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# Clinical and radiographic comparison between cobalt chromium and polyetheretherketon removable partial dentures in mandibular Kennedy's class II with posterior implant placement: A crossover study

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***Abstract***
***Aim:*** *This study was conducted to compare the effect of different denture framework materials (Cobalt Chromium (Co-Cr) &Polyetheretherketone (PEEK)) on bone resorption, gingival index and pocket depth in relation to the (abutment and implant)in Kennedy's class II removable partial dentures with posterior implant placement.*
***Subjects and methods:*** *Ten partially edentulous male patients, mandibular Kennedy's class II opposed by maxillary natural teeth or restored with fixed restoration, were selected. Each patient received partial over-denture supported by a single implant in the area of 2nd molar tooth. Each patient received the two types of dentures alternatively. At the first year 5 patients received an implant-supported partial over-denture with a metallic framework, then at the 2nd year they received the same denture design but with PEEK framework. The other five patients received RPDs with PEEK framework at the 1st year and metallic framework at the 2nd year. A relief period of 2 weeks was given before the exchange of RPDs. Evaluation of bone resorption, gingival index and pocket depth in relation to the abutment and the implant was carried out radiographically and clinically at the time of insertion, six and twelve months later for each denture type.*
***Results:****Analysis of the results revealed significant difference between the two types of denture frameworks in relation to the abutment and the implant (P< 0.05) at 12 months, the Co-Cr denture framework showed higher gingival index scores that increased by time. While for bone resorption and pocket depth there was no significant difference between the two framework types.*
***Conclusion:****Within limitation of this study PEEK partial denture framework had better biological effect on soft tissues (lower MGI scores) than Co-Cr partial denture framework. While it showed no significant difference regarding crestal bone loss and pocket depth.*
***Key words:*** *PEEK, partial overdenture, gingival index, pocket depth.*

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## I. Introduction:

One of the major benefits of RPDs for patients who have lost posterior teeth is a noninvasive and cost-effective method of improving masticatory performance. Since the 1930s, partial denture frameworks had generally been made from metallic alloys and resin polymers such as Cobalt-Chromium and Polymethylmethacrylate. However, the main limitations of these materials over the last 15 years are related to their biocompatibility and long term performance[(1)].

Recent advancements in the field of dental materialsand the development of newer and different forms of denture base materials have allowed denture base resins to overcome some of these drawbacks. For example, PEEK based materials have been developed to overcome the mucosal irritation and polymerization shrinkage that is associated with the conventional (PMMA) resins[(2)].

PEEK is a good alternative to conventional dentures, which not only provide better aesthetics and security but also the material is strong and flexible[(3)].The main problem with mandibular distal extension RPDs is of biomechanical origin. Occlusal forces move the saddle into a tissue-ward direction due to absence of distal support, compromising the anterior abutment teeth in addition to potentially destructive rotational forces[(4)].

A number of authors have reported the placement of a distal implant associated with a removable partial denture to make this restoration more stable. This strategy may represent an option for resolving the problem of the intrusive movements of the PRDs and for reducing treatment costs[(5)].

Pocket probing is an essential procedure in diagnosis of the peri-implantitis and for the evaluation of its therapy[(6)]. Probing pocket depth and bleeding on probing, are reliable indicators of the peri-implant tissue conditions. Probing pocket depths around dental implants often exceed 4 mm without the presence of any pathology. Hence, it is recommended to perform a baseline evaluation, including a periodontal pocket chart and radiographic assessment, at the time-point of prosthetic restoration to allow the long-term discrimination between peri-implant health and disease[(7)].

Probing depths around the teeth should be within normal limits (3-4 mm) and it can be measured by periodontal probe and optical coherence tomography[(8)].Early crestal bone loss is defined as a bone resorption around dental implant neck within 1 year post loading. Due to its frequency, the certain amount of bone loss is becoming a standard. 1.5 mm of bone loss at the 1 year after loading can be considered as a success, if later bone loss does not exceed 0.2 mm annuallyas reported by Albrektsoon et[(9)].

After the first year of function, crestal bone loss up to or beyond the first thread of titanium screw implants, characterized by "saucerization," is often observed radiographically (V or U shaped) round the implant. Many possible etiologies of early crestal bone loss around implants (from implant placement to 1-year post-loading) including surgical trauma, occlusal overload, peri-implantitis, the presence of microgap, reformation of biologic width and implant crest module[(10)].

Bone resorption, gingival index and pocket depth in relation to the (abutment and implant) in Kennedy's class II removable partial dentures with posterior implant placement were evaluated in this study to compare between the effects of the two framework types.

