بسم الله الرحمن الرحيم

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بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.

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INTRODUCTION

Implantation is generally the preferred choice to replace a missing single tooth avoiding vital teeth preparation and bridge fabrication.[1] Implant-supported crowns are more prone to occlusal overloading than tooth-supported crowns because of the absence of the periodontal ligament of natural dentition that provides proprioception, tactile sensation, as well as shock absorption or damping effect. Therefore the masticatory forces are directly transferred to the peri-implant bone.[2]

There are several factors that affect force magnitudes in peri-implant bone. The application of functional forces induces stresses and strains within the implant prosthesis complex and affect the bone remodeling process around implants. [1] The stress/strain concentration can cause micro damage accumulation and can induce bone resorption. [3]

Although clinical evidence of the impact of overloading on peri-implant bone loss is unavailable, it appears important to control the forces transmitted to the bone-implant interface with respect to biomechanical aspects. [4] Damping effects similar to those of natural teeth may be wishful thinking, but shock absorption of crown materials may prevent micro motions at the implant platform level and reduce the risk of fractures of prosthetic restorations.[2][4]

The role of dental materials in occlusal stress transmission to the peri-implant bone seems to be particularly relevant, as the application of various CAD/CAM-fabricated materials with different moduli of elasticity has been increasing over the past several years. Their shock absorbing properties might be further influenced by their combination with different luting agents. [5] Monolithic zirconia & lithium disilicate are high-strength ceramics that exhibit superior fracture resistance and can therefore withstand force peaks; however, owing to their high stiffness, they might transfer these stresses to other parts of the implant or abutment.[2]

In contrast, composites or other resin-based materials with lower moduli of elasticity may absorb more energy than brittle materials and have a damping effect on applied loads, thereby also decreasing their effect on the bone-implant interface. Despite promising in vitro results of resin-based materials used for implant-supported restorations, their mechanical properties may not reach those of ceramics or metals. [2] Examples of resin based materials that will be discussed in our study; [PEEK, VITA Enamic].

Polyetheretherketone (PEEK) is a semi-crystalline linear polycyclic aromatic polymer. That has been claimed to be an advantageous material for dental applications due to the material's improved mechanical properties and biocompatibility. [6]

VITA Enamic [Polymer Infilterated Ceramic Network] is composed of a ceramic part (75% by volume) and a polymer part (25% by volume). Its ceramic phase includes 23% Al2O3 and the polymer part contains urethane dimethacrylate (UDMA) and triethy- lene glycol dimethacrylate (TEGDMA).[7] Their shock absorbing properties might be further influenced by their combination with different luting agents. Although these materials in combination with various luting agents and protocols are used clinically, little scientific information exists and there are no clinical long-term data available about their shock absorbing behavior. Therefore, laboratory shock absorption tests may allow a first prediction of their performance with regard to damping effects. (2)

It's worth mentioning that clinical performance and survival of implant-supported crowns can benefit from a favorable combination of crown material and luting agent that demonstrates both strength and shock-absorbing capacity.

REVIEW OF LITERATURE

Implant placement may be the ideal choice to replace a single missing tooth, however, single tooth restoration may present challenges in the surgical and prosthetic stages.Clinical success is not only dependent on successful osseointegration, but also on the performance of the respective supra-structure. The prosthodontists' goal is to produce implant- supported restorations that are esthetically, functionally and biologically successful. Different materials and components are available for posterior implant-supported restorations.

Dental implants must fulfill certain criteria: biocompatibility, adequate mechanical strength, optimum soft and hard tissue integration, and transmission of functional forces to bone within physiological limits.(8)

Natural teeth and dental implants distribute forces differently in the surrounding bone. The main biomechanical difference is that dental implants lack a stress-reducing element, such as the periodontal ligament, which exists around natural teeth to absorb and distribute occlusal forces to supporting bone.(8)

For normal healthy teeth the impact energy generated by mastication is attenuated by the periodontal ligament at the healthy bone-natural tooth interface. However, when the natural tooth must be replaced by an implant due to damage or disease the ligament is lost and the implant will transmit the masticatory forces directly into the bone. (9)

