Retention Assessment of PEEK Telescopic Attachment with Two Different Matrix Materials for Implant Retained Over Dentures (Randomized Clinical Trial)

Zeinab Ahmed EL-Shorbagy, Mohamed Maamoun El-sheikh, Nashwa Ali Saleh Ali

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Abstract

Objectives: This parallel study aimed to evaluate the retention values of Poly Ether Ether Ketone (PEEK) telescopic attachment with different matrix materials (PEEK, Titanium) for implant retained mandibular overdenture. **Materials and Methods:** Fourteen completely edentulous patients were selected for this study, to receive mandibular complete overdentures supported by 2 implants in the canine region using a surgical guide. (CAD/CAM) PEEK telescopic attachment was fabricated to retain overdenture; the patients were divided into two groups 7 each according to matrix material Group A: matrix part of the attachment was constructed by PEEK Group B: patient's matrix part of the attachment was constructed by Titanium Finally; direct pick-up of the matrix was done. Retention values were measured at the time of overdenture insertion (T0), after 6 months of use (T6), and After 12 months used (T12). **Results:** There was a highly significant decrease with time for each group and a highly significant difference for comparing two groups in each interval. **Conclusion:** Within the limitation of this study, it was concluded that**:** PEEK telescopic attachment with titanium matrix attains better values of retention with time when compared to PEEK matrix

Keywords: Overdenture, Telescopic attachment, CAD/CAM, PEEK, Titanium.

Prosthodontics department, Faculty of Dentistry, Tanta University
Corresponding author: Nashwa Ali Saleh Ali

Introduction

Overdentures are connected to implants using a wide range of commercially available attachment devices. Stud, bar, magmatic, and telescoping attachments are among the most popular types. Each of these categories has unique benefits, drawbacks, and usage requirements. The amount of retention required, the amount of inter arch space available, the patient's manual dexterity, the dentist's expertise, and finally the cost all go into the choice of attachment mechanism.[1]

Crown and sleeve coping, or twin crowns are terms used to describe telescopic attachments (CSC). A detachable prosthesis is attached to the outer or secondary telescopic coping, which is connected to the abutment. Since telescopic attachments convey occlusal stress along the abutment's long axis and offer assistance, direction, and defense against dislodging pressures, several studies have advocated its usage for maintaining over dentures.[2]

Due to its excellent mechanical and physical qualities, Poly Ether Ether Ketone (PEEK) material was launched as a significant advancement in prosthetic and implant dentistry. PEEK has demonstrated respectable flexibility, good mechanical wear resistance, and high tensile, fatigue, and flexural strengths. [3]

Titanium's strong biocompatibility and resistance to corrosion make it a likely candidate for usage as a dental metal. The invention and application of the casting process and special dental investment material have eliminated titanium's previously identified weakness concerning workability.[4]

Denture retention is described as a denture's resistance to torsional and vertical stresses, or its resistance to being removed from the mouth in the opposite direction from when it was inserted.[5]

The friction between the axial walls of the inner and outer crowns, as well as varied crown tapers, heights, and materials utilized, all affect how well double-crown-held prostheses are retained. The wear between the materials, however, may cause the retention to decline with time. which could be abrasive and/or adhesive wear. Double-crown wear is a typical issue that may need the replacement of the prosthesis.[6]

Various explanations for the worsening of the attachment's retention have been put forth, including wear, design, the clinical setting, inter-implant distance, and implant angulation. The oral microbiological environment and everyday wear from prosthesis removal and insertion, however, may cause a loss of prosthetic component function, which would then cause the attachment mechanism to fail. [7]

The null hypothesis is that there is no difference in retention value between the two types of telescopic attachment.

Materials and methods

Fourteen completely edentulous patients of age ranging from 50-65 years were carefully selected from those who attended the outpatient clinic of the Prosthodontics Department, Faculty of Dentistry, Tanta University. This study was conducted as a Randomized Clinical Trial.

This parallel study was performed between 2019-2021 in the university clinic.

