EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 68, 1623:1631, APRIL, 2022
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 2022-01-21 • Accept Date : 2022-02-17 • Available online: 2022-03-30 • DOI : 10.21608/edj.2022.117575.1957

RETENTION EVALUATION OF MAXILLARY PARTIAL DENTURE CONSTRUCTED FROM DIFFERENT FLEXIBLE DENTURE BASE MATERIALS. AN IN-VITRO STUDY

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ABSTRACT

Purpose: The aim of this in vitro study was to measure and evaluate the retention of four different flexible denture base materials.

Materials and Method: Forty Kennedy class I partially edentulous models with the first premolar bilaterally as the last standing abutments were used in this study. Models were divided into four equal groups. Group I: partial denture with PEEK clasp assembly and denture base, Group II: partial denture with Bre-flex clasp assemble and denture base, Group III: partial denture with Polyoxymethylene clasp assemble and denture base (Acetal) and Group IV: partial denture with polyamide clasp assembly and denture base (Valplast). All the RPD were constructed in two steps: the major connector and the meshwork were casted first with chrome –cobalt alloy and the rest of the partial denture was then constructed with different flexible denture base materials according to the distribution of the previously mentioned groups.

Retention of each partial denture in each group was measured after applying repeated insertion and removal cycles using the chewing simulator integrated with thermo-cyclic protocol operated on servo-motor. The data of the retentive force magnitudes at different intervals for the four different materials were collected, tabulated and statistically analyzed.

Results: The results of this study showed that PEEK has statistically significant higher retention values when compared to the other three types of thermoplastic materials.

Conclusion: PEEK is one of the promising esthetic materials that provides superior retention when used as a framework for a removable partial denture.

KEYWORDS: Removable partial denture, Retention, flexible denture base.

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INTRODUCTION

Most of the removable partial denture wearers are complaining from the metal display and seeking a partial denture with metal-free clasps in order to improve their esthetics. Several types of non-metal clasp dentures are presented due to superior esthetics. Moreover, flexibility and highly elastic nature minimizes stresses on the abutment teeth. [1,2]

Furthermore, Sufficient retention and esthetics of removable partial dentures (RPDs) are considered the most important factors affecting their clinical success. So, achieving optimal esthetics while maintaining retentive integrity, and preserving the health of the abutment is an important issue. Also, the retentive clasp arms of the Removable partial denture must be capable of flexing and returning to its original form and should resist the plastic deformation during function because the clasp fatigue is based on the repeated deflection of the clasp during insertion and removal of the RPD over the undercuts of the abutments. In addition, claps should exert stresses within the physiologic limit on the abutment teeth[3-6].

Polyether ether ketone (PEEK) is a semi-crystalline thermoplastic material with excellent mechanical and chemical resistance properties. Also, it has high durability and firmness, mainly in relations to fatigue and strength [4]. One of the important characteristics of PEEK is its reduced modulus of elasticity, which ranges between 2 and 6 GPa and efficiently prevents the pressure protecting influence [5]. PEEK now is used as a substitute for titanium in the field of traumatology and orthopedics [6,7]. Moreover, PEEK has also been proposed to produce prosthetic infrastructures and abutments for titanium-based implant systems in the prosthodontics field. The material exhibits high mechanical strength, wear resistance and aesthetic features compatible with those of tooth and bone tissues.

The polyoxymethylene (Acetal) is a thermoplastic material that has favorable mechanical properties such as high strength, superior abrasion resistance and lower creep with higher surface luster. Also, it expresses high stiffness, hardness, low coefficient of friction, impact strength, high wear resistance, and dimensional stability [8,9,10]. In addition, it has high chemical resistance, low water absorption and high biocompatibility [11,12]. Also, due to the flexibility of these materials no deformation occurs for the Acetal resin clasps after 36 months of simulation and that required less force for insertion and removal in comparison to the traditional Co-Cr clasps [13,14].

