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EVALUATION OF RETENTION AND STRAINS INDUCED ON ANTERIOR AND PIER ABUTMENTS IN KENNEDY CLASS II MODIFICATION 1 CASES RESTORED BY PARTIAL TELESCOPIC OVERDENTURES CONSTRUCTED DIGITALLY FROM TWO DIFFERENT FRAMEWORK MATERIALS: AN INVITRO STUDY

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ABSTRACT

Aim: Evaluating the retention, measuring the amount of stresses transmitted to the principal and pier abutments and ridge in mandibular Kennedy class II restored by milled (PEKK) partial telescopic over-denture as compared to that of milled chrome cobalt.

Methodology: Both abutments were reduced to receive telescopic Co-Cr primary crowns and the usual preparation for class II partial denture was made on intact side. Twelve partial telescopic overdentures (PTO) frameworks were milled from two materials. Group I (GR I), six PTO frameworks were milled using Co-Cr, while the other six PTO frameworks of group II (GR II) were milled using poly –ether ketone ketone (PEKK). Each PTO was seated on its cast to be placed within chewing simulator where PTO was exposed to insertion/removal and loading cycles Retention was evaluated. Strains induced within both abutments and supporting ridge were measured using five strain gauges.

Results: For chrome-cobalt PTO had significantly higher retention than that expressed by PEKK PTO framework. under both unilateral and bilateral loading, pier abutment received much more strains than that exerted on principal abutment, additionally distal surfaces of both abutments expressed higher significant strains than mesial surfaces. Under both unilateral and bilateral loading, chrome-cobalt PTO (GR I) framework exerted higher significant strains on proximal surfaces of abutments than that expressed by PEKK PTO (GR II) framework.

Conclusion: PEKK PTO could be a promising option in cases of Kennedy class II having pier abutment.

KEYWORDS: Pier abutment, telescopic overdenture. kennedy class II, retention

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INTRODUCTION

Distal – extension removable partial dentures (DISRPD) are associated with several challenges in relation to retention, stability, and support[1]. Support is the most damaging problem to the periodontium of abutments due to the difference in displaceability of supporting mucosa in relation to that of periodontal ligament. [2]

Functional forces applied to the distal extension bases create an axis of rotation around the most distal abutment teeth subjecting them to distal tipping, rotation, torque and horizontal movement. When the most distal abutment is isolated one (pier abutment), it will be subjected also to mesial tipping due to lack of mesial contact, promoting a fulcrum like situation of mesiodistal torquing leading to rapid destruction of its supporting periodontium. [3,4] The design of the distal-extension removable partial denture is a challenge when a solitary tooth is to be used as an abutment.

Different treatment modalities have been recommended to reduce harmful forces directed to pier abutments. One of them involves splinting of the pier abutment to the nearest tooth by a fixed partial denture. Splinting creates an intact dental arch anterior to the free end edentulous space; stabilizes the abutment teeth in a mesiodistal direction and provides multiple abutment support[3,4]. Investigators recommend that pier abutments not be clasped but may receive two rests. [5] and the use of only two proximal plates on the mesial and distal surfaces of the isolated tooth to minimize lateral forces directed to it also has been described in the literature. [6] Nowadays many of the problems associated with DISRPD design can be solved with proper placement and use of one or more implants.

Telescopic crowns were proven to be an efficient way of retaining tooth-tissue-supported RPD. They consist of a primary coping cemented to an abutment tooth and a precisely fitted secondary crown, as a part of the framework of the subsequent RPD to form partial telescopic overdentures (PTO) that have benefits of transferring forces along the long axis of the abutment teeth, thus creating maximum areas of tension and minimum amount of compression in the periodontal membrane.[7] Moreover, PTO protects supporting alveolar bone from resorption through transferring occlusal forces via the roots of natural abutment teeth[8]. PTO showed the most even transmission of occlusal forces compared to other design alternatives with precision attachments, clasps, or stress breakers. [9] PTO are regarded to be functionally equivalent with FPDs and are the most efficient alternate for missing teeth. This is considered true, as it has a favorable influence on stabilization of the remaining dentition and improvement of their periodontal health, [10,11] and because of its retrievability, rendering it more accepted psychologically by some patients. [12]

Telescopic crowns are classified into two main categories [13]: which are rigid and resilient designs. The retention of rigidly cylindrical interlocked telescopic crowns is dependent on friction between parallel walls of outer and inner copings. Rigid system has several disadvantages including rapid loss of retention due to excessive wear of materials forming outer and inner copings, and transmission of all occlusal forces to the peridontium of abutments.

