Review Article

# BIOMECHANICS OF OCCLUSION IN IMPLANTS: A REVIEW

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**Abstract**

The implant treatment has become the most suitable treatment of choice to replace the missing teeth in partially edentulous patients. The biological and biomechanical characteristics of dental implants differ from those of natural teeth. The success of the implant treatment is greatly dependent on occlusion. Establishing the functional occlusion should be the goal of any prosthodontic procedure. Implant protected occlusion is an important criteria for improving the longevity of the dental implant as well as the prosthesis. Dr. Carl E. Misch proposed an occlusal scheme which reduced the forces acting at the crestal bone and the implant interface. A number of biomechanical complications may occur due to occlusal overload. These include early implant failure, component failure, porcelain fracture, early crestal bone loss, intermediate to late implant failure, screw loosening, uncemented restoration, component fracture and peri-implant disease. The treatment planning and its execution is the earnest requiste of implant supported prosthesis. On a larger aspect it's a multifactorial approach which includes presence of good amount of bone, location of the implant, number of implants placed, length of the implant, it's distribution and inclination, vertical dimension aesthetics, dynamic occlusal schemes and many more.

**Keywords:** Dental implants, Implant occlusion, Implant protected occlusion, Occlusal schemes.

## Introduction

The longevity and the success of any restoration in the oral cavity depends on the forces that act on it and also the ability of the underlying structures to absorb and withstand these forces. In implants the longevity depends on the nature of attachment of bone to the titanium surface of implant. The relationship of occlusal overload with implant overload and concomittant failure is a well-accepted phenomenon.[1] The implant-supported restoration has to replace the missing teeth and maintain it's form, function and aesthetics to optimize it's longevity. Implants and the surrounding bone should be good enough to support the functional and parafunctional demands of occlusal loading.[2]

Occlusion is considered to be the most important criterion for implant success. Implant protected occlusion is imperative as it provides the maximum intercuspation even in the presence of clenching force, also it reduces occlusal load on implant.[3] Moreover, the success of implants is based on the biomechanical aspects of occlusal design, configuration and anatomy that falls in harmony with the stomatognathic system; it highly contributes to the long term success of implant. [4]

Unlike natural teeth the implants have no periodontal ligaments thus they react in a dissimilar fashion to the occlusal force, leading to the occlusal overloading. The occlusal overload might accelerate the peri-implant bone loss and may lead to the implant failure. In implants the most common complications due to occlusal overload are screw loosening, screw fracture, fracture of veneering material, prosthesis fracture, and continual marginal bone loss, implant fracture. IPO loss. Thus, it is mandatory to confirm the occluasl scheme for an implant supported restoration that will decrease cuspal interference, The clinicians used similar standards of occlusion as they do in the natural dentition based on the experiments and researches in the implant science. The current concepts of replacing the complete arches on three or four implants, angulated implants and supporting occlusal loads on bone substitutes are the most challenging rehabilitation methods, thus creating a huge amount of perplexity. Implant supported restorations requires a substantial planning considering the natural anatomy of the dentition, occlusion and alveolar support mechanisms.[2]

## What is an Ideal Occlusion

Occlusion is defined as any contact between the incising or masticating surface of the maxillary or mandibular teeth (GPT-8). An ideal occlusion is the one that provides resourceful mastication and satisfactory esthetics without causing any physiologic abnormalities. Dawson in 1974 has given five different concepts of occlusion viz. Centric relation, anterior guidance, posterior disclusion in protrusive movements, posterior disclusion on balancing side and non-interferance of posterior teeth on working side and border movements.[6]

Centric relation is defined as the maxillomandibular relationship in which the condyles articulate with the thinnest avascular portion of their respected disks with the complex in the anterior-posterior position against the shape of the articular eminencies (GPT-8). This position of the mandible does not show any tooth contact but clinically it can be seen when it's directed antero-superiorly. Purely rotary movement is restricted around a transverse horizontal axis. The border movements of the envelope of function along with disclusion of posterior teeth in protrusive movements must be in harmony with the anterior guidance. There should be no fiddling with

all the posterior teeth present on the working side when carrying out border movements of the condyles or the lateral anterior guidance. The pattern of occlusion differs for each individual, whereas a suitable pattern can be found on the basis of Dawsons criteria. The ideal occlusion schemes were explained by Pameijer et al in 1983 which included 3 types of occlusion namely; group function occlusion, balanced occlusion, and canine protected occlusion.[6,7] The differences between the implant and tooth biomechanics are listed in Table 1.