Another flexible material is the Bre-flex second edition. It is unbreakable, flexible and monomer free developed to improve the property of this polyamide as it offered better color stability, improved durability and increased flexibility. It is supplied in variable shades such as crystal clear and pink and pink-veined. It is a suitable prosthesis for a hypersensitive patient seeking esthetic appearance. Also, it is Ideal for patients who need temporary appliances during the healing period of implant-supported restorations. It may be used in combination with metal frameworks or precision attachments. Other applications also include splints and sports mouth guards. However, full dentures, crowns, and bridges, attachments are a contraindication for its use [15-17].

Valplast is also a type of polyamide has relatively low flexural strength, modulus of elasticity and rigidity, but they demonstrate great impact strength, toughness, and resistance to fracture. It was suggested that by adding glass fibers to polyamides, their stiffness and other mechanical properties could be increased. The use of these materials for non-metal clasp dentures has some advantages regarding their esthetics and degree of retention. However, these materials show some degree of color instability. Some researchers reported that Using the denture cleansers would increase the surface roughness of these materials and their cytotoxicity increases after long-term use. It was demonstrated

that polyamides have rougher surface than other resin materials and it causes more bacterial and fungal colonization[18-20].

MATERIALS AND METHODS

The aim of this in-vitro study was to measure and evaluate the retention of partial dentures constructed from four different types of flexible denture base materials.

An experimental model with bilateral free end saddles were fabricated acting as a master cast having the first premolars bilaterally as the last standing abutments.

A Tentative partial denture design was drawn on the master model. The master model was then surveyed in zero tilt position where the occlusal plane of the master cast (model) was parallel to the base of the surveyor and to the floor (Ney Surveyor, DENTSPLY, USA). The surveyor-analyzing rod was used to analyze the cast and the proximal surfaces of the last standing abutments. 0.02 Inch depth undercuts were created on the mid-buccal surface of the last standing abutments. After guiding planes were prepared and finished the occlusal rest seats were prepared mesially on the main abutments. RPI clasps are used on the last standing abutments and antero-posterior palatal strap as a major connector for this partial denture design.

Inverted V-shape cingulum rests were prepared on the lingual surface of the canines in order to accommodate the indirect retainers.

After finishing the partial denture design on the master model, modifications were done by blocking-out all the undesirable undercuts and building up of the relief wax. The modified master cast was then duplicated in the conventional manner. 40 refractory casts were poured on the silicon mold.

The wax pattern of the major connectors and the saddles were built up on the refractory models then the conventional casting procedures were followed to create the metal frame work that included only the major connector and the meshwork. The rest of the partial denture was then constructed from different flexible materials according to the models grouping **(figure 1).**

Waxing up for the clasp assembly and the denture base covering the metal framework was done for the 40 models while the cobalt chrome major connector and meshwork that was previously casted was on the model. The models were randomly divided into 4 equal groups each containing 10 models as follows:

Group I: partial denture with PEEK clasp assembly and denture base.

Group II: partial denture with Bre-flex clasp assembly and denture base.

