

Effect of CAD/CAM PolyEtherEther Ketone versus Conventional Cobalt Chromium Kennedy's Class I Removable Partial Dentures on Gingival Health and Patient's Satisfaction

RM Akrim¹, NM Harby², BA El- Wakeel³, OA Baraka⁴

¹M.D.S 2018 G, Faculty of Dentistry, Mansoura University, Egypt

²Associated Professor of Removable Prosthodontics, Faculty of Dental Medicine (Cairo, Boys), Al-Azhar University

³Lecturer of Removable Prosthodontics, Faculty of Dental Medicine (Cairo, Boys), AlAzhar University

⁴Professor of Removable Prosthodontics, Faculty of Dental Medicine (Cairo, Boys), AlAzhar University

Abstract

To study the effect of CAD/CAM polyetherether ketone (PEEK) versus conventional cobalt chromium kennedy's class I removable partial dentures (RPD) on gingival index, pocket depth and patient's satisfaction. Twenty partially edentulous patients with mandibular Kennedy's Class- I were selected. The patients were classified randomly into two group (Ten patients in each group). Group 1: Patients received cobalt chromium RPD. Group 2: Patients received PolyEtherEther ketone RPD. Evaluation of gingival index, pocket depth and patient's satisfaction were carried out clinically at the time of insertion, six, twelve and eighteen months later for each patient. Analysis of the results revealed significant difference between the two types of denture frameworks ($P < 0.05$), the Co-Cr denture framework showed higher gingival index and pocket depth that increased by time. While for patient's satisfaction polyetherether ketone RPD framework was more satisfactory. Within limitation of this study Polyetherether ketone partial denture framework had better biological effect on soft tissues than Co-Cr partial denture framework. Also, Polyetherether ketone RPD was more satisfactory for the patient.

Keywords: PEEK, Pocket depth, Gingival index, Patient's satisfaction, Kennedy's class I

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1. Introduction

Removable partial denture (RPD) is considered as an acceptable and economical treatment modality for patients with partially edentulous arches [1]. Many longitudinal studies were accomplished on their effects on the oral health and the periodontium of the abutment and non-abutment teeth [2]. Materials used in construction of RPD play a major role in the periodontal health of the abutment teeth and alveolar ridge. Several clinical studies have reported that acrylic removable prosthesis tends to develop significant damaging effects on the periodontal status of abutment teeth more than the cast metal removable partial dentures [3]. Biocompatible metal such as cobalt chromium is a widely used material for RPD frameworks. Metal -based frameworks have many advantages as they provide high strength and so could be used in thin sections [4]. They have good thermal conductivity for more natural experience. However, esthetic problems with metal

display, hypersensitivity, oral galvanism and adverse tissue reactions are recorded with metallic RPDs and increasing the demand for non- metallic frameworks [5]. Polyetheretherketone (PEEK), a member of the polyaryletherketone (PAEK) family, possesses a high biocompatibility, excellent mechanical characteristics, a high chemical stability, and a high temperature resistance. Due to its high flexibility, PEEK RDPs induce less stress on abutment teeth and may be less prone to deformation or fracture than standard alloy counterparts. PEEK furthermore possesses a low weight and allows for an individual to adapt the clasp color to the patients' natural tooth color [6]. Digital dentistry in general utilizing computer-aided design computer-aided manufacturing (CAD/CAM) technology, high precision and scanners, mass industrial casting and production techniques are predicted to enhance the fit, esthetics, and functional

components of RPDs while reducing costs and effort, hence increasing potency and manufacturing outcomes [6]. A newly introduced CAD/CAM PEEK requires investigation. Therefore, this study was done to evaluate the effect of CAD/CAM (PEEK) RPD frameworks on gingival index, pocket depth and patient satisfaction.

2. Materials and Methods

Twenty patients with lower Kennedy's class I edentulous ridges were selected for this study. They were randomly divided by flip coin methods into two groups. Group I: Patients received cast cobalt chromium frameworks. Group II: Patients received CAD/CAM (PEEK) frameworks fabricated by milling technique.