Resilient conical design is characterized by the presence of small space (30 -50micron) between inner and outer coping where the retention is provided by wedging action. Built-in flexibility allows vertical motion between inner coping and outer ones that is attached to the partial denture framework, this motion compensates for the difference in resiliency of mucosa under functional occlusal stresses leading to reduction of forces exerted on supporting abutments. [14] Extra - coronal resilient attachment can be used on terminal and pier abutments to reduce stresses on them and put more strains to distal edentulous ridge. [15,16,17] Conical-retained partial denture achieved better clinical success along 5-10 years of longitudinal follow-up than did clasps or other precision attachments. [16]

Different materials have been introduced in the fabrication of distal extension RPD, to control excessive torque forces acting on the abutments and their related supporting structures. [18] In the literature, there are contradictory results about the force-transmission characteristics of telescopic RPDs, and little is known about their force transmission patterns related to different material types, rigidity (rigid or resilient). [19] The most common material for construction of RPDs frameworks is the Cobalt- chromium alloy that has excellent biocompatibility and strength, however, it is rigid with high modulus of elasticity with subsequent transmission of stresses to the bone and the supporting abutment teeth. [20] Fibre-reinforced thermoplastic polymer Polyaryletherketone (PAEK) has been lately used as dental prosthetic material that has strong damping effect, excellent high biocompatibility and low modulus of elasticity which is near to that of bone sequentially with less stresses transmitted to abutments. [21] PEKK (POLYETHERKETONEKETONE) is the most recent form of PEAK family, it has both amorphous and crystalline characteristics to increase its compressive strength and physical properties. [21] Hence, it seemed of value to investigate the stresses induced mesial and distal to the abutments during unilateral and bilateral loading conditions, using two different materials; Co-Cr alloy and PEKK for PTO fabrication with pier abutment.

Conventional casting method using lost wax technique is used for construction of telescopic retainers that are made of either gold or non -precious alloys. [22] This technique provides satisfied results; however it has some drawbacks including multiple procedures requiring a highly skilled dental technician to establish accurate fitting with proper retentive force.[23,24] CAD/CAM technique has recently been approved in fabricating telescopic dentures with less working time and technical errors [23,25], moreover, it is an easy technique allowing construction of telescopic system from a variety of metallic and non-metallic combinations. [26-28]

The magnitude of retention of any removable prosthesis should be reasonable to avoid damage to the underlying teeth. The required range of retentive force for telescopic dentures is variable in the literatures. [29] The aim of this in-vitro study was to evaluate retention and amount of stresses transmitted to the principal and pier abutments as well as the supporting ridge in mandibular Kennedy class II modification 1 cases when restored by milled chrome cobalt PTO as compared to that of milled polyether ketone ketone (PEKK) PTO after one year of clinical simulation. Null hypothesis was that there would be no differences between the two PTO types as regards the stresses transmitted to the supporting structures and retention.

MATERIALS AND METHODS

Preparation of partial telescopic over-denture

This in vitro study was done on a mandibular stone model with unilateral free end saddle with an anterior edentulous area (Kennedy class II modification 1), bounded by the mandibular canine and the second premolar which acted as a pier abutment. On the stone cast, the abutments were prepared creating a deep chamfer finishing line with 2-2.5 mm occlusal-incisal reduction producing secondary planes and 1-1.5 mm axially to accommodate the thickness of the primary and secondary copings as well as veneer material. The amount of reduction was verified by comparison with the intact side. The usual preparation of class II partial denture was followed on the intact side by preparing a distal occlusal rest seat on the first molar a mesial occlusal rest seat on the second molar to receive rests of butterfly clasp on molars. Another rest seat was prepared mesially on the first premolar to receive a mesial occlusal rest as an indirect retainer. The drill press machine (Nouvag

Headquarters, 9403 Goldach - Switzerland) was used for all the preparations on the stone cast. Then, the prepared cast was scanned using a desktop scanner (3Shape D850 A/S, Holmens Kanal 7, 1060 Copenhagen) to form STL file that was transferred to the Exocad software.

