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Evaluation of Bacterial Accumulation on the Inner Surface of PEEK and Zirconia Secondary Telescopic Crowns

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ABSTRACT

Objectives: This study aimed to evaluate the bacterial accumulation on the inner surface of secondary telescopic crowns constructed from zirconia and PEEK Materials.

Materials and methods: Three pieces of each of the tested materials (PEEK &Zirconia) were incubated in bacterial suspensions that contained $1X10^6$ cfu/ml of bacteria (*Streptococcus mutans* ATCC 35668 or *Lactobacillus acidophilus* ATCC 4356) and the surface examined using a scanning electron microscope.

Results: Bacterial counting showed statistically significant higher values in the PEEK samples with both types of bacteria. A biofilm mass containing a large number of bacilli and little number of cocci was observed on the surface of the PEEK material while aggregates of bacilli and little amount of cocci appeared without biofilm mass on the surface of the zirconia material.

Conclusion: PEEK secondary telescopic crowns showed more bacterial accumulation with biofilm formation than zirconia secondary telescopic crowns.

Keywords: Telescopic crowns, PEEK, zirconia

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INTRODUCTION

The term (telescopic denture) means a type of prosthesis that includes double crowns as retainers or attachments. These retainers (or attachments) consist of 2 crowns; primary or inner crown which is attached to a tooth or implant and secondary or outer crown which is attached to the denture. The external surface of the outer crown may have the anatomic shape of the natural tooth, or it may be a simple coping without anatomic landmarks (1,2).

CAD / CAM technology has improved the world of implant dentistry. CAD / CAM technology has greatly enhanced the restorative aspects of implant dentistry, manufacturing of bars and frames, resulting in minimizing distortion, fewer manufacturing steps, improved health, and improved patient experience (3).

ZrO2 was used in prosthetic dentistry for abutments, implants, and various structures, because of its low surface roughness and its esthetic ability. Polyetheretherketone (PEEK) is a thermoplastic polymer. PEEK gives some advantages over the conventional alloys and ceramic dental materials due to these interesting physical and mechanical properties. PEEK has been used for the construction of crowns or bridges, clasps in the removable dentures, bars, and provisional implant abutments. Analysis of newly introduced dental materials concerning plaque accumulation is widely used in dental material science (4,5). So, this study aimed to evaluate the bacterial accumulation on the inner surface of secondary telescopic crowns constructed from zirconia and PEEK.

MATERIALS AND METHODS

Construction of secondary crowns

6 secondary crowns 3 from each material constructed as following:

Spraying of a cone shape telescopic primary crown with anti-reflection spray to avoid reflection during scanning, scanning using an extraoral scanner (Smart optics Activity 885, Smart optics, Bochum, Germany). Designing using CAD program (exocad software, exocad GmbH, Darmstadt, Germany). Milling using CAM machine (DWX-51D, Roland, Shizuoka-ken, Japan). In the case of zirconia, it was milled from a pre-sintered zirconia disc (BZ20257-52 DB_LUX, BETTINI ZIRCONIA DENTAL, Marenzo, Italy) then sintered using sintering furnace for about 7 hours to 1450 C° and maintained at this temperature for two hours and then cooled normally. PEEK secondary copings milled from PEEK disc (Natural PEEK, Bloomdent Bioceramics, Changsha, China) and after finished it only needs cutting of the supporting structures.

Bacterial accumulation testing

Three pieces of each of the tested materials (PEEK &Zirconia) were incubated in bacterial suspensions that contained $1X10^6$ cfu/ml of bacteria (*Streptococcus mutans* ATCC 35668 or *Lactobacillus acidophilus* ATCC 4356) in 5 ml of Trypticase soy broth (TSB, BBL, USA) to allow bacterial adherence and biofilm formation. After incubation at 37C for 24 h, the samples were removed and rinsed three times with phosphate buffer saline (PBS). Then, placed in 10 ml fresh sterile saline and sonicated for 30 seconds to dislodge the sessile adherent cells. Serial dilutions of the sonicated saline were cultured. The number of sessile bacteria that indicates the degree of adherence was determined by the viable count technique.

Scanning electron microscopy (SEM)

Streptococcus mutans ATCC 35668 and *Lactobacillus acidophilus* ATCC 4356 cells were suspended in a saline solution containing 0.2% Tween-80 and incubated with the tested material at 37°C. After 24 h, the tested material was then washed and fixed in tris-acetate buffer containing 1.5% glutaraldehyde, and then freeze-dried. Each bacterial culture was observed by SEM at different magnifications.

Statistical analysis

Data analysis was done using SPSS statistical analysis software (IBM SPSS Statistics version 21). Due to the small sample size, non-parametric tests were used. Numerical data were presented as a mean and standard deviation. Differences were considered statistically significant when the p-value less than 0.05.

