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Implant Occlusion – The Determinant of Clinical Viability

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Dr.Ponjayanthi V[1], Dr.Femin David[2], Dr.T.Sreelal[3], Dr. Aparna Mohan[4], Dr. T C Giri[5], Dr. Allen Jim Hines[6]

[1,2]P.G Students, [3] Professor and Head of the department, [4,5,6]Readers.

Dept of Prosthodontics, Sree Mookambika Institute of Dental Sciences, Kulasekaram, Kanyakumari, Tamilnadu

Email: *vdponjayanthi@gmail.com*

ABSTRACT:

One of the criteria for long-term implant success being "occlusion". Careful considerations have to be given while determining an occlusal scheme for the restoration of dental implants. This stems from the fact that, mechanical stresses beyond the physilogical limits of hard tissues have been propounded as the preliminary cause of initial and long-term loss of bone around implants after osseointegration. Dental implants necessitate different biomechanical considerations compared with natural teeth. The occlusal rehabilitation scheme that is selected for implant supported restorations should decrease stresses to the implant to bone interface. This concept is known as implant-protected occlusion (IPO) scheme that has been put forward by Carl E Misch to improve the longevity of both implant and prosthesis. The article reviews implant protected occlusal scheme and its applicability in different clinical scenarios.

KEYWORDS: proprioception, osseoperception, load direction, implant protective occlusion, medially positioned lingualized occlusion, anisotropy of bone, mutually protected articulation.

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INTRODUCTION

Occlusal overload is often considered as one of the main causes of peri implant bone loss and implant prosthesis failure because it can cause crestal bone loss, thus increasing anaerobic sulcus depth and peri implant disease state[1,2]. The choice of occlusal scheme for implant supported prosthesis is broad and controvertial. A biomechanically controlled occlusion that follow sound mechanical principles, direct forces predominantly along the long axis of the implant body and minimize off centered forces should be given to impart and enhance biological stability[3].

NATURAL TOOTH Vs IMPLANT BIO MECHANICS:

The interface between implant and bone is direct, unlike the PDL is present between tooth and bone, which significantly reduces the amount of stress transmitted to the bone (fig 1). The Periodontal mechanoceptors have a key role in sensory discriminative capabilities and provide feedback on the magnitude, direction and rate of occlusal load for sensory perception and motor function of the jaws known as proprioception with a high occlusal awareness (proprioception) of about 20 µm[4]. Although implant lacks this protective mechanism against biomechanical force overload, it does receive minimal mechanoreception from the temporomandibular joint, associated musculature and cutaneous structures known as osseoperception[5](fig 2).

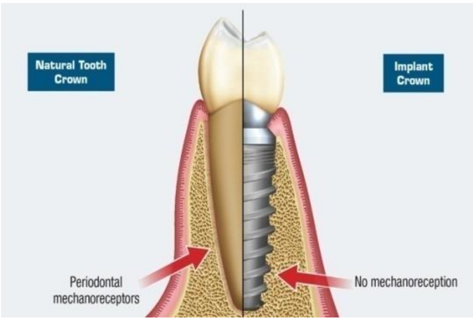

Fig 1

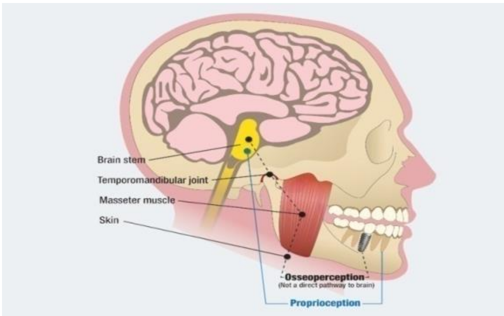

Fig 2

Unlike natural teeth, the cross-section of implants is rounded and the diameter is selected primarily according to bone available, not according to the load that it is anticipated to be subjected to. When non-vertical loading occurs on natural teeth, they adapt more favourably than dental implants that the forces are rapidly dissipated away from the bone crest toward the apex of the tooth. A dental implant, however, will not pivot or rotate; therefore, the non-vertical stress will most likely transmit to the crest and results in trauma to the supporting bone. Forces placed on teeth will result in movement in two phases: Initial Movement Phase, in which the movement is within limits of the PDL and Second Phase, in which movement is proportional to the density of the surrounding bone. Non axial force on an implant results in shear forces placed on the crestal bone, which can lead to bone loss. The presence of periodontal ligament acts as a shock absorber in natural tooth, which brings about an apical intrusion by about 28 µm and lateral movement by around 50-108 µm. In the case of a similar load acting on an implant, no initial movement is seen and the delayed apical movement observed is around 10-50 µm and lateral movement of about 10-50 microns [4,6](fig 3).

