articles were excluded, except in those instances when they were of "classic" value in describing philosophy and/or technique.

Implant Protected Occlusion

Differences between teeth and implants

The primary difference between the tooth and the implant is that an endosseous implant is in direct contact with the bone, while a natural tooth is suspended by PDL. The mean values of axial displacement of teeth in the socket are 25-100 μm, while that of the osseointegrated dental implants has been reported approximately 3-5 μm.[7] PDL is functionally oriented towards an axial load, leading to the physiological-functional adjustment of occlusal stress along the axis of the tooth and periodontal-functional adaptability to changing stress conditions.[11] Also, adaptability to torsion or jaw skeletal deformation in natural teeth can provide the tooth mobility from PDL. Dental implants do not possess those advantages due to the lack of PDL. When the natural tooth is loaded, the movement begins with the initial phase of periodontal compliance that is primarily nonlinear and complex, followed by the secondary movement phase occurring with the engagement of the alveolar bone. On the other hand, when the load is applied on an implant, it initially deflects in a linear and elastic pattern, and the movement of the implant under load is dependent on elastic deformation of the bone. To accommodate the disadvantageous kinetics associated with dental implants, gradient loading was suggested.[7] A natural tooth moves rapidly 56-108 μm and rotates at the apical third of the root upon a lateral load,[12] and the lateral force on the tooth is diminished immediately from the crest of bone along the root.[13] On the other hand, the movement of an implant occurs gradually, reaching up to about 10-50 μm under a similar lateral load. Concentration of greater forces is found at the crest of surrounding bone of dental implants without any rotation of implants. Richter[14] also reported that the highest stress in the crestal bone is a result of a transverse load and clenching at centric contacts. The studies suggested that the implant sustains a higher proportion of loads concentrated on the crest of surrounding bone. In natural teeth, PDL has neurophysiological receptor functions, which transmit information of nerve ends with corresponding reflex control to the central nervous system. The presence or absence of the PDL functions makes a notable difference in detecting early phase of occlusal force between teeth and implants.[7]

Loading of the teeth

Distinct differences between load thresholds for anterior and posterior teeth are as follows: Anterior teeth are very sensitive to forces o1N and posterior teeth to forces o4N. At higher forces, this dynamic sensitivity is less and appears to arise from the greater number of mechanoreceptor afferents associated with anterior teeth that can detect varying loads in all directions, while posterior tooth afferents appear to detect loads only in distal and lingual directions. This is in complete contrast with static sensitivity that increases progressively with motor unit recruitment to generate the power stroke required for crushing food. Studies confirm that,[15] because of the unique positioning of periodontal mechanoreceptors, they play a major role in controlling the jaw movement associated with food manipulation during chewing and provide dynamic and static influences on muscle spindle activity.

Furthermore, anterior and posterior teeth have similar static responses. Dynamic responses are different and afferents respond over a defined force range; anterior teeth have higher sensitivity to low forces, but reach their force limit early, while posterior teeth have higher sensitivity at higher force levels and for longer periods. To facilitate anterior tooth function and to provide delicate control of anterior bite force, developing anterior guidance on the teeth appears to be desirable. For the control of vertically and laterally directed forces, the reduced periodontal innervations of posterior teeth appears to be associated with the generation of larger posterior bite forces, while the reduced directionally specific feedback on posterior teeth appears to be adequate.

Loading on implants

The peripheral feedback system is different for implants because of the absence of the periodontium and the mechanoreceptors located in periodontal tissues. Unless the food bolus is dense, tough, and difficult to breakdown (e.g., tough meat), functional loading is in general transient. In this situation, the load points or areas with respect to implants are vital and high loads (as in posterior quadrants) ideally should be directed along the long axis of the implant or tooth. As the possibility of this is rare, heavy loads generate bending moments that are transferred to the supporting bone. Increased bone density, a result of static continuous loads on implants, was reported by Gotfredsen.[16] The adaptive capacity of bone for dynamic growth (modeling) and remodeling has been emphasized by Stanford and Brand,[17] allowing the implant interface in general to withstand and adapt to varying occlusal loads in function and parafunction. A crucial element is initial implant stability, which varies with bone density in different regions of the mouth. Shear strength of interface bone is related to implant design – shear resistance can be enhanced by optimizing the following features like macroscopic features of screw design and microscopic features of pit depth, diameter, and density. A complex feedback mechanism and central neural plasticity occurs by modulation of occlusal loads in dentate individuals and where implant crowns and bridges are located between natural teeth. Peripheral feedback principally involves periodontal mechanoreceptors located around tooth roots. This is backed by a multiple feedback system involving jaw muscles, skin, and jaw joints, associated with dimensional changes in bone, length changes in jaw muscles, changes in articular capsule tension in the jaw joint, as well as vibration-evoked stimulation of vibration-sensitive mechanoreceptors in jaw joint, facial skin, and jaw muscles.[18] These mechanisms are present with implant restorations as "osseoperception," albeit with a change in mechanotransduction and feedback. The restoration of function in implant-restored situations is permitted by Osseoperception. This occurs to a degree that approaches dentate function. Bone interface leading to predictable anchorage and support for fixed or supported superstructures is attributed to the progressive osseointegration of the implant. The anchorage to bone allows functional loads to be transferred to bone and bone cells as well as to the associated mechanoreceptors.

