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Evaluation of Retention of Two Implants Retained Mandibular Complete Overdenture with Telescopic Attachments of Different Biocompatible Materials

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KEYWORDS

Zirconia telescopic crown, PEEK telescopic crown, Implants-Retained Overdenture, Retention, Telescopic Attachments

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ABSTRACT

Aim: The objective of this investigation was to assess and compare the retention of two implants that maintained complete mandibular overdentures with telescopic attachments made entirely of zirconia (ZrO2), entirely of polyether-ether-ketone (PEEK), and ZrO2-PEEK **,Subjects and methods:** Three acrylic edentulous mandibular overdenture models were separated into three main groups based on their telescoping attachment systems: group ZZ was made up entirely of ZrO2; PP group was made entirely of PEEK; and ZP group was made up entirely of ZrO2 (primary crown)-PEEK (secondary crown). The acrylic models were scanned with a laboratory scanner to gain a three-dimensional (3D) virtual image and the primary crowns were CAD designed to ensure a similar insertion route and then milled from ZrO2 and PEEK blanks. Each primary crown was then scanned separately and the secondary crown was created with mechanical projections and then milled. After that, mandibular acrylic overdenture with a metal framework and the metallic lingual bar were fabricated. For measuring the retention forces of each telescopic crown type, a universal testing machine (UTM) was utilized to employ 400, 600, 1200, 1500, and 1800 cycles of removal and insertion to the metal bar during the retention test. **Results:** The outcomes revealed that the ZZ group possessed significantly greater mean retentive forces followed by PP and then the ZP group. However, the retentive forces decreased respectively with an increase in the number of cycles. **Conclusion:** Despite the loss of retention over time, PEEK remains suitable for use as a secondary telescopic crown in substitution of zirconia or PEEK main crowns

INTRODUCTION

An efficient alternative treatment method for the rehabilitation of edentulous patients is an overdenture using either natural teeth abutments or implants. Implant use has been linked to a higher likelihood of treatment success in studies.[1]

Various types of attachments used with implant overdenture. These attachments may be retained mechanically, magnetically, frictionally, or in a combination of mechanical and magnetic ways. The telescopic attachment is one of attachments that widely is used today. It is formed of a primary coping that is affixed to the implant abutments and a secondary coping that is connected to the prosthesis and fits over the main coping. [2, 3,4]

The primary dental trend in recent years has been the substitution of traditional materials, particularly metallic ones, with metal-free ones. Due to patients' demands for the best aesthetics and their worries over the biocompatibility of metallic alloys, this trend has emerged. [5] With its great aesthetics, superior mechanical qualities, wear resistance, and biocompatibility, ZrO_2 had emerged as a viable alternative to gold alloys for the production of primary copings in telescopic attachments. All-ZrO_2 double crown systems are biologically promising telescopic attachments. [6] The high-performance thermoplastic polymer PEEK, which is tooth-colored, is another good CAD-CAM material with outstanding physical, biocompatibility, and chemical resistance. [7-10]

Hence, this research was carried out to assess and contrast the retention of implant overdentures with telescopic attachments made of entirely ZrO2, entirely PEEK, and ZrO2-PEEK combination.

MATERIALS AND METHODS

Determination of the sample size depended on the retention analysis by Emera et al. (2019) [9] by an alpha-type error of 0.05, a power test of 0.95, and a total sample of at least 3 samples (1 sample for each group). Three acrylic edentulous mandibular overdenture models were separated into three main groups based on their telescoping attachment systems: group ZZ was made up entirely of ZrO_2; PP group was made entirely of PEEK; and ZP group was made up entirely of ZrO_2 (primary crown)-PEEK (secondary crown).