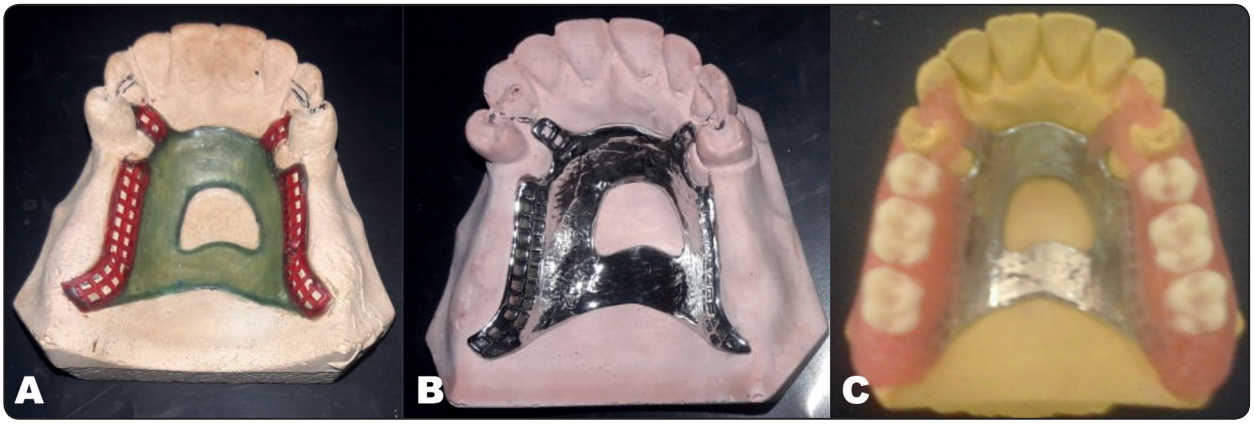

Fig (1): A) Wax pattern. B) Cobalt chromium major connector and meshwork. C) Bre FLEX clasp and denture base.

Group III: Partial denture with Polyoxymethylene clasp assembly and denture base (Acetal).

Group IV: Partial denture with polyamide clasp assembly and denture base (Valplast).

Setting up of the artificial teeth was done for the 40 models taking into consideration the standard guidelines for setting up of teeth.

Injection moulding technique was the technique of choice for all the flexible materials in the four studied groups. This was done as follows:

First, spruing of the wax pattern was done with multiple sprews before the injection moulding procedure was done. The casts with the wax pattern was invested in a mould using its special investment material (Brevest, Bredent, HmbH, Germany)

The material was supplied as granules which was used for the injection moulding method where the thermopress 400 injection moulding system was used to preheat and press the material according to the set programs. Each cartridge was filled with 25 grams of the pressed granules. The mould was heated first to melt the wax. The temperature and pressure of the thermopress machine was adjusted according to the material used in each of the four groups as recommended by the manufacturer and then it was vacuum pressed into the mould cavity under the recommended pressure.

After the injection process was finished, any excess material remaining in the injection channel was removed to avoid any residual material from being injected into the mold cavity together with the material during the next injection process. Finishing and Polishing were made with pumice powder and brush then with the high luster polishing paste with the cotton polishing buff.

Retention measurement

Before performing the retention test. The models are placed in programable controlled chewing simulator (Four-stations multimodal ROBOTA chewing simulator) integrated with thermo-cyclic protocol operated on servo-motor (Model ACH-09075DC-T, AD-TECH TECHNOLOGY CO., LTD., GERMANY). Each partial denture sample was fixed to Jakobe's chuck of the upper part of the machine through inverted t-shaped auto-polymerizing acrylic resin (Caulk, Dentsply) centrally positioned on a horizontal bar between the 2nd premolar and 1st molars to facilitate the aligning with the loading axis of machine and proper load distribution **(Figure 2).**

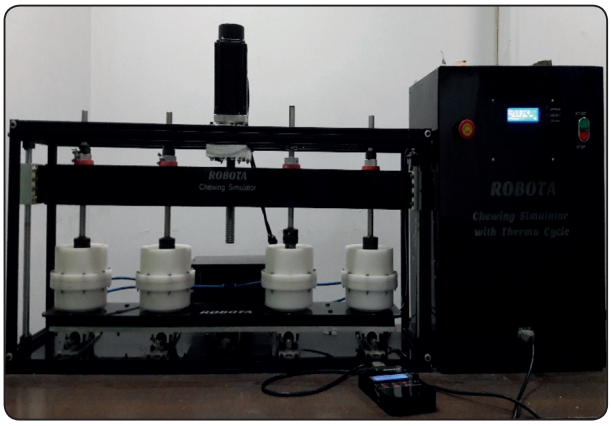

Fig. (2): Four-stations multimodal ROBOTA chewing simulator

The machine allowed the placement of the clasp to its predetermined terminal position and its subsequent removal from the abutment, thus simulating the placement and removal of the partial denture. The models with the partial denture were mounted in a housing in the lower holder of the chewing simulator.

