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RETENTION OF ZIRCONIA-PEEK VERSUS COBALT- CHROMIUM-PEEK TELESCOPIC ATTACHMENTS FOR IMPLANTS RETAINED MANDIBULAR OVERDENTURE

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ABSTRACT

Objective: The study compared the retention of two types of telescopic attachments made of Zirconia-PEEK and cobalt-chromium-PEEK for complete lower dentures retained by implants. **Subjects and Methods**: Twelve completely edentulous patients were randomly chosen. The patients were allocated into two group; Group I, Patients received a zirconia primary coping and PEEK as a secondary coping's telescopic attachment. Group II (The control group): Patients received a cobalt chromium primary coping and PEEK as a secondary coping's telescopic attachment. A nexygen universal testing machine measured retention at three month intervals for 12 months in both groups**. Results:** Zirconia-PEEK double crown has recorded higher retentive value than cobalt-chromium-PEEK double crown at baseline, three months and six months with difference not considered as statistical significances as P value > 0.05. But at 9 months Cobalt-chromium-PEEK double crown recorded higher retentive value than zirconia-PEEK double crown with differences considered as statistical significance as P value ≤0.05. **Conclusion**: In spite of the good esthetic and lightweight advantages of zirconia, cobalt-chromium has significantly higher retentive value than zirconia.

KEYWORDS: Implant-retained overdenture; retention; telescopic attachment; PEEK; Zirconia.

INTRODUCTION

Treatment for edentulous patients now mostly involves mandibular implant overdentures (MIOD). People who wear Conventional mandibular dentures complain about their fittings being loose, unstable, and painful. Dental implants can help with these issues. When choosing the suprastructures to secure the denture to the implant, there are a variety of options available, including Locator, ball attachment, telescopic, and bar attachment [(1)].

To take advantage of its tremendous benefits, the usage of telescopic retainers has been broadened to include implant prostheses. Due to the frictional fit between the main and secondary copings, these retainers offer excellent retention [(2)].

Metal-free restorations have become more popular due to the high cost of metals and the desire for better esthetics. High-strength ceramics with enhanced features such as marginal quality, esthetics, and wear properties have been developed as a result [(3)]. Zirconia is one of the most widely

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used ceramics because of its advanced dental technologies and aesthetic properties[4].

New CAD-CAM materials were suggested for use in the creation of telescopic attachments. Zirconium dioxide (ZrO2), also called zirconia, is more aesthetically pleasing, biocompatible, resistant to wear, and has better mechanical qualities than metals. The creation of double crowns has been proposed recently [5].

Poly-ether-ether-ketone (PEEK) is a modified form of poly-ether-aryl-ketone (PEAK), which belongs to the main group of thermoplastic high-performance polymers. PEEK has many advantages, such as outstanding mechanical properties, high heat resistance, high hardness, low water absorption, chemical inertness, exceptional biocompatibility and solubility, and mild biofilm formation[6]. According to a study on retention load evaluation, PEEK is a suitable material for making telescopic crowns on zirconia primary crowns [7].

Cobalt-chromium (CoCr) is also very compatible with the double crown technique, as it has a precise fit, high elastic modulus, mechanical strength, lower weight than gold alloys, high biocompatibility and corrosion resistance[8]. These materials can simplify clinical procedures in complex cases with loss of vertical dimension of occlusion, and they can also be used as a permanent tooth replacement material[9]. They have more CAD/CAM processing features and can be used with lower thickness than ceramic materials[10].

The success of the complete denture depends on achieving the three basic properties of retention, stability, and support. However, mandibular dentures often face more challenges in obtaining these properties than maxillary dentures, because the mandible ridge has less residual ridge for retention and support and a higher resorption rate than the maxilla. Atwood and Tallgren have reported that mandibular bone resorption is four times more than in the maxilla [11].

The ability to hold the removable prosthodontics in place is a crucial factor. Many studies have shown that patients are more satisfied when their overdentures have better retention. Burns et al reported that patients preferred the overdenture attachment that had the highest retention [12].

The lower jaw's denture may move more during chewing due to less grip and resistance, which can lower the chewing efficiency [13]. The degree of retention that is clinically acceptable is influenced by the dislodging pressures, the prosthesis' functionality, and the patient's capacity to put on and take off the prosthesis [14].

In order to demonstrate the clinical importance of retention and stability of the prosthesis under function, Petropoulos et al. defined the "release period" as the amount of time needed for the attachment system to lose retention or disengage from the abutment during forced separation[15]. Reviewing the literature, very rare data is available about the clinical performance of zirconia-PEEK telescopic attachments. Consequently, this study was conducted to evaluate retention of two implant retained complete mandibular over denture with Zircon-PEEK versus Cobalt Chromium-PEEK telescopic attachment.