1. Acrylic model construction:

A commercially available rubber mold (Trimould, Tokyo, Japan) for a largely edentulous mandibular jaw. Using a mechanical vibrator, molten base plate wax (Anutex toughened pink dental modeling wax, ADP Ltd, England) was poured into the rubber mold and allowed to be set. The wax model was removed from the rubber mold once the wax had fully hardened. The wax model was then flasked, wax elimination was done, heat-cured acrylic resin (Vertex[tm] Dental Company, Germany) was packed inside the cavity of the mold and flasked and processed according to manufacture instructions.

Two identical internal hex implants (Lagacy[TM] implant) of 11 mm length and 3.7 mm diameter were introduced into the canine location parallel to each other and perpendicular to the residual ridge area bilaterally and to the horizontal occlusal plane using milling machine (Paho-Deng, Dalseoku, Taegu, Korea). The sites were prepared by an initial cylindrical drill of 1.8 mm diameter followed by successive drills then final preparation was carried out with a 3.5 diameter drill. The drilling depth was 14 mm from the top of the cast to accommodate for the abutment shoulder. A mix of self-cured acrylic resin (Acrostone cold cure, England) was introduced to the drilled implant sites and the implants were tightened. Two straight abutments with a diameter of 3.5 mm, length of 2 mm, and gingival height of 1.5 were screwed then into the pressured implants. Then, the acrylic resin model was scanned for overdenture construction.

2. Designing and fabrication of telescopic attachments

A tiny coating of scan spray was applied to the acrylic model (DFS Telescan white, Germany) and then was scanned with a laboratory scanner (3D Neway Open Technologies Scanner, UK) to gain a 3D virtual image. The CAM system received computer numeric control (CNC) data that was memorized as stereolithography (STL) files, then a separate scan was performed for each implant

