

Original Article

Evaluation of Periodontal Health of The Abutment Teeth in Partial Dentures Made of Injection Molded PEEK Framework Versus Cobalt Chromium Framework in Mandibular Kennedy Class I Free End Saddle Edentulous Cases: A Randomized Clinical Trial

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Abstract

Aim: The objective of this study was to evaluate the periodontal health of the abutment teeth in partial dentures made of Injection molded PEEK framework compared with cobalt chromium framework in mandibular Kennedy class I free end saddle edentulous cases.

Methodology: Two groups of patients representing Kennedy class I with last standing premolar teeth bilaterally. A conventional cobalt chromium RPD was constructed for each patient in the control group, while PEEK RPD (utilizing injection technology) was constructed for each patient in the intervention group. Periotest used to evaluate the periodontal health of the abutment teeth at the time of insertion and after 3 and 6 months.

Results: In the control group, there was no significant difference between values measured at different intervals. The highest value was measured after 3 months, followed by 1 month, while the lowest value was measured at baseline. And the same was for the intervention group as there was no significant difference between values measured at different intervals. The highest value was measured after 1 month, followed by 3 months, while the lowest value was measured at baseline. Comparing the two groups together, there was no statistically significant difference between them.

Conclusions: There was an increase in abutment teeth mobility for both groups from zero to three months, but finally both RPD frameworks offered an acceptable degree of periodontal health preservation. The injected PEEK RPD frameworks provided less degree of abutment teeth mobility with better preservation of their periodontal health.

Keywords: Partial edentulism, Removable partial denture, Cobalt chromium, PEEK, Perio test.

Introduction:

Many treatment options are available for the patients with bilateral missing posterior teeth (Kennedy class I) including implant supported fixed prosthesis, cantilever fixed bridge, dental attachments and framework partial denture (RPD). RPDs are considered a suitable treatment option in many situations, especially when the edentulous area is too long for fixed prosthesis.

There are 15 Different materials available for construction of RPDs, cobalt-chromium metal alloy is considered the gold standard material. Recently, thermoplastic materials are used for RPDs fabrication. PEEK is a high performance polymer, biocompatible thermoplastic material has good stiffness, strength properties with high resistance to wear and fracture and considered to be ideal material for allergic patients due to its biocompatibility. *Ma R and Tang T. (2014)*

Materials and methods:

The patients were randomly assigned to either one of two groups: Group I: Cobalt Chromium metal framework removable partial denture with acrylic teeth. Group II: Injected molded PEEK framework removable partial denture with acrylic teeth. Preliminary maxillary and mandibular impressions were made. The mandibular diagnostic casts were initially surveyed at zero tilt and the design of Kennedy Class I RPD was drawn on the cast. The maxillary cast was mounted on semi adjustable articulator using face-bow record, then jaw relation record was done to mount the lower cast to achieve full diagnostic casts mounting. Guiding planes were prepared on the proximal surface of abutment teeth by flattening of 2-3 mm of occluso-gingival height of the proximal wall using diamond stones. Rest seat preparation Mesial rest was prepared with a diamond round stone on the free end abutment. Triangular shaped preparation (apex

near center of the tooth) with concave floor (spoon shaped) which encompass 1/3 of buccolingual width of the tooth and 1/3 of mesio-distal width of the tooth. Depth of the rest seat was about 1.5mm for metal framework, while for Peek framework deeper preparation was done 2mm rests of indirect retainers, Cingulum rests on bilateral canines were prepared. Secondary impressions were taken by irreversible hydrocolloid (alginate) impression material using cold cure acrylic resin special trays. After the master cast has been surveyed, wax block out was performed. After the master cast was duplicated, the design was transferred to the refractory and stone casts and the wax pattern was completed. (Fig.1)



Fig.1: Wax Pattern of stone cast

Multiple spruing techniques were used and sprues were large enough. The sprues lead directly into the mold cavity and are attached to the wax at its bulkier sections.

Investing and casting of metal (Group I). The refractory casts were dipped in slurry water then centralized in the ring then mixed investment was applied in two coats then burn out of wax pattern was done by heating the investment pattern to prepare the mold to receive the molten metal in a special oven and the temperature was slowly increased to 150 F (67.7C) then this temperature was maintained for half an hour (heat soaking).