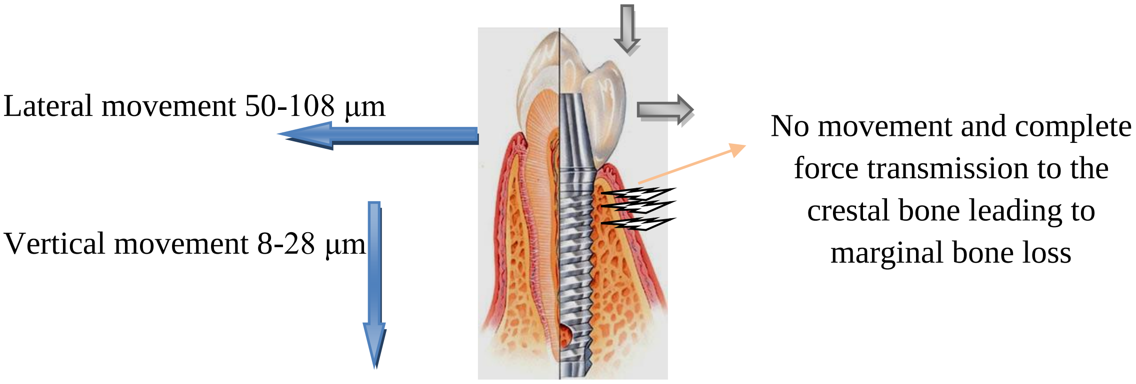

Fig 3

IMPLANT PROTECTED OCCLUSION:

These differences that exist between natural teeth and implants lead to the development of implant-protected occlusion (IPO). It is also termed as medially positioned lingualized occlusion, and it stems from the change in relation between the edentulous mandibular ridge to the maxillary ridge due to its resorption in a medial direction[6,7]. The goal of IPO is to reduce the biomechanical stress to the implant interface and the prosthesis. There exists 14 considerations for following the IPO scheme, which should be judiciously implemented before restoration.

IMPLANT PROTECTIVE OCCLUSION

REDUCE FORCE MAGNITUDE	IMPROVE FORCE DIRECTION	IMPROVE SUPPORT AREA
1. Premature contact elimination 2. Occlusal contact position 3. Cantilever prosthesis 4. Crown height 5. Crown contour 6. Parafunction 7. Favouring weak arch 8. Occlusal material	1. Implant angle 2. Cusp angle 3. Mutually protected occlusion 4. Occlusal table width	1. Loading time 2. Adequate surface area (implant number, width and length)

ELIMINATION OF PREMATURE OCCLUSAL CONTACTS:

The surface area of a premature contact is minute; thus, the magnitude of stress to the bone will increase proportionately. While restoring an implant, a thin, articulating paper of <25 µm is used for adjusting the initial implant occlusion in centric occlusion under light tapping forces. The surrounding teeth in the arch should exhibit greater initial contact and the implant prosthesis should barely make contact. Once equilibration under the application of light occlusal force is completed, the occlusion is then harmonized under heavy load. The heavy occlusal load positions the natural teeth closer to the depressed position of the implant, thereby permitting equal sharing of the load between the natural teeth and implant[1,8].

OCCLUSAL CONTACT POSITIONS:

The most ideal occlusal contact is over the body of the implant. This contact leads to the axial loading of implants. The ideal primary contact should be within the implant diameter which resides within the central fossa of the restoration. The secondary occlusal contact should remain within 1 mm of the periphery of the implants to decrease the moment loads (fig 4). The marginal ridge contact is not an offset load when located between implants splinted to one another, and is acceptable only under such circumstances[9].

CANTILEVERS AND IPO:

The magnitude of loads sustained by the implants is approximately proportional to the length of the cantilevers and the load differs as a result of implant number, location and spacing. Twice the load applied at the cantilever will act on the abutment that is located farthest from the cantilever, and the load on the abutment located closest to cantilever is the sum of the other two components (fig 5). The lenghth and the force of the cantilever are directly proportional to the force on the implant. For an implant system with 4-6 implants, the following cantilever lengths are recommended: Maxillary anteriors-10 mm of length; maxillary posteriors-15 mm; mandibular posteriors-20 mm[10,11]. In general the goal is to reduce the length of the cantilever and hence the force acting on the implant.

