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Occlusal principles and considerations for the osseointegrated prosthesis

Dr. Smitha Annie Jacob[1], Dr. V.Vidyashree Nandini[2], Dr. Sanjna Nayar[3], Dr. Anoop Gopalakrishnan[4]

[1](Assistant Professor, Department of Prosthodontics, Dr. Syamala Reddy Dental College Hospital and Research Centre, India)
[2](Professor and Head, Department of Prosthodontics, SRM Kattankulathur Dental College, India)
[3](Professor, Department of Prosthodontics, Balaji Dental College, India)
[4](Assistant Professor, Department of Prosthodontics, Azeezia College of Dental Sciences and Research, India)

Abstract : *The utilization of oral implantology in the field of dentistry is growing at a rapid rate. Although the surgical aspect of the field has expanded into many high-profile areas (i.e., immediate implant placement, distraction Osteogenesis, and the orthodontic anchorage implant), it is the prosthetic aspect that is the most critical for long term success. More specifically, the occlusal considerations for implant supported prostheses make a major contribution to ensure predictable results. This article reviews occlusal principles and clinical applications for long term success of endosseous implants.*

Keywords - *Occlusion, Implant protective occlusion, occlusal scheme, biomechanics, occlusal stability.*

I. Introduction

Rehabilitation of missing teeth with prosthesis has undergone a series of changes over the years. Various treatment options considered are complete dentures, removable partial dentures, fixed partial dentures and overdentures. The quest for replacements as close to natural teeth as possible resulted in the development of implants[1,2].

Presently, implant restorations are considered to be the most ideal restorative option available. Implants provide with advantages such as maintenance of bone, restoration and maintenance of occlusal vertical dimension, maintenance of facial aesthetics, improved esthetics, improved phonetics, improved occlusion, improvement or allowance for regaining of oral proprioception, improved stability and retention of removable prostheses, improved psychological health and elimination of the need to alter adjacent teeth[2,3,4]

Gradually, with the increase in the number of implant cases, an increased number of failure rates were also reported. An increase in failed implants led to an introspection of the various reasons for the same[3,5,6]. Studies proved that occlusal load was one of the primary contributing factors. This resulted in the concept of a restoration driven implant, rather than an implant driven restoration[7,8,9].

The restoring dentist has specific responsibilities to minimize overload to the bone-to-implant interface. These include a proper diagnosis leading to a treatment plan providing adequate support, based on the patient's individual force factors; a passive prosthesis of adequate retention and progressive loading to improve the amount and density of the adjacent bone and further reduce the risk of stress beyond physiologic limits. The final element is the development of an occlusal scheme that minimizes risk factors and allows the restoration to function in harmony with the rest of the stomatognathic system[8,10,11].

Occlusion specific to implants can be termed Implant Protective Occlusion. Implant-Protective Occlusion is that occlusal scheme which reduces the forces at the crestal bone/implant interface. Biomechanical principles form the basis of this concept. The direction of force, force magnification, and implant position relative to arch or location are blended together for a consistent approach to implant reconstruction[12]. The direction of force demonstrates that angled forces increase the type of forces, alter their point of application, and reduce bone strength. Force magnifiers include cantilevers, offset loads, and monumental forces to the implant body. These magnifiers dramatically increase the amount of force applied to a prosthesis[13,14]. The implant position is often determined by the density of bone and the amount of force. Adequate surface area of implant includes width, length, and number[15]. The surface area is a primary component in the resistance of force factors. In addition occlusal table width and occlusal contacts contribute to the amount of force, type and direction and may be modified to reduce crestal loads[16,17,18].

The primary goal of Implant-Protective occlusion is to maintain the occlusal load transferred to the implant within the physiologic limits of each patient. Implant dentistry continues to struggle with what is the appropriate occlusal concept for implant-supported restorations[19]. The biological and mechanical consequences of the loading environment leads to establishing and maintaining an implant interface in a wide variety of bone quality, implant and prosthesis designs[8,10]. To the restorative dentist, the role occlusion is more focused on extending the service life of the restoration and the connecting abutments than protecting the osseous integration of the implants[20,21].

II. Discussion

1. Natural Tooth Versus Implant Biomechanics

It is critical for the practitioner to appreciate the differences between natural teeth and endosseous implants in regard to the application of stress[22] (Fig. 1). The most significant difference is created by the periodontal ligament and its unique properties (TABLE 1). As a result, ways to decrease stress are a constant concern to minimize the risk of implant complications (TABLE 2).

