RETENTION OF A CHROME-COBALT VERSUS PEEK TELESCOPIC RETAINER FOR AN IMPLANT SUPPORTED OVERDENTURE: AN INVITRO-STUDY

Khaled Mahmoud El Samanoudy[1], Iman Abd El Wahab Radi[2], Nouran Abd El Nabi[3]

[1]*Master degree student at Department of Prosthodontics, Faculty of Dentistry, Cairo University, Egypt.*
Email: Khaled.ali@dentistry.cu.edu.eg

[2]*Professor of prosthodontics department, faculty of Dentistry, Cairo University, Egypt.*
Email: iman.abdelwahab@dentistry.cu.edu.eg

[3]*Professor of prosthodontics department, faculty of Dentistry, Cairo University, Egypt.*
Email: nouranabdelnabi@dentistry.cu.edu.eg

Corresponding Author: Khaled Mahmoud El Samanoudy

Khaled.ali@dentistry.cu.edu.eg

ABSTRACT

Aim: The aim of this in-vitro study was to evaluate and compare the changes in retention between two different secondary coping materials; chrome-cobalt and PEEK for a mandibular implant supported overdenture before and after they were subjected to different masticatory chewing cycles.

Methodology: An epoxy resin model of a completely edentulous mandible was constructed and prepared to receive four implants in the intra-foraminal area corresponding to the first premolar and lateral incisor regions bilaterally. Four pre-milled titanium abutments were screwed to the four installed implants and these four pre-milled abutments were considered to be the primary coping. The primary coping was the pre-milled titanium abutments, while the secondary coping was different in the groups according to the material used whether milled poly ether ether ketone (group P) or milled cobalt chromium (group C) frameworks. The changes in retention between the primary and secondary coping was recorded at the base line for each group frameworks using universal testing machine each secondary coping framework was attached to the primary coping and then subjected to chewing cycles of 12,500 equivalent to 1 month and then subjected to chewing cycles of 37,500 equivalent to 3 months using the chewing simulator (robotic simulating machine) then retention was evaluated using INSTRON universal testing machine.

Results: Milled chrome- cobalt and milled PEEK groups showed a decrease in retention when subjected to the different chewing cycles. When comparing between group C and group P, group C showed a statistically significant higher retention than group P up to an equivalent period of one month (12500 cycles) while after 3 months there was no significant difference between both groups.

Conclusion: Within the limitation of this in-vitro study, it can be concluded that the milled Co-Cr frameworks showed a statistically significant higher initial retentive values than PEEK frameworks up to an equivalent period of one month, after which retention of both frameworks became equivalent.

Keywords: edentulous mandible, dental implants, Retention, telescopic attachments, CAD/CAM.

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INTRODUCTION

The introduction of dental implants have solved the problems of complete denture. The number of implants to retain mandibular overdenture remains controversial. The standard care is to place two implants in the mandible. While implant supported by four implants-retained overdentures offers an alternative treatment that was reliable and improved phonetics, hygiene, esthetic and was of economic advantages. ***(Kimoto et al 2009)***.

Several types of attachments could be used to retain implant retained or supported overdenture. The role of telescopic retainers in enhancing the retention of implant supported overdentures proved to be reliable. In addition to its secondary splinting effect that is beneficial to implant retained overdenture. In vivo and in vitro investigations proved, that telescopes, when used to retain an implant supported overdenture, ensured a stable denture position, minimized rotational movement and transferred load to the individual fixtures mostly in a vertical direction, which reduced the risk of micro movement. ***(May et al., 2001).***

The materials most commonly used for construction of the inner and outer crowns of the telescopic attachments include gold alloys, chrome cobalt metal alloys, titanium, and zirconia. Numerous methods to fabricate Secondary copings of telescopic crowns as conventional one-piece castings, casting and spark erosion, casting and laser welding, copy milling, and computer-aided design/computer-aided manufacturing (CAD/CAM). The (CAD/CAM) provide rapid construction, high precision and passive seating. Rapid prototyping provides automatic wax-up of the copings which later will be converted into metal copings by traditional lost-wax process. ***(Emarah et al 2020).***

Retention is considered to be a very important factor that would have an impact on patient satisfaction. Retention can be measured through objective or subjective methods, but objective methods seem to be more reliable. Objectives methods of measuring retention using universal testing machine proved to yield more reliable results especially in in –vitro studies.

The question would now arise when using four implant supported telescopic mandibular overdenture, which material used as secondary coping, milled Co-Cr or milled PEEK will provide optimum retention when subjected to different chewing cycles.

Materials and methods

The implant system used in this in vitro study was Implant Direct with length 10 mm and diameter/platform 3.5 mm placed in one epoxy resin model of edentulous mandibular arch. Four implants were installed at lateral incisor and first premolar area and the custom- made abutments used were considered the primary coping for both groups. The primary coping in this study was considered the four pre-milled abutments while the secondary coping used was different in the two groups, one was milled cobalt chromium frameworks and the other group was milled PEEK frameworks.