SUBJECT AND METHODS

Twelve completely edentulous patients were randomly selected from the out-patient clinic of Removable Prosthodontics Department, Faculty of Dental Medicine (Boys), Al-Azhar university;(Cairo). Based on the study of Emera et al[5]. the mean and SD values of retention in Newton (N) at insertion and after 12-month was 21.62±1.50 and 20.13±1.27 respectively. For this study, a sample size of 6 patients per group was obtained using two sample two-tail t-test. The effect size (df=3.024) and the required sample size were calculated for α =0.05 and a confidence power of 0.03353%, assuming a normal distribution

The study proposal was approved by the Research Ethics Committee of Al-Azhar University's

Faculty of Dental Medicine (EC Ref No.: FDA-zUC-REC_740/306).

The patients were divided into two groups. Each group included six patients. The study group (group I): Patients with zirconia as a primary copings and PEEK as a secondary coping's telescopic attachment Control group (group II): Patients with cobalt chromium as a primary copings and PEEK as a secondary coping's telescopic attachment.

Clinical intervention:

A complete denture was constructed for each patient with bilateral balanced occlusion. The denture's esthetics, stability, retention, occlusion, and comfort were evaluated. Patients were told to wear their dentures until they acclimated. Cone beam computed tomography was used to determine the height of the mandibular alveolar ridge, as well as the quality and type of bone[16]. Two dental implant fixtures (Oxy, Italy) with) with a length of 10 mm and, a diameter of 3.7 mm were implanted at the interforaminal region of the mandible. Complete dentures were converted to mandibular overdenture using a telescopic attachment. The patients were randomly allocated to one of two groups based on the attachment utilized.

Attachments Construction:

• Primary Telescopic Crown Construction:

After three months of implant installation, implants were uncovered surgically. Then, two straight abutments of 3 mm in height were screwed for two weeks. Then the attachment abutments were joined to the implants.

The previously installed abutment was scanned with an intra-oral scanner (Omnicam Scanner, UK) to gain a three-dimensional (3D) virtual image for designing the telescopic double crown attachments using CAD/CAM technology. A separate scan was performed for each implant abutment with an intra-oral scanner. The primary crowns (zirconia or CoCr) were CAD designed ensuring a common path of insertion.

The following parameters were maintained for all groups; the primary crowns had the same insertion path and a 5mm height, (with a 2mm parallel gingival height and a 2 mm occlusal height tapered at 4°) and the cement gap 0.02 mm occlusal to increase retention. All recorded and designed computer numeric control data were saved as STL files. The designed primary crown's STL file was imported into a 5-axis milling machine (MILL Box 2018 milling machine: ARUM, 400 Corea) to build the primary crown from zirconia blocks (Zirconia Katana) or CoCr metal blocks. The line angles of the primary crowns were rounded and polished to eliminate any edges or corners. The primary crowns were then polished using a special paste (Spofa Dental, A KerrCompany, 5704624, Czech Republic).

• Secondary Telescopic Crown Construction:

The primary copings were tried in the mouth (fig. 1) and then sprayed with a thin layer of scan spray (Scantist 3D, Irland) on the cast and the outer surface. The cast and each primary coping were scanned separately with an extra-oral scanner to improve the data quality. The secondary crowns were designed with parallel walls and minimal thickness, and a space was created between them and the primary crowns. Mechanical projections were added to the secondary crowns to help them interlock with the denture base material. The design data were sent to the milling machine to mill the secondary crowns from PEEK(Brident, Germany).

FIG (1) Primary crown placement in the patient mouth

Pick up of secondary crowns procedures:

The primary copings were attached to the implant abutments with cement. Venting holes were made on the fitting surface of the mandibular overdentures through the lingual sides. The secondary crowns were fitted over the primary ones following the correct insertion path. The secondary crowns were secured to the overdenture surface with self-curing acrylic resin. The excess acrylic resin was trimmed with a diamond bur (Fig. 2)

Modification in the overdenture to accept the universal testing machine:

Two small perpendicular metal tubes were placed a few millimeters underneath the canines in the mandibular denture base. Then the denture was rigidly and reproducibly connected to the horizontal metallic arm with two pens. The patient sat with his head in the upright position with the head resting firmly on chin support during retention measurements (Fig. 3)

Retention measurement:

Retention was measured by a nexygen universal testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) at three month intervals for 12 months in both groups [17,18]. The universal testing machine with a computer software package was used to deliver a vertical dislodging force at a crosshead speed of 30 mm/min to the overdenture from the vertical direction.

The load required to lift each denture of vertical deflection was recorded with computer software (Nexygen; Lloyd Instruments Ltd). The custom-made retention measuring device was gripped firmly in the movable compartment of a computer-controlled materials testing machine with a loadcell of 5 kN. The maximum load (retentive forces) required to separate the overdenture from the supporting implants was measured for both groups at the time of overdenture insertion, three months, six months and nine months later.