2.1. Clinical procedures of denture construction

2.1.1. Pre-prosthetic mouth preparation

Panoramic x-ray with full mouth examination. Surgical preparation such as extraction of teeth with poor prognosis. Periodontal preparation such as scaling, root planning and elimination of gross occlusal interferences by selective grinding procedure were made when needed. Then oral hygiene instructions were given for each patient.

2.1.2. Prosthetic procedures

For each patient of both group Preliminary irreversible hydrocolloid alginate impressions (Cavex, Holland) were made in a properly selected stock tray for upper and lower arches for each patient. Mouth preparations were carried out as determined on the primary casts. These preparations included: Guide planes were prepared on the proximal and lingual surfaces of the selected abutments. The guiding planes were made at distal surfaces of the abutment teeth. Occlusal rest seats were prepared on the mesial surfaces of the abutment anterior to the edentulous ridge. Preparation of the occlusal rest seat was kept within the thickness of the enamel in the form of saucer shape. The border of the special tray was traced using low fusing compound. The secondary impression was made using silicon medium body rubber base (Thixoflex® M – C. Zhermack®).

2.1.3. For cobalt chromium frameworks construction

The design of the partial denture was drawn on the master cast according to surveying results then cast block out and relief by wax was done. This was followed by duplication of the master cast to obtain the refractory cast on which the wax framework was fabricated. Wax pattern was done by readymade wax pattern for cobalt chromium (Crowax; Renfert GmbH). The wax pattern was sprued. The refractory cast with the wax pattern and attached sprue were invested in a casting ring (BEGO, Germany). Wax elimination was done in burnout oven (Thermopaste 400, Bredent, Senden, Germany). Casting the mold by centrifugal machine in cobalt chromium alloy and then finishing and polishing of framework was carried out. Then the framework checked on the master cast followed by try in intraorally. Fig (1).

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2.2. CAD/CAM PEEK framework construction

The mandibular definitive cast was fixed on the scanner table and scanned using the 3D scanner (Medit T300, Korea) to obtain the standard triangulation lithographic (STL) file format which was then imported into the CAD software used in this study (ExoCad) to start the designing process and then virtual definitive cast was done. Secondary surveying of the virtual definitive cast was performed digitally according to the selected path of insertion then all undesirable undercuts were blocked out. All components of the framework were selected from a menu and placed in the correct position in the form of a spine of points Fig (2). The width and thickness of any part of every component can be changed at these points. Lingual plate were selected and placed on the virtual model in usual manner. Rests, minor connectors, finish lines were placed according to principles of RPD design in distal extension cases. Based on the contour of the surveying line, the trajectory of the clasp was "delineated". Aker arm was designed to engage .02 inch retentive undercut with only its superior border is allowed to contact the tooth at the survey line and the remaining of the clasp arm was relieved. The whole framework design was checked from all surfaces after finishing and smoothening. A stereolithographic resin pattern of the framework was made using rapid prototyping technology to evaluate the fitting of the designed framework intraorally before milling. After the fitting of the 3D printed framework was found satisfactory intraorally, it was imported into the milling machine (Ceramill Motion 2, Amann Girrbach) to begin the milling process out of medical grade PEEK dental discs (Bio-HPP, Bredent, Germany). The PEEK framework was checked on the master cast then finished and tried intraorally to check its fitting. Fig (3). After that, acrylic resin custom tray was made over the edentulous ridge for both frameworks, Then selective pressure impression was made for purpose of correcting the master cast. The resultant altered cast was used to complete the partial denture. Jaw relation was recorded then denture base extension was checked. The vertical dimension and centric occlusion were evaluated using key teeth as guide and were corrected when indicated. Try in of the denture was done intraorally. Processing of waxed partial denture using heat cured acrylic resin (Stellon, DeguDent GmbH, England), finishing and polishing were carried. Partial denture was checked out the patient mouth and checked intraorally for retention, stability and extension. The patient was recalled after twenty-four hours for checkup.