| Tooth | Implant |
|---|---|
| **1. Periodontal membrane** | **1. Direct bone-implant** |
| a. Absorbs shock | a. High implant force |
| b. Longer force duration (decreased impulse of the force) | b. Lesser duration of force (increased impulse of the force) |
| c. Distribution of force around tooth | c. Force primarily to crest |
| d. This force leads to mobility of the tooth | d. Any mobility may lead to implant failure; therefore it should be rigid |
| e. Mobility dissipates the forces acting laterally | e. Strain bone is increased during lateral forces |
| f. Forces may lead to fremitus | f. No fremitus |
| g. Reversible changes are seen radiographically | g. Irreversible changes are seen radiographically at crest |
| **2. Biomechanical designing** | **2. Implant design** |
| a. Cross-sectional view related to direction and amount of stress | a. Round cross-section |
| b. Has similar elastic modulus to bone | b. Has elastic modulus of 5 to 10 times than that of cortical bone |
| c. Magnitude of force is related to diameter | c. Diameter is related to the existing bone |
| **3. Complexity of sensory nerve in and around tooth** | **3. Absence of sensory nerves** |
| a. Hyperemia and cold sensitivity are induced due to occlusal trauma | a. No antecedent sign of slight occlusal trauma is seen |
| b. Proprioception (reduced maximum bite force) | b. Occlusal awareness of 2 to 5 times less (higher maximum bite force functional) |
| c. Functional bite force is less | C. Functional bite force 4 times higher |
| **4. Occlusal material: Enamel** | **4. Occlusal material: Porcelain (metal crown)** |
| a. Presence of pits, stress lines, abfraction and enamel wear due to the force. | a. No early signs of force are seen |
| **5. Presence of cortical surrounding bone** | **5. Presence of trabecular bone which may be fine** |
| a. Resistant | a. Conducive to change.[8] |

*Table 1: Tooth versus Implant Biomechanics*

Occlusal overload is attributed to be one of the important cause for the bone loss in peri-implant region and also for the failure of the implant or implant prosthesis.[9,12] According to literature it has been seen that occlusal overload leads to the loss of bone around the implant and also affects the osseointegration after the implant is successful. [11]

The long term survival of implants depends on a proper occlusal scheme. This is mandatory in cases where parafunctional activities are present and also in the presence of marginal bone loss. The magnitude of loads is increased and mechanical stresses (and strain) are intensified in case of poor occlusal scheme thus complicating the bone support. The consequences of biomechanical overload related to the stress are listed in Table 2.

| | Consequences of biomechanical overload |
|---|---|
| 1. | Leads to early implant failure |
| 2. | Early crestal bone loss is seen |
| 3. | Transitional to late implant failure |
| 4. | Transitional to late implant bone loss |
| 5. | Screw loosening occurs between the abutment and the coping of the prosthesis |
| 6. | Weakening of the restoration |
| 7. | Fracture of the components |
| 8. | Fracture of porcelain |
| 9. | Fracture of prosthesis |
| 10. | Bone loss leading to peri-implant disease [12,13] |

*Table 2: Consequences of Biomechanical Overload*

**Implant Protected Occlusion**

Bone loss may lead to abnormal sulcus depths and peri-implant diseases. The most important factor to obtain longevity of the implant as well as the prosthesis is implant occlusion. Less amount of forces should be present at the crestal bone and the implant interface. In accordance with this concept an occlusal plane is designed specifically to restore the endosteal implants thereby increasing the lifespan of the implant and the prosthesis. The biomechanical risk factors may be expressed at different levels in the system. The IPO (Implant Protected Occlusion) concept includes a number of factors which lead to a decrease in the stress at the implant interface.[6] The various factors influencing implant protected occlusion are:

- No interferences or premature occlusal contacts should be present
- Surface area
- Canine guided/mutually protected articulation
- Angulation of implant body to occlusal load
- Cuspal inclination(cusp angle of the crown)
- Horizontal offset(cantilever).
- Contact positions in occlusion

- Contour of the implant crown
- Weakest component protection
- Occlusal materials[14]

In case of an implant supported prostheses occlusal prematurity between maximum intercuspation and centric relation occlusion should be kept in mind. The reason being that when the mobile natural teeth comes in contact with the non-mobile implants, they bear the entire load of the prosthesis. The more the premature contact on the implant prostheses, the more the crestal bone loss.[15] Besides that, Isidor F also reported a study stating that; excessive occlusal overload during pre mature contact causes severe crestal bone resorption and loss of osseointegration.[16] The natural teeth move away from the centric when functioning thereby leading to premature occlusal contacts on the implant. This leads to an increase in the stress and strain in the interfacial tissue. There are several factors which can minimize this stress which includes placement of more number of implants in the region of concern, decreased crown height, augmentation of the ridge or by using implants with greater width.