Overloading factors of implant occlusion

A large cantilever of an implant prosthesis that can generate overloading may result in peri-implant bone loss and prosthetic failures.[3,19,20] Duyck *et al*.[21] reported that the loading position on fixed full-arch implant-supported prostheses could affect the resulting force on each of the supporting implants. When a biting force was applied to the distal cantilever, the highest axial forces and bending moments recorded on the distal implants were more pronounced in the prostheses supported by only three implants as compared with prostheses with five or six implants. In a number of studies, it was evident 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.[22-24] Heavy occlusal contacts on the posterior cantilever segment might be created by the displacement of complete denture during function. This finding suggested the significance of simultaneous occlusal contacts along the prosthesis, the opposing complete denture carefully controls the number and distribution of occlusal contacts on cantilever segments. A clinical study regarding a cantilever length demonstrated that long cantilevers (>15 mm) induced more implant-prosthesis failures as compared with cantilevers <15 mm.[20] The findings 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. The parafunctional activities (bruxism, clenching, etc) and improper occlusal designs correlated with implant bone loss/failure, implant fractures, and prosthesis failures have been reported by several studies.[3,4,22,23] Excessive marginal bone loss and/or implant loss in patients with lack of anterior contacts, presence of parafunctional activities, and full-fixed implant-supported prostheses in both jaws have been reported by Quirynen.[3] The retrospective study suggested a correlation between occlusal overloading resulting from those factors and severe marginal bone loss and/or loss of osseointegration. The occlusal design (the number and distribution of occlusal contacts) with a significant influence on the different force distribution between a cantilever segment and implant-supported area that increased the local forces significantly on the cantilever unit was reported by Falk *et al*.[23] To sum it up, it is implied that heavy occlusal force and undesirable distribution of occlusal contacts may be factors of overloading, possibly leading to higher susceptibility to implant bone loss, implant fractures/loss, and prosthesis failures. For the success of implants at both surgical and functional stages, bone quality has been considered the most critical factor, and it is therefore suggested that occlusal overload in poor quality bone can be a clinical concern for implant durability.[25] Along with poor bone quality, higher failure rates in the maxilla may be a result of unfavorable load direction.[26-28] Appleton *et al*.[29] also noted that progressively loaded implants had not only reduced amounts of crestal bone loss but also increased bone density. These results suggest that carefully monitored loading and extended healing time may be needed in poor quality bone. From the above studies, one can contemplate that (1) implant longevity can be related to the amount of stress and the quality of the bone; (2) a limiting factor for implant longevity can be occlusal overloading, possibly resulting from large cantilevers, excessive premature contacts, parafunctional activities, improper occlusal designs, and/or osseointegrated full-fixed prostheses in both jaws; (3) increasing number of implants may significantly reduce occlusal overload on implants and implant prostheses and even distribution of occlusal contacts avoiding occlusal interferences; and (4) extended healing time and carefully monitored loading (e.g., progressive or delayed loading) reduce poor quality bone and may be more vulnerable to occlusal overloading.