The metal (Co-Cr) on the crucible former was melted according to the manufacturer's instructions. After casting was completed, the mold was removed from the machine and allowed to bench cool according to the manufacturer's instructions.

Injection molding of PEEK (Group II), the PEEK granules¹ were used for the injection moulding method and thermopress 400 injection molding system² was used to preheat and press the material according to the set programs.

PEEK preheating was performed for 20 minutes, Once the heated screw is melted, the molten PEEK flows into the mold under thermopress pressure.

Devesting procedure was done to ensure the success of injection procedure (Fig.2) and finally Peek frameworks were finished carefully.

After finishing, the fit of the framework was checked and confirmed on the original stone

casts, Then frameworks were inserted intraorally (Fig.2).



Fig.2 : Try-in of frameworks intraorally

Frameworks had to be stable, passive when seated without any soft tissue impingement. The framework was seated intraorally with waxed rim and centric occluding relation was recorded. The upper cast was mounted on the semi-adjustable articulator³ using facebow⁴ record, then the lower master cast with the framework in position was

¹ Biohpp PEEK Bredent GmbH &co.KG

Germany

² Thermos Press 400 Bredent GmbH Germany

³ Bio Art Belgium.

⁴ Bio Art Belgium

mounted on the articulator and setting up of acrylic teeth was done. Before insertion of the Framework with acrylic teeth intraorally, occlusion was checked on the articulator and then inserted and evaluated in the patient mouth. The waxed-up dentures were flaked, packed and processed into heat-cured acrylic resin, then finished and polished. Then removable partial dentures were finally evaluated in the patients' mouth and required corrections were performed.

The dentures were delivered after educating the patient on how to properly remove and insert it after informing him the needed instructions.

The mobility degree of the abutment teeth was measured with the periotest instrument manufactured by Siemens. Periotest values were made at the time of denture placement (control) and at zero, 1 and 3 months after the denture placement. The values of the periotest measurements are calculated and range from 8 to +50, corresponding to four different scores of mobility.(Fig.3)



Fig.3 : periotest measurement

Results:

Intergroup comparisons:

Mean and standard deviation (SD) values for periodontal health in different intervals were presented in table (1)

- **Cobalt Chromium:**

There was no significant difference between values measured at different intervals ($p=0.084$). The highest value was measured after 3 months (8.27 ± 1.91), followed by 1 month (8.10 ± 2.16), while the lowest value was measured at baseline (7.63 ± 2.25).

- **PEEK:**

There was no significant difference between values measured at different intervals ($p=0.449$). The highest value was measured after 1 month (7.61 ± 2.63), followed by 3 months (7.44 ± 2.15), while the lowest value was measured at baseline (7.16 ± 2.68).

Groups	Periodontal health (Mean±SD)			p-value
	Baseline	1 month	3 months	
Cobalt Chromium	7.63 ± 2.25^A	8.10 ± 2.16^A	8.27 ± 1.91^A	0.084ns
PEEK	7.16 ± 2.68^A	7.61 ± 2.63^A	7.44 ± 2.15^A	0.449ns

Table (1): Mean and standard deviation (SD) values for periodontal health in different intervals

Intergroup comparisons:

Mean and standard deviation (SD) values for periodontal health percentage change (%) in different groups were presented in table (2)

- **Baseline:**

Cobalt Chromium group (7.63 ± 2.25) had a higher value than PEEK (7.16 ± 2.68) yet the difference was not statistically significant ($p=0.619$).

- **1 month:**

Cobalt Chromium group (8.10 ± 2.16) had a higher value than PEEK (7.61 ± 2.63) yet the difference was not statistically significant ($p=0.592$).

- **3 months:**

Cobalt Chromium group (8.27 ± 1.91) had a higher value than PEEK (7.44 ± 2.15) yet the difference was not statistically significant ($p=0.291$).