The model was scanned using a desktop scanner (3Shape D850 A/S, Holmens Kanal 7, 1060 Copenhagen). On the modified stone cast, a clear vacuum formed stent was pressed.

By using model creator module and Mish mixer of Exocad (exocad GmbH; Darmstadt, Germany), STL file of the stone cast was converted into a virtual model with two separate dies for mandibular canine and premolars. Each die was surrounded by a 0.2 mm space from the wall of its virtual socket to simulate the thickness of periodontal ligament.[30] The edentulous ridge, gingival contours of abutments and limiting borders of denture bearing areas were cutback at 1.5 -2 mm thickness. Also, the design of the primary coping was adjusted on the virtual model using Exocad so that the first 1.5-2 mm height from the finishing line of the primary coping would be parallel then tapered 6 degrees occlusally.

Twelve acrylic models (with their sets of separate dies were printed using (3D printer ©2019 Mogassam Co.). And twelve sets of primary coping were milled from fully sintered Co-Cr discs.

On the printed models , the cut back of denture bearing areas was painted with adhesive material of rubber base (Zetaplus, Zhermack., Italy) , then medium body rubber base (Speedex, colton A. G, Alsatten, Switzerlan) was pressed on the reduced areas guided by the previously constructed clear vacuum stent that was painted first by separating medium. This was done to produce even thickness of impression material to simulate thickness of mucosa [31] .Five grooves were made mesial and distal to the abutments as well as at the area of second molar on the edentulous ridge, each groove was 1 mm width and 0.2 mm depth. The milled primary copings were cemented on their corresponding dies using glass ionomer cement (Medicem; Promedica Dental Material GmbH, Germany). (Fig. 1) Acrylic casts of both groups were scanned.

The usual design of class II partial denture was made on Exocad after proper electronic surveying so as to adjust the path of insertion of the secondary coping with that of the butterfly clasps on the first and the second molars. Lingual bar was used as a major connector. Also, 30-50 micron were left occlusally between the inner and outer copings. The twelve casts were equally divided as follows:

1. ***Group I (Gr I):*** Frameworks of partial overdenture were milled using Co-Cr discs. (Fully sintered Co-Cr discs, Travagliato (BS) ITALY.)
2. ***Group II (Gr II):*** Frameworks of partial overdenture were milled using PEKK discs. (Bredent GmbH, Senden, Germany).

The printed acrylic models were duplicated into stone ones. On the stone model, each partial overdenture framework was seated on its relevant cast and waxing up of the denture base on the edentulous areas was performed followed by setting up of the acrylic artificial teeth guided by the occlusal level and the size of the natural teeth on the intact side. The casts were then invested in molds where the acrylic resin was injected under vacuum pressure after wax elimination. After finishing and polishing of the acrylic resin denture bases, the partial overdenture samples of both groups were returned on their acrylic models to be ready for retention assessment and strains evaluation.

The sample size for the study was calculated using G power software for windows version 3.1.9.4. [32]

Determining the geographic center of the mandibular arch:

When the mandibular partial overdentures were finished, they were prepared for the retention tests.

It has been documented that the measurement of complete denture retention was best attempted by pulling the denture from its geographic center [33]. Hence, it was essential to locate this center for all partial overdentures. This procedure was carried out on the casts as explained below:

Four Lines were drawn on each cast and extended to the cast base in the following sequence;

1. Line (1): connecting two points at the apices of the retromolar pads of both sides of the arch
2. Line (2): passing from canine to canine, and parallel to line (1),
3. Line (3): passing through the midline of the cast and perpendicular to both lines (1) and (2), a midpoint was determined between line (1) and (2), called point (a) and placed on line (3),
4. Line (4): passing through point (a) and running parallel to lines (1) and (2), to aid in placing the lingual orthodontic wire.