Several factors determine the long-term success of implant supported restoration:

a- **The choice of material**; an ideal material should have enough strength and toughness to withstand occlusal forces, have optical properties that resemble the neighboring teeth and do not disturb the color of the surrounding mucosa and the surface should be smooth to inhibit biofilm formation yet rough enough to enable fibroblast attachment.

b- **The restorative design**; should match the clinical requirement whether screw retained or cement-retained while taking account of functional loads, inter-occlusal distance, implant angulation,

c- **The implant-abutment connection**; internal connections have been documented to have superior success rates than external connections, also platform switching have been reported to provide less marginal bone loss as confirmed in several systematic reviews and meta-analysis. [10] [11]

Based on the high clinical success rates longitudinally reported, osseointegration (direct bone contact) is the most predictable interface between bone and endosseous dental implants. [12] Thus, the connection between osseointegrated dental implants and the surrounding bone is direct and relatively stiff in opposition to the viscoelasticity of the periodontal ligament.[13]

This structure results in a very strong connection between bone and implant, so that the 2 components cannot be separated without fracture, because of this connection, implants exhibit no micro-mobility in the alveolar bone, which would affect their behavior when they are exposed to occlusal forces. An osseointegrated implant may move only 10 µm when loaded, this is primarily because of bone flexure. At the molecular level, the bone-implant interface could be described as a zone of cells and proteins in close apposition to a poly- crystalline surface of titanium.(14)

On the contrary, natural teeth show a different mobility pattern when loaded. The PDL partially consists of a group of specialized connective tissue fibers that surround the root of a tooth, extending from the base of the gingival mucosa to the fundus of the bony socket. These fibers act as shock absorbers for the substantial compressive stresses that occur during chewing.

Furthermore, PDL contains high blood levels, assuring hydrodynamic damping each time teeth are loaded, The range of 50 to 200µm Because of these fundamental differences in tooth and implant support.(14)

If compensation for the lost periodontal ligament is deemed appropriate, it is paramount that the implant or restoration be designed to transmit near to natural level stresses to the surrounding tissues. As per today's clinical techniques, this compensation must primarily be borne by the abutment or restoration, rather than the implant.(4)

Osseointegration and prognosis are greatly influenced by the biomechanical environment. The internal stresses that develop in an implant system and surrounding biological tissue under an imposed load have a significant influence on the long-term longevity of the implant. These stresses may induce strains on both the implant and the surrounding bone with the probability of bone resorption and loss of the implant. These induced strains are the engineering strains that signify the ratio of changed dimension divided by the original dimension, while micro-strains are reported in parts per million.

Biomechanics and Strain

Peri implant strain is the deformation in the bone around the implant in response to occlusal forces acting on the implant supported prosthesis. According to ***Vasconcellos Reddy et al.*** [15] when an occlusal load is applied on an implant supported prostheses, the load is partially transferred to bone, with the highest stress occurring in the peri-implant area.

Minimum peri-implant strain is one of the criteria for long term survival of any implant prosthesis. Peri-implant strain more than 4000 micro-strain leads to pathologic fracture of the bone. Therefore, while selecting the type of prosthesis for a given clinical situation, along with the esthetics and function, peri implant strain generated in the surrounding bone should also be considered to ensure the long term success of the prosthesis.[15]

Impact load applied to the implant-supported prosthesis may cause bone micro fractures. An abnormal rate of marginal bone loss might be an indication of over stressing of the implant. [12]

Clinical evidence on the impact of overloading on peri-implant bone is not available. Only some case reports and animal studies are present. In fact, clinical trials evaluating overloading are difficult to design due to ethical reasons. Moreover, it is generally impossible to identify the reason for peri-implant bone loss in clinical cases, distinguishing overloading from other potential sources of bone loss. In vitro studies also demonstrate that off-axial loads increase stress on the bone-implant interface with respect to axial loads and may also be responsible for increased resorption of crestal bone.(16)

The tactile threshold of osseointegrated implants is higher when a static load is applied than when a dynamic load is imparted.(17) Thus, proprioception might be, in such a situation, inefficient, leading to bone micro-fractures. It has been suggested that stress-absorbing systems should be incorporated in the superstructures of implant-supported prosthesis to reduce the impact loads on the implants occurring because of lack of viscoelasticity at the bone–implant interface. The amount of bone around implants was greater when a stress absorbing-system was used. (17)

