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Prosthodontics

CLINICAL BIOMECHANICS IN IMPLANT DENTISTRY

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ABSTRACT The goal of modern dentistry is to restore the patient to normal contour, function, comfort, esthetic, speech and health, whether by removing caries from the tooth or replacing several teeth. Biomechanics play a role in dentistry because the teeth and jaw perform biomechanical activities during mastication. Any oral implants will be exposed to intra-oral forces and moments. Implants have to deal with axial forces and bending moments which exerts stress gradients in the implant as well as in the bone. The possibility of stress-generated implant failure has created an interest in mechanical and biomechanical studies of oral implant systems.

KEYWORDS :

DEFINITION

Dental biomechanics is defined as the relationship between the biologic behavior of oral structures and the physical influence of a dental restoration [GPT-9].

Biomechanics comprises of all kinds of interactions between tissues of the body and forces acting on them and response of the tissues to the applied loads[1].Implant biomechanics can be reactive or therapeutic in nature. It deals with biomechanical factors that are of destructive nature to the implants and the clinical process of altering each biomechanical factor to reduce the cumulative response causing implant overload.[2]

FORCES ACTING ON THE IMPLANT

Forces applied to the implant may be assessed in type, direction, magnitude, duration and presence of any parafunctional forces.

The magnitude of stress is dependent on two variables: - 1. Force magnitude 2. Cross-sectional area over which the force is dissipated. Functional cross-sectional area is defined as that surface that participates significantly in load bearing and stress dissipation. It may be optimized by:
(1) Increasing the number of implants for a given edentulous site, and
(2) Selecting an implant geometry that has been carefully designed to maximize functional cross-sectional area.

Cowin in 1989 suggested that cortical bone is strongest in compression and also can be well tolerated by the bone implant system.[3] Shear and tensile forces, being angular in nature, direct stresses over the crestal bone and bone implant interface, which can be detrimental to implant in the long run. A 30-degree angled load will increase the overall stress by 50% compared to the load applied along the long axis. [4]. Craig in 1980 described that the magnitude of bite force is greater in the molar region (200 lbs.), less in the canine area (100 lbs.), least in the anterior incisor region (25 to 35 lbs.) and increases up to 1000lb in the presence of parafunctional habits such as bruxism, clenching and tongue thrusting. [5]

IMPLANT RELATED FACTORS

IMPLANT MACROTOPOGRAPHY

1. Thread shape and stress distribution:

Thread shapes available for screw-retained implants include square shape, V-shape, buttress and reverse buttress threads, which are defined by the thread thickness and face angle. Using Finite Element Analysis, Chia Ching Lee and his colleagues evaluated the effects of implant threads (symmetrical, square and buttressed) on the contact area and stress distribution of marginal bone. Among the three thread shapes, the contact area with square thread was highest and the force dissipation around marginal bone was least [6].

Minatel et al (2017) [7], evaluate the Morse taper connections and the stress distribution of structures associated with the platforms witching (PSW) concept. It was concluded that the increase in diameter is beneficial for stress distribution.

Eraslan et al (2010)[8] evaluated the effects of different implant thread designs on stress distribution characteristics at supporting structures. Eraslanet al, performed with four different thread forms under a static axial load of 100 N, it was observed that maximum stress was concentrated at the cervical cortical regions around the first thread and the stress value was lowest in the square thread type.