Point (a) is the geographic center of the mandibular overdenture. (Fig.1)

- Preparing the partial overdenture for the retention test:

Three metallic wires 18 gauge in diameter were used and soldered to the lingual aspect of the partial overdenture, taking into consideration to have the junction of the three wires at point (a), representing the geometric center. The junction of the three wires ended with a hook to facilitate the attachment of the universal testing machine. The junction between the wires and the denture was reinforced using acrylic resin. (Fig.2)

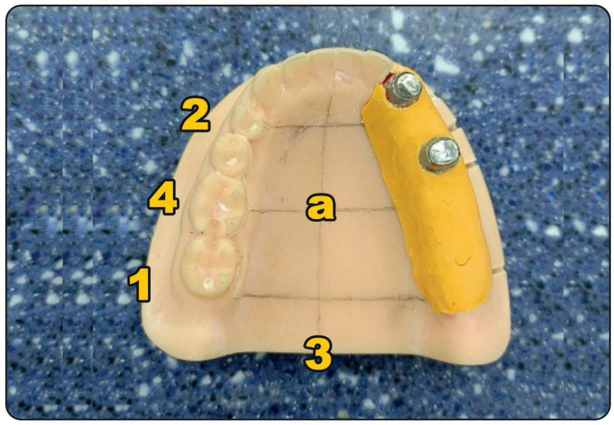

Fig. (1) Showing the 3D printed acrylic model with the grooves for strain gauges installation, the lines drawn for geometric center determination (1–4) and the geographic center (a).

Assessment of Retention:

Each PTO was placed on its corresponding cast and then introduced into chewing simulator (Robota, Chewing Simulator), Model ach09075dc-t, ad-tech technology co., ltd., Germany). Each PTO and its model were fixed in a teflon housing in the lower holder of the chewing simulator and exposed to 1440

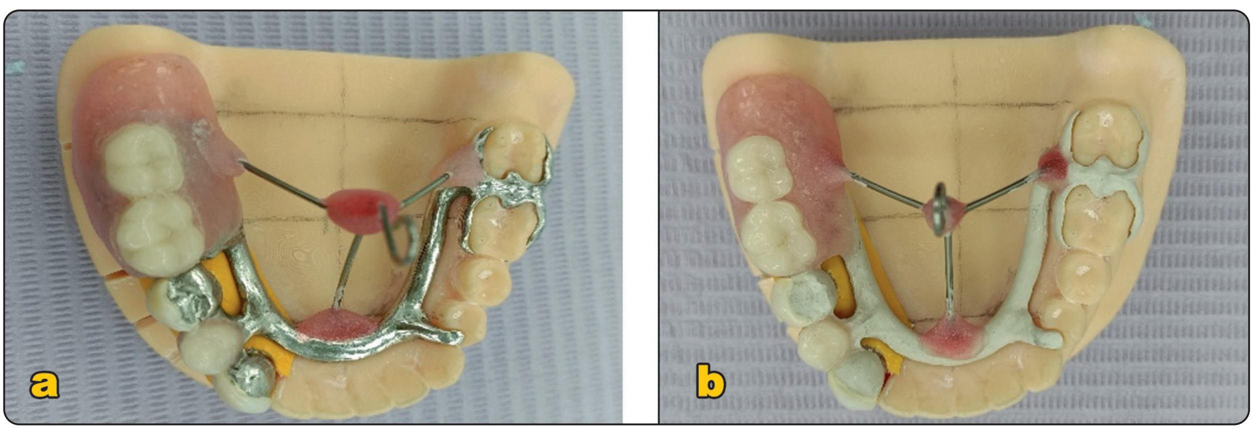

Fig. (2): Attachment of orthodontic wires and hook to the partial overdentures at the geometric center for the two groups. (a: Group I; b: Group II) cycles of insertion and removal loads to simulate a 12 months clinical periods (estimating that patient would insert and remove each denture four times per day). [34] To evaluate retention, each PTO was attached to a universal testing machine (bench mounted, 2015 AMETEK. Inc.) (Fig. 3). Crosshead speed of 5 mm/min was used to apply tensile load with pull out mode of force. The dislodging force required for each PTO was recorded in Newton 5 times and the average force was calculated.