The effect of non-axial load on implant function and survival

The reasons mentioned for avoiding application of non-axial forces to dental implants relative to implant supported prosthesis is the concern, which focuses primarily on the absence of a periodontal ligament supporting the implants and the observation that non-axial forces will create areas of high stress concentration instead of uniform compression along the implant to bone interface.[9,30] The shape and surface texture of cylindrical endosseous implants make it impossible for a vertically applied load to be transmitted to the bone exclusively through compressive loading. The load will be transferred to bone by compression in some areas, but also in tension and shear in other areas if the implant has a threaded profile or even a rough surface.[31] The location and magnitude of compressive, tensile, and shear forces will be altered by changing the direction of load application, but all three continue to participate in the transfer of load through the implant to surrounding bone. The forces of occlusion that are rarely vertical must be recognized. Mastication is a side-to-side action that does not lend itself to axial loading of teeth or implants in the jaws. Similarly, lateral friction between the occlusal surfaces of maxilla and mandible create damaging effects of bruxism. Thus, the resultant forces are not vertical.

Progressive loading and occlusal overload of dental implants

Considering the role of Wolff's Law in bone remodeling, where bone mass will increase in response to stress is the concept making intuitive sense out of numerous authors writing on progressive loading. Allowing that bone to increase in mass and density by gradually increasing the load applied to implants in poor quality bone, seems logical. The evidence obtained,[32,33] however, does not support the need for progressive loading. The occlusal overload generated at the time of abutment connection or initial functional loading was tolerated by the implants without evidence of deleterious effect in all situations. The principle of progressive loading without negative effect does not support loading the previously unloaded implants by immediately subjecting the implant to extreme overload.

Implant occlusion: Types and principles

Occlusal principles in tooth restoration help largely to derive the types and basic principles of implant occlusion. Throughout clinical trials and conceptual theories, three occlusal concepts (balanced, group function, and mutually protected occlusion) have been established.[34] During habitual and/or centric occlusion, all of the concepts may have maximum intercuspation (MIP). To begin with, bilateral balanced occlusion has all teeth contacting during all excursions. It is essentially used in complete denture fabrication. In group-function occlusion, during lateral movements, posterior teeth contact on the working side without balancing side contacts. In order to share lateral pressures to posterior teeth instead of the canine, this occlusion is used primarily with compromised canines.[35]

Mutually protected occlusion has light contacts on anterior teeth and anterior guidance during all excursions, while posterior teeth protection in habitual and/or centric occlusion via posterior contacts in MIP. This occlusal scheme is based on the concept that the canine is a crucial element of occlusion avoiding heavy lateral pressures on posterior teeth. Although scientific evidence does not yet provide its clinical advantages, it has been considered a convenient and reasonable type of occlusal scheme for prosthetic rehabilitation. These occlusal concepts (i.e., balanced, group-function, and mutually protected occlusion) have been successfully adopted with modifications for implant-supported prostheses.[1,36-38] Furthermore, implant-protected occlusion has been proposed strictly for implant prostheses. This concept is designed to protect implants and to reduce occlusal force on implant prostheses. For this, several modifications from conventional occlusal concepts have been proposed, which include providing load sharing occlusal contacts, modifications of the occlusal table and anatomy, correction of load direction, increasing of implant surface areas, and elimination or reduction of occlusal contacts in implants with unfavorable biomechanics. Also, when establishing implant occlusion, the following factors are considered occlusal morphology guiding occlusal force to the apical direction, utilization of cross-bite occlusion, a narrowed occlusal table, reduced cusp inclination, and a reduced length of cantilever in mesio-distal and bucco-lingual dimension.[34,37] Basic principles of implant occlusion may include (1) bilateral stability in centric (habitual) occlusion, (2) evenly distributed 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. Bilateral occlusal stability provides stability of the masticatory system and a proper force distribution along with evenly distributed occlusal contacts.[39] This can reduce the possibility of premature contacts and decrease force concentration on individual implants. In addition, premature contacts during function can be minimized with wide freedom in centric, accomplishing more favorable vertical lines of force. Quirynen *et al*.[3] reported that excessive marginal bone loss in posterior implants was created by lack of anterior contacts in an implant-supported cross-arch bridge. Destructive forces in posterior implants can be minimized potentially by the anterior or canine guidance. In addition to the advantage of the anterior guidance, to provide proper force distribution and to protect the anterior region, it may be preferred to have a smooth and even lateral working contact without cantilever contacts in the posterior region. When constructing implant prostheses, an important factor to consider is the developing tooth morphology to induce axial loading. 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.[9] The occlusal force in an apical direction can be directed by a flat area around centric contacts. One of the most significant factors in the production of bending moment is cusp inclination. The resultant bending moment with a lever-arm reduction can be decreased by the reduction of cusp inclination and improvement of axial loading force. A reduced cusp inclination, shallow occlusal anatomy, and wide grooves and fossae could be beneficial for implant prostheses. The important factors to consider when deciding the size of an occlusal table are the diameter and distribution of implants and harmonization to natural teeth. 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. A narrow occlusal table increases axial loading and reduces the chance of offset loading, which eventually can decrease the bending moment. A narrow occlusal table also improves oral hygiene and reduces risks of porcelain fracture. Palatal placement of implants as compared with the position of natural teeth may be enforced by the posterior maxillary region with buccal bone resorption. A significant buccal cantilever in a biomechanically poor environment (heavy bite, poor bone, and poor crown/implant ratio) can be created by normal occlusal contour on the palatally placed implant. In this case, the utilization of cross-bite occlusion can avoid the buccal cantilever and increase the axial loading. Serial and gradient occlusal adjustments can accomplish the force distribution between implants and natural teeth in a partially edentulous region.[37] 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 (25-50 μm) easily with any occlusal force. It was proposed that elimination of mobility difference between implants and teeth under heavy bites could perform occlusal adjustments. This approach may evenly distribute loads between implants and teeth. Over the years, while implants do not change their positions, natural teeth have positional changes in vertical and mesial direction. In addition, enamel on the tooth wears more than porcelain on implant restorations. The occlusal stress on implants may be intensified by the positional changes of teeth. In order to prevent the potential overloading on implants from the positional changes, re-evaluation, and periodic occlusal adjustments are imperative.[9,39]