Although titanium implants available commercially at present have got many disadvantages such as mismatches between the elastic modulus of the implant and of the bone, different bonding strength between the implant and the bone. A stress shielding or concentration can be easily induced on the interface and results in a potential risk to the long-term stability of the implant. The success or failure of an implant is determined by the manner how the stresses at the bone-implant interface are transferred to the surrounding bones. It is important to comprehensively navigate the various factors controlling the success of dental implants.(18)

Some authors maintain that the type of material used for the prosthesis supported by the titanium implant could affect occlusal load. In particular, in the 1980s, some investigators recommended resilient occlusal materials such as acrylic resin to reduce the forces exerted on implants. The role of dental materials in occlusal stress transmission onto peri-implant bone seems to be especially relevant over the past few years because of the increasing use of esthetic but rigid materials, such as glass-ceramic and zirconia. These materials are reported to have excellent mechanical and biologic properties, but their impact on peri-implant bone and on the whole masticatory system has not yet been investigated.(16)

According to ***Skalak*** *(19)* the viscoelastic behavior of an acrylic resin as occlusal material would be enough to delay the transmission of force and reduce its peak compared with materials with greater elastic moduli. An in vitro study by ***Gracis et al.*** *(20)* concluded that the harder and stiffer the material, the higher the force transmitted onto the implant and the shorter the rise time. In fact, according to **Hooke's law**, the higher the modulus of elasticity of a material, the less the material will deform under pressure and the more likely the force will be transferred through the material. Conversely, the more resilient the material, the more easily it will deform under pressure, the longer the rise time, and the smaller the stress. However, a review of the literature over the last years demonstrated that many articles refute the existence of a shock absorption capacity of resilient dental materials.(16)

The choice of the restorative material to be used in implant restorations should be made in light of newly introduced concepts of osseosufficiency and osseoseparation As long as the host, the implant, and the clinical procedures induce and allow for maintaining osseointegration, an osseosufficiency state is present. But some patient-related or non-patient-related factors could induce osseoseparation, compromising the obtainment or maintenance of osseointegration. As reported earlier, evidence is lacking on the role of overloading in peri-implant bone loss. However, bone has been demonstrated to be sensitive to loading conditions. This suggests that to control the occlusal loads in implant prosthodontics as much as possible, clinicians should aim to reduce load entity and extra-axial loads.(16)

Biomechanics is one of the main factors for achieving long-term success of implant supported prostheses. Dental implants are used to provide mechanical support to a superimposed and crown, for daily chewing loads. Long-term failures mostly depend on biomechanical complications. The major factors affecting transmission of stresses from the prostheses to the implant–bone interfaces include the material and design of the supporting prostheses and the implant geometry, It has been suggested that implants be positioned as perpendicular to the occlusal plane as possible and the corresponding prostheses should be designed with a geometry that will minimize the peak bone stress caused by standard loading.(21)

One of the critical elements influencing the long-term uncompromised functioning of a dental implant is its design. Implant design is characterized by its composition material, overall shape, thread design, prosthetic platform, abutment connection surface topography, and physiochemical composition, all of which determine its biomechanical behavior.(8)

It is important to distinguish the effects of macro design of the implants. According to ***Horita et al.*** *(22)* energy transfer to the bone will be influenced by the design and material of the implant restoration, which is traditionally directly connected with a screw or can be cemented to the abutment, itself attached to the implant with a screw. New research has suggested a differing restorative design with promising esthetic and biomechanical qualities. [9]

For several years, it has been suggested that implant-to-tooth interconnected restorations behave like a cantilever, with the implant bearing the higher load. Various complications have also been reported for partial dentures with implant-to natural-tooth fixation, such as hypofunction, disuse atrophy intrusion of the abutment. Teeth peri-implantitis, and failure of osseointegration, bone fracture, implant fracture, loosening of screws, and failure of luting cement. [14]

It's worth mentioning that the high durability of dental restoration is not only the result of mechanical properties but also marginal fit plays a significant role in their longevity and long-term success. This includes the fit of implant abutment to the implant and also the fit of customized abutment to the titanium insert. [10]