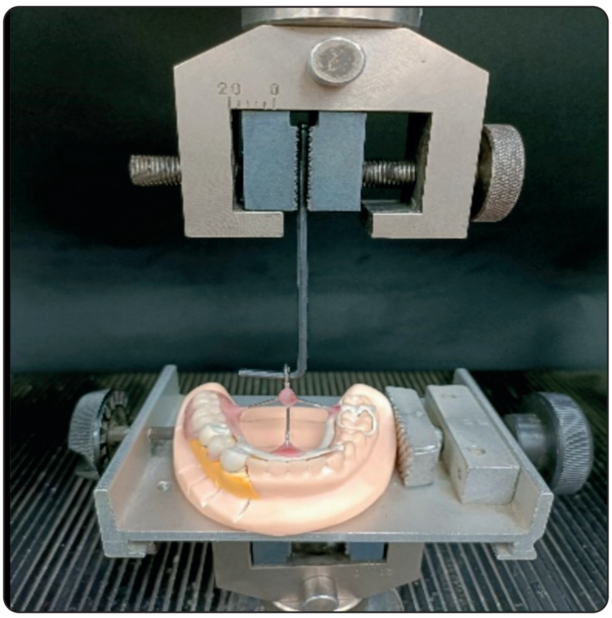

Fig. (3) Installation of the cast on the machine ready for the retention test

Evaluation of strains induced in the supporting structures

Five strain gauge sensors (Strain gauges Kyowa-Electronic Instruments Co, LTD, Tokyo, Japan of 3 mm length, electric resistance 119.6 ± 0.4 Ω, and gauge factor 2.1 ± 1.0%) were fixed at the previously cut grooves on the acrylic models using cyano-acrylate adhesive (2016 Permabond LLC.). (Fig. 4,a)

Each PTO was installed on the acrylic cast and introduced into the chewing simulator. A series of 240,000 biaxial loading cycles were applied to simulate a 1 year under function for the PTOs. By using a universal testing machine, 100N static load was applied bilaterally at the central fossae of the first molars and then unilaterally at the artificial first molar of the edentulous side where the force of mastication concentrates. [35] (Fig. a,b) Four-channel strain indicator (Strainmeter PCD-300A Kyowa-Electronic Instruments Co, LTD, Tokyo, Japan) were secured into their prepared grooves in the cast. The load was applied 5 times to each PTO with15 minutes in-between to get zero balance allow complete rebound of silicon simulating mucosa before successive reading and then the average of readings was taken.

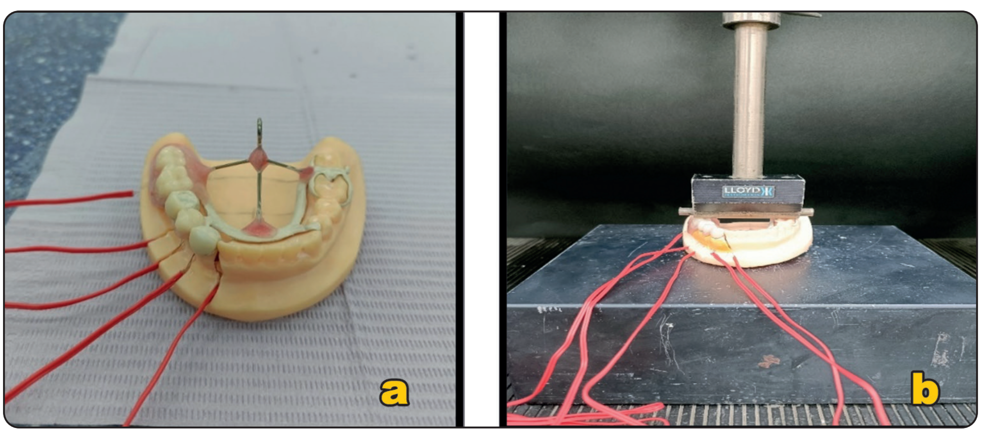

Fig. (4) a: The strain gauges were installed to the corresponding grooves on cast. b: The test machine used for strain measurements.

Statistical Analysis

Retentive force (N) of both groups, strains(μm/m) around abutments (principal and pier) and strains exerted on the ridge were expressed as means and standard deviation (SD) values. All data displayed normal distribution by using D'Agostino-Pearson test. One-Way ANOVA test was applied to compare strains exerted at the proximal surfaces of the abutment within each group under both unilateral and bilateral loading conditions. Duncan's multiple range test [36] was used to test differences within means of treatments while level of significances was set typically at minimum (P≤0.05). Student –t test was used to compare between the two groups at significance level (P≤0.05). IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows was used for statistical analysis.

RESULTS

1- Retention

Results are displayed in table (1). Statistical analysis revealed that chrome-cobalt PTO (GP I) had significantly higher both initial and final retentive force values than that of PEKK PTO (GPII). Also, the percentage of retentive force reduction of GR II PTO was significantly higher (p= 0.004) than that percentage expressed by GRI PTO.

