Volume-9 | Issue-3 | March-2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

IMPLANT PROTECTED OCCLUSION-A REVIEW

Prosthodontics

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ABSTRACT

Occlusion is a key factor for implant success in the long run. As occlusal overload is regarded as one of the main causes of peri-implant bone loss and implant prosthesis failure. The occlusal rehabilitation schemes for implant-supported prostheses are derivatives of the occlusal scheme for natural dentition. The implant-protected occlusion (IPO) scheme has been designed to ensure the longevity of both prosthesis and implant. The article reviews the concepts of IPO and their applicability in different clinical scenarios.

KEYWORDS

loading of implant, occlusal scheme, implant -protected occlusion.

INTRODUCTION-

Dental implants require different biomechanical considerations apart from natural teeth. Occlusion is a determining factor for implant success in the long run as occlusal overload is often regarded as one of the main causes of peri-implant bone loss and implant prosthesis failure due to crestal bone loss. The other consequences of biomechanical overload are crestal bone loss, screw loosening and abutment loosening, porcelain and prosthesis fracture. The implant-protected occlusion (IPO) scheme has been designed to ensure the longevity of both prostheses and implants. The choice of an occlusal scheme for an implant-supported prosthesis is broad and often controversial. Almost all concepts are based on those developed with natural dentition and are transposed to implant-supported systems with a few modifications.

Implant-protective occlusion (IPO) is an occlusal scheme suggested to decrease overload on the implant-supported prosthesis and enable its successful functioning in the oral set-up[1]. After the achievement of rigid fixation with proper crestal bone contour and gingival health, the mechanical stress or strain beyond the physical limits of hard tissues has been suggested as the primary cause of initial and long-term bone loss around implants.[1,2]

The relationship between stress and strain determines the modulus of elasticity (stiffness) of a material. Modulus conveys the amount of dimensional change in a material for a given stress level. The modulus of elasticity of a tooth is similar to cortical bone. Dental implants are typically fabricated from titanium or its alloy. The modulus of elasticity of titanium is five to ten times greater than that of cortical bone. **Composite beam analysis**, concept states that when two materials of different elastic moduli are placed together with no intervening material and one is loaded, a stress contour increase will be observed where two materials first come in contact[3].

The issue of such differences between natural teeth and implants lead to the establishment of **implant-protected occlusion (IPO),** the credit for which goes to **Dr. Carl Misch and Dr. MW Bidez** [4,5]. It is also called **medially positioned lingualised occlusion**, and from the change in the relation of the edentulous maxillary ridge to the mandibular ridge due to resorption of edentulous ridges in a medial direction.

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[6,7].

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 [8,9,10].

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. 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[7,11].

Basic principles of implant occlusion may include ,bilateral stability in centric (habitual) occlusion, evenly distributed occlusal contacts and force ,no interferences between retruded position and centric (habitual) position ,wide freedom in centric (habitual) occlusion, anterior guidance whenever possible, and smooth, even, lateral excursive movements without working/non-working interferences.

The rationale of this paper is to illustrate the importance of implant protected occlusion for implant longevity and to provide clinical guidelines for 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.

Biomechanically controlled occlusion can achieve the clinical success and longevity of dental implants. 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.

Difference between natural tooth and implant under load-

Criteria	Tooth	Implant
Connection	PDL	Function ankylosis
Proprioception	Periodontal mechanoreceptors	Osseoperception

Load-bearing characteristics	Shock breaker effect of PDL	Stress concentration at the crest
Movement phase	2 phases-Primary phase-non-linear & complex Secondary phase-Linear & elastic	1 phase-Linear & elastic
Movement pattern	Primary –immediate movement Secondary –Gradual movement	Gradual movement
Axial movement	25-100 µm	3-5 µm
Lateral movement	56 to 108 µm	10 to 50 µm
Modulus of elasticity	With or without cortical bone	5 to 10 times more than cortical bone
Tactile sensitivity	High	Low
Signs of overloading	PDLthickening,mobility,wear facets,fremitus,pain .	Screw loosening and fracture, Abutment or prosthesis loosening and fracture, Bone loss, Implant fracture.