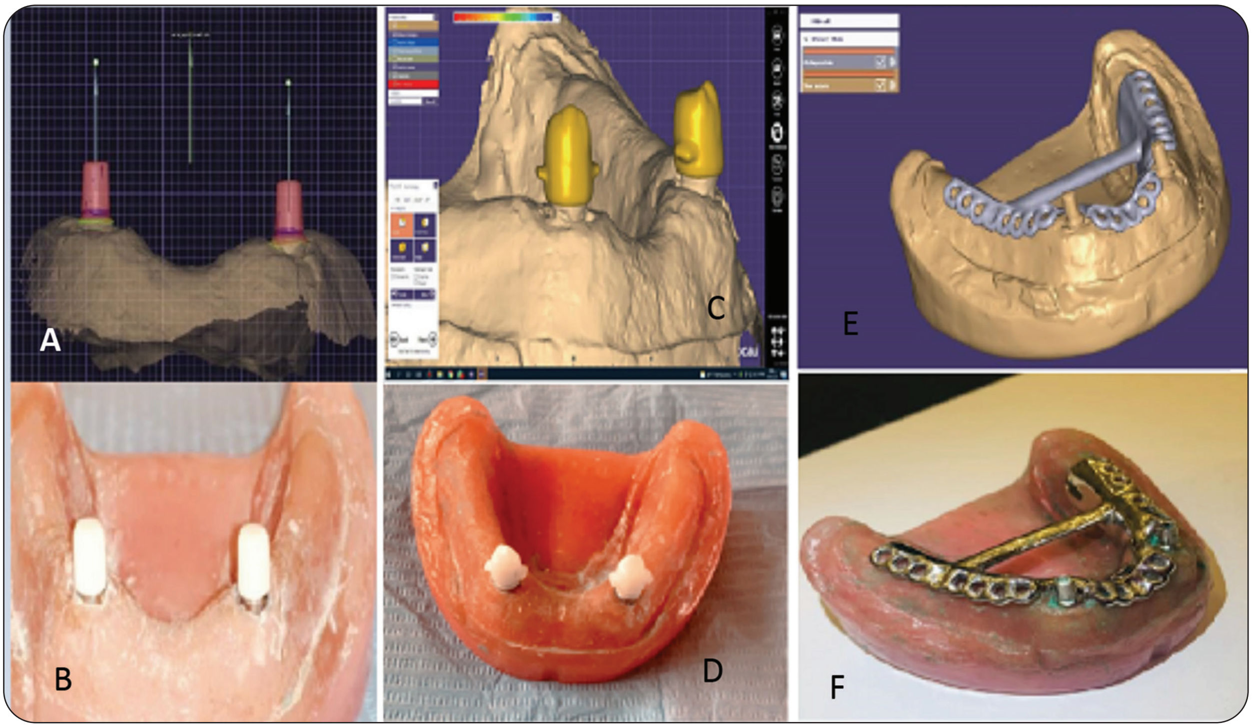

Fig. (1) (a):CAD designed of the primary crowns with a common path of insertion,(B)finished primary zircon crowns,(c)secondary crowns designed mechanical projections,(D) Finished secondary crowns,(E) metal framework design using Exocad,(F) Fitting of metal framework on the master cast.

abutment with a laboratory scanner. The primary crowns were CAD created to guarantee a consistent insertion route. The primary crowns had the same insertion way and a 4.96 mm height (the gingival 3mm was paralleled, the occlusal 2 mm was tapered 2 degrees), and the cement gap 0.02 mm occlusal. The primary ZrO_2 and PEEK crowns were machined from ZrO_2 and PEEK blanks, respectively. Zinc polycarboxylate cement (Adhesoer Carbofine, Czech Republic) was employed to bond the main crowns to the abutment.

Parallel walls with a minimum thickness of 0.5 mm were implemented to design the secondary crowns, and an occlusal gap of 0.3 mm was created between the primary and secondary crowns. Mechanical projections were added to each secondary crown to help in the mechanical interlocking of secondary copings with the overdenture base. In order to mill the ZrO_2 and PEEK secondary crowns from ZrO_2 and PEEK blocks, data were transmitted to a CAM system. (Fig. 1)

3. Construction of the mandibular overdenture:

After installing abutments, around abutments and the anterior and posterior edentulous regions, relief wax with a 1.5 mm thickness was placed to create space for the acrylic resin of the overdenture. Undercuts from the master cast were blocked and scanned. Then overdenture framework was designed with a rod that was affixed lingualy in the first molars regions. The wax framework was then printed and invested in the traditional manner, burnt out, cast, divested, completed, and polished. The precision of design on the master cast was assessed for the framework.

The secondary telescopic crowns were installed in front of the primary crowns. Alginate imprison material (Cavex CA37, Holland) was used to duplicate the acrylic resin model. Dental stone was then poured into the imprison. Following the creation of the wax rim, the occlusal plane was modified to sit halfway down the retromolar pad location on the stone cast. Waxing, flaking, curing, finishing, and polishing were performed on the mandibular denture after semi-anatomical artificial teeth (Acrostone, Egypt) were fitted. The lingual flanges were used to create venting holes in the fitting surface. (Figure 2;A)

4. Testing procedures:

For measuring the retention forces of each telescopic crown type, a UTM (INSTRON Instrument, USA) was used to apply tensile force to the metal bar during the retention test. The pull-off test was implemented with a load cell of 5 kilonewtons and a speed of 50 millimeters per minute. At the start of the trial (initial retention), the maximum values of retention force were listed. Each overdenture with a different combination of main and secondary telescopic crowns underwent 400, 600, 1200, 1500, and 1800 cycles of insertion and removal, which corresponds to 1 year and 6 months of clinical service. The retention was assessed at the baseline (T0) and at different repeated cycles. The final retention was assessed by running the pull-off test once more. (Figure 2;B)