2- Strains exerted on both principal and pier abutments

The recorded strains exerted on around mesial and distal surfaces of both principal and pier abutments were compressive in nature (negative).

A- During unilateral loading

Results are displayed in table (2). Statistical analysis revealed that within both groups and during unilateral loading, proximal surfaces of pier abutment received significantly higher strains (p1=0.000) than that exerted on proximal surfaces of mandibular canine. Distal surfaces of both mandibular canine and pier abutments had significantly higher strain values than that received by mesial surfaces.

TABLE (1) Means and standard deviation (SD) of retentive force (N) of both groups.

	Chrome-cobalt	PEKK	p-value
Initial Force	20.39±3.78 (Mean±SD)	12.95±6.39 (Mean±SD)	0.004
Final Force (After1440 cycles)	15.32±2.79 (Mean±SD)	9.03±3.74 (Mean±SD)	0.004
Percentage (%) of force reduction	24.87 %	30.27 %	0.001

P value: Significance In-between groups at p≤0.05.

TABLE (2) Means and standard deviation (SD) of strains (μm/m) around proximal surfaces of abutments during unilateral loading condition.

Material used	(Mandibular canine abutment)		Pier Abutment (Mandibular 2nd premolar)		p1-value
	Mesial (3)	Distal (3)	Mesial (5)	Distal (5)	
Chrome-cobalt	$-304.55^{d}\pm6.68$	$-320.00^{c}\pm4.47$	$-354.22^{b}\pm5.59$	$-382.27^{a}\pm5.70$	0.0001
PEKK	$-118.28^{d}\pm7.81$	$-214.25^{c}\pm8.81$	$-281.35^{b}\pm5.94$	$-299.17^{a}\pm6.49$	0.0001
p2-Value	<0.0001	<0.0001	<0.0001	<0.0001	

P1 value: Significance within each group, different small letters within each row are significantly different at p≤0.05.

P2 value: Significance In-between groups at p≤0.05.

Between group comparison, revealed that the, proximal surfaces of both abutments (mandibular canine) and pier abutments in GR II were subjected to significantly lesser strains (P2= 0.000) than those exerted on abutments of GR I.

B- During bilateral loading:

Within each group, proximal surfaces of the pier abutments received significantly (p1=0.000) more strains than that of the canine abutment. Also, distal surfaces of both abutments were subjected to significantly more strains than that exerted on the mesial surfaces (Table.3).

PEKK PTO frameworks (GRII) expressed significantly (P2= 0.000) lesser strains on abutments than that were shown in chrome-cobalt PTO frameworks (GRI).

2- Strains exerted on the edentulous ridge:

All stains exerted on the edentulous ridge were compressive in nature. Results are displayed in table (4). Bilateral loading exerted significant lesser strains on the edentulous ridge than that exerted by unilateral loading. Moreover, during both unilateral and bilateral loading, PEKK PTO frameworks expressed significant higher strains on the ridge than that exerted by the chrome-cobalt PTO frameworks.

TABLE (3) Means and standard deviation (SD) of strains (μm/m) around proximal surfaces abutments during Bilateral loading condition.

Material used	Canine Abutment (3)		Pier Abutment (5)		p1-value
	Mesial	Distal	Mesial	Distal	
Chrome-cobalt	-274.16[d]±6.71	-284.83[c]±8.64	-299.00[b]±9.90	-320.32[a]±5.59	0.0001
PEKK	-56.67[d] ±12.05	-186.00[c] ±7.58	-193.00[b]±12.08	-290.00[a]±5.55	<0.0001
p2-Value	<0.0001	<0.0001	<0.0001	<0.0001	

P1 value: Significance within each group, different small letters within each row are significantly different at p≤0.05.

P2 value: Significance In-between groups at p≤0.05.

TABLE (4) Means and standard deviation (SD) of strains (μm/m) exerted on the edentulous ridge. during both bilateral and unilateral loading conditions.

Type of Loading	Material used		P1-value
	Chrome-cobalt	PEKK	
Bilateral loading	- 113.32±7.77	-160.67±8.83	<0.0001
Unilateral loading	-120.83± 9.036	-221.83±17.03	<0.0001
P2- value	<0.0001	<0.0001	

P1 value: Significance within each group at p≤0.05.