Patients 'rights: Approval of this research was obtained from the Research Ethics Committee, Faculty of Dentistry, Tanta University. All the patients were informed about the aim of treatment and the need for frequent recalls through the total period of research and written informed consent of agreement according to guidelines on human research adopted by the Research Ethics Committee, Faculty of Dentistry, Tanta University.

The inclusion criteria of the study involved completely edentulous patient at least 6 months from last extraction, free from systemic disease that may influence soft or hard tissue healing, Sufficient residual alveolar bone quality and quantity verified by cone-beam computer tomograph technology (CBCT) for each patient, All patients should be Angel class I maxillomandibular relation with inter-arch space sufficient for restoration 20mm at least and the residual alveolar bone width in the mandibular canine areas was at least 6 mm and Patients should have relatively good oral hygiene.

The exclusion criteria of the study were patient with a history of radiation therapy in the head and neck region, with current treatment with steroids, with a neurological or psychiatric handicap that could interfere with good oral hygiene, with immune-compromised status, with para functional habits., with heavy smoking habit, alcohol, or drug abuse and non-cooperative patient (those who do not follow the instruction).

Power analysis: The minimum sample size for this study is 14 samples. The significance level was, and the power sample size was more than for this study and the confidence interval 95% and the actual power is 97.27%. The sample size was calculated using a computer program G power version 3.

The formula of sample size

$$sample\ size = \frac{(\sigma_1{}^2 + \sigma_2{}^2)\left(Z_\alpha + Z_\beta\right)^2}{(\Delta - \Delta_0)^2}$$

Z = Z value (1.96 for 95% confidence level) α= alpha level (The significance level was 0.05), β= beta level. Δ= difference under the null hypothesis

Intervention:

A standard acrylic full denture was made for each patient according to Zarb el al.[8] Then a radiographic template was prepared[9]**.**Dual-scan technique in which two independent CBCT (CAT FLX V17, Nc 28273, Kavo, charlotte, USA.) scans of the radiographic stent were made. In implant planning software, DICOM data obtained by superimposition were examined (In2guide software by 3DIEMME) ® and so that since the prosthesis was visible over the accessible bone architecture, the implant sites in the edentulous regions could be accurately evaluated (Virtual placing of implants taking in consideration the relation to anatomical structures and prosthetic requirements). For all patients, two vertical implants (Narrow sky 3512, bredent, Germany) 3.5 mm diameter and 12 mm length (narrow plate form) were bilaterally placed in the canine regions, followed by the screwing of two healing abutments. After 7 days of healing, with silicon soft lining materials, the denture was relined and intended for usage for one month.

The patients were divided randomly into two groups 7 each according to matrix material; (GA): the patient who received the implant retained overdenture with PEEK patrix and matrix. Group B (GB): the patient who received the implant retained overdenture with PEEK patrix and Titanium matrix.

Randomization and group allocation:

The selection of the side was done randomly through the permuted block randomization technique. The allocation sequence and the code were hidden from the person allocating the participants to the intervention arm by using sealed envelopes. This selection was done by another person other than whose participated in the study.

After one month of Osseointegration mandibular functional impression was taken and to produce the final impression, a special tray was built on top of the stone cast and two holes corresponding to each implant location were drilled into it. The healing abutments were unscrewed, and the impression was taken by (open tray technique) [10]

Primary telescopic crown was construct as follow, [11]The titanium (Ti-base) abutment (bredent GmbH & Co., KG,Senden, German) was secured to the analog in a poured cast then the cast was scanned by an extra-oral scanner (DS Mizar dental scanner, EG solution 40138 Bologna, Italy) to gain a 3D virtual image for designing a resilient telescopic attachment using CAD/CAM technology. On software (Exocad dental 2019; exocad GmbH, Darmstadt, Germany the same parameters for designing patrix were maintained for all groups concerning 5mm height (2mm gingival height was paralleled and the occlusal 3mm was 4^o occlusally tapered). The computer numeric control (CNC) data were transmitted to a milling machine (Sheraeco_scan3, Germany) connected to the CAD system to mill the patrix from PEEK (BioHPP disk, bredent Medical Gmbh&Co. KG, Senden, Germany) After that Ti- base was sandblasted with 110µm aluminum oxide at 3Bar pressure by a sand blasting machine (OXYKER DUETV.230 M.50/60HZ, Manfredi, Italy), seal the screw channel was with wax, and apply Visio link (PMMA &composit Primer, bredent GmbH & Co.,