An impression of a completely edentulous mandibular jaw using alginate impression was made and then poured to create a stone model.

The completely edentulous ridge chosen for this study was of sufficient width in the area corresponding to the lateral incisors and first premolars to accommodate implants of diameter 3.5mm and height 10mm.

The stone model was then duplicated to create the acrylic resin (epoxy) model to simulate a clinical condition.

Duplication of the stone model was done to create a silicon model Trial denture base was constructed using self-cure acrylic resin denture base d on the epoxy resin model which was used for setting up the teeth following the conventional guidelines, followed by marking over the epoxy model between the intra-foramainal area corresponding to the first premolar region and lateral incisor region bilaterally to prepare fo the drilling and placement of the four implants.

A wide diameter fissure bur was used to drill for implant installation in the epoxy resin model slightly larger than implants to facilitate installation and parallelism at the first premolar and lateral incisor areas bilaterally following the acrylic resin trial set up of teeth (Fig.1).

The four implants with diameter 3.5 mm and length 10 mm were installed using a surveyor Soft mix of acrylic resin was placed within corresponding four holes during implant placement to ensure that the implants were well attached within the epoxy resin model.

Figure 1

After placing the implants and setting of them on the epoxy resin, pre-milled titanium cylindrical abutments were screwed to the implants using torque ratchet at 30 N/ cm. while the model was placed on the surveying table a 2 degrees taper bur was inserted into a hand-piece that was mounted on the surveyor to create the required tapering on the abutments, with a chamfer finish line. The abutments were sprayed using scanning powder by (Renfert-Scanspray) and the model was scanned using bench top scanner. For both groups, the designs of the frameworks were done using exocad software. Three frameworks for each group were constructed. Frameworks for both groups were constructed to be covering all the abutment surfaces. All the frameworks covered the abutments to the finish line leaving 2mm space from crest of the ridge.

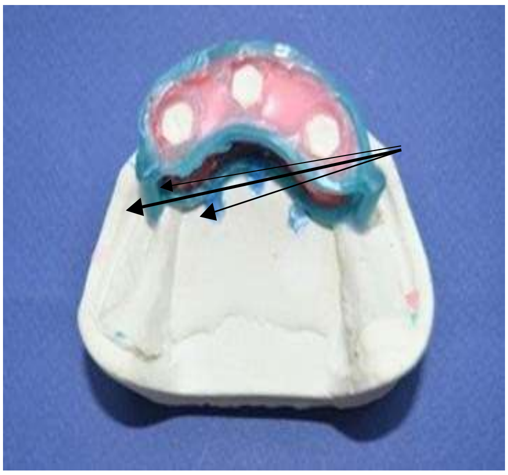
Figure 2

For both groups, the frameworks were milled by VHF milling machine i (Fig. 10) from Co/Cr block by Dentaurum (Fig. 2) and PEEK block by Dentaurum (Fig. 2) to fabricate the milled frameworks, with horse shoe shape connecting four intera-frominal implant leaving 2 mm space from the ridge and then checked for proper seating by alternate finger pressure technique on abutments to be ready for next step.

Finishing and polishing of the framework of both groups was carried out. The framework was checked for proper seating on the model using alternate figure pressure technique. Also, fit checker was used to check the proper seating of the frameworks by applying it over the framework, then the framework was gently seated on the abutments then removed. Areas that exhibit metal showing through or appear as a bright shiny spot were adjusted and the high spots were removed.

After the frameworks were ready, 3 layers of base plate wax was applied over the framework. The 3 layers of the base plate wax would cover all the abutments height. This space of the base plate wax would be later used to create space for the pickup of each framework. The applied wax was 10 mm in width to accommodate 3 nuts that would further be used to attach the 3 screws for measuring retention using orthodontic wires for better engagement.

Using the investment model, the metal prosthetic part was waxed up. The top had a horse shoe shape with sufficient width for 3 nuts. At the bottom (base), there were 3 lingual triangular shaped extensions present at the two terminal abutments bilaterally and one in the midline. The prosthetic part would extend at the terminal implants bilaterally. (Fig. 3). The waxed up part was sprued, invested and casted over the metallic nuts.



Three lingual triangular shaped extensions

Figure 3

After the casting process of the metallic prosthetic part was done, the lingual area of the cast was indexed using a large parallel shaped bur. A thick mix of stone plaster was placed on the lingual area of the model, the prosthesis was returned to the model while the stone was still soft. Excess stone was removed until the three triangular shaped extensions were flushed at the same level with the stone. This stone index was made on the lingual surface of the epoxy model. After the casting process, finishing and polishing for the metal prosthetic parts were done.