2.2.1. Clinical observation

Pocket depth

The gingival tissue around the abutment were isolated and gently dried by a piece of gauze, and then each surface was individually scored. The pocket depths were recorded using graduated periodontal probe to the nearest millimeter on 6 surfaces of the terminal abutment: mesio-buccal, mid-buccal, distobuccal, mesio-lingual, disto-lingual and mid-lingual. The periodontal probe was held parallel to the long axis of the tooth and pocket depth was measured from the gingival margin to the bottom of the pocket using

gentle pressure. The meaning of the six measurements was calculated.

2.2.2. Gingival health

Gingival index

Modified gingival index for the abutment was recorded according to (Loe and Silnes; 1963) [4] as follows: - Score of 0: absence of inflammation/Normal gingiva. - Score of 1: Mild inflammation, slight change in color, slight edema and no bleeding on probing. Score of 2: Moderate inflammation, moderate glazing, redness, edema, hypertrophy and bleeding on probing- Score of 3: Severe inflammation, marked redness and hypertrophy, ulcerations and tendency to spontaneous bleeding.

2.2.3. Overall patient satisfaction

Patients were asked to first grade their dentures in general, and then they were asked to provide separate grades on the retention, aesthetics, ability to speak and ability to masticate with their RPD. - Patients graded their satisfaction by using an analogue scale ranging from 0 to 3 score: - Score of 0: Not satisfied. - Score of 1: Satisfied, level is adequate. - Score of 2: Satisfied, level is good. score of 3: Satisfied, level is very good.

2.3. Data management and analysis

Data was collected, tabulated and statistically analyzed. One-way anova was done for the clinical changes around abutments by time. Group t - test was done to test the difference between the two groups.

3. Results and discussion

The mean, standard deviation and p value of group t-test of gingival index are shown in table (1). The recorded mean and standard deviation values of gingival index in relation to the abutment for both cobalt chromium and PEEK group were (0.25±0.19 and 0.15±0.08) after 6 months, (0.90±0.42 and 0.35±0.11) after 12 months, (1.85±0.54 and 0.80±0.17) after 18 months follow-up periods respectively. The results showed statistically significant higher scores of gingival indexes in relation to Cobalt Chromium group when compared to Polyether ether ketone group (p<0.01). Table (1). The mean, standard deviation, and p value of group t-test of pocket depth are shown in table (2). The recorded mean and standard deviation values of pocket depth in relation to the abutment for both cobalt chromium and PEEK group were (1.95±0.92 and 0.75±0.40) after 6 months, (2.75±0.91 and 1.40±0.54) after 12 months, (4.05±0.80 and 2.10±0.90) after 18 months follow-up periods respectively. There was statistically significant increase of Pocket depth values in relation to Cobalt Chromium group when compared to Polyether ether ketone group (p<0.01). Table (2). Statistically significant higher mean values of average patient's satisfaction scores in relation to polyether ether ketone group (2.18±0.24) when compared to cobalt chromium group (1.73±0.18) (p<0.001). Table (3) shows statistically significant higher satisfaction scores for the PEEK RPD group as regards the esthetic Akrim et al., 2023