Loading of the teeth -The load thresholds for anterior teeth is 01N and posterior teeth is 04N. 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. Because of the unique positioning of periodontal mechanoreceptors[12], they play a major role in controlling the jaw movement associated with food manipulation during chewing and provide dynamic and static influences. Furthermore, the anterior and posterior teeth have similar static responses and dynamic responses are different and afferents respond over a defined force range[6].

Loading on implant – The peripheral feedback system is different for implants because of the absence of the periodontium and the mechanoreceptors located in periodontal tissues. A complex feedback mechanism and central neural plasticity occur by modulation of occlusal loads in dentate individuals and where implant crowns and bridges are located between natural teeth. These mechanisms are present with implant restorations as "osseoperception," along 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.[6]

As a result, a few unique concepts are associated with an implant-supported prosthesis and these constitute the guidelines for IPO. There are following considerations for the IPO scheme are as follows-

Premature occlusal contacts-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. It has been speculated that occlusal load from excessive lateral loads arising from premature contact may cause bone loss and implant failure. Prior to the evaluation of occlusion on implant reconstruction, the occlusion should be evaluated and all occlusal prematurities should be eliminated during maximum intercuspation and centric relation[13].

Influence of surface area -Increased load can be compensated for by increasing the implant width; reducing crown height; increasing the number of implants, or splinting the prosthesis[14].

Occlusal table width-The width of the occlusal table is directly related to the width of the implant body. The wider the occlusal table, the greater the force developed. However, a restoration mimicking the occlusal anatomy of natural teeth often results in offset load (increased stress and increased risk of porcelain fracture).As a result, in the non-aesthetic regions, the width of the occlusal table must be reduced in comparison to a natural tooth[5,15].

Mutually protected articulation-During excursion the posterior teeth are protected by the anterior guidance, whereas during centric occlusion the anterior teeth have only light contact and are protected by the posterior teeth. The anterior guidance of the implant prosthesis with anterior implants should be as shallow as practicable. The steeper the anterior guidance, the greater will be the anticipated forces on anterior implants. In the case of a single tooth implant replacing a canine, no occlusal contact is recommended on the implant crown during an excursion to the opposite side[4].

Implant body orientation and influence of load distribution- Whether the occlusal load is applied to an angled implant body or an angled load is applied to an implant body perpendicular to the occlusal plane, the biomechanical risk increases. This is attributed to the anisotropic nature of the bone, resulting in separation of the load to compressive, shear, and tensile stresses. Anisotropy refers to the character of bone whereby the mechanical properties depend on the direction in which the bone is loaded. The greater the angle of the load, the greater is the shear component of the load. Cortical bone is the strongest and withstand compressive forces. Its ability to withstand tensile and shear forces are 30% and 65% less, respectively than its ability to withstand compressive forces[5].

Crown cusp angle - Angle of force to the implant body may be influenced by cusp inclination, which in turn will increase crestal bone stress. The occlusal contact over an implant crown should, therefore, ideally be on a flat surface perpendicular to the implant body. This positioning is accomplished by increasing the width of the central groove to 2-3 mm in posterior implant crowns, which are positioned over the center of the implant abutment. It may be necessary to recontour the opposing cusp to occlude in the central fossa over the implant body. If the implant crown mimics the natural cusp angle, the premature contact will occur on a cuspal incline and the resulting direction of the load may be 30 degrees to the implant body[15].

Cantilevers and IPO – Cantilevers are class-1 levers, which increase the amount of stress on implants. Twice the load applied at the cantilever will act on the abutment farthest from the cantilever, and the load on the abutment closest to the cantilever is the sum of the other two components. Cantilevers also add to noxious stresses (force on a cantilever is compressive, while the force on a distal abutment is tensile). The force and the length of the cantilever are directly proportional to the force on the implant [5,15,16].