The achieved force was expressed in Newton. The test was repeated five times for each patient. The results of the two different denture telescopic attachments were recorded, calculated, and statistically analyzed.

FIG (2) Direct incorporation of outer PEEK coping in the overdenture

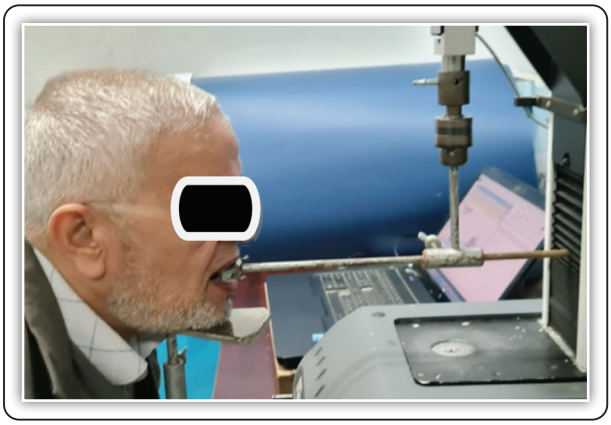

FIG (3) The mandibular denture attached to the universal testing machine by the attachment arm

Statistical analysis of the data:

Statistical analysis was carried out using IBM SPSS software package version 20.0 (Armonk, NY: IBM Corp) to analyze the data. We checked the normality of distribution with the Shapiro-Wilk test. We reported quantitative data using range, mean, and standard deviation. We set the significance level at 5%. We used Student t-test and ANOVA with repeated measures for normally distributed quantitative variables, and Post Hoc Test (adjusted Bonferroni) for pairwise comparisons.

RESULTS

Intergroup comparison

Comparison between the two studied groups according to retention.

At baseline: retention of Co Cr group was 34.09 ± 3.32 and Zirconia group was 37.23 ± 6.10. The difference was a statistically non-significant (p=0.294). At three months: retention of Co Cr group was 28.65 ± 4.02 and Zirconia group 28.76 ± 1.57. The difference was statistically non-significant (p=0. 953). At six months: retention of Co Cr group was 22.90 ± 2.58 and Zirconia group 24.99 ± 3.06. The difference was statistically non-significant (p=0. 229). At nine months: retention of Co Cr group was 17.80 ± 2.41 and Zirconia group 14.35 ± 2.64. The difference was statistically significant (p=0. 040*). Zirconia group showed a lower retention than Co Cr group (Table 1).

Intragroup comparison

Comparison between the different studied periods according to retention. Co Cr group showed a significant decrease in retention at three months, six months, and nine months (p<0.001*). Zirconia group showed a significant reduction in retention at six months and nine months (p<0.001*) (Table 2).

TABLE (1) Comparison between the two studied groups according to retention

Retention	Co Cr (n = 6)	Zirconia (n = 6)	t	P
Baseline				
Min. – Max.	29.34 – 38.30	31.93 – 48.83	1.107	0.294
Mean ± SD.	34.09 ± 3.32	37.23 ± 6.10		
3months				
Min. – Max.	23.36 – 32.45	27.04 – 31.43	0.061	0.953
Mean ± SD.	28.65 ± 4.02	28.76 ± 1.57		
6months				
Min. – Max.	20.10 – 25.75	20.42 – 29.29	1.280	0.229
Mean ± SD.	22.90 ± 2.58	24.99 ± 3.06		
9months				
Min. – Max.	13.58 – 19.46	11.87 – 19.46	2.364*	0.040*
Mean ± SD.	17.80 ± 2.41	14.35 ± 2.64		

SD: Standard deviation t: Student t-test
P: p-value for comparing between the studied groups
**: Statistically significant at p ≤ 0.05*

TABLE (2) Comparison between the different studied periods according to retention

Retention	Baseline	3months	6months	9months	F	P
Co Cr (n = 6)						
Min. – Max.	29.34 – 38.30	23.36 – 32.45	20.10 – 25.75	13.58 – 19.46	35.470*	<0.001*
Mean ± SD.	34.09 ± 3.32	28.65 ± 4.02	22.90 ± 2.58	17.80 ± 2.41		
p_0		0.042*	0.004*	0.001*		
Sig. bet. periods		p_1=0.155,p_2=0.035*,p_3=0.068				
Zirconia (n = 6)						
Min. – Max.	31.93 – 48.83	27.04 – 31.43	20.42 – 29.29	11.87 – 19.46	43.850*	<0.001*
Mean ± SD.	37.23 ± 6.10	28.76 ± 1.57	24.99 ± 3.06	14.35 ± 2.64		
p_0		0.119	0.017*	0.002*		
Sig. bet. periods		p_1=0.381,p_2=0.001*,p_3=0.006*				