appearance when compared to the Co-Cr RPD group P<0.01. There were insignificant differences (P>0.05) between the two groups as regard to retention, speech, and masticatory function. In the current study, patients were treated with RPDs to restore function and improve their quality of life. Campbell et. al. [4] stated treatment with RPDs should ideally result in improvements in overall oral health, patient satisfaction, and compliance. Design, materials, ease of repair, patient education, and follow-up for RPD treatment all are pragmatic issues that have a significant impact on treatment success. As regards gingival index related to the abutment tooth the results showed statistically significant difference (at 6, 12 and 18 months for the abutment) between the two groups. CoCr denture framework showed higher gingival index median values than that of PEEK framework, but this is in the favor of PEEK. Taimur stated that wearing Co–Cr RPDs was shown to be related to a higher prevalence of plaque, gingivitis, gingival recession, and a higher incidence of root caries [7]. The results of this study showed an increase in gingival index and pocket depth by time in both groups. Removable partial denture in the mouth has the potential of increase plaque formation on tooth surface in contact with RPD, especially to abutment teeth to which clasps or attachments are attached due to forces transmitted by the clasps may cause destruction to the periodontium, clasps change the flow of food over the tooth surface disrupting the self-cleansing action and preventing the mucus of the lips, tongue and cheeks from measuring the gingival tissues [8]. These results agree with studies found that the periodontal conditions of the teeth adjacent to the dentures were poorer than around those not directly involved in its construction due to food stagnation and difficult oral hygiene caused by the removable partial denture components. In addition, removable partial denture might sink into the soft tissues causing bone resorption [9, 10]. These results agree with a clinical study conducted to investigate the effects of cobalt chromium removable partial denture on oral tissues. The patient's dental, periodontal and mucosal statuses were assessed. However, a high prevalence of plaque, gingivitis, and gingival recession were found especially in dentogingival surfaces in close proximity (within 3 mm) to the dentures. Thus, there was a special need for regular oral hygiene reinforcement, scaling and prophylaxis among removable partial denture wearers [8]. It could be argued that a larger, bulkier clasp design would be detrimental to oral health by contributing to plaque accumulation. However, if plaque control is established and the patient presents for regular recall visits, there is no evidence suggesting that any harm will result [11]. Descriptive statistics of the results regarding overall patient's satisfaction revealed that group I (cobalt chromium) recorded lower mean value than group II (PEEK) at insertion and after 6,12 and 18 months. This could be because achieving optimal superior esthetics usually takes place by utilizing PEEK clasps since their color matches with that of teeth, and it was documented for high ability to eliminate appearance of metal clasps, which improve esthetics [12]. These results agree with a study that reported that thermoplastic RPDs without metal elements provided higher patient satisfaction than conventional metallic RPDs [13]. Also, it agreed with Fueki et al. [14] who compared thermoplastic RPDs and conventional RPDs with regards to

Table 1. Mean and SD values of gingival index when comparing between the two groups at different times ($p < 0.05$)

gingival index	After 6 months Mean± SD (in mm)	After 12 months Mean± SD (in mm)	After 18 months Mean± SD (in mm)	F-ratio	p-value
Cobalt chromium	0.25±0.19	0.90±0.42	1.85±0.54	15.23	<0.001*
Polyetherether ketone	0.15±0.08	0.35±0.11	0.80±0.17	10.104	<0.001*
t-value between groups	-1.534	-4.006	-5.865		
p-value	0.142	<0.001**	<0.001**		

Table 2. Comparison between Cobalt chromium and Polyether ether ketone groups according to Pocket depth measurements at different times.

Pocket depth	After 6 months Mean± SD (in mm)	After 12 months Mean± SD (in mm)	After 18 months Mean± SD (in mm)	F-ratio	p-value
Cobalt chromium	1.95±0.92	2.75±0.91	4.05±0.80	12.43	<0.001*
Polyetherether ketone	0.75±0.40	1.40±0.54	2.10±0.90	9.236	<0.001*
t-value between groups	-3.783	-4.034	-5.121		
p-value	<0.001**	<0.001**	<0.001**		

t-Independent sample t-test p -value > 0.05 is insignificant * p -value < 0.05 is significant: ** p -value < 0.001 is highly significant.

Table 3. Comparison between Patient’s satisfaction for the studied groups

Patient’s satisfaction	Cobalt chromium	Polyether ether ketone	Test value	p-value
Retention	2.00±0.67	1.90±0.32	0.429	0.673
Aesthetics	0.60±0.52	2.60±0.52	-8.660	<0.001**
Speech	2.00±0.00	2.00±0.00	0.000	1.000
Masticate	2.30±0.48	2.20±0.42	0.493	0.628
Average	1.73±0.18	2.18±0.24	-4.736	<0.001**

Using: t-Independent Sample t-test for Mean±SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p value <0.001 is highly significant .