The test conditions were maintained at room temperature (20±2 °C) and wet condition (distilled water). To analyze the data obtained during the simulation test, intervals every 360, 720, 1440 and 2880 cycles were established, representing the simulated insertion and removal of the partial denture over 3, 6, 12 and 24 months, estimating that the patient would perform four insertion and removal per day.

For the retention measurement, the universal testing machine was used as follows: Each sample was attached to the machine through centrally positioned horizontal inverted t-shaped auto-polymerizing acrylic resin bar that was previously constructed **(figure 3).** The model was then attached to the teflon housing in the lower holder of the chewing simulator A tensile load with pull out mode of force was applied at a crosshead speed of 5 mm/min. The load required to totally dislodge sample was recorded in Newton **(figure 4).**

RESULTS

Statistical analysis was performed by using SPSS 24, graph pad prism and windows excel. Retention results were explored for normality by checking the data distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests and revealed normally distributed data. Results were presented as mean (Newton) ± standard deviation (SD) to evaluate retention at each interval. Also, the data was presented as MD (Mean difference) ± Standard deviation (SD) to evaluate changes in retention between different intervals in all groups. **(Table 1, Figure 5,6)**

Evaluation of retention

Mean ± standard deviation of retention in all groups were presented in **table (1)** and **figure (5)**, Comparison between different groups was performed using One Way ANOVA test which revealed significant difference in all intervals, followed by Tukey's Post Hoc test for multiple comparisons which revealed significant difference in means with different capital superscript letters as $P < 0.05$, while revealed insignificant difference in means with the same capital superscript letters as $P > 0.05$, (PEEK was significantly the highest then Bre-Flex, Acetal and Valplast was the lowest with insignificant difference between them).

Also, comparison between different intervals using One Way ANOVA test revealed significant difference as $P < 0.05$ in all groups, followed by Tukey`s Post Hoc test which revealed significant difference in means with different small superscript letters as $P < 0.05$, while revealed insignificant difference in means with the same small superscript letters as $P > 0.05$.

Retention changes

Mean difference (MD) ± standard deviation of retention changes between baseline and each interval in all groups were presented in table (2) and figure (6), Comparison between different groups was performed using One Way ANOVA test which revealed significant difference in all intervals, followed by Tukey`s Post Hoc test for multiple comparisons which revealed significant difference

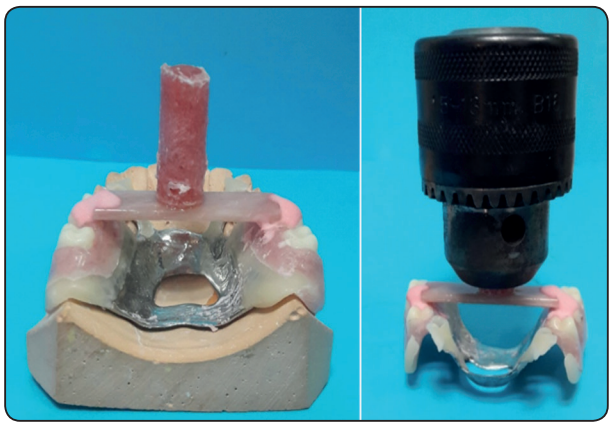

Fig. (3): Inverted t-shaped auto-polymerizing acrylic resin

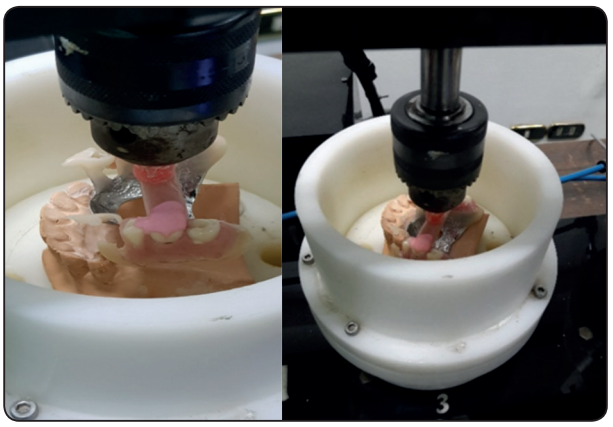

Fig. (4): Model attached to the Teflon housing in the lower holder of the chewing simulator

in means with different capital superscript letters as $P < 0.05$, while revealed insignificant difference in means with the same capital superscript letters as $P > 0.05$,

