Introduction

Using zirconia as implant-supported restorations is due to its lower modulus of elasticity and its higher toughness and these abutments are distinguished by their matching to 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 Methods

Fabrication 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 angulations and 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.

**Preparation of 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).

<table>
<thead>
<tr>
<th></th>
<th>PEEK</th>
<th>Zirconia</th>
<th>e.max CAD</th>
<th>ANOVA p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>25.14±1.9</td>
<td>25.08±1.3</td>
<td>25.12±1.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Loosening torque</td>
<td>22.61±.59</td>
<td>22.38±.68</td>
<td>22.49±.47</td>
<td>0.68</td>
</tr>
<tr>
<td>Torque loss</td>
<td>2.55±.50</td>
<td>2.70±.59</td>
<td>2.63±.46</td>
<td>0.8</td>
</tr>
<tr>
<td>Percentage of torque loss</td>
<td>10.11%±1.99%</td>
<td>10.74%±2.39%</td>
<td>10.45%±1.83%</td>
<td>0.79</td>
</tr>
</tbody>
</table>

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 aesthetic 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. 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. Using zirconia as implant-supported restorations is due to its higher toughness, matching the tooth color, lower plaque accumulation and their good tissue compatibility. IPS e.max CAD lithium disilicate (LS2) 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.

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 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 abutment connection 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 who concluded that the removal torque is 85% up to 90% of tightening torque. Assunção et al. 2012 and Feitosa PC et al. 2013 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 who compared CAD/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