Occlusal materials

The transmission of forces and maintenance of occlusal contacts are affected by the materials that are used for the occlusal surface of the prosthesis affect. Occlusal materials may be determined by aesthetics, impact force, chewing efficiency, wear, fracture, and interarch space.[40,41] In the long-term success of implant-supported complete dentures, occlusal loading of osseointegrated implants is believed to be an important factor.[42] Acrylic resin was the material of choice for the occlusal surfaces. The resiliency of acrylic resin was suggested as a safeguard against stress and microfracture of the implants.[43,44] In contrast with the foregoing studies, Ismail and his associates[45] revealed that the function of the resin teeth as a shock absorber was not valid. Porcelain teeth in both arches is the material most often selected when there are para-functional habits and marginal interarch space.[46,47]

Clinical Applications

Occlusion on full-arch fixed prostheses

Bilateral balanced occlusion has been successfully utilized for an opposing complete denture for full-arch fixed implant prosthesis, while group-function occlusion has been widely adopted for opposing natural dentition. For opposing natural dentition, mutually protected occlusion with a shallow anterior guidance was also recommended.[34,38] 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 scheme.[3,37] In addition, smooth, even, lateral excursive movements without working/non-working occlusal contacts on cantilever should be obtained.[37] For occlusal contacts, more favorable vertical lines of force and thus minimize premature contacts during function can be accomplished by wide freedom (1-1.5 mm) in centric relation and MIP.[48] Infra-occlusion (100 μm) on a cantilever unit was suggested to reduce fatigue and technical failure of the prosthesis, when a cantilever is utilized in a full-arch fixed implant prosthesis.[23,24] Implant prostheses with <15 mm cantilever in the mandible demonstrated significantly better survival rates than those with >15 mm cantilever.[20] On the other hand, <10-12 mm cantilever was recommended in the maxilla due to unfavorable bone quality and unfavorable force direction as compared with the mandible.[8,49]

Occlusion on overdentures

For the occlusion on overdentures, use of bilateral balanced occlusion with lingualized occlusion on a normal ridge has been suggested. On the other hand, monoplane occlusion was recommended for a severely resorbed ridge;[38,50] however, there are no clinical studies that demonstrate the advantages of bilateral balanced occlusion for overdenture occlusion compared with other occlusal schemes.