Comparison between different intervals (360, 720, 1440 and 2880 cycles) in all group showed that baseline recorded significantly the highest mean value followed by 3 months and 6 months then 9 months while the lowest retention value recorded at 24 months.

Comparison between different groups (PEEK, Bre-Flex, Acetal and Valplast groups) showed that group I (PEEK) recorded statistically the highest mean value followed by group II (Bre-Flex), group III (Acetal) then group IV (Valplast) respectively.

After 2880 cycles (12 month simulation), it was also found that the mean difference comparison between group I and II showed statistically significant values with higher values for the PEEK group while the mean difference comparison between group III and IV showed non-significant results but with higher values for group III.

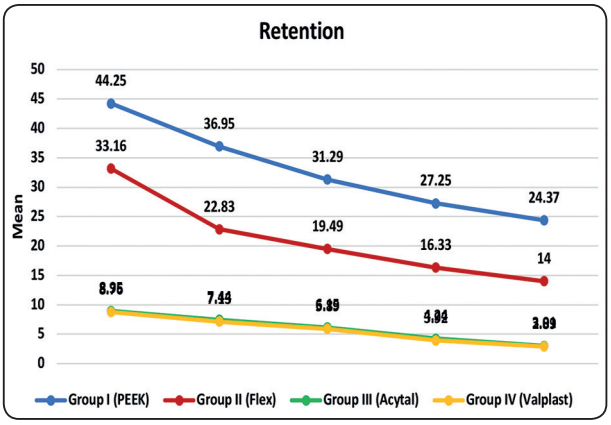

Fig. (5): Line chart representing retention at different follow up visits in all groups

TABLE (1): Mean ± standard deviation of retention in all groups at baseline, after 3 months, after 6 months, after 9 months & after 12 months:

Evaluation time	Group I (PEEK)		Group II (Bre-Flex)		Group III (Acetal)		Group IV (Valplast)		P value
	M	SD	M	SD	M	SD	M	SD	
Baseline	44.25 ^{Aa}	10.46	33.16 ^{Ba}	1.85	8.95 ^{Ca}	0.92	8.76 ^{Ca}	0.81	<0.0001*
3 months (360 cycles)	36.95 ^{Ab}	8.73	22.83 ^{Bb}	1.08	7.44 ^{Cb}	0.23	7.13 ^{Cb}	0.21	<0.0001*
6 months (720 cycles)	31.29 ^{Ab}	7.4	19.49 ^{Bc}	1.08	6.15 ^{Cb}	0.4	5.89 ^{Cb}	0.35	<0.0001*
9 months (1440 cycles)	27.25 ^{Ac}	6.44	16.33 ^{Bd}	2.09	4.24 ^{Cc}	0.47	3.92 ^{Cc}	0.42	<0.0001*
12 months (2880 cycles)	24.37 ^{Ac}	5.76	14 ^{Bd}	1.4	3.01 ^{Cd}	0.44	2.89 ^{Cd}	0.32	<0.0001*
P value	<0.0001*		<0.0001*		<0.0001*		<0.0001*		

M; Mean, SD; Standard Deviation, P; Probability Level

Different lowercase letters in same column indicating significant using Tukey`s post hoc test (p<0.05)

Same lowercase letters in same column indicating insignificant using Tukey`s post hoc test (p>0.05)

Different uppercase letters in same row indicating significant using Tukey`s post hoc test (p<0.05)

Same uppercase letters in same row indicating insignificant using Tukey`s post hoc test (p>0.05)