## II. Patients And Methods:

This study was a randomized crossover clinical study. Ten partially edentulous (mandibular Kennedy class II) male patients were selected for partial denture construction and implant placement, from those attending the outpatient's clinic of Removable Prosthodontic Department, Faculty of Dental Medicine, Al – Azhar University, Cairo, Boys.

The selected patients were ranging from 41-50 years old, free from any systemic disease or neuromuscular disorder that might affect their bite force, free from any temporo-mandibular joint disorder and with normal occlusal relationship, had their maxilla in complete set of teeth or restored by fixed, and the remaining natural teeth had apparently good periodontal condition. All patients had sufficient bone volume at the mandibular molar regions, covered with normal thickness of muco-periostium and showing no signs of inflammation or ulceration. Patients with history of drug therapy interferes with bone resorption or deposition, immuno-compromised patients, patients with current chemotherapy or radiotherapy, hemophiliac disorders, physical and mental disabilities which interfere with the maintenance of implants, severe skeletal jaw discrepancies, severe clenching habits, patients who have already received or lost implants, current or previous smokers were excluded. All selected patients were informed about the nature of this research and their informed consents were obtained.

After thorough mouth examination of both hard and soft tissues cone beam ct. (Dentsply, Sirona, Germany) was carried out for each patient on the mandibular edentulous posterior segment to assess bone width, length and density of the second molar area. Only patients with adequate bone were selected.

Thorough scaling of all the remaining teeth was done. After selection of suitable tray size and establishment of any required modifications, accurate primary alginate (Cavex, Holland) impressions for both arches were made. The impressions were poured with die stone (Chera, Germany) to get the study casts, and then mandibular acrylic special tray was constructed. Border molding using green stick compound (Pyraxpolymars, India) was made and a secondary impression was made using rubber base impression material. The impression was poured with dental stone. Maxillo-mandibular relationship was determined for each patient using mandibular unilateral record block. Artificial teeth (Acrostone, cross linked acrylic teeth, Egypt )were arranged and tried in the patient's mouth. Acrylic partial dentures were constructed with maximum teeth intercuspation, processed in conventional method to make temporary partial dentures that used by the patients during osseointegration period.

Vacuum formed(Bioart, Brazil )hard clear tooth supported surgical guide was constructed with a hole drilled in 2$^{nd}$ molar area (by the aid of pre stetted acrylic teeth of suitable size) to act as a guide to the implant (Implance, Turkey) site during the following surgical step and disinfected. A prophylactic antibiotic dose was prescribed. Surgery was carried out in two stages under local anesthesia on the dental chair. Post-operative instructions and follow up were made and the patient was asked to maintain good oral hygiene. Panoramic radiograph was made to assure correct implant position. After seven days the sutures were removed and the denture was relieved over the surgical area and relined with tissue conditioning material. After three months

each patient was recalled and the implant was exposed using tissue punch drill under local anesthetic coverage followed by cover screw removal and ball abutment with suitable gingival height was installed.

**Partial denture construction:**

After surveying the study cast, the framework was drawn and the areas to be prepared were marked on the cast. Then Tripoding was done to transfer the three anatomical points marked on the study cast to the upcoming master cast. RPI (mesial occlusal rest, distal proximal guiding plane and I bar) clasp was placed on the premolar tooth adjacent to the free end saddle. Embrasure clasp (two occlusal rests, two bracing arms, two retentive arms and one minor connector) was placed on the opposite side. Lingual plate major connector was used for both denture types.

Special tray was constructed using the previously made mandibular study cast. After mouth preparation border molding was done using green stick compound and an accurate impression was made using rubber base impression material for construction of master cast. Then the master cast was placed on the surveyor in the previous tilt position using the previously made tripoding marks. Then the survey line was drawn and the design transferred to the master cast.

Scanning process was done to the master cast using lab desktop 3d scanner (Medit T300, Korea). The resulting STL model file was exported to partial denture module of Exocad software (Exocad 2.2 Valletta, Exocad GmbH, Germany). In Exocad partial window the model was adjusted in the predetermined path of insertion and virtual undercut blocking was done. Then partial denture framework was designed. STL file of partial denture framework was exported to the CAM software (Chito, Korea.) to add support and to make slicing to the supported framework resulting in SLC file format which was processed by the 3d printer (Phrozen shuffle, Taiwan) to print the framework twice (one for PEEK and the second for Cobalt Chromium frames) for each patient. Castable resin was used for this purpose.

The 3d printed frameworks were rinsed, cleaned and light cured. After post processing all supports were removed and the resin frame was cleaned and then checked on the master cast for any interference. Using lost wax technique, Cobalt Chromium (BEGO, Germany) framework was fabricated using casting machine (BEGO, Germany) while PEEK (Bio-HPP, Bredent, Germany) framework was fabricated using pressing machine (For 2 Press machine, bredent, Germany).