Time	Periodontal health (Mean±SD)		p-value
	Cobalt Chromium	PEEK	
Baseline	7.63±2.25	7.16±2.68	0.619ns
1 month	8.10±2.16	7.61±2.63	0.592ns
3 months	8.27±1.91	7.44±2.15	0.291ns

Table (2): Mean and standard deviation (SD) values for periodontal health in different groups

Discussion:

Mandibular Kennedy class I cases (bilateral free end saddle) were chosen as they are much more common than the upper ones due to the common pattern of tooth loss. (*Devishree et al., 2018*) Co-Cr metal framework has been considered as a gold standard type of removable partial denture but unfortunately metal frameworks have several disadvantages concerning esthetics, heavy weight, lack of resiliency , metallic taste and allergic reactions for some patients.

Due to the viscoelasticity of the edentulous ridges, distal extension RDPs exhibit a greater rotation around the supporting rests under occlusal loading. This could lead to creation of distal torque on the abutment teeth. Use of BioHPP for the construction of the framework of a Kennedy class I RDP was thought to be beneficial for the periodontal health of the abutment teeth. The elasticity of this material might reduce the distal torque and the stress on the abutment teeth. Therefore, it could be hypothesized that BioHPP would be a viable alternative for abutments with reduced periodontal support when restoring distal extension cases (*Zoidis et al. 2016*)

In this study PEEK was used as an alternative to Co-Cr metal framework following recent advances in the field of dental materials and according to investigations of *Tannous et al., 2012* as it is considered to be more aesthetic, stable, biocompatible and lighter material to be used for construction of removable partial dentures.

The design for the partial dentures was performed according to the general principles applied in free end saddle cases . Diagnostic mounting of Iry casts on a semi-adjustable articulator was done to evaluate the occlusion from the buccal and lingual views and to check any over eruption (*Karthigeyan, 2014*).

Surveying of the study casts were done to plane the design necessary to fabricate RPD, check undercut areas and to determine the necessary mouth preparation for the design necessary to fabricate RPD (*Davenport et al., 2000*)

Mesial occlusal rests were prepared on the abutments in order to decrease the torque on them, so that the abutment teeth when loaded will tilt mesially and gain bracing from the adjacent teeth anterior to it (**Bural, 2016**). Auxillary rest seats were prepared on both canines anteriorly because there are no posterior abutments in the free end saddle cases and act as indirect retainer. (**Loney, 2011**)

The conventional gingivally approaching RPI clasp was selected because of its stress releasing action, better esthetics and more retentive than the occlusally approaching clasps gained from their inherent tripping action. (**Carr and Brown, 2011**)

Block out procedure of the master cast was done to eliminate all undesirable undercuts while relief was done on the master cast before duplication, to prevent tissue impingement and to create room for acrylic resin under the retentive ladder. Duplication of master cast from refractory investment material in case of metal framework to withstand high temperature, while in case of PEEK pressing procedure, duplication of master cast was done using stone material because the stone could withstand temperature of pressing (400 C) without disintegration. (**Carr and Brown 2011**).

According to **Kurtz,2011** granulated PEEK is the best material for injection molding and this granulated form is the only commercially available implantable type. The injection molding temperature, pressure and the cooling were standardized to ensure most favorable qualities of the denture surface.

After the injection process was accomplished, the flask was then released and pulled out. In order to achieve optimal quality of the material, the flask was quenched in a water bath. At least 15 minutes were needed for cooling down. Then BioHPP PEEK was divested and this was to decrease stresses. The divesting was done using the divesting aid and punch under spindle press that allow for careful handling and extended service life of the flasks. (**Saja 2016**).

Periotest Measurement:

Assessment of the state of the periodontal ligament has proved difficult because it cannot be examined directly in vivo. During this study, the mobility was measured with an electro-mechanical instrument. The Periotest was selected because it's the power to acknowledge fine gradations of clinical mobility, combined with a demonstrated capacity to get highly reproducible results. [*Manz MC, et al., 1992*]

The measurements are sensitive, and also the readings are automated and thus objectives. [**Andresen et al.,2003**] suggested that the Periotest measurement is more sensitive than traditional methods. It had been important to create sure that each one of the records were done at the identical point or position whenever of recording to insure the balance while measuring the retention which the recorded results are reliable and accurate. This position or point of measurement was done at the geometric center of the dentures as determined by previous investigators. [*Sabet 2004*].

