REVIEW

Correlation of implant protective occlusion with implant failures

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ABSTRACT:

It is believed that dental implants may be more prone to occlusal overloading, which is often regarded as one of the potential causes for peri-implant bone loss and failure of the implant/implant prosthesis. Implant-protective occlusion can be accomplished by increasing the surface area of implants, decreasing the width of the occlusal table, improving the force direction, and reducing the magnification of the 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.

Key words: Implant protective occlusion, implant prosthesis

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INTRODUCTION

Endosseous dental implants have successfully been used during the last few decades as a treatment modality for the replacement of missing teeth in partially or completely edentulous patients. The clinical success and longevity of endosseous implants are largely controlled by the mechanical setting they function in.[1] Implant treatment has a high success rate that has been rated as high as 95 to 99%, despite high success rate with endosseous titanium implants, failures unavoidably occur. Optimal oral hygiene and proper occlusion are considered critical for long-term success of endosseous oral implants.[2] Most of the complications like porcelain fracture, unretained prosthesis, screw loosening, bone loss etc occur due to faulty occlusion.

Due to lack of the periodontal ligament, osseointegrated implants, unlike natural teeth, react biomechanically in a different fashion to occlusal force. It is therefore believed that dental implants may be more prone to occlusal overloading, which is often regarded as one of the potential causes for peri-implant bone loss and failure of the

implant/implant prosthesis. Overloading factors that may negatively influence on implant longevity include large cantilevers, parafunctions, improper occlusal designs, and premature contacts. Hence, it is important to control implant occlusion within physiologic limit and thus provide optimal implant load to ensure a long-term implant success.

Occlusal overload can cause mechanical complications on dental implants and implant prostheses such as screw loosening and/or fracture, prosthesis fracture, and implant fracture, eventually leading to compromised implant longevity.[3,4]

The crestal bone around dental implants may act as a fulcrum point for lever action when a force (bending moment) is applied, indicating that peri-implant tissues could be more susceptible to crestal bone loss by applying force.[5] It is essential for clinicians to understand inherent differences between teeth and implants and how force, either normal or excessive force, may influence on implants under occlusal loading.

Differences between teeth and implants

The presence of a periodontal membrane around natural teeth significantly reduces the amount of stress transmitted to the bone, especially at the crestal region. The force transmission is so complete that a thin layer of cortical-like bone (cribriform plate) forms around the tooth. When the tooth is lost, the cortical plate lining disappears, showing that this is a result of ideal strain interface to the bone.[1] Compared with a tooth, the direct bone interface with an implant is not as resilient, so the energy imparted by an occlusal force is not dissipated partially (the displacement of the periodontal membrane dissipates energy) but rather transmits a higher intensity force to the contiguous bone.

The mobility of a natural tooth can increase with occlusal trauma. This movement dissipates stresses and strains. The tooth then returns to normal position once the trauma is eliminated.

Mobility of an implant also can develop under occlusal trauma. However, after the offending element is eliminated, an implant rarely returns to its original rigid condition.

The width of almost every natural tooth is greater than the width of the implant used to replace the tooth. The greater the width of a transosteal structure (tooth or implant), the lesser the magnitude of stress transmitted to the surrounding bone The cross-sectional shape of the natural tooth at the crest is biomechanically optimized to resist lateral (buccolingual)

Tooth versus implant biomechanics[1]

Tooth	Implant
1. Periodontal membrane a. Shock absorber b. Longer force duration c. Distribution of force around tooth d. Tooth mobility can be related to force e. Mobility dissipates lateral force f. Fremitus related to force g. Radiographic changes related to force reversible	1. Direct bone-implant a. Higher impact force b. Short force duration c. Force primarily to crest d. Implant is always rigid e. Lateral force increases strain to bone f. No fremitus g. Radiographic changes at crest(bone loss) not reversible
2. Biomechanical design a. Elastic modulous similar to bone b. Diameter related to force magnitude	2. Implant design a. Round cross section and designed for surgery b. Elastic modulus 5 to 10 times that of cortical bone c. Diameter related to existing bone.
3. Sensory nerve complex in around tooth a. Occlusal trauma induces hyperaemia and leads to cold sensitivity b. Propioception (reduced max. Bite force) c. Less bite functional force	3. No sensory nerves a. Occlusal trauma induces hyperaemia and leads to cold sensitivity b. Occlusal awareness of two to five times less c. Functional bite force four times higher
4. Occlusal material: enamel a. Enamel wear, stress lines, abfraction and pits.	4. Occlusal material porcelain(metal crown) a. No early signs of force
5. Surrounding bone- cortical a. Resistant to change	5. Surrounding bone is trabacular a. Conductive to change

loads because of the bending fracture resistance (moment of inertia) of the tooth and the direction of occlusal forces.