KG, Senden, German) to the Ti base and patrix then apply DTK-adhesive and press patrix onto Ti-base and insert the screw into the channel then polymerize with light curing power unit 2 (bredent GmbH & Co.KG, Senden ,Germany) for 180 sec screw was removed from the channel and remove excess from patrix. Fig (1)

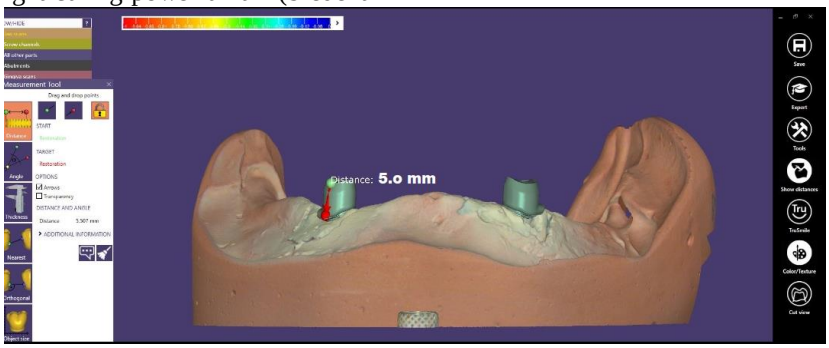


Fig (1) Final software design for patrix

Secondary telescopic crown was construct [11] after using the primary copings intraorally, scanning was completed to create the secondary copings based on their 3D image. Parameters used for designing secondary copings were parallel walls with a minimal wall thickness of 0.5 mm and an occlusal space (0.3mm) was preserved between the primary and secondary copings. Secondary copings were designed with means of retention added to improve their mechanical retention to the over-denture fitting surface.[12]Fig (2a,b) .For all patients, the direct pick-up of the peek matrix (For group A) and titanium matrix (for group B) was done [11].

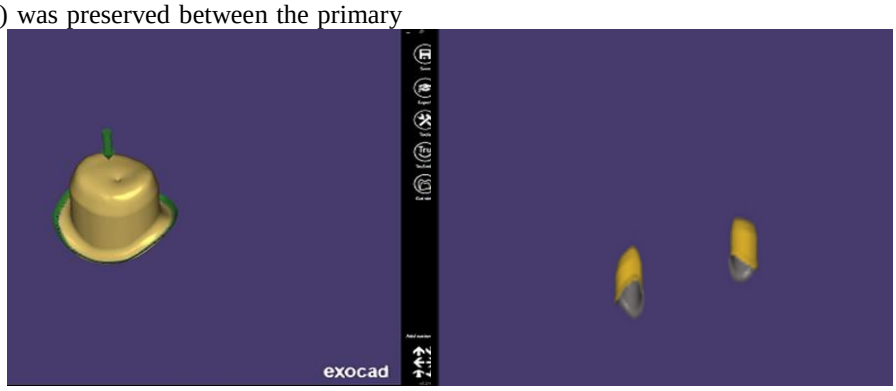


Fig (2,a) Scanning of the patrix Fig (2,b) Designing of the matrix

Retention force was measured in Newton using[13] a digital force meter (47544Lanetech Instrument, cooperation, Beijing) which has a wide range of force measurement (0-5000) gm, connect to a wire loop on the lower denture and pulled vertically.The patient's occlusal plan was recorded in a vertical direction perpendicular to the retention measurement, and the maxillary denture was taken out to measure force as vertically as possible.Before each measurement of retention, the display of the force meter was adjusted to zero using the zero buttons. The force measuring unit is selected to be in newton.The pull end of the digital force meter was connected to a metal hook located in the geometric center [13] of each mandibular conventional denture that was identified on the lower cast at the intersection of three lines bisecting the angles of the triangle, formed by both retro-molar pads and the midline Fig(3 a, b)The measuring procedure was repeated three times and the average was calculated. The same measuring procedure was repeated for the mandibular dentures of each group.