Invalid measurements were recognized in and of itself and eliminated. The tapping head is electro magnetically retracted into the handpiece. In 4 s, 16 exactly defined tapping impulses are applied to the tooth [*Schulte W, et al., 1992*]

Five measurements were made to every abutment tooth. Before the experiments, the inter-individual and intra-individual variabilities were tested to see the reproducibility of the Periotest measurement. Employing a volunteer. Periotest measurements were conducted thrice by four skilled experts to get the three Periotest readings for every expert. Pearson's parametric statistic showed reliability coefficient starting from 0.93 to 0.96 thus indicating no evidence of an outsized random error between the readings. All the measurements were meted out by the identical clinician to avoid interexaminer variability.

Periotest values were made at the time of denture placement (control) and at 1, 3 and 6 months after the denture placement. The values of the Periotest measurements are calculated from the contact time between tapping head and tooth and range from 8 to +50, cherish four different countless mobility. For every clasp design data, Friedman test was wont to compare the mobility scores at zero, 1 and 3 months examinations. [Lukas D and Schulte W. 1990].

A five minutes period was recommended between each succeeding measurement to allow recovering of the distortion that happens in both mucosa and also the synthetic resin denture bases after loading, which could have an impression on the measurements. (Mustafa, A. Z. 2015).

Mustafa, A. Z. (2015). Effect of the lingual ledge of neutral zone impression on the retention and stability of mandibular complete denture in elders with atrophied alveolar ridge.

Three records were taken for every patient in each follow-up visit, so the mean of the records was calculated and this was done to attenuate the human, technical and manual errors the maximum amount as possible. (El Mekawy, N., & Gad, E. 2016).

The results of the study showed that the mean tooth mobility of abutment teeth in Co-Cr RPD was found to be higher than that in PEEK RPD, but with no significant difference.

Within the PEEK group, there was no significant difference between values measured at different intervals ($p=0.449$). The highest value was measured after 1 month (7.61 ± 2.63), followed by 3 months (7.44 ± 2.15), while the lowest value was measured at baseline (7.16 ± 2.68).

Comparisons between the results from the present investigation with those from previous studies are difficult because the observations periods are very different. In addition, the investigators assessed the tooth mobility using traditional and subjective methods such as palpation and percussion of the teeth [Carlsson et al.1965] and [Yusof and Isa 1994].

Other important differences should be between this and other studies. The patients were selected to meet fairly rigid general and periodontal health criteria and were followed up for 3 months. A rigid quality control system was also followed for the fabrication of the removable partial dentures.

An important factor that may have contributed to the favorable results from the present investigation was the use of mesial rest, transferring the chewing forces more perpendicular to ridges than distal occlusal rests. Hence, the gingival mucosa of the abutment tooth was better protected [DeBoer J.1988]. As opposed to distal-extension removable partial dentures, the movement of the base of an entirely tooth-borne partial denture toward the edentulous ridge is prevented primarily by rests placed on the abutment teeth located at each end of each edentulous space. As a result, the rotation of the tooth-borne partial denture is relatively non-existent.

Other factors might have contributed to the stability of the abutment teeth. The parallel guiding planes achieved on the diagnostic casts were accurately transferred to the natural teeth [Rudd RW, et al.1999]. It has become accepted that parallel surfaces on the teeth, enclosed by the framework (guiding planes), make a substantial contribution to stability and can also aid retention [Ali M, et al.2001] and [Sato Y and Hosokawa R 2000].

Conflict of Interest:

The authors declare no conflict of interest.

Funding:

Ethics:

This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo university on: 25-12-2018, approval number 18 12 6

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Conclusion:

Our findings suggest that adequate oral hygiene instructions, careful prosthetic treatment planning and regular recall appointments play an important role in preventing changes in abutment tooth mobility caused by removable partial denture placement. Despite these favorable clinical findings, it is important to mention that future long-term investigations are needed before definitive conclusions can be made.

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