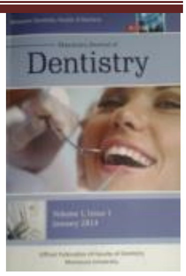

Machinable Non-Segmented Implant-Supported Restorations: Impact of Material Types on The Torque Maintenance

Ahmed Mohammed Mohammed Ebrahim Elmisery1. Walid Abd El-Ghafar Al-Zordk 2.Mohamed Hamed Ghazy 3.

1.(Post Graduate Student at Fixed Prosthodontic Department, Faculty of Dentistry, Mansoura University).
2.(Associated, professor of Fixed Prosthodontics Department, Faculty of Dentistry, Mansoura University).
3.(Professor and Head of Fixed Prosthodontics Department, Faculty of Dentistry, Mansoura University).

Abstract:

Objectives:
The aim of this study was toevaluate the torque maintenance of zirconia,glass-ceramic and PEEK non-segmented implant-supported restorations after artificial aging.

Materials and Methods:
Thirty implant fixtures and their titanium bases were divided into three groups (n=10) according to the type of abutment material into:**Group Z**: non-segmented zirconia abutments.**Group G**: non-segmented glass-ceramic abutments.**Group P**: non-segmented PEEK abutments.
All implants were installed in the epoxy casts and the titanium bases were anchored. The non-segmented abutments were fabricated from zirconia, glass-ceramic and PEEK materials. The milled abutments were luted to the titanium base with dual cure resin cement. The abutments were attached to their corresponding implants to the recommended torque. All specimens were subjected to artificial aging (7000 cycles). The digital torque meter was used to determine the torque loss. Data was analyzed by using ANOVA and Tukey post hoc.

Results:
There was no significant difference in torque maintenance between (zirconia, IPS e.max CAD and PEEK) but in each group, there was significant difference.

Conclusions:
Under the conditions of this study:
1.Thermal aging affected the torque maintenance of all tested non-segmented abutments.
2.The abutment material (zirconia, IPS e.max CAD and PEEK) didn't affect the torque maintenance of non-segmented abutments.

Keywords: custom abutments,zirconia, PEEK, IPS e.max CAD, torque.

Introduction

Using zirconiaas implant-supported restorations isdue to its lower modulus of elasticity and its higher toughness and these abutments are distinguished by their matching the tooth color, their lower plaque accumulation and their good tissue compatibility. [1]

PEEK materials have been used in implant dentistry as an implant material in the superstructures, abutments and also the implant body. PEEK uses as an implant body are limited to bench test. Its application to the mandible as the implant body has no report. As a result of the nearer mechanical properties and compatibility between bone and PEEK, PEEK material might show less shielding stress than Titanium.[2]

One of the most critical mechanical complications is screw loosening or abutment screws fracture. Loosening of abutment or prosthesis screws is more likely to be happened in implant supported single-tooth and cantilevers and in the presence of parafunction habits. It is more Common in maxilla than in mandible. The screw loosening rate after 5 years has been reported to be 5.8–12.7% .[3]

The aims of this in-vitro study were to calculate the torque loss of the three different custom abutment materials to evaluate any relation between the torque maintenance and material types. Also, to evaluate the fracture resistance of these materials.

Materials and MethodFabrication of epoxy resin blocks:

By using a silicon mold designed from upper maxillary cast with removed upper first premolars, the epoxy resin materials were mixed and poured in the silicon mold slowly and left for complete hardening.

Fabrication of surgical guide:

Surgical guide was fabricated for proper placement of implant fixture without any faults in angulationsand for standardization of the dimensions of the future non segmented customized abutments it was fabricated by exocad.

Fixture placement in epoxy casts:

Using the surgical kit, we drilled through the missed first premolars in the epoxy casts with drill sequences to their recommended place using surgical guide on the epoxy casts after insurance of proper fit between guide and epoxy cast.

Titanium base placement:

The titanium base (n=30) are aligned over the fixture and anchored with ratchet wrench according to recommended torque (25 Ncm) and inspected for its proper position.

Fabrication of the custom abutments:

The titanium base (n=30) are cut at 3 mm only height to provide space for customized abutment and epoxy casts with their titanium bases were sprayed by anti-reflection scan powder spray. the casts were scanned with optical scanner in many different angles, the custom abutments were designed by CAD/CAM and data was collected and sent to the milling machine.