Figure 1. Insertion of Co/Cr RPD

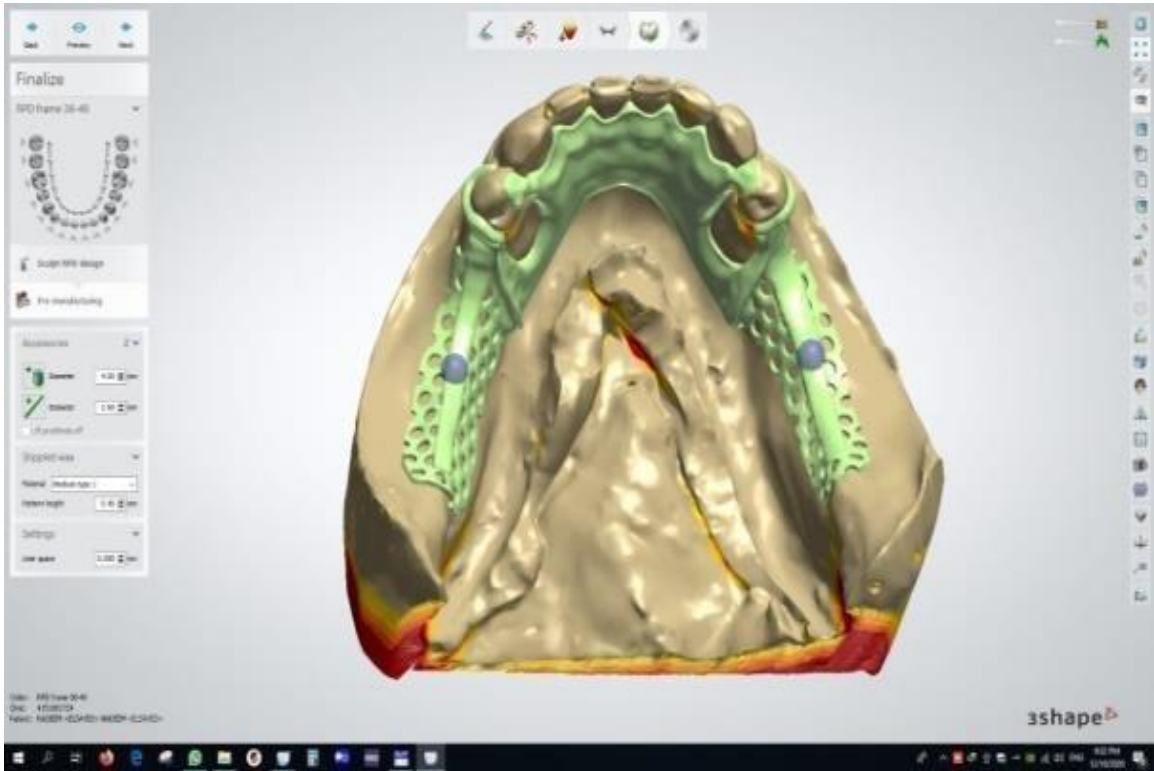


Figure 2. All components of the RPD framework were selected



Figure 3. Insertion of PEEK RPD

both clinical and patient-reported outcomes. They reported that patient satisfaction and self-rated oral appearance was higher with thermoplastic resin RPDs than metal clasp retained RPDs. Curinga et al. [15] compared patient preference and satisfaction of PEEK frameworks partial denture and metallic partial denture. They concluded that PEEK RPD holds an advantage over metallic RPD in terms of oral appearance and over greater satisfaction. In this study, patients were more satisfied with PEEK frameworks, which was in accordance with Skirbutis et. al. [16] who mentioned that mechanical properties of PEEK are similar to dentin and enamel, thus it has superiority over metal alloys and ceramic restorations, as PEEK has high fracture load resistance, it is suitable for producing frames. Harb et. al. [17] also concluded that, the low specific weight of PEEK material permits the fabrication of lighter prostheses with good functionality; this is in agreement with the results of our study. On the contrary, a study by Zoidis et. al. [18] who found that, in the absence of more clinical studies along with some concerns about PEEK's behavior under fatigue stresses during use, suggests that it should still be used with caution and yet cannot be recommended as an alternative to cobalt chromium frameworks.

4. Conclusions

From this study, we can conclude that: PEEK clasps were superior to cobalt-chromium clasps in terms of lower gingival and pocket indices. PEEK material increases patients' satisfaction with RPDs than the conventional metal framework material in relation to esthetic appearance.

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