Crown height and IPO-An increased crown height acts as a vertical cantilever, magnifying the stress at the implant-bone interface. It also leads to angled load with a greater lateral component of force. It is important to note that crown height is determined at the time of diagnosis and that all methods of either reducing the load or reducing the crown-implant ratio should be applied before restoration.

Occlusal contact position-The ideal occlusal contact is over the implant body. This contact leads to the axial loading of implants. A posterior implant is hence placed under the central fossa of the implant crown. A buccal cusp contact is an offset or cantilever load. A marginal ridge contact is also a cantilever load, as the marginal ridge may also be several millimeters away from the implant body. In fact, the marginal ridge contact may be more damaging than the buccal offset, as the mesiodistal dimension of the crown often exceeds the buccolingual dimension. Moreover, the moment of force on the marginal ridge may contribute to forces that increase abutment screw loosening. Thus, the ideal primary occlusal contact should reside within the diameter of the implant within the central fossa. The secondary occlusal contact should remain within 1 mm of the periphery of the implants to decrease the moment loads. The marginal ridge contact is not an offset load when located between implants splinted to one another, and is acceptable only under such circumstances. Moreover, adjacent crowns should preferably be splinted in order to decrease occlusal stresses to crestal bone and to reduce screw loosening[5].

Implant crown contour -Due to ridge resorption, the direction of the remaining ridge shifts lingually and the implant body is most often not under the buccal cusp tip position of natural teeth. In fact, it may be either under or near the central fossa or more lingual under the lingual cusp of a natural tooth, depending on the resulting position of the remaining ridge due to resorption. Hence, making the buccal contour the same as the original, natural tooth will lead to a buccal offset load to the implant. All attempts should be made to provide a narrow occlusal table with reduced buccal contour, facilitating daily home care, improving axial loading, and reducing the risk of porcelain fracture.

Occlusal material-The selection of occlusal materials depends on the opposing dentition, the remaining dentition, and the quadrant to be restored. The selection is usually made from among porcelain, zirconia, metal, and resin-based materials.

Timing of loading-Implant loading can be either delayed (submerged), progressive bone loading or immediate bone loading. Bone density is the key determinant in deciding the amount of time between implant placement and prosthesis restoration. Progressive bone loading is specifically indicated for less dense bones[17,18]. Progressive bone loading allows a "development time" for load-bearing bone and allows bone adaptability to load via the gradual increase in loading.

Occlusal guidelines for different clinical situations-

Occlusion on 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. 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 distributing the occlusal force on teeth and implants are light contacts at the heavy bite and no contact at the light bite in MIP[11].

Like posterior-fixed prostheses, the 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[19] 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.

Occlusion on posterior fixed prosthesis-The potential lateral force on osseointegrated implants can be reduced by anterior guidance in excursions and initial occlusal contact on the natural dentition. During lateral excursions, working and non-working interferences should be avoided in posterior restorations[11].

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. 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[14,20].

Occlusion on overdentures - For the occlusion on overdentures, the 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[10,20].

Occlusion on full-arch fixed prosthesis-Bilateral balanced occlusion has been successfully utilized for an opposing complete denture for full-arch fixed implant prosthesis. For opposing natural dentition, mutually protected occlusion with shallow anterior guidance and group function occlusion are also recommended [10]. 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. 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. Infra-occlusion (100 mm) 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.

CONCLUSION-

Occlusion is the key factor for the success or failure of most prosthodontic rehabilitation. The status of the occlusion must be properly diagnosed, corrected or compensated for, and properly integrated into the design of the definitive restoration. Occlusal overload can be the main factor for an already osseointegrated implant to lose osseointegration. Hence careful consideration of the various components of implant protective occlusion is mandatory for the successful functioning of the implant supported prosthesis. 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.

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