P2 value: Significance In-between groups at p≤0.05.

DISCUSSION

The results of this in-vitro study indicated that retentive qualities of Co-Cr PTO were superior to that of PEKK. Also, strains exerted on both abutments and residual ridge by either type of PTO were not the same. So, the null hypothesis was rejected.

To the best of the authors' knowledge, the results of this study was not comparable to other studies, because it may be the first in-vitro study that compared Co-Cr partial telescopic overdentures with that made of PEKK to restore unilateral mandibular edentulous space with pier abutments. However, the current results could be considered as reliable results, because in-vitro comparative studies are more practical and accurate than in-vivo that cannot be repeated under the same conditions of histological structures of the periodontal tissues and bone consistency that are variable in between patients and additionally the inconsistency in length and width in roots of teeth. [35] However, the mechanical behavior of the silicone material simulating the PDL in vitro is not the same the PDL in vivo and this should be considered a limitation of this study.

The strain analysis around abutments and on the edentulous area was done using strain gauge quantitative analysis that is the most common dental analytical technique due to their linearity and small size causing little interference during measurement.[37]

Retentive wedging qualities of resilient conical telescopic attachment have been affected by multiple factors. CAD\ CAM telescopic crowns retention is greatly influenced by manufacturing technique maneuvers, in our study milled inner Co-Cr copings might have surface milling grooves that increase surface roughness. Friction and initial retentive forces between inner and outer copings have been enhanced by roughness that increases micro-mechanical interlocking between inner and outer copings under occlusal loading. [38] However, both co-Cr and PEKK frameworks final retentive forces reduced significantly from initial retention, this could be due to the wear occurring in-between rough surfaces of double crowns especially in dry conditions in absence of artificial saliva that increases retention. [39,40] These results were in line with studies [41,42] which reported that wet conditions had enhanced retention and adaptation of primary crowns with smooth surfaces of double crowns when compared to crowns with rough surfaces, this could be attributed to hydraulic adhesive forces of saliva.

The percentage of retention loss was greater for PEKK frames than Co-Cr ones, as the PEKK is a type of re-inforced polymer having a resiliency that caused deformation of outer coping under occlusal load into occlusal gap in-between inner and outer copings that had surface roughness causing more wear of polymer resin of PEKK with harder surface of Co-Cr inner crown. [43]

Despite the loss of retention for both Co-Cr and PEKK frames after 1440 cycles of insertion and removal (equivalent to one-year clinical use), the amount of retention remained within the recommended limits. As Stańcíc and Jelenkovíc[19] reported that the accepted range was (5–9 N) to provide denture function and avoid damage to the supporting structure. While another study recommended that the minimum accepted force was 2.5 to 3 N and the maximum retentive force per abutment should not exceed 6.5 N. [44] Korber concluded that the retentive force per abutment should be within the range (5–10 N). [445

Retention of double crown is also affected by type of material of coping that is inter-related to the taper angle of primary coping. The retention of telescopic retainers follows the equation:

$F = \mu s. L/\sin \Theta$ where : Θ = taper angle of primary crown

μs = coefficient of static friction which is characteristic for each material

F= Force of retention

So, the increase of coefficient friction of the material used and\or decrease of taper angle enhances retentive force of double crown. [41.46,47]

The high retentive force of Co-Cr frames could also be explained on the basis that coefficient of friction is greatest for metals and lowest for plastics, so 6° taper angle would enhance retention of Co-Cr frames and reduce it for PEKK ones. Previous studies reported that PEEK and Co-Cr specimens with taper 0_ recorded the retention force range of 3.6 to 13.83 Nand 15 to 28.46 N respectively. [48-52]

Telescopic partial overdenture provides splinting action like fixed restoration [10,11] that distributes load on abutments to overcome mediolateral and torque forces on isolated 2nd premolar. However, proximal surfaces of pier abutment under both unilateral and bilateral loading in both groups, exhibited greater strains than that showed by the canine abutment. This could be attributed to lack of proximal neighboring tooth buttressing the tooth at risk during torquing that results from settling of denture base on resilient mucosa. [4,5] Soliman et al.,[53] mentioned in their clinical study that restoring a missing mandibular first premolar by a fixed restoration on the 2nd premolar pier abutment and canine resulted in great loss of marginal bone around pier abutments having round and tapered roots. Also, previous in-vitro studies reported that the most distal abutment in cases of free end sddle cases always receives the highest strain. [54-56]