SD: Standard deviation
F: F test (ANOVA) with repeated measures, Sig. bet. Periods was done using the Post Hoc test (adjusted Bonferroni)
P: p-value for comparing between the studied periods.
p_0: p-value for comparing the Baseline and each other periods.
p_1: p-value for comparing between 3months and 6months. p_2: p-value for comparing between 3months and 9months.
*p_3: p-value for comparing between 3months and 9months. *: Statistically significant at p ≤ 0.05*

DISCUSSION

A prosthetic treatment that is very successful for the mandible is the implant-retained overdenture, because it has many advantages such as simplicity, low invasiveness, low cost, better retention, stability, function, and patient satisfaction [19]. The attachment system that was tested in this study was the telescopic attachment because it can provide support, retention, and prosthesis even if there is a local failure, and it can be restored without rebuilding the whole superstructure [20, 21].

Telescopic crowns are also called double crowns or crowns and sleeve coping. They consist of an outer, removable (secondary) telescoping crown that is attached to a removable prosthesis and an inner, (primary) telescopic coping that is fixed to an abutment. The telescoping unit is formed by the primary coping and the secondary crown, and the secondary crown acts as an anchor for the rest of the dentition [22].

The primary crown material for group one (study group) was zirconia, because it has good biocompatibility, tooth color, and wear resistance. It has also been suggested that using tooth-colored ceramic materials can improve the psychological well-being and oral hygiene of patients. Zirconia has the advantages of lower thermal conductivity and no cold-welding or galvanic current with electroformed gold, compared to metal [23].

We used cobalt chromium as the primary crown material for group two (control group), because it is suitable for the double crown technique due to its precision, high elastic modulus, and mechanical strength. Cobalt-chromium (CoCr) also has lower weight than gold alloys due to its lower density. It has high biocompatibility and corrosion resistance. The material can be either made by casting or milling from ready-made chalky blocks using CAD/CAM. The pieces are sintered after milling to give the material the final shape, density, and mechanical properties [24].

Retention is a crucial factor for the attachment systems used in implant overdenture. It is a key aspect of the removable prosthodontics. Many studies have shown that retention is very important for patient satisfaction. Burns et al, reported that patients preferred the overdenture attachment that had the best retention [25].

Universal testing machine UTM is mostly utilized for standard testing for the tensile and compressive strengths of the materials, components and structures [26]**.** In order to evaluate & compare the change of retention force of each attachment system, the universal testing machine was used in this study because it's considered a vital element for retention measurement according to many researches. To standardize the forces and the machine was programmed to apply a tensile with pull out mode of force at a crosshead speed of 5 mm/min. Then, the principal investigator recoded in Newton the tensile load which was able to dislodge each overdenture [27].

We used a machine (Model 3345; Instron Industrial Products) to measure the retention of the prosthesis in Newton. The machine applied a vertical load (1mm/min) until the prosthesis came off. We used software (Bluehill Lite; Instron Instruments) to record the data. We modified the denture by putting two metal tubes in the canine area with acrylic resin. We attached the metal rods of the machine to the tubes. The patient sat with his head upright and firm against the head rest. The machine pulled the denture down until it was detached. We recorded the force in Newtons as the retention of the denture. We repeated this five times for each patient and took the average [28]. PEEK is a material that can absorb functional stresses and act as a stress breaker. It has high rigidity and biocompatibility, as well as low water solubility and high chemical and thermal stability [29].

In the present study, at baseline: retention of Co Cr group was 34.09±3.32 and Zirconia group was 37.23±6.10. the difference was statistically

non-significant (p=0.294). at 3months: retention of Co Cr group was 28.65±4.02 and Zirconia group 28.76±1.57. the difference was statistically non-significant (p=0.953). at 6months: retention of Co Cr group was 22.90±2.58 and Zirconia group 24.99±3.06. the difference was statistically non-significant (p=0. 229). at 9months: retention of Co Cr group was 17.80±2.41 and Zirconia group 14.35±2.64. The difference was statistically significant (p=0.049*).

The retention forces of different materials for two implant-retained mandibular overdentures were compared by Gujjalapudi et al., [30] They measured the retention force at the start and after 540 cycles of insertion and removal, which simulated 6 months of clinical use. They found that a combination of zirconia and PEEK had the best retention force. The retention values of the PEEK and Zirconia groups dropped significantly from the initial values, while the Titanium group had a small retention loss (P = 0.05). Zirconia (ZrO2) with PEEK combination was preferred as a secondary telescopic. Even though PEEK lost some retention over time, it could still be used as a secondary

CONCLUSION

The following conclusions can be drawn within the limitations of this in vivo study. As in the present study, in spite of good esthetic and light weight advantages of zirconia, cobalt-chromium has higher retentive value which recommended it with PEEK when telescopic attachment was recommended.

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