Implant abutment fabrication techniques

Prefabricated versus customized abutments:

Implant abutments can be produced in several ways; **Prefabricated**, which is usually straight or angulated, then modified intraorally by the dentist (direct procedure) or in the laboratory by the dental technician on the working cast (indirect procedure). **Customized** through a wax-up of a gold cylinder and cast with a metal noble alloy (ex: UCLA). This modality is less commonly used nowadays. Digitally designed (or scanned from a wax or resin matrix) and milled in a CAD/ CAM process. [10]

Prefabricated abutments cannot provide an ideal emergence profile. They usually have a straight or divergent emergence profile and lack enough support to the labial and proximal peri-implant soft tissues. This is due to the fact that a prefabricated abutment cannot predict or resemble the soft tissue contours of different cases. The difference in the cross-sections of the implant shoulder and natural tooth at the gingival level makes the reproduction of the emergence profile difficult. The transition from the implant shoulder’s circular section to the anatomic section of the clinical crown has to be performed either by the abutment or by the crown. Performing the desired contours by the crown will make the crown margins end deeply submucosal, leading to difficulty in removal of excess cement. In most cases. Performing these contours using abutments requires abutments that mimic the patients’ morphologic contours, i.e. custom abutments. (23)

Custom abutments can be produced using computer-aided design/computer-aided manufacturing (CAD/CAM) technology. The CAD/CAM process can optimally control the geometry of the abutment and adjust it according to the geometry of the neighboring natural tooth and the gingival margin. The abutment finish line location can also be controlled, especially when using tooth-colored abutments, to be equi- or supra-gingival, thus reducing the risk of leaving excess cement deep in the sulcus. Finally, it is less time consuming and does not require extra finishing procedures. (10)

Custom made hybrid-Abutments

Hybrid-abutments were introduced to gain the benefits of both the titanium abutments and all-ceramic abutments. They consist of a prefabricated titanium insert onto which a customized tooth-colored abutment is cemented extra-orally. Fabrication of customized ceramic abutments by the use of titanium inserts has been recommended to avoid fractures occurring at the implant-abutment connection. Also, this will lead to better emergence profile with enhanced support to the supra-implant soft tissue and precise control on the finish line location thus reducing the likelihood of leaving residual cement. (23)

This technique combines the strength and the precise fit of a titanium-to-titanium connection with the esthetic advantage of custom ceramic abutment. (24)

Titanium inserts are available in different designs, different heights ranging from 3 to 6 mm depending on the manufacturing company, they also have different anti-rotational features and might have platform switching or not. The process of combining the titanium inserts to custom abutments is through bonding. Bonding titanium inserts to hybrid-abutments takes place by adhesive cementation after surface treatment of each bonding surface. Surface treatment of titanium inserts usually take place by air-borne particle abrasion while the overlying abutment must be surface treated according to the material used. (25)

Two designs are available for the customization of ceramic abutments with titanium inserts. The first design consists of a one-piece hybrid abutment crown, where the abutment and crown are manufactured as one unit that will be bonded to the titanium insert and then screwed to the implant (screw retained) The second design is a two-piece hybrid abutment and a monolithic crown, where the abutment is first bonded to the titanium insert and then screwed to the implant followed by cementation of an all-ceramic crown on the abutment (cement-retained). These designs are usually selected according to clinicians' preferences and the clinical situation. Different materials such as oxide ceramics, glass ceramics and hybrid ceramics, can be used in combination with titanium inserts for customized ceramic abutment. (11)

Zirconia abutments with titanium inserts:

Several studies now recommend the use of zirconia abutments with titanium inserts than using zirconia abutments alone.

Aramouni et al. in 2008 *(26)* compared the fracture resistance of titanium (UCLA) abutments, zirconia abutments (synOcta) and zirconia with titanium insert (ZiReal) after static loading. They found that ZiReal and UCLA had similar fracture resistances and mode of failures (792.7 N and 793.6 N, respectively), while synOcta had lower fracture resistance (604.2 N). Abutment fracture was the most common mode of failure.

Bertolini et al. in 2014 *(23)* published a clinical report on the use of custom made zirconia abutment on titanium base in the posterior region. They indicated its use for posterior areas when the abutment shoulder