**Canine guidance or mutually protected articulation**

In tooth - supported fixed prosthodontics anterior disclusion and mutual protection are believed to be viable restorative occlusion options. Parafunctiong, occlusal loading and TMDs are reduced by the implementation of neuromuscular protective mechanisms and the mechanical benefit of a Class III lever. However, there implication to implants is problematic. Implants are more susceptible to cervical bone loss and occlusal overload because they are often not supported buccally due to the presence of thin buccal plates that do not have periodontal receptors. There is a difference of conditions in cases with mixed tooth and implant-supported dentitions and between wholly implant-supported fixed restorations. In mixed type i.e, tooth and implant-supported dentitions, decisions need to be made depending on whether the teeth disclude implants, or whether implants or teeth and only implants support excursive guidance, and also if the restorations are independent or splinted. The advantages obtained of anterior disclusion and mutual protection from neuromuscular protection are overweighed by local biomechanical considerations. Disclusion properties are complicated in cases where full- arch splinting is carried out. This is because in such a case both the anterior and the posterior segments of the prostheses become rigid as they are splinted together and are no longer independent elements with differing biomechanical properties.

In the presence of natural canines the excursive movements permit the teeth to distribute the horizontal load and also causes disclusion of the posterior teeth.. This conception is known as canine guidance or mutually protected articulation. No contact should be present during excursion to the opposing side and also during protrusion on the contact surface of the crown. The anterior implant should have a shallow anterior guidance of the implant prosthesis. This is because, it may lead to a greater the force on the anterior implants.[6,17]

A high level of torque is produced by inclining the cusps. With an increase of 10° in cusp inclination, there is just about 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.[18]

The impact of forces acting on the bone and implant interface are different depending upon the direction of the load even if the forces applied are of the same magnitude. Implants are mainly designed for long axis loads. The height of the implant crown is greater than that of the natural anatomical crown.[19] With an increase in the implant crown height, the crestal moment with any lateral component of force also increases. Therefore the selection of the cusp angle, implant body angle or angled load to the crown should be done in such a way that there are no harmful effects of the crown height measurements.[20]

Cantilevers with unfavourable crown or implant ratio, cause more stress to the implant, which will further cause peri implant bone loss and prosthesis failure.[19,21] The magnitude of load acting on the implants is just proportional to the length of the cantilevers but is also dependant on the implant number, spacing, and location.[22,23]

In maxillary arch the edentulous ridge resorbs in the medial direction whereas in posterior mandible, the resorption occurs in lingually. Center of implant is placed in the center of the edentulous ridge because the ridge resorps 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. Occlusal theory by Peter K Thomas suggested that there should be a tripod contact on each and every occluding cusp. And on each marginal ridge and central fossa with 18 and 15 individual occlusal contacts on a mandibular and maxillary molars whereas, the other occlusal contact scheme indicates that, number of occlusal contact for molars can be reduced.[25] 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.[24] If the occlusal scheme designed is poor it causes an increase in mechanical stresses and strains at the crestal bone for which the crestal bone acts as a fulcrum when there is an occlusal overload. The result of which may be the biological and mechanical complications.[26]

## Conclusion

Long-term prosthetic efficiency, careful treatment planning and sound decision are pre-requisites for the success of implant prosthesis. The weakest link in the overall restoration should be carefully identified and occlusal and prosthetic schemes should be established to protect that component of the structure. Each patient must be treated with an individualistic approach. The guidelines for the choice of restoration or type of occlusal scheme must be customized to allow the longevity of the restoration in harmony with the surrounding tissue health. The objectives of implant protected occlusion is to reduce noxious occlusal load on the bone implant interface and implant prosthesis, to establish a consistent occlusal philosophy, to maintain implant load within the physiological limits of individualized occlusion, and finally to provide long-term stability of implants and implant prostheses. Therefore principles of implant protected occlusion are one of the very important criteria for implant as well as the prosthesis longevity.

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