Preparationof abutments for cementation on titanium base:

The outer surface of the titanium base (n=30) were sandblasted with 110 µm aluminum oxide powder (Renefert, Germany) at 2 bar with distance 10mm for 10 s according to manufactures instructions for bonding titanium base, then cleaned in ultrasonic cleaner (MCS Digital ultrasonic cleaner) with distilled water for 10 minutes, then dried by oil free compressed air for 30 seconds, and application of primer. (MKZ Primer, Bredent Medical, Senden, Germany) for 60 seconds.

Each zirconia abutments (n=10) fitting surface were sandblasted by aluminum oxide powder (Renefert, Germany) with particle size 50 µm at 2 bar with distance 10mm for 10 sec, , then cleaned in ultrasonic cleaner with distilled water for 10 minutes, then dried by oil free compressed air for 30 seconds according to manufacturer instructions , and application of primer (MKZ primer, Germany).

Each IPSe.max CAD abutments (n=10) fitting surface were etched with 5% hydrofluoric acid (ceramic etchant , DENTOBOND, France) for 60 seconds , then the etched surface was cleaned by rinsed water followed by ultrasonic cleaning in distilled water for 10 minutes, then dried by oil free compressed air for 10 minutes and application of silane coupling (K primer, Germany) for 60 seconds.

Each PEEK abutments (n=10) fitting surface were sandblasted by aluminum oxide powder (Renefert, Germany) with particle size 50 µm at 2 bar with distance 10mm for 10 seconds , then cleaned in ultrasonic cleaner with distilled water for 10 minutes, then dried by oil free compressed air for 30 seconds according to manufacturer instructions , and application of primer (VISIO-Link primer, Bredent, Germany) for 60 seconds.

Cementation:

Every titanium base sealed with a gutta percha point to avoid contamination of screw channel by resin cement.According to the manufacturer's instructions adhesive resin cement (DTK Adhesive Bredent Medical, Senden, Germany) are mixed and applied onto the fitting surface of each abutment, then each abutment fixed to its corresponding titanium base and transferred to customized loading device.

Load cementation device:

It is used to apply a constant seating load parallel to the long axis of every abutment until complete setting of the cement. Then the screw channel was sealed with composite material.

Thermal cycling:

Thermal cycling device is a device used to mimic the oral environment conditions, the used device is (SD Mechatronic thermocycler THE-1100, Germany). We made 7000 cycles (equivalent to two years) in temperature between 5º c and 55 ºc for 30 seconds in each temperature room.

Measuring of torque loss:

By using digital torque meter.

Results:

There was no significant difference in torque maintenance between (zirconia, IPS e.max CAD and PEEK) but in each group, there was significant difference. According to the fracture resistance test there was significant difference between the three groups. Zirconia non-segmented abutments showed the higher mean maximum fracture load (1567.17±111.39 N) followed by PEEK group (556.76±95.32 N), while IPS e.max CAD group showed the smallest value (460.26±43.08 N).

	Peek	**Zirconia**	**e.max CAD**	**ANOVA p value**
Tightening torque	25.14±.19	25.08±.13	25.12±.15	0.7
Loosening torque	22.61±.59	22.38±.68	22.49±.47	0.68
Torque loss	2.55±.50	2.70±.59	2.63±.46	0.8
Percentage of torque loss	10.11%±1.99%	10.74%±2.39%	10.45%±1.83%	0.79

Discussion:

In this study, a clinical condition was duplicated to evaluate the effect of different abutment materials on fracture resistance and torque maintenance after the thermal aging. As the area of the first premolar is an esthetic zone area, selection of the material should have an esthetic consideration. Three types of materials were used for non-segmented abutments fabrication: zirconia, glass ceramic (IPS e.max CAD) and PEEK, luted to titanium bases with dual cure resin cement.

In this in vitro study, the implant fixtures were embedded in epoxy resin casts. Epoxy resin cast used as a media that mimic the cortical bone intraoral.[4]Surgical guide was fabricated for proper placement of implant fixture without any faults in angulations (buccolingually nor mesiodistally) and for standardization of the osteotomy position.[5]Using zirconia as implant-supported restorations is due to its higher toughness, matching the tooth color, lower plaque accumulation and their good tissue compatibility. [6]

IPS e.max CAD lithium disilicate (LS_2) glass-ceramic is ideally suitable for the fabrication of monolithic restorations in the anterior and posterior region. Due to its natural-looking tooth coloring, excellent light-optical properties and high strength, this material produces impressive results. The outstanding performance of the material is based on a combination of excellent flexural strength and high fracture toughness adjusted to the given dental requirements.[7]

Torque maintenance:

There were no significant differences regarding the torque loss values between the three groups because the same connection was found in all groups, as the abutment screw connect the implant body with the titanium base in all the study groups.