Occlusion on posterior-fixed prostheses

The potential lateral force on osseointegrated implants can be reduced by anterior guidance in excursions and initial occlusal contact on natural dentition. Group-function occlusion should be utilized only when anterior teeth are periodontally.[34] During lateral excursions, working and non-working interferences should be avoided in posterior restorations.[37] Moreover, key factors to control bend overload in posterior restorations have been proposed as follows: Reduced inclination of cusps, centrally oriented contacts with a 1-1.5 mm flat area, a narrowed occlusal table, and elimination of cantilevers. 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.[51] The study also suggested that, in unfavorable loading conditions, the following need to be considered soft diet and reduction of the buccolingual, occlusal surface, such as immediate loading, initial healing phase, and/or poor bone quality, axial positioning, and reduced distance between posterior implants are important factors to decrease overloading.[50] The utilization of cross-bite occlusion with palatally placed posterior maxillary implants can reduce the buccal cantilever and improve the axial loading. If the number, position, and axis of implants are questionable, additional support to implants can be considered to provide by natural tooth connection with a rigid attachment.[50,52]

Occlusion in anterior fixed prosthesis.[21,33,53]

- Minimal buccal bone of 2-mm thickness[21]
- Augmentation of buccal bone would appear to improve biomechanical resistance to facial loading, but indications are as yet undefined (biomechanical durability and longevity of buccally augmented bone unproven)[33]
- Lengths >10 mm
- Diameters <3.75 mm sometimes unavoidable, but at greater risk of interface component fracture
- Crown / implant ratio >1:1 becomes biomechanically unfavorable with increased risk. No absolute criteria for contraindication based on clinical outcome data
- Splinting adjacent anterior units is currently accepted paradigm
- Number of implants 2-6 (depends on bone dimensions width of arch and aesthetic factors. No evidence base to define minimum acceptable number and dimensions)
- Vertical and horizontal overlap (overbite, overjet syn old): Flatten or round-out protrusive and working guiding inclines to reduce lateral forces when possible (within limitation imposed by skeletal relations and aesthetic factors of tooth display and lip support)[53]
- Contact in MI simultaneous with remaining posterior quadrants, skeletal, and relations permitting (anterior MI contact in infra-occlusion not substantiated)
- Selective excursive guidance: Choose protrusive and working guidance according to the best biomechanical abutment distribution
- Skeletal Class II Div I: Mild retrognathia-flat lingual incisal platform within phonetic and comfort limitations. Severe retrognathia-protrusive guidance on mesial maxillary premolar inclines
- Skeletal Class II Div II (increased vertical overlap, deep bite syn old) increased biomechanical risk when unavoidable. Raising OVD to flatten anterior guidance requires full-arch restoration at an increased iatrogenic biological risk and economic burden
- Skeletal Class III flat protrusive guidance-mild anterior disclusion to slightly disclude posterior teeth or combine premolar protrusive contact according to case-specific clinical determinants
- Use of full-arch night splint is strongly recommended particularly if bruxism is diagnosed or suspected.

Occlusion of single implant prosthesis

The occlusion in a single implant should be designed to maximize force distribution to adjacent natural teeth and minimize occlusal force onto the implant.[37] Any anterior and lateral guidance should be obtained in natural dentition to accomplish these objects. In addition, working and non-working contacts should be avoided in a single restoration. A reasonable approach to distribute the occlusal force on teeth and implants are light contacts at heavy bite and no contact at light bite in MIP.[37] 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. Wennerberg and Jemt[54] 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.

Effect of splinting

The potential overload of the implant due to differential resiliency confounds the connection of teeth and implants, by the problem of retrievability of a rigid connection, and the potential tooth abutment intrusion with a non-rigid connection. Implant connection particularly with unfavorable crown / implant ratio has been linked with increased torque loads and bending moments to the implant, abutment, crown, and supporting bone. Mandibular flexure and retrievability for repairing damaged superstructures are considered when deciding on full-arch or segmental splinted units.[55] To avoid intrusion of abutment teeth, the connection, if made, should be rigid.[56]

Complications and potential solutions

Implant overloading gives rise to clinical complications such as screw loosening, screw fractures, fractures of veneering materials, prosthesis fractures, continuing marginal bone loss below the first thread along the implant, implant fractures, and implant loss.[6,26,57] By application of sound biomechanical principles such as passive fit of the prosthesis, reducing cantilever length, narrowing the bucco-lingual/mesio-distal dimension of the prosthesis, reducing cusp inclination, eliminating excursive contacts, and centering occlusal contacts these complications can be prevented.[6,9,26,53,57] Furthermore, changing the type of prostheses and adding more implants are sometimes recommended.

Summary

The objectives of implant protected occlusion are minimizing 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. In addition, prerequisites for optimal implant occlusion are systematic, individualized treatment plans, and precise surgical/prosthodontic procedures based on biomechanical principles. 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.

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