Interocclusal wax record was made in maximum intercuspation using record block. The casts were mounted on semiadjustable articulator. Setting of the artificial teeth, try in, processing, finishing, polishing and occlusal adjustments were performed to accommodate processing discrepancies then delivered to the patients. After final adjustment of the two dentures, conventional loading protocol (two stage delayed occlusal loading) was followed using ball abutment and metal housing in direct pickup technique.

Grouping was done randomly by coin flipping method in two equal groups(5 each).Patients of group I received Co-Cr implant-supported partial over-denture while patients of group II received the same partial over-denture design as group I, but in PEEK material.The patients were allowed to wear the dentures then comparison parameters were evaluated at insertion, after six months and one year for each patient .After one year the patients were instructed not to wear the dentures for at least two weeks as a wash out period and oral hygiene measures include scaling and polishing were done after patient motivation.New impressions were made and new dentures were constructed as mentioned before and each patient received the other type of denture and wore it for another year during which comparison parameters were evaluated at insertion, after six months and one year.

**A) Clinical observation:**

**Pocket depth:**

The gingival tissue around both implants and abutments 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, disto-buccal, 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 mean of the six measurements for each patient was calculated and recorded.

**Modified Gingival Index (MGI):**

Modified gingival index described by Lee and Silness (1963) was used as an indicator of periodontal status by multiple authors [(11)].

Modified gingival index for both the implant and the abutment were recorded according to (Lee and Silness) as follows:

Score 0: Normal gingiva.

Score 1: Mild inflammation; slight change in color, slight edema but no bleeding on probing.

Score 2: Moderate inflammation, redness, edema, and bleeding on probing.
Score 3: Sever inflammation; marked redness and edema, ulceration, tendency to spontaneous bleeding.

**B) Radiographic observation:**

Digital panoramic radiograph was made for each patient at time of insertion, six months and after one year for both denture types. Bone length was measured mesial and distal to the implant and the abutment in relation to its apex.Marginal bone loss was measured by subtracting the residual bone length at various intervals from the original bone length at insertion of the denture .

## III. Results:

The mean, standard deviation and p value of group t-test of mesial and distal crestal bone loss, gingival index and pocket depth of the abutment teeth and the implant are shown in table (1).

Analysis of the results revealed no significant difference in bone height between the two types of denture frameworks (P>0.05) for both the abutment and the implant. There was also increase in the marginal bone loss values by time in each type. Changes occurred with time were the same in both types.

**Table (1):**Comparison between Co-Cr and PEEK dentures.

| | | Abutment | | | | | Implant | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Co-Cr denture | | PEEK denture | | P value | Co-Cr denture | | PEEK denture | | P value |
| | | Mean | SD | Mean | SD | | Mean | SD | Mean | SD | |
| Crestal bone loss | Mesial 6m. | 0.74 | 0.28 | 0.64 | 0.28 | 0.45 | 2.16 | 0.71 | 1.96 | 0.61 | 0.51 |
| | Distal 6m. | 0.74 | 0.27 | 0.65 | 0.29 | 0.46 | 2.11 | 0.68 | 1.94 | 0.58 | 0.56 |
| | Mesial 12m | 1.01 | 0.39 | 0.80 | 0.34 | 0.21 | 2.68 | 0.64 | 2.42 | 0.48 | 0.32 |
| | Distal 12m. | 1.03 | 0.38 | 0.79 | 0.34 | 0.15 | 2.65 | 0.67 | 2.40 | 0.46 | 0.35 |
| | Mesial 6m vs.12m. | P value | 0.001** | 0.001** | | | 0.001** | | 0.001** | | |
| | Distal 6m vs.12m | | 0.001** | 0.001** | | | 0.001** | | 0.001** | | |
| Gingival index | Insertion | 0.50 | 0.53 | 0.80 | 0.42 | 0.18 | 0.50 | 0.53 | 0.90 | 0.32 | 0.054 |
| | At 6 m. | 1.30 | 0.48 | 1.0 | 0.47 | 0.18 | 1.40 | 0.52 | 0.80 | 0.42 | 0.011* |
| | At 12m. | 1.60 | 0.52 | 1.10 | 0.32 | 0.018* | 1.70 | 0.67 | 1.10 | 0.32 | 0.02* |
| | Inser vs.6m. | P value | 0.003** | 0.34 | | | 0.004** | | 0.59 | | |
| | Inser vs.12m. | | 0.001** | 0.08 | | | 0.005** | | 0.17 | | |
| | 6 vs. 12 m. | | 0.081 | 0.34 | | | 0.193 | | 0.081 | | |
| Pocket depth | Insertion | 1.55 | 0.90 | 1.60 | 0.84 | 0.90 | 2.20 | 0.79 | 2.40 | 0.70 | 0.56 |
| | At 6 m. | 2.30 | 0.95 | 2.1 | 0.94 | 0.64 | 3.20 | 0.79 | 2.70 | 0.82 | 0.18 |
| | At 12m. | 2.85 | 0.91 | 2.2 | 0.89 | 0.12 | 3.50 | 0.53 | 3.0 | 0.67 | 0.08 |
| | Inser. vs.6m. | P value | 0.001** | 0.032* | | | 0.001** | | 0.081 | | |
| | Inser. vs.12m. | | 0.001** | 0.09 | | | 0.001** | | 0.005** | | |
| | 6 vs. 12 m. | | 0.003** | 0.64 | | | 0.193 | | 0.081 | | |