After osseointegration, mechanical stresses and strains beyond the physical limits of hard tissue have been suggested as the primary cause of both initial and long-term bone loss around implants. If the occlusal overload is not corrected, crestal bone loss will continue until the implant fails. Occlusal overload is often regarded as one of the main causes for 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 if patients oral hygiene status is poor.[7]

Differences in the magnitude, duration, direction, and frequency of the applied occlusal load and the tolerance threshold of the host are the underlying reasons for the conflicting observations obtained through the clinical studies on occlusal overload. Possible mechanisms of why occlusal overload can lead to peri-implantitis are conceivable. Implants are considered less tolerable to non-axial occlusal load compared to teeth because of a lack of a periodontal ligament. Finite element studies have suggested that the occlusal load is concentrated at the implant marginal bone. Bone remodels in response to the strain. Excessive stress can cause microfracture within bone and eventual bone loss.

Consequences of biomechanical overload[1]

1. Porcelain fracture
2. Prosthesis fracture
3. Uncemented or unretained restoration
4. Screw loosening
5. Early crestal bone loss
6. Intermediate to late implant failure
7. Peri implant disease
8. Component fracture

Principles of implant protective occlusion

1. *No premature occlusal contact*: During maximum intercuspation, no occlusal contact should be premature. 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.[6]

2. *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. 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

3. *Mutually protected articulation*: When the natural canines are present, during excursions it allows the teeth to distribute horizontal load and also the posterior tooth to disocclude. This concept is known as canine guidance or mutually protected articulation. However, there should be no contact on the implant crown during excursion to the opposing side and also during protrusion. The anterior guidance of implant prosthesis with anterior implant should be shallow. This is because, the steeper the incisal guidance the greater the force on the anterior implants. Weinberg et al have reported a study stating, every 10- degree change in the angle of disclusion, there is a 30 % difference in the load.[1]

4. *Cusp angle of crown*: Natural dentition has steep cuspal inclination whereas in denture teeth, the cuspal inclination given is 30 %. Cusp inclination has been found to produce a high level of torque [6]. For every 10° increase in cusp inclination, there is an approximately 30% increase in torque. Weinberg et al in 1995 have reported a study regarding the torque of a gold screw, abutment screw, and implant. They have concluded that, the cuspal inclination produces the most torque, followed by maxillary horizontal implant offset, while implant inclination and apical implant offset produce minimal torque. Occlusal contact over an implant crown should be on a flat surface perpendicular to implant body. This is achieved by increasing 2 to 3mm of the width of the central groove in the posterior implant crowns and the opposing cusp is recontoured to occlude the central fossa directly over the implant body.

5. *Implant body angle to occlusal load*: There can be different impact on the bone and implant interface based on the direction of the load applied even if it's of same magnitude of force, however implant is mainly designed for long axis load. A study was reported by Binderman in 1970, where 50 endosteal implant designs were assessed and found that all the design sustained lesser under a long axis load. The greater the angle of load to the implant long axis, the greater the compressive, tensile and shear stresses which leads to bone loss and unsuccessful bone re growth.

6. *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. 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.

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7. *Cantilever*: Cantilevers with unfavourable crown or implant ratio, increase the amount of stress to the implant. These can further lead to peri implant bone loss and prosthesis failure. The magnitude of load obtained by the implants is approximately proportional to the length of the cantilevers but it also varies with the implant number, spacing, and location. Long cantilevers are correlated with increase crestal bone lost.

8. *Occlusal contact position:* Occlusal contact position determines the direction of force especially during parafunctional activity. In different theories, the number of occlusal contact varies. Occlusal theory by Peter K Thomas suggest that there should be tripod contact on each occluding cusp, on each marginal ridge and central fossa with 18 and 15 individual occlusal contacts on a mandibular and maxillary molars whereas, the other oclusal contact scheme indicates that, number of occlusal contact for molars can be reduced.

9. *Implant crown contour*: In maxilla, the edentulous ridge resorbs gradually in the medial direction whereas in posterior mandible, the resorption occurs in lingual direction. Center of implant is placed in the center of the edentulous ridge because the ridge resorbs lingually with resorption hence the implant is mostly not kept under the buccal cusp tip but near the central fossa or more lingually, under the lingual cusp of the natural tooth. The size of the implant body which is the buccolingual dimension is smaller than the natural tooth.[1]

10. *Occlusal material*: Occlusal material fracture is one of the most common complications of implant restoration therefore consideration of the occlusal material restoration is very essential for each patient. Occlusal material may be evaluated by esthetic, impact force, static load, chewing efficiency, fracture, wear, inter arch space requirement, and accuracy of casting.[3]

CONCLUSION

The objectives of implant occlusion are to minimize overload on the bone–implant interface and implant prosthesis, to maintain implant load within the physiological limits of individualized occlusion, and finally to provide long-term stability of implants and implant prostheses. To accomplish these objectives, increased support area, improved force direction,

and reduced force magnifications are indispensable factors in implant occlusion.

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