2. General Occlusal Scheme

The concept of occlusion suitable for osseointegrated prostheses is basically the same as that of gnathologic occlusion.

In centric, all of the posterior teeth should have contacts, and anterior teeth should have a clearance of about 30µm. If the entire arches are restored with osseointegrated prostheses such as a fully bone anchored bridge, it will be easier to establish such an occlusion. In the mixed dentition, which is composed of natural teeth and osseointegrated bridgework, the natural tooth sinks approximately 30µm during its function. An osseointegrated bridge, which is supported only by bone, does not sink. Therefore, the centric contacts of the osseointegrated fixed bridge should be slightly more open than the natural teeth. In centric, the osseointegrated bridge should not contact with opposing teeth under the soft bite pressure, while strong bite pressure, the bridge should contact after the natural tooth intrudes approximately 30µm. The osseointegrated bridge begins to contact after the contact of all the natural posterior teeth. In order to avoid the overloading of the occlusal surface, the osseointegrated prosthesis should not have plane-to- plane contact. Point contact especially cusp-to-fossa tripodal contact is preferred[23,24,25].

During eccentric movement, the concept of disclusion is generally recommended. Anterior segments of the osseointegrated prosthesis should guide the mandible to produce the posterior disclusion[26]. Canine-guided occlusion is not recommended for the osseointegrated prosthesis as it generates excessive occlusal forces into the single implant fixture, which is placed in the canine area. In order to distribute the stress over the entire fixture, anterior group function is recommended[27].

The specific amount of disclusion to be given to the osseointegrated prosthesis is not clearly understood. The average consensus for the amount of disclusion observed at the mesiobuccal cusp tips of the mandibular first molars while the condyle moves 3mm from the centric are in protrusion is 1.1±0.6mm, non-working side is 1.0±0.6mm, working side is 0.5±0.3mm[28,29].

3. Classification Of Osseointegrated Prostheses

Osseointegrated prostheses can be classified as follows[28,30,31]:

i. Fully bone anchored bridge.
ii. Overdenture.
iii. Free standing bridge –
    a. Kennedy Class I
    b. Kennedy Class II
    c. Kennedy Class III
    d. Kennedy Class IV
iv. Bridge connected to the natural teeth.
v. Single tooth replacement.

The occlusion for each case will be discussed.

3.1 Occlusion For Fully Bone Anchored Bridge

The occlusion recommended for a fully bone anchored bridge is the mutually protected occlusion. In centric, it is necessary to have a 30µm clearance at the anterior region and to have centric stops on the posterior teeth. In order to eliminate harmful horizontal stress, the disclusion should be employed. To avoid the localization of the stress, anterior group function must be used[32,33]. The anterior guidance should be made slightly flatter than that of the natural teeth to avoid overstress of the fixture. This produces a smaller amount of disclusion. Recommended amounts of disclusion for fully bone anchored bridges are as follows: Protrusive 1mm; Non-working side 0.8 mm; Working side 0.3 mm[32,34].

3.2 Occlusion For Overdentures

The occlusion recommended for the overdenture is the fully balanced occlusion with lingualized occlusion. The concepts that apply to the regular denture are accepted for the osseointegrated overdenture. However, in the case of an edentulous maxillary overdenture and a mandibular fully bone anchored bridge, in centric a small clearance is recommended in the anterior teeth, while the posterior teeth contact simultaneously[35,36]. The amount of disclusion in protrusive and lateral movement non working side and working side is 0 mm.

3.3 Occlusion For Free Standing Bridges

3.3.1 Kennedy Class I – In this, both sides of the arch are restored by osseointegrated bridges, and they maintain the vertical height. Careful consideration should be taken to determine the amount of clearance given to the natural anterior dentition. As the osseointegrated prosthesis does not sink during function, the clearance of anterior teeth should be smaller than the one given to natural teeth[22,37,38]. The amount of disclusion required for this case is the same as in the natural dentition because anterior guidance is provided by the natural dentition: Protrusive 1.1 mm, non-working side 1.0 mm; working side 0.5 mm[39].