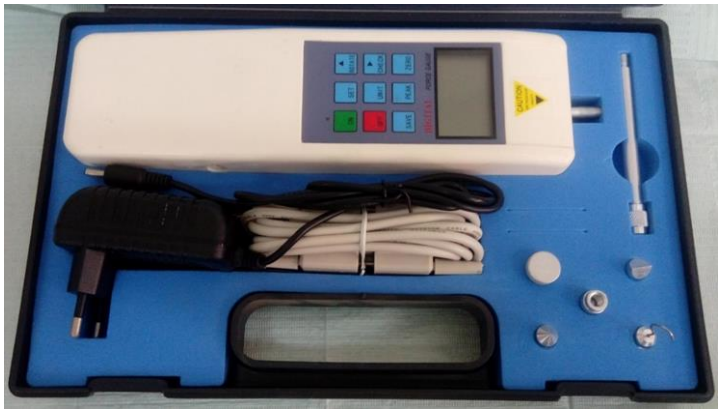


Fig (3) Digital force meter device for retention measurement

Statistical analysis: For clinical evaluation, radiographic evaluation and retention force value statistical analysis performed using IBM SPSS 20 ; Statistical Package for Scientific Studies (SPSS: An IBM company, Chicago, IL, USA) and Microsoft Office XP (Excel) for Windows. Descriptive statics was used to describe the data using mean and standard deviation. Repeated measure ANOVA was used to compare the durations in each group also independent T-test was used to compare between the two groups in each duration. Multiple comparison Tukey test was used to determine significant between every two durations in the same group. P-value was considered significant ($p<0.05$)*, and highly significant($P<0.001$)**

Results

In this study, all participants attended all follow-up visits, and their results were analyzed. No implant failure occurred throughout the study period, no implant or super structure fracture, no screw loosening or fracture and no over denture fracture occurred. The success rates for both types of prosthesis were 100% .Comparing the two groups revealed that there was a highly significant difference all over the observation period between both groups with (*p*-value =0.000**, 0.000**,0.000**) At (T_0), (T_6) and at (T_{12}), (t-test) as showing in the table (1).Upon intragroup comparison through different follow-up periods, there was a highly significant difference between durations in groups *p*-value = 0.000* *, 0.000* * for (GA),(GB) respectively (ANOVA test) were listed in Table (1) .

Table (1): The mean, standard deviation (SD) values of retention along different follow up times of both groups.

Retention (N)	T_0 Mean ± SD	T_6 Mean ± SD	T_{12} Mean ± SD	*P-value*
GA	**16.58 ± 0.62**	**15.48 ± 0.69**	**14.78 ± 0.77**	**0.000****
GB	**24.03 ± 0.64**	**23.31 ± 0.85**	**22.59 ± 0.99**	**0.000****
P-value	**0.000****	**0.000****	**0.000****	---------

(*): There is a significant at P-value< 0.05, and (**) highly significant at P-value< 0.001.

Multiple comparison Tuckey test was used to determine the significance between every two durations in the same group. Table (2)

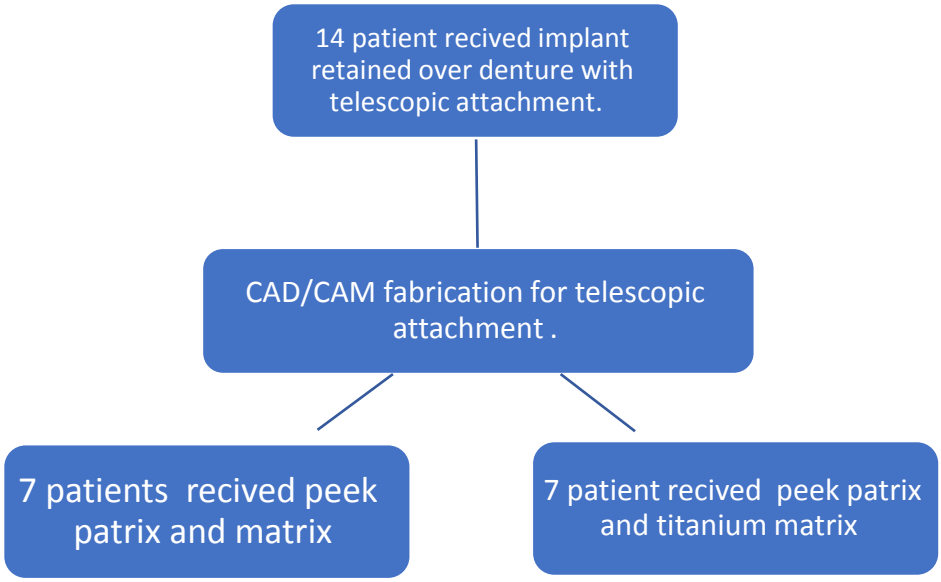
Table (2): Tuckey test to determine significance between every two durations in the same group