This result was in agreement with Siadat H. et al. 2017[8]who used a digital torque wrench (TQ-8800, Lutron, Taipei, Taiwan) to measure the torque loss of 14 customized zirconia abutments (internal and external connections) with 14 prefabricated titanium abutments (internal and external connections). They found that neither abutmentconnection nor material affected torque loss values.

The tightening torque and the loosening torque in each group of this test showed a significant difference. Student's t-test used to compare between the tightening torque and the loosening torque for each group: PEEK, zirconia and IPS e.max CAD groups.This result was in agreement with the study done by Tzannas Ket al. 2008[9] who concluded that the removal torque is 85% up to 90% of tightening torque.Assunção et al. 2012[10] and Feitosa PC et al. 2013[11] found that the percentage of torque loss was 12.7% at 5 years.

This result was not in agreement with the findings in a study by Yi-Hyung Woo et al. 2016[12]who comparedCAD/CAM and prefabricated abutment by measuring removal torque before and after cyclic loading using an electric torque controller (iSD900; NSK, Tochigi, Japan). They concluded that no significant difference among initial tightening torque, first or second removal torque (P>0.05). This result was due to the retightening technique they used as after 10 minutes; the same tightening torque was applied to compensate for the loss of preload caused by surface settling of the interface.

Limitations of this in-vitro study:
1. In this study, thermal aging was done to stimulate the oral conditions which not completely mimic as for example: no saliva.
2. In fracture resistance test, PEEK veneering by composite material didn't allow us to compare monolithic full structure PEEK non-segmented abutments with zirconia and IPS e.max CAD monolithic full structure non-segmented abutments.

Conclusion:
1.Thermal aging affected the torque maintenance of all tested non-segmented abutments.
2.The abutment material (zirconia, IPS e.max CAD and PEEK) didn't affect the torque maintenance of non-segmented abutments.

References

*1. **Lee W,Koak J, Lim Y, Kim S, Kwon H, Kim M.** Stress shielding and fatigue limits of poly-ether-ether-ketone dental implants. Biomaterials 2012; 100:1044–1052.*
*2. **Sella G, Lopes Pereira NetoA, MazieroVolpato C, De Vasconcellos D, Pekkan G, Ozcan M.**"Influence of different maintenance times of torque application on the removal torque values to loosen the prosthetic abutment screws of external hexagon implants". Implant Dentistry. 2013; 22:534–539.*
*3.**Kim ES, Shin S.** Influence of the implant abutment types and the dynamic loading on initial screw loosening. J Adv Prosthodont 2013; 5:21-8.*
*4.**Kaleli N, Sarac D, Külünk S, Öztürk Ö**. The fracture resistance of PEEK and zirconia customized abutments. ProstheticDent 2017; 17:302-314.*
*5. **Adham E, Gasser F, Matthia K.** Influence of different CAD CAM crown and abutment materials on the fracture of custom-made titanium and zirconia implant abutments after artificial aging. Int J Prosthodont 2019; 32:91-96.*
*6.**Yildirim M, Edelhoff D, Hanisch O.** Ceramic abutments--a new era in achieving optimal esthetics in implant dentistry. Int J Perio Dent 2000; 20: 81-91.*
*7.**Kelly JR, Benetti P.** Ceramic materials in dentistry: historical evolution and current practice. Aust Dent J 2011; 56:84–96.*
*8.**Siadat H, Beyabanaki E, Mousavi N, Alikhasi M**.Comparison of fit accuracy and torque maintenance of zirconia and titanium abutments for internal tri-channel and external hex implant connections. J Adv Prosthodont 2017; 9:271-277.*
*9.**Tzannas K,Theoharidou A, Petridis HP, Garefis P.** Abutment screw loosening in single-implant restorations: a systematic review. Int J Oral Max Impl 2008; 23:681-690.*
*10.**Assunção WG, Delben JA, Tabata LF, Barão VA, Gomes EA, Garcia IR.** Preload evaluation of different screws in external hexagon joint. Implant Dent 2012; 21:46-50.*
*11. **Feitosa PC, de Lima AP, Silva-Concílio LR, Brandt WC, Neves AC.** Stability of external and internal implant connections after a fatigue test. Eur J Dent 2013; 7:267-71.*
*12.**Yi-Hyung Woo, Ahran P, Kwantae N, Hyeonjong L, Kung-Rock.** Comparative analysis of screw loosening with prefabricated abutments and customized CAD/CAM abutments. Implant Dent 2016; 25:770–774.*