3.3.2 Kennedy Class II – This situation is ideal for the osseointegrated free-standing bridge because the contralateral side of the arch will maintain the vertical height, while the other side is restored by the osseointegrated bridge. It induces less stress to the implant while it holds centric. In centric, the posterior osseointegrated bridge should have 30μm open contacts, while anterior teeth also have 30μm openings, and it begins to contact under strong bite pressure[40,41]. In the Kennedy Class II situation, because the anterior teeth are natural teeth, they can bear the occlusal load safely. The amount of disclusion suggested for this case is the same as for a natural dentition: Protrusive 1.1 mm; Non-working side 1.0 mm, Working side 0.5 mm[42].

3.3.3 Kennedy Class III – This situation is also ideal for osseointegrated implants because the vertical height is maintained by natural teeth. In centric, the osseointegrated bridge only contacts under strong bite pressure. Eccentric movement is guided by the natural dentition. The amount of disclusion suggested for this case is the same as for a natural dentition: Protrusive 1.1 mm; Non-working side 1.0 mm, Working side 0.5 mm[43,44].

3.3.4 Kennedy Class IV **-** In this case, posterior disclusion is guided by the osseointegrated bridge[45]. In order to minimize the horizontal load introduced to the implant site, group-function occlusion is preferred. During lateral movement, posterior teeth on the working side can help bear the horizontal load, while the non-working side is discluded[39,46]. During protrusive movement, an osseointegrated bridge will guide the mandible and produce posterior disclusion. In order to minimize the load induced to the fixtures during protrusive movement, anterior guidance should be flatter than the natural dentition. The amount of disclusion suggested for this case is as follows: Protrusive 0.8mm; Non-working side 0.4mm; Working side 0.0mm[47,48]. Because an anterior fixed bridge does not sink like natural teeth, the clearance of natural teeth must be greater than the one given to natural anterior teeth (> 30μm)[40,49].

3.4 Connection For Natural Teeth

When single fixtures are used to restore the bridge, in order to prevent loosening of the screw by the rotation of the bridge, the mesial end of the bridge must be connected to natural teeth. As mentioned earlier, the natural tooth is depressed during its function, while the osseointegrated implant is not. If the osseointegrated implant prosthesis and the natural teeth are connected rigidly, under the occlusal loads, the implant receives the majority of the stress and is overloaded[50]. To avoid this, a non-rigid connector is used. The female (keyway) is placed on the distal end of the retainer supported by the natural tooth; the key connected to the osseointegrated bridge is engaged into the keyway. Thus, the natural tooth can be depressed freely without interference of the osseointegrated bridge[51,52,53].

However, based on long term observation[54,55,56], it was found that the natural tooth depressed permanently and produced a gap between key and keyway. The osseointegrated prosthesis with the key is extruded a visible amount and the retainer cemented to the natural tooth is depressed. The reasons are not clear. It has been stated that this phenomenon may have been caused when the key and keyway are made very precisely[57,58]. When the natural tooth is depressed, the key and keyway are sometimes locked; then the natural tooth is depressed permanently[59,60,61].

In order to avoid this phenomenon, some suggested[62,63,64] the use of telescopic crown to connect the osseointegrated bridge. However through a long term observation[65,66,67], it was found again that the natural tooth depressed often, the cement connecting the outer crown to the inner coping was broken down and the cement washed out, producing plaque accumulation.

At present, the use of a rigid connector between the osseointegrated bridge and the natural tooth is suggested, rather than a non-rigid connector[68,69]. This may result in the ankylosis of the root of the abutment tooth, creating resorption of the root or absorption of the alveolar bone[70]. This progresses more slowly. It may be better to have this than the situation mentioned above. The connection of natural teeth is questionable and the freestanding procedure preferred[71,72].

3.5 Occlusion For Single Tooth Replacement

Occlusion required for this restoration is equal to the natural dentition. In centric for anterior teeth, it must have a clearance of 30µm; for premolar, it should contact only under heavy load[73,74,75] (Fig. 2) . Because natural teeth depresses under heavy load, the amount of contact to be given to the osseointegrated restoration must be designed carefully (Fig. 3) .

During eccentric movement, the anterior restoration should contact with opposing teeth in order to create anterior group function. This eccentric contact is essential to prevent the extrusion of opposing teeth[75,76,77]. Because the restoration does not contact in centric, contact during eccentric movement is required. For premolars, the restoration must disclude during eccentric movement and avoid lateral stress.