Retention index	P1	P2	P3
GA	**0.000****	**0.000****	**0.009***
GB	**0.000****	**0.000****	**0.001***

P1: Comparison between T_0-T_6
P2: Comparison between T_6-T_{12}
P3: Comparison between T_0-T_{12}

There is a significant at P-value< 0.05 (*), and highly significant at P-value< 0.001 (**)

Flow chart:



Discussion

(CBCT) was used for diagnostic purposes to assess the amount and quality of the alveolar bone. The precise location of the implant was another crucial factor. It is possible to precisely quantify bone height and breadth. It is simple to calculate the proposed implant's diameter and length. Implant angulation can be changed bone architecture and consideration of important structures.[14]

Numerous studies suggested using telescopic attachments to hold overdentures in place because they transmit occlusal stress along the abutment's long axis and offer stability, direction, and defense against pressures that may cause them to fall out of place.[2]

Digital force meter was utilized to assess the resistance of the dentures to vertical displacement it is being utilized in this way right now because of its precision and portability, and any physician or clinical researcher may use it in the future to test attachment retention, facilitate modifications, and provide data on component changes that occur during the function in the oral environment.[15]

There was a highly significant difference in comparing the duration throwing two groups and there was a highly significant difference in comparing between groups in each interval.

This may be due to the degree of wearing because of the relative movement between the surfaces of the copings depending on whether the elevated areas of the material are abraded and leveled, or other areas are broken off.

Emera *et al.*[16]showed that compared to all PEEK and all zirconia telescopic attachments, the combination of PEEK and Zro2 materials caused higher changes in surface topography (mostly in secondary crowns).

Ramadan *et al.*[17]indicated that after simulating a year of overdenture use, the retentive force values for implant-retained telescopic overdentures dramatically dropped, and both BioHPP and titanium are regarded as suitable abutment materials to retain telescopic overdentures.

Schubert *et al*[18]concluded that secondary crowns manufactured from PEEK that are CAD-CAM created to have the potential to be a reliable replacement for electroformed secondary crowns

by offering adequate and stable retention force values.

These results disagree with Besimo *et al* . [19]study in which different combinations of gold, titanium, and CoCr for both inner and outer crowns were tested, and the study showed that the mean retention increased over 10,0 0 0 insertion and separation cycles.

The mechanical adaptation at the level of the junction between the inner and outer crowns was probably the cause of this rise.

Conclusion

Within the limitation of this study, it was concluded that**:** PEEK telescopic attachment with titanium matrix (GB) attains better values of retention with time when compared to PEEK telescopic attachment with PEEK matrix (GA)

Data availability statement

Data are available on reasonable request with the corresponding author's mail.

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Author contributions: NA: conceptualization, methodology, writing, review, and editing. ZE: supervision, reviewing. ME: supervision, reviewing. All the authors approved the final version of the article for publication.

Ethical policy and Institutional Review board statement: Ethical approval was obtained from the Institutional Research Ethical Committee at the Faculty of Dentistry, Tanta University on February 25, 2019. (#R-RP-2-19-7).

Patient declaration of consent: The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Data availability statement: Data are available on reasonable request with the corresponding author's mail.

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