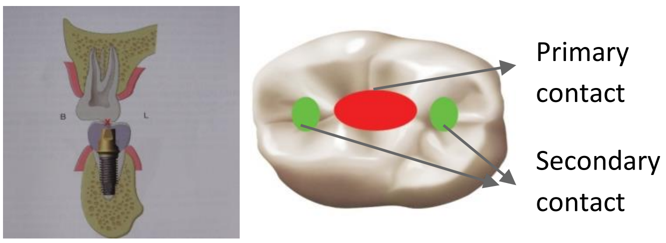

Fig 4

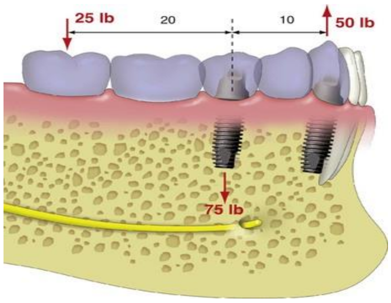

Fig 5

CROWN HEIGHT AND IMPLANT-PROTECTIVE OCCLUSION:

The crown length to implant ratio of 1:2 is ideal. The implant crown height is often greater than the original natural crown. Increased crown height with a lateral load may act as a vertical cantilever and magnifier of stresses at the implant to bone interface[10]. Hence crown height is determined at the time of diagnosis and crown to implant ratio have to be reduced to reduce cantilever.

IMPLANT CROWN CONTOUR:

Making the buccal contour of implant prosthesis similar to the original, natural tooth will lead to buccal offset load to the implant. When single implant is opposed by natural tooth in division A bone then the central fossa of implant crown is broadened 2-3 mm to receive functional cusp from natural tooth(fig 6). When maxillary implant supported prosthesis opposes mandibular implant supported prosthesis then central fossa of the maxillary prosthesis should be flattened to direct the axial load to the prosthesis to favour the weaker maxillary arch(fig 7)[12].

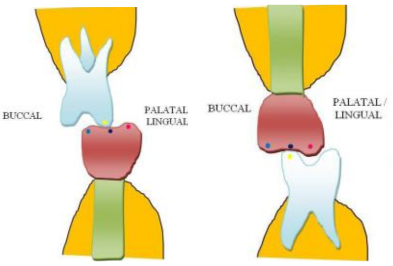

Fig 6

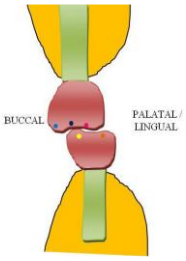

Fig 7

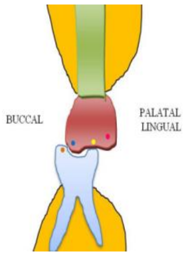

Fig 8

In Division B-Division D bone, implant position is often lingual to the position of the natural tooth hence angled abutments can be preferred. Maxillary posterior implants in division B-D bones may often require ridge augmentation and restoration in crossbite (fig 8)[12,13].

PARAFUNCTIONAL ACTIVITY:

Improper occlusal designs and parafunctional activity are correlated with implant bone loss and failures. Naert *et al* reported that overloading from parafunctional habits such as clenching or bruxism seemed to be the most probable cause of implant failure and marginal bone loss[1,14]. Use of shorter cantilevers, proper location of the fixtures along the arch and night-guard protection should be prerequisites to avoid parafunctional habits or the overloading of implants in these patients.

DESIGN OF THE PROTHESIS SHOULD FAVOUR THE WEAKEST ARCH:

Usually the maxilla is the weaker of the two arches, predominantly due to less dense bone. From a biomechanical perspective, a premaxilla restored with implant is considered as the weakest section compared with the other regions of the mouth. The anterior premaxilla, restored with straight abutment showed 15% higher bone strain when compared to an angled abutment. It has been suggested that, when restoring implants in the anterior maxilla, the use of an angled abutment may decrease the strain on the bone[7]. In fact, it has been recommended to increase the number and the diameter of implants and provide splinting when force factors are great.

OCCLUSAL MATERIAL:

Materials such as all ceramic, zirconia, metal ceramic restorations, all metal and resin based restorations can be used as implant prosthesis depending on the opposing dentition, the remaining dentition, and the quadrant to be restored[15]. The materials selected for the occlusal surface of the prosthesis not only maintains the occlusal contact with opposing arch but also it affect the transmission of forces to the underlying implant. Occlusal materials maybe evaluated by esthetics, impact force (low Young's modulus is preferred), chewing efficiency, material fracture, wear and interarch space requirements.