III. FIGURES AND TABLES

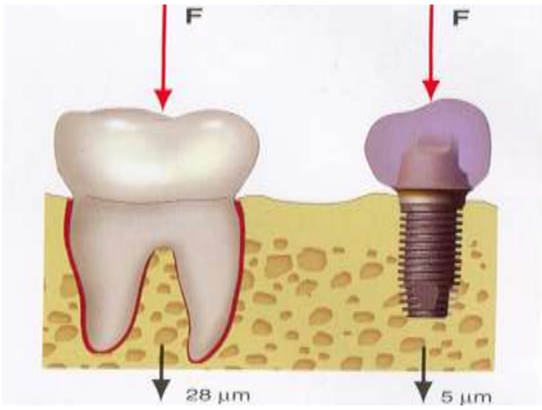

Fig. 1: A tooth exhibits more vertical movement than an implant.

Fig. 2: A light occlusal force is applied first to the implant and teeth. The first molar implant crown has less initial contact than the teeth.

Fig. 3: The first molar crown is then evaluated with heavy bite force. The occlusal contacts ideally should be similar to the teeth under a heavy load.

TABLE 1 : NATURAL TOOTH VERSUS IMPLANT BIOMECHANICS.

TOOTH	IMPLANT
1. Periodontal membrane. a) Shock absorber. b) Longer force duration (decrease impulse of force). 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 to force – reversible.	1. Direct bone-implant. a) Higher impact force. b) Short force duration (increased force impulse). c) Force primarily to crest. d) Implant is always rigid (mobility is failure). e) Lateral force increases strain to bone. f) No fremitus. g) Radiographic changes at crest (bone loss)- not reversible.
2. Biomechanical design. a) Cross-section related to direction and amount of stress. b) Elastic modulus similar to bone. c) 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 and around tooth. a) Occlusal trauma induces hyperemia and leads to cold sensitivity. b) Proprioception (reduced maximum bite force). c) Less functional bite force.	3. No sensory nerves. a) No precursor sign of slight occlusal trauma. b) Occlusal awareness of 2 to 5 times less (higher maximum bite force functional). c) Functional bite force 4 times higher.
4. Occlusal material: Enamel. a) Enamel wear, stress lines, abfractions, pits.	4. Occlusal material: Porcelain (metal crown) a) No early signs of force.
5. Surrounding bone is cortical. a) Resistant to change.	5. Surrounding bone is trabecular. a) Conducive to change.

TABLE 2 – NATURAL TOOTH VERSUS IMPLANT CHARACTERISTICS UNDER LOAD.

CRITERION	TOOTH	IMPLANT
Connection	Periodontal ligament	Function ankylosis
Impact force	Decreased	Increased
Mobility	Variable Anterior teeth more than posterior teeth	None
Movement	Shock breaker effect of Periodontal ligament	Stress captured at crest
Apical	Intrude quickly 28µm	No initial movement
Lateral	56 to 108µm	10 to 50µm
Diameter	Large	Small
Cross section	Not round	Round
Modulus of elasticity	With or without cortical bone	5 to 10 times greater than trabecular bone
Signs of hyperemia	Yes	No
Orthodontic movement	Yes	No
Fremitus	Yes	No
Radiographic changes	Periodontal thickening and cortical bone resorption	No
Progressive loading	Since childhood	Shorter loading period
Wear	Enamel wear facets, Localized fatigue, stress fracture, cervical abfraction, pitting on occlusal cusps.	Minimal wear, screw loosening, stress, fracture of prosthetic components or implant body
Tactile sensitivity	High	Low
Occlusal awareness (proprioception)	High detection of premature contacts	Low; higher loads to premature occlusal contacts

IV. CONCLUSION

The objectives of implant occlusion are to minimize overload on the bone-implant interface and implant prosthesis, to maintain implant load within the physiologic limits of individualized occlusion, and finally to provide long-term stability of implants and implant prostheses. To accomplish these objectives, increased support area[78], improved force direction[79], and reduced force magnification[80] are indispensable factors in implant occlusion. In addition, systematic individualized treatment plans[81] and precise surgical/ prosthodontic procedures based on biomechanical principles[82,83] are prerequisites for optimal implant occlusion.

Occlusion has been an important variable in the success or failure of most prosthodontic reconstructions. With natural teeth, a certain degree of flexibility permits compensation for any occlusal irregularities. Implant occlusion is not as forgiving as natural occlusion. Implant occlusion should be re-evaluated and adjusted, if needed, on a regular basis to prevent from developing potential overloading on dental endosseous implants, thus providing implant longevity[84,85].

It must be emphasized that there is no evidence–based, implant-specific concept of occlusion. Further studies in this area are needed to clarify the relationship between occlusion and implant success.

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