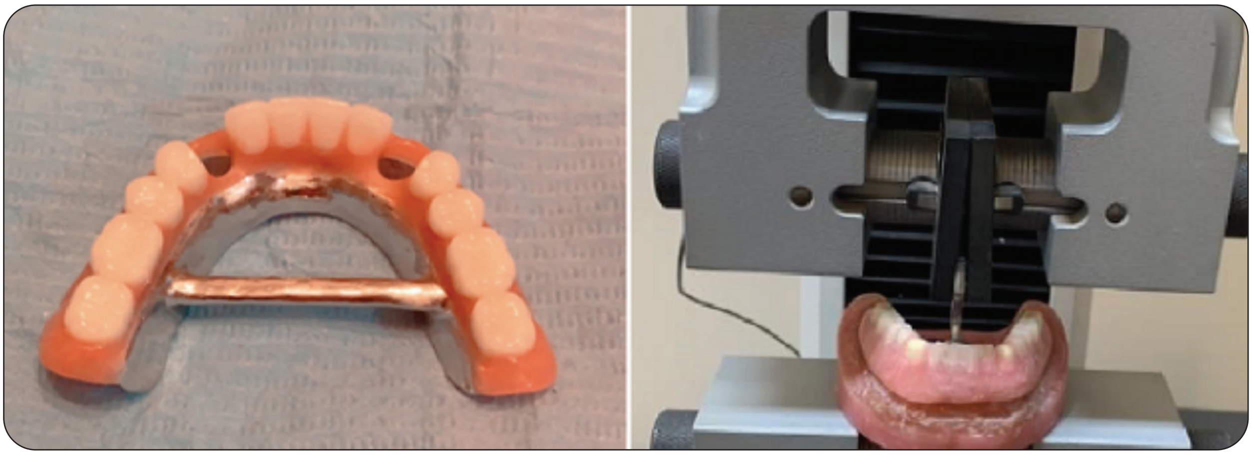

Fig. (2): (a) Finished over denture with metallic lingual bar,(B) Measurement of retention forces using a universal testing machine.

5. Statistical analysis:

With the help of SPSS® statistics Version 20, data were gathered, tabulated, and statistically examined. The normality of the distribution was examined using the Shapiro-Wilk test. A mean and standard deviation were utilized to illustrate the numerical data. ANOVA compares more than two groups for quantitative variables with normally distributed. Tukey's HSD test was used for multiple comparisons among the divisions. The substantial threshold was established at p0.05≤. Every test was two-tailed.

RESULTS

The normality test results assumed that all the groups distribute normally or have a big sample size, at least 30. The findings of the One-Way ANOVA test presented that there was a statistically substantial variation between the retentive mean values of all tested groups' number of cycles. The greatest average initial retention score for all cyclic loading was detected at the mean initial retentive force. However, the retentive forces decreased respectively with an increase in the number of cycles in all groups. (Table 1)

Table (1)

Variable	ZZ	PP	ZP	p-value
T0 (0 cycles)	24.15± 0.77[Aa]	16.54± 0.66[Ca]	18.32± 0.91[Ba]	0*
T1 (400 cycles)	23.83±0.91[Aa]	14.34±0.46[Bb]	13.58±0.34[Cb]	0*
T2 (600 cycles)	22.6±0.56[Ab]	13.46±0.48[Bc]	11.96±0.37[Cc]	0*
T3 (1200 cycles)	21.01±0.65[Ac]	11±0.57[Bd]	8.12±0.39[Cd]	0*
T4 (1500 cycles)	19.06±0.95[Ad]	9.53±0.46[Be]	5.97±0.36[Ce]	0*
T5 (1800 cycles)	17.49±0.61[Ae]	8.29±0.43[Bf]	4.13±0.32[Cf]	0*
p-value	<0.001*	<0.001*	<0.001*	

**; Significant at p<0.05.*
Different uppercase letters in the same raw mean are statistically significant.
Different lowercase letters in the same column mean are statistically significant.

DISCUSSION

In this current study, the telescopic attachment was selected as the tested attachment system because the telescopic attachment provided support, retention of prosthesis despite a localized failure, and it can be restored without necessitating the reconstruction of the entire superstructure. [11, 12] Moreover, the double crowns also provide horizontal stabilization and shield prostheses from lateral dislocation pressures because of their cone-shaped wall construction.