****; significant (p<0.05)***

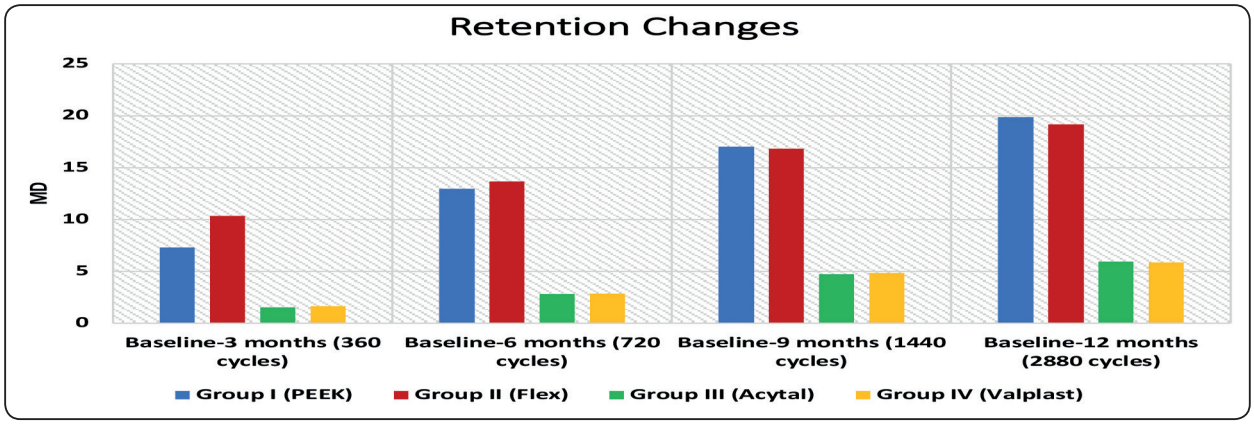

Fig. (6): Bar chart representing retention changes at different intervals in all groups

DISCUSSION

The main complaint from the removable partial denture is the bad aesthetics of the metallic framework and direct retainers, so all the thermoplastic denture base materials aimed to solve the esthetic problem of the chrome cobalt definitive removable partial denture. Aesthetics is not the only consideration when dealing with removable partial dentures, but also mechanical considerations is important. The retentive clasp arm must be capable of engaging the undercuts and returning to their original position for long time without permanent deformation and at the same time minimizing the unfavorable lateral stresses on the abutment [21, 22, 23].

Regarding retention, most researchers revealed that the retention with CoCr alloy clasps is remarkably greater than thermoplastic materials. One of the important factors for enhancing retention is the creation of appropriate guiding plane on the proximal surfaces of the abutment teeth. Also, the clinical experience indicates that ineffective reciprocation may result in lack of both retention and stability [24,25].

In this study, the major connectors and the meshwork were constructed from Cr-Co alloy in the four groups, then denture base and direct retainers were constructed from different thermoplastic materials in order to evaluate the retention of each material. This combination between Cr-Co and thermoplastic material provided adequate strength for the prosthesis [26,27].

The results of this study showed that PEEK has statistically significant higher retention values when compared to the other three types of thermoplastic materials (BRE FLEX, Acetal and Valplast). This is in accordance with many researches which proved that PEEK has superior mechanical properties and is more stable even at high temperature with high stiffness and good chemical stability which might be the cause of higher retention values than the other thermoplastic materials [28,29]

Also, the study showed that Bre-flex came next to the PEEK in retention values, but higher than Acetal. This might be due increased flexibility that enables it to engage deeper undercuts [30].

Moreover, the results showed that Acetal and Valplast groups had the lowest retention mean value when compared to the PEEK and Bre-Flex with insignificant difference between them. This may be due to their higher impact strength which make it prone to retention loss easily by time due to repeated insertion and removal. Also due to the inherent high impact strength of valplast, most authors recommended to engage shallower undercut to avoid rapid loss of retention by time [31]

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