Implant design should maximize implant surface area and create a better spreading of stress and primary stability.[9]

2. Thread Pitch And Lead

Implants having smaller pitch indicates more threads, leading to greater surface area[10.] In a histological analytical study conducted by Paolo Trisi et al on sheep bone, it was observed that large threaded implants showed significantly higher %BIC and bone volume than small threaded implants in low density bone and statistically higher secondary stability in cancellous and cortical bones.[11]

3. Thread Depth And Width

According to Misch, thread depth is the distance from the outermost tip to the innermost body of the thread. Implants with deep thread depth can be used in low density bone, to increase the functional surface area. A study conducted by Sun-Young Lee et al to evaluate the effect of thread depth on primary stability in low density bone concluded that implant with deep threads provide better mechanical stability in areas of low density bone.[12]

4. Implant Length And Width

An increase in implant length has a benefit for initial stability as overall total surface area increases. Ding et al (2009)[13,] evaluvated the effect of the diameter and length on the stress and strain distribution of the crestal bone around implants under immediate loading. They concluded that Increasing the diameter and length of the implant decreased the stress and strain on the alveolar crest. Bataineh et al (2017)1[4] investigated the influence of length of implant on primary stability. They concluded that increasing dental implant length is considered to play a fundamental role in increasing dental implant primary stability, even in poor bone quality, through controlling the bone preparation process.

IMPLANT MICROTOPOGRAPHY AND NANO TOPOGRAPHY

Bahrami et al (2014)[15] , investigated by means of FE analysis, the effect of surface roughness treatments on the distribution of stresses at the bone–implant interface in immediately loaded mandibular implants. Von Mises stress data showed that the two-part surface treatment created the better stress distribution at the implant–bone interface.

Implant Nano-topography Comprises of Cell-implant interaction at cellular and protein level. It includes anodic oxidation, laser ablation, TiO2 blasted implants. These implants are proven to prevent crestal bone loss and increase soft tissue seal. [16]

BONE FACTORS:

1. Available bone height: Measured from crest of ridge to opposing anatomical landmark. Related to density of bone. High density bones- shorter implants can be accommodated. Low density bones- longer implants needed.[17]
2. Available bone width: Wider ridges allow placement of wider implants, thus increasing surface area and force dissipation.
3. Available bone length: Length minimum should be 8mm
4. Bone angulation: Ideally, bone is perpendicular to the plane of occlusion, aligned with the forces of occlusion and is parallel to the long axis of prosthodontic restoration. Bone angulation should be less than 30^0.
5. Available Crown height space Vertical distance from crest of the ridge to occlusal plane Considered as a vertical cantilever Greater the Crown height space greater the moment of force or lever arm Ideally Crown height space should be <=15mm

CLINICAL MOMENT ARMS

Three clinical moment arms exist in implant dentistry

1. Occlusal height
2. Cantilever length
3. Occlusal width

Minimization of each of these moment arms is necessary to prevent unretained restorations, fracture of components, crestal bone loss, or complete implant system failure.

1. Occlusal Height

The occlusal height serves as the moment arm for force components directed along the faciolingual axis such as working or balancing occlusal contacts, tongue thrusts, or in passive loading by cheek and oral musculature, as well as force components directed along the mesiodistal axis. The moment contribution of a force component directed along the vertical axis is not affected by the occlusal height because no effective moment arm exists. Offset occlusal contacts or lateral loads, however, introduce significant moment arms .

2. Cantilever length moment arm

Large moments may develop from vertical axis force components in cantilever extensions or offset loads from rigidly fixed implants. A lingual force component may also induce a twisting moment about the implant neck axis if applied through a cantilever length.[18] According to Misch, the amount of stress applied to system is determined by the length of the distal cantilever.

3. Occlusal Width Moment Arm

Wide occlusal tables increase the moment arm for any offset occlusal loads. Faciolingual tipping (rotation) can be significantly reduced by narrowing the occlusal tables and/or adjusting the occlusion to provide more centric contacts.

CONCLUSION:

Biomechanics play a role in dentistry because the teeth and jaw perform biomechanical activities during mastication. Any oral implant will be exposed to intra-oral forces and moments. Mastication induces both vertical and transverse forces in the dentition. The maximum compressive stresses, generated in an osseointegrated implant, increase as the inclination of the implant towards the load direction increases. Thus, for a long term favourable prognosis, it is necessary to take into consideration the antagonistic teeth and the positioning of the implants when designing the prosthetic appliances.

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