A significant difference was found between the gingival index of the two types of denture frameworks (P< 0.05) at 12 months for both the abutment and the implant. The Co-Cr denture framework showed higher gingival index scores that increased by time. While there was no significant difference between the two types of denture frameworks (P> 0.05) at insertion.

No significant difference in pocket depth was found between the two types of denture frameworks (P> 0.05) for both the abutment and the implant at insertion, 6 months and 12 months. But there was significant increase in pocket depth in case of Co-Cr framework type by time (P< 0.05).

## IV. Discussion:

Kennedy class II RPD designs have great a challenge to dental professionals because teeth and mucosa respond differently under pressure. The mucosa depresses more than natural teeth under pressure, leading to unfavorable torque on the abutment teeth. With broad application of dental implants, it has become increasingly practical to use implants to improve RPD designs for patients to significantly improve mastication and stability of these prostheses[(12)].

The major connector design in the present study was a lingual plate instead of the conventional lingual bar to better withstand the torsional forces from the distal extension RDP[(13)].

Advances in polymer-based materials and digital fabrication strategies would allow increased biocompatibility, accuracy, durability, elasticity, as well as more esthetically pleasing and cost-effective benefits[(14)].PEEK has been used as new material for construction of distal extension RDP frameworks. This material can be used for patients allergic to metals, or who dislike the metallic taste, the weight, and the unpleasant metal display of the denture framework and retentive clasps. This modified PEEK material, known as BioHPP, used in the present study is a biocompatible, nonallergic, rigid material, with flexibility comparable to bone, high polishing and low absorption properties, low plaque affinity, and good wear resistance. It has been used for years in orthopedics and medical technology [(13)].

Measurement of pocket depth has become a standard for judging clinical response in restorative therapy. A number of probing methods and instruments have been developed in an attempt to address limitations in obtaining this measurement[(15)].Periodontal diagnosis depends on accurate and reliable clinical measurement of probing depth and attachment level. This is particularly important when measurements are obtained over time to detect change[(16)].

As regard to crestal bone loss related to both the abutment and the implant, analysis of the results revealed no significant difference between the two types of denture frameworks.

This result was in accordance with Alameldeen and associates who studied the effect of PEEK as denture base material on peri-implant bone level changes in implant bar retained overdenture compared to acrylic resin denture base and the results revealed no significant difference between the two types of dentures[(17)].

Bone resorption progressed with time in both groups. This may be due to bone remodeling which occurs after implant placement and bone response to healing combined with functional stresses specially after the first year[(18)].

No significant difference in pocket depth was found between the two types of denture frameworks the results were in accordance with Zaid, et al [(19)] who found that there was no significant difference between PEEK and Co-Cr dentures at any follow up period. It seems that use of PEEK framework RPDs are no more determental to periodontal health of remaining teeth than Co-Cr framework RPDs over 1 year follow up. Longer follow up periods may be required to determine the longer term effects of PEEK compared to Co-Cr RPDs on periodontal health.

In line with these findings, Zoidis et al [(20)]advocated that PEEK materials for overdentures reduce stresses transmitted to the natural teeth abutments since PEEK has modulus of elasticity similar to that of dentin, but the metal has higher one.

The gingival index related to the abutment tooth and the implant results showed statistically significant defference ( at 12 months for the abutment and at 6 and 12 months for the implant) between the two groups.Co-Cr denture framework showed higher gingival index median values than that of PEEK framework but this is in the favor of PEEK.

In line with these findings, Young et al [(21)] stated that wearing of Co–Cr RPDs was shown to be related to a higher prevalence of plaque, gingivitis and gingival recession, and a higher incidence of root caries.

## V. Conclusion:

Within limitation of this study, PEEK partial denture framework had better biological effect on soft tissues (lower MGI scores) than Co-Cr partial denture framework. While it showed no significant difference regarding crestal bone loss and pocket depth.

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