IMPLANT BODY ORIENTATION AND INFLUENCE OF LOAD DIRECTION:

Whether an angled load is applied to an implant body perpendicular to occlusal plane or the occlusal load is applied to an angled implant body, the biomechanical risk increases. This is imputed to the anisotropic nature of the bone, resulting in dissociation of the load to shear, compressive and tensile stresses. The greater the angle of the load, the more will be the shear component of the load. The ability of cortical bone to withstand tensile and shear forces is 30% and 65% less, respectively, than its ability to withstand compressive forces[9,16]. Additionally, a force at a 30-degree angle decreases the bone strength limit by 25% under tension and 10% under compression. There is almost three times increase in the shear component of stresses, which predisposes to increased crestal bone loss. Whenever angled loads cannot be eliminated, selecting implant design with greater surface area, increasing the diameter of angled implants, splinting of implants and adding an additional implant next to the most angled implant can be followed to reduce the force magnitude[17].

CROWN CUSP ANGLE:

Kaukinen et al stated that increase in cusp angle will leads to efficient incision of food, but premature occlusal contact along the cusp angle which causes increased angled load to the implant which in turn will results in increased crestal bone loss and implant failure. Cusp inclination produces a higher level of torque due to increased shear force. For every 10° increase in cusp angle, there is an approximately 30% increase in torque. Hence implant supported prosthesis should have a shallow occlusal anatomy[18,19].

MUTUALLY PROTECTED ARTICULATION:

The rationale of mutually protected occlusion is that the forces are distributed to segments of the jaws with an overall decrease in force magnitudes. The anterior guidance of the implant supported prosthesis with anterior implants must be as shallow as practicable. The steeper the anterior guidance, the higher the forces acting on the anterior implant[18]. In cases with a single tooth implant replacing a canine, occlusal contact is not recommended on the implant crown during movement to the opposite side. If anterior implants should disocclude the posterior teeth, then two or more implants splinted together must help dissipate lateral forces whenever possible.

CONTROLLING THE OCCLUSAL TABLE WIDTH:

The occlusal table width should directly related to the implant body width. A restoration mimicking the occlusal anatomy of natural teeth often results in offset load and shear forces which are detrimental to the implant and supporting bone. Hence, the width of the occlusal table must be reduced in the nonaesthetic regions. For maxillary implant prosthesis, the palatal contour that is out of the esthetic zone and is a stamp cusp for occlusion should be reduced to decrease the offset load. The buccal contour of the mandibular posterior implants should be modified to decrease offset loads and lingual contour should be similar to the natural tooth to prevent tongue biting during function[6,7,9].

TIME OF LOADING:

Implant loading can be either immediate, delayed (submerged), progressive 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. Immediate loading is preferred in esthetic zone using resin based prosthesis because of damping effect. Delayed loading is preferred in grafted situations, non esthetic zones and where implant stability is less than 45 Ncm.

INFLUENCE OF SURFACE AREA:

An important parameter in implant protective occlusion is the adequate surface area to sustain the load transmitted to the prosthesis. When implants of decreased surface area are subject to angled or increased loads, the magnified stress and strain magnitudes in the interfacial tissues are produced which can be minimized by placing an additional implant in the region of concern. Increased load can be compensated for by increasing the implant width, reducing crown height, ridge augmentation if necessary, increasing the number of implants and splinting the prosthesis[3,20]. When multiple implants were placed they should be positioned in a staggered pattern instead of a straight line to increase the surface area (fig 9).

Fig 9

OCCLUSAL GUIDELINES FOR DIFFERENT CLINICAL SITUATIONS:

In case of full mouth implant supported fixed prosthesis, the factors to be considered includes: number of implants, position of implants, surface area of implants, parafunctional habits, presence of cantilevers, opposing dentition. In case of severely resorbed ridges, monoplane occlusion should be used. Bilateral balanced occlusion which is the bilateral, simultaneous occlusal contact of the anterior and posterior teeth in excursive movements is indicated when a fixed implant prosthesis opposes a conventional complete denture or a removable partial denture. Mutually protected occlusion is indicated when a fixed implant prosthesis opposes a natural dentition, fixed implant prosthesis or an implant supported removable over denture[17].

CONCLUSION:

Protecting the implant and surrounding peri-implant bone requires an understanding of how occlusion plays a role in influencing long-term implant stability.A poor selection of occlusal scheme can lead to biological and mechanical complications. An IPO scheme addresses several conditions to minimize overload on bone/implant interfaces and implant prostheses, thus restricting implant loads within physiological limits. The guidelines need to be implemented in specific conditions to decrease stresses and develop an occlusal scheme to allow the restoration to function in harmony with the rest of the stomatognathic system and to maximize the longevity of the implants and prosthesis.

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