Merk et al. (2016) [13] stated that combining these two biocompatible materials, such as ZrO^2 and PEEK, could be a novel idea for creating telescopic crowns and metal-free dental prosthesis.

In this present study, ZrO_2 was used as the primary crown substance because of its good biocompatibility, tooth color, and wear resistance. Additionally, it is said that using ceramic materials that mimic tooth color helps patients feel better psychologically and encourages advancements in oral hygiene. Another benefit of this application is that ZrO_2 has lower thermal conductivity than metal. [14] Moreover, ZrO_2 were selected as primary crown materials since they have higher hardness levels and they are less expensive than precious metals, and are likely to sustain less wear. [15]

Merk et al. (2016) [13]. Moreover, Abdullah et al. (2016) [15]reported that CAD/CAM milled PEEK blanks and pellets displayed a rise in mechanical characteristics due to industrial prepressing methods, however, PEEK granular revealed an incomplete fracture and a higher plastic deformation.

In this current study, the universal testing machine was used to test the retention of the overdenture under different repeated insertion and removal loading (00,400,600,1200,1500,1800 cycles respectively) to test the release period "loss of retention". This is because it was Kadeeb et al. (2020) [17] concluded that the degree of retention that is clinically acceptable is influenced by the dislodging pressures, the prosthesis' functionality, and the person's capacity to put on and take off the prosthesis. Moreover, Chaware and Thakkar (2020)[17] highlighted the clinical importance of prosthesis retention and stability while in use as the amount of time needed for the attaching mechanism to either lose retention or detach from the abutment upon forceful disengagement.

The ZZ system resulted in higher initial retentive forces when compared with other systems. This could be attributed to the better friction between the

ZZ system and higher hardness and higher rigidity (modulus of elasticity) which resulted in better initial retention when compared to the PEEK that has a lower elastic modulus (4 GPa) when compared to zirconia (210 GPa). [18-24]

In disagreement with the results of Emera et al. (2020) [24] found that the ZP system has a higher initial mean retentive value when compared with ZZ and ZP systems.

Additionally, the outcomes of this present study revealed that the average retentive values of all tested systems decrease significantly with time (number of repeated cycles). These results could be attributed to the wear which results in the material of the double crown system because of friction forces within the primary and secondary crowns. [25]

According to Majcher et al. (2017)[25] and Bayer et al. (2012)[26], frictional wear occurs during the operation of the telescopic attachment and is a common retention issue. These results are in agreement with Emera et al. (2020) [28] who found that Final retention scores for the PP and ZP divisions were substantially lower than initial scores, whereas they found the ZZ group experienced an insignificant retention loss.

Also, there is a remarkable drop in the retentive force of all attachment systems with time could be attributed to substantial wear occurring in all categories following simulating 1 year and 6 months of overdenture employment, where simulation was performed only in the axial way, which resulted in selective wear of specific attachment surfaces. A sun=bstantial variation among the initial and final retention within all divisions was demonstrated.[24,27]

Moreover, the findings of this current experiment demonstrated that the ZZ and PP groups have a significantly higher retentive force than the ZP group at the termination of the test duration. This could be attributed to the heterogenous ZP system of different hardness whereas the zirconia has higher hardness than PEEK which resulted in significant wear in the PEEK secondary crown with time.[18] This outcome is in line with Emera et al. (2019) [28], who assessed the surface topographic changes of all zirconia, all PEEK, and zirconia-PEEK telescopic junctions after simulating 6 months of overdenture use. They discovered that the combination of PEEK and zirconia for the fabrication of telescopic attachments was associated by significant modifications in surface topography (mostly in secondary crowns) when compared to all zirconia and all PEEK telescopic attachments.