Distal surfaces of both abutments under unilateral and bilateral loading, had higher strains than that expressed by mesial surfaces. This could be due to the absence of adjacent tooth distal to mandibular canine and 2nd premolar. [4,5] Also, pivoting of PTO anterior around fulcrum axis passing through canine with longer effort arm resulting in trauma of supporting structures due to exertion of more retentive forces to keep the denture in place. [53] Moreover photo-analytical and finite element analysis (FEA) studies detected that stresses usually concentrate at the distal side of abutments in free-end saddles. [57,58]

Components of removable partial prosthesis transmit stresses to supporting structures of abutments through both the design of prosthesis as well as the biomechanical properties of the framework material. [53,54] The design of PTO in this trial was the identical for both groups especially with the use of resilient telescopic attachments that reduce strains on abutments, so the in-between groups variation of strains created around abutments were due to the biomechanical properties of framework material. Where, Chrome-cobalt group (GrI) PTO frames transmitted greater strains to the abutments under unilateral and bilateral loading than did frames of PEKK group (Gr II). This might be attributed to the difference in nano-hardness and modulus of elasticity that control amount of pressure exerted by the material. PEKK has low modulus of elasticity near to that of bone and dentine of abutments, so it is flexible and elastic material that reduces the stresses transmitted to abutments. On the contrary, Co-Cr a considerably higher modulus of elasticity than that of bone and tooth structure, so it is a rigid material that tend to transmit higher stresses to the abutments. [59-61]

Free-end saddle cases are complicated by the visco-elastic property of the mucosa and the difference in resiliency between the mucosa covering the edentulous ridge and the periodontal fibers of distal abutment. This causes not only torquing of distal abutment but also deflection of denture base toward the mucosa with subsequent bone resorption particularly in the area of first molar where the forces of mastication concentrate. [62,63] So it was found that bone resorption is more pronounced in partially edentulous free end spaces restored with removable partial denture than that unrestored one. [64]

Edentulous ridge under Co-Cr frames during unilateral and bilateral loading, received lesser strains than that transmitted by PEKK frames (Gr II). As mentioned earlier, the Co-Cr frame is rigid hence helps in distributing the occlusal forces over wide areas of mucosa with less deflection of denture base, while PEKK frame is flexible and elastic hence transmitting more strains to the ridge especially with the use of resilient telescopic retainers that usually convey more stresses to the ridge. [65,66,47-49]

The use of telescopic retainers and the use of double Aker clasp provide good stability.[19,44,4,6], however, unilateral loading enhances denture frame mobility and deflection of denture base on the mucosa. So edentulous ridges under bilateral loading in both groups, received lesser strains than they did under unilateral loading. While during bilateral loading, non-interfering occlusion with the opposing teeth distributes occlusal load on both sides, enhances denture stability and reduces mobility of base toward mucosa. This agrees with Shahmiri et al., [67] who mentioned that establishment of bilateral balanced occlusion provides equal distribution of masticatory forces for distal extension partial denture cases, although this occlusal scheme is not used with opposing natural teeth.

LIMITATIONS

Limitations of this study like any in-vitro study that ignores wetting effect of saliva on retention of telescopic retainers. The variability in the thickness of both mucosa and periodontal ligament intra-orally play essential role in occlusal force transmission. Occlusal load applied is variable from patient to another and it is not standardized like the one used in the study. So, these results must be confirmed or denied by more clinical research studies.

CONCLUSION

Within the limitations of this in-vitro study that simulated a one-year clinical period, we can conclude that:

- Both milled Co-Cr and PEKK frameworks partial telescopic overdentures are viable treatment options in restoration of Kennedy class II modification 1 cases with reasonable accepted retention, however primary Co-Cr in combination with the milled Co-Cr framework provided better retention than that provided by the Co-Cr and milled PEKK combination.
- Biomechanically, PEKK framework partial telescopic overdenture is a promising treatment option for restoration of pier abutment in cases of Kennedy class II, as it reduces strains on supporting structures of both abutments (including pier abutment). However, PEKK framework puts more strains on the residual ridge of edentulous area. Co-Cr framework partial telescopic overdenture transfers more strains to pier abutment, but it is less destructive for residual ridge of edentulous area.

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