RESULTS

In-vitro testing of the ability of (Streptococcus mutans ATCC 35668) and (Lactobacillus acidophilus ATCC 4356) to adhere to the surface of the tested materials revealed

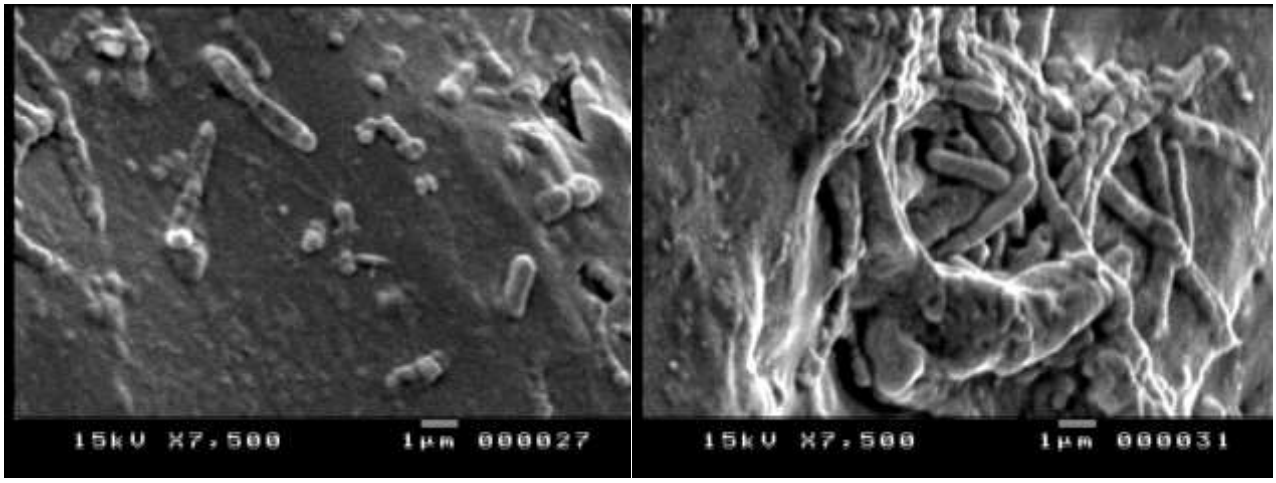
that the number of viable cell counts was smaller with zirconia samples than observed with the PEEK samples. Bacterial counting showed statistically significant higher values in the PEEK samples with both types of bacteria **Table (1)**.

Table 1: Mean values of the bacterial count with Zirconia and PEEK with each type of bacteria.

Bacterial species	Zirconia	PEEK	P-value
Streptococcus mutans ATCC 3668	2.3±0.57 (x10^2)	19±1.7 (x10^3)	0.04*
Lactobacillus acidophilus ATCC4356	6.3±0.58 (x10^2)	20±3 (x10^3)	0.04*

Scanning electron microscopy (SEM) observation

A biofilm mass containing a large number of bacilli and little number of cocci was observed on the surface of the PEEK material while aggregates of bacilli and little number of cocci appeared without biofilm mass on the surface of the zirconia material. Fig. (1)



(A) (B)

Fig. 1: SEM images of Zirconia (A) and PEEK (B).

DISCUSSION

Bacterial accumulation and biofilm development can be greatly affected by surface qualities of dental materials, which incorporate chemical composition, surface irregularities, free energy surface, and surface topography, irregular topography, and surface irregularities give good interfaces to bacterial colonization, securing microscopic organisms against shear forces during their initial reversible attaching and biofilm development. Also, the surface free energy, hydrophobicity, have a strong impact on oral biofilm formation(6). The bacterial adhesion was evaluated by measuring colony-forming units (CFU). Serial dilutions were made to obtain the lower quantity of bacteria in the sample. Subsequently, a plate dissemination method was utilized (7,8).

For the microbiological in vitro test, two bacterial species were selected *Streptococcus mutans* and *Lactobacillus acidophilus* these species are commonly used for evaluation of bacterial accumulation investigations because *Streptococcus mutants* are characterized by the high capacity for adhesion and biofilm formation, and *Lactobacillus acidophilus* is the source of the acid production. So increased presence of these species can increase the risk of oral diseases (9–11).

These results agreed with the results of a previous study (12) in which they evaluated four groups including blasted PEEK, PEEK, CP Ti, and Ti6Al4V. The results showed that the roughness and contact angle was highest in blasted PEEK followed by PEEK and CP Ti and finally Ti6Al4V, and also there was increased biofilm formation on blasted PEEK by ***S. sanguinis, S. oralis*, and *S. gordonii*,** while the bacterial biofilm was similar in the other groups.

Also, another study (13) in which they compared the formation of biofilm of three dental materials used for crown constructions (Modified PEEK (BIOHPP), Ceramic, and Zirconia) by using adenosine triphosphate (ATP) driven bioluminescence as an innovative tool for the rapid chair-side evaluation of oral bacteria and assessment of oral hygiene. The results showed that the lowest value of biofilm formation was in zirconia. Also, authors of previous studies (14–16) concluded that zirconia allows for less bacterial accumulation on its surface. Another study (17) concluded that zirconia is characterized by low plaque accumulation and high strength which enable it to be a promising material for telescopic crowns.

On the other hand, another study (18) investigated the biofilm formation on the surface of three materials including PEEK, zirconia, and titanium, and specimen made from polymethylmethacrylate (PMMA) used as a control group. They prepared the samples to be highly glossy by polishing them using silicon carbide paper and the profilometry was used to measure the degree of roughness and the contact angle measurements were recorded and used for detecting the surface energy. The tested materials exposed to suspension of microorganisms contains (Streptococcus mutans, Streptococcus gordonii, Candida albicans, and Actinomyces naeslundii). Regarding the surface roughness, the results showed that PEEK and PMMA less rough than zirconia and titanium. Regarding the surface, energy zirconia material has less free surface energy than PEEK.

CONCLUSION

Under the limitation of this study PEEK secondary telescopic crowns showed more bacterial accumulation with biofilm formation than zirconia secondary telescopic crowns.

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