Furthermore, the outcomes of this current research described that the ZZ group has a significantly higher retentive force than the PP group at the termination of the test duration. This could be attributed to the physical differences between the two substances, where PEEK has a lower modulus of elasticity than zirconia, which was used to explain this conclusion. As a result, PEEK restorations absorb occlusal loads and experience wear. The ZZ division, on the other hand, displayed the least wear scores, and as a result, its reported initial retention scores were kept. [14, 24, 28]

CONCLUSION

Within the constraints of this in vitro investigation, the results showed that as opposed to a primary zirconia telescopic crown, zirconia is favored as a secondary one. PEEK is preferred as a secondary telescopic crown when PEEK is utilized as a secondary one. Regarding the appropriate initial and final retention values, PEEK could remain employed as a secondary telescopic crown in place of zirconia or PEEK primary crowns despite the loss of retention with time.

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تقييم استبقاء وتوزيع الاجهاد للطقم السفلي المحمل على غرستين بواسطة الوصلات التلسكوبية بمواد مختلفة (دراسة معملية)

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الملخص :

الهدف: أجريت هذه لتقييم توزيع الاستبقاء والتوتر لغرستين مغروستين تحتفظ بهما الفك السفلي بالكامل مع ملحقات تلسكوبيه من مواد مختلفة..

المواد والاساليب: قسمت هذه الدراسة إلى ثلاث مجموعات حسب نوع المرفق التلسكوبي. المجموعة الأولى كل مرفق كلي تلسكوبي من زركونيا. المجموعة الثانية؛ مرفق كلي تلسكوبي من بولي إيثير كيتون. بينما المجموعة الثالثة؛ زركونيا - بولي إيثير كيتون) الزركونيا كتاج أولي وبولي إيثير كيتون كتاج ثانوي (مرفق تلسكوبي.

النتائج: أظهرت نتائج الاستبقاء في هذه الدراسة أن جميع مجموعات التلسكوبات التلسكوبية من زركونيا كانت لها قيم احتفاظ أعلى بشكل ملحوظ تليها جميع مجموعات التلسكوبات التلسكوبية من بولي إيثير كيتون ومع ذلك. أظهرت مجموعة المرفقات التلسكوبية زركونيا وبولي إيثير كيتون ضغوطًا متراجعة أقل بشكل ملحوظ في جميع الدورات الم مختبرة باستثناء الخط الأساسي. علاوة على ذلك. أوضحت نتائج هذه الدراسة أن متوسط قيم الاستبقاء لجميع الأنظمة المختبرة يتناقص بشكل ملحوظ مع مرور الوقت (عدد الدورات المتكررة). وايضا من. أظهرت نتائج توزيع الإجهاد لهذه الدراسة الحالية أن مجموعة الزركونيا بأكملها سجلت أعلى قيم الإجهاد تحت كل من التحميل الثنائي والأحادي الجانب. تليها مجموعة بولي إيثير كيتون. تم الإبلاغ عن أقل قيم الإجهاد من قبل مجموعة زركونيا - بولي إيثير كيتون التي تضم تيجان بولي إيثير كيتون الثانوية وتيجان الزركونيا الأولية.

الخلاصة: يُفضل بولي إيثير كيتون باعتباره تاجًا تلسكوبيًا ثانويًا عندما يتم استخدام بولي إيثير كيتون كتاج أولي. ز فيما يتعلق بقيم الاحتفاظ الأولية والنهائية المناسبة. لا يزال من الممكن استخدام بولي إيثير كيتون كتاج تلسكوبي ثانوي بدلاً من الزركونيا أو التيجان الأولية بولي إيثير كيتون على الرغم من فقدان الاحتفاظ بمرور الوقت.

الكلمات المفتاحية : اج زركونيا تلسكوبي، تاج تلسكوبي , بولي إيثير كيتون ، طقم أسنان علوي مزروع، الاحتفاظ، ملحقات تلسكوبية.