Strain Assessment of Two Types Of Implant Supported Hybrid Abutment Restorations

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Introduction

Various treatment options are available for patients with a single missing tooth, such as removable partial dentures, fixed partial dentures, or implant-supported restorations. When considering either of these treatment options, the clinician must weigh the risks and benefits of each approach. Removable partial dentures are usually uncomfortable by the patient and not convenient. Fixed partial dentures may require the preparation of unnecessary sound tooth structure of neighboring teeth or even well restored abutments. Implant treatment is considered a conservative approach, regarding other factors are ideal. The decision-making process must be based on scientific evidence in addition to other patient related factors such as cost and quality of life.

Different materials and components are available for posterior implant-supported restorations. Titanium abutments are the most commonly used implant abutment. Titanium abutments have shown excellent clinical survival rates and very few complications, however, they have an esthetic problem.[(1)] Patients with wide smile, high lip line, gummy smiles, thin gingival biotype, insufficient papillae and bone resorption all possess clinical challenges to hide the buccal gingival margin of the titanium abutment.[(2)]

The increased awareness and high esthetic needs and expectations of both dentists and patients, have increased the attention on all-ceramic abutments but to avoid fractures occurring at the implant-abutment connection, The use of titanium inserts

with all-ceramic abutments has been recommended. Customizing abutments to the desired tooth contours lead to better emergence profile thus better support to the supra implant soft tissue and better control on the finish line location thus reducing the likelihood of leaving residual cement.[3]

Many materials are used to fabricate the hybrid abutment crowns such as lithium disilicate, different types of zirconia and hybrid ceramics that incorporate resin into the ceramic structure. The performance of tooth-colored restorations such as zirconia and hybrid ceramics with short titanium bases in the posterior region is an interesting treatment alternative that needs to be investigated in order to predict the outcome of these restorations clinically especially the stresses that are transmitted through different materials to the implant body and subsequently, the surrounding bone.

The most important reason to investigate the micro strain in the bone around implants is the possibility to provide enough information for implant planning to optimize the implant placement and restorations design.[4] Despite this, masticatory overload is one of the primary factors for fractures and dental implant loss.[5] That is why during the prosthetic phase of implant treatment, careful choice between different materials with different elastic modulus is advocated as they can generate different stress and strain values in the implant and peri-implant bone.

Review of literature

Implants 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.[6] Clinical success is not only dependent on successful ossteointegration, 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.

- ***Survival rates of dental implants:***

Success and survival rates of dental implants were previously measured in terms of ossteointegration only according to ***Albrektsson et al in 1986***.[7] However, ossteointegration success rule alone was not enough. Success and survival of implant-supported restorations is also crucial.[8]

Several *systematic reviews* were carried out to determine the success and survival rates of implant-supported restorations, ***Torabinejad et al in 2007*** [9] studied the benefits and outcomes of different treatment plans, they reported that implant-supported restorations had survival and success rates ranging 95% and 97% after more than 6 years. Another systematic review and meta-analysis done by ***Jung et al in 2012*** [10] reported that survival rates of implant-supported single-crowns are 97.3% after 5 years and 95% after 10 years.

Several factors determine the long-term success of implant-supported restorations: **a. *choice of the material***; an ideal material should have enough strength and toughness to withstand occlusal forces, have optical properties that resembles 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. restorative design;*** should match the clinical requirement whether screw retained or cement-retained while taking account of functional loads, interocclusal distance and implant angulation, ***c. 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.[11]

- ***Implant abutments:***

There are several types of implant abutments; either they are supplied by the implant manufacturer as stock prefabricated abutments that can be adjusted by the operator or the laboratory, or they are custom made for each tooth and patient.

- ***Prefabricated abutments versus Custom abutments:***

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.[12]

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.[13] Performing these contours using abutments requires

abutments that mimic the patients' morphologic contours, i.e. custom abutments.

Custom abutments can be produced using several technologies such as casting, pressing and most recently computer aided designing, computer aided milling (CAD/CAM). 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 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.[14]

Usually Custom abutments are indicated in situation that need decreased inter-occlusal space, an angle correction problem higher than 15°, splinting three or more implants or to replicate the original gingival profile of the tooth in order to obtain an ideal emergence profile.

Korsch et al [15] made a study to determine whether implant-supported restorations on customized computer-milled abutments will loosen less frequently than those placed on prefabricated abutments, and they concluded that Loosening of single-crown restorations can be reduced using customized abutments so they can offer a valid alternative to prefabricated abutments.

Muhlemann et al **[16]** made a systematic review on the efficiency and effectiveness of the use of digital technologies for the fabrication of implant-supported reconstructions and comparing them to conventional techniques, 12 clinical studies were included in their review and they found that implementation of the studied digital technologies increased time efficiency for the laboratory fabrication of implant-supported reconstructions.

Grizas et al [17] made a study to present a detailed workflow for the restoration of anterior maxillary implants focused on the creation, preservation, support, and transfer of the emergence profile of the soft tissues through a series of clinical cases and they stated that a customized abutment is necessary in order to maintain the emergence profile that has been created during the previous stages.

While others as **Schepke et al** [11] who made a randomized controlled clinical trial aiming to study potential benefits of customization of zirconia implant abutments with respect to preservation of marginal bone level and several clinical and patient-based outcome measures, found that the use of a customized zirconia abutment in single tooth replacement of a premolar is not associated with an improvement in clinical performance or patients' contentment when compared to the use of a stock zirconia abutment.

- ***Implant abutment materials:***

1) Titanium abutments:

Titanium abutments are considered the gold standard of implant supported restorations due to their high strength, superior fit and long-term documented success rates.[18]

However, titanium abutments can show through the gingival tissues especially in patients with thin gingival biotype and lead to unnatural bluish appearance of the soft tissues.[19] Future bone resorption, insufficient papilla and soft tissue recession can expose the titanium abutment, which is a very sensitive situation especially

in esthetic areas and leads to patient dissatisfaction and esthetic failure of the implant-supported restoration.[2]

To achieve optimal esthetics, it has been suggested to restore single tooth implants with all ceramic crown/abutment combinations.[20] Bluish appearance of the cervical soft tissues encountered with metal abutments can be avoided and light transmission is facilitated when using all-ceramic abutments.[21] Furthermore, bio-adhesive properties are improved and galvanic and corrosive side effects are minimized.[13]

2) All-ceramic Abutments:

Ceramics were the next choice for replacing titanium as a material for implant abutments especially custom-made CAD/CAM abutments due to their proper physical and esthetic properties. All-ceramic abutments were reported to improve the peri-implant soft tissue color and mimic the color of the natural teeth.[20]

Dental ceramics may be classified into glass ceramic materials, polycrystalline ceramics and hybrid ceramics,[22] another class of materials used for abutments are high performance polymers such as polyether-ether-ketone (PEEK). From the main advantages of PEEK is its biocompatibility along with its low elastic modulus (3– 4 GPa) which is close to human bone. The close match of elastic modulus between bone and PEEK decreases the stress shielding effects and encourage bone remodeling.[23] These reasons make PEEK a choice for implant abutment materials.[24]

Drawbacks of all ceramic abutments:

Fracture of the *apical part* of all-ceramic abutments is very common as it is the weakest part of its structure; it is the area of crack initiation and the part exposed to the highest torque and tensile stresses.[25]