The six fabricated frameworks were divided into two groups; C and P. One epoxy model was used for both groups. Group C received the milled Co-Cr frameworks and Group P received the milled PEEK frameworks.

The epoxy resin model was painted with a separating medium to prevent the adherence of acrylic of pick up to the epoxy model. After proper seating of the framework over the primary abutments, trial seating of the metal prosthetic part was carried out on the framework. To ensure proper placement of the framework, the lingual triangular shaped extension rests had to properly engage their defined position in the lingual stone index. The framework was then removed and a soft mix of self-cured acrylic resin then placed inside the fitting surface of the metal prosthetic part. The metal prosthetic part would be seated over the framework with the lingual triangular shaped extensions properly placed over the stone index. After complete setting of the self-cure acrylic resin, the metal prosthetic part was

removed to be checked properly to the picked-up framework. This was carried out with all the frameworks of both groups. (Fig. 4).

Figure 4

One epoxy resin model with the frameworks of both groups were subjected to tensile forces using universal testing machine to record the retention at the baseline. Retention was measured in Newton. The epoxy resin model was attached to the lower compartment of the universal testing machine by the aid of a hole made in the epoxy model to be fixed to the cast holder by a tightening screw while the upper compartment of the universal testing machine was attached to the metal prosthetic part over the framework. The metal prosthetic part was suspended from the upper movable compartment of the testing machine by triple orthodontic wire loop of height 12 cm and width 0.7 mm through custom-made 3 hooks fixed to metal pickup. The orthodontic wires were narled over each other and then fixed into the center of the upper compartment of the universal testing machine through a Jacobs chuck. The device was subjected to a slowly increasing vertical load (1mm/min) until total dislodgment of the prosthetic part from their initial position.

The chewing simulator used in this study was the multimodal ROBOTA m allowing horizontal movements of 10mm and vertical movements of 3mm simultaneously in the thermodynamic condition. The rising and forward speeds were 90mm/s while the descending and backward speeds were 40mm/s. the cycle frequency was 1.6 Hz with torque 2.4 Nm and the weight per sample was 3 kg. These cycles were performed in wet environment of distilled water simulating the saliva.

Each framework of the two groups was then placed on the corresponding abutment and fixed to Jakobe's chuck of the upper part of machine through inverted t-shaped auto- polymerizing acrylic resin centrally positioned horizontal bar to facilitate the aligning with the loading axis of machine and proper load distribution. The prosthetic part had enough width occlusally to accommodate the width of the inverted t-shaped acrylic resin.

The test conditions were maintained at room temperature (20±2°C) and wet condition (distilled water). To analyze the data obtained during the simulation test, a weight of 3 kg, comparable to 29.4 N of chewing force was exerted. The test was repeated 12500 and 37500 times to clinically simulate the one- and three-months chewing condition respectively, according to previous studies **(Nawafleh et al., 2016).** This test was performed for each framework in each group (Group C, P).

The Instron universal testing machine was used in measuring the retention of each framework. Retention tests were performed at baseline, after 12500 cycle and after 37500 cycles clinically simulate the one- and three-months chewing condition respectively.

The load required for dislodgment was recorded in Newton. After measuring the retention of a framework using the universal testing machine were recorded after being subjected to the chewing cycles, the framework was removed from the prosthetic part. Using a fissure bur, all acrylic resin was removed carefully from around the framework. The same steps were carried out for each new pickup with a new framework for both groups. Data were recorded using the computer software. The obtained data was tabulated and subjected to statistical analysis.

RESULTS

1. **Comparison between group C & P:**

Regarding retention at each follow up:

Comparison between both groups regarding retention revealed that retention at baseline, after 12500 cycles (1 month) was significantly higher in group C than group P, while after 37500 cycles (3 months) there was no statistically significant difference between them, as presented in table 1.

Table (1): Mean ± Standard deviation of both groups at baseline, 12500 cycles (1 months) & 37500 cycles (3 months):

	Retention				
	Group C		Group P		p-value
	M	SD	M	SD	
Baseline	15.552	1.408	8.130	0.885	<0.0001* **(0.000*)**
12500 (1 months)	14.818	1.286	5.667	0.886	<0.0001* **(0.000*)**
37500 (3 months)	9.319	1.374	4.148	0.844	<0.0001* **(0.07)**

M; mean SD: standard deviation P; probability level (significant < 0.05)

Retention in changes during different intervals:

Group P showed a greater significant change in retention from baseline to 12500 cycles while from 12500 to 37500 and from baseline to 37500 group C showed greater change in retention compared to group P, as presented in table 2. All changes in retention were not significant between the two groups.

Table (2): Mean difference ± Standard deviation of retention changes in both groups at different intervals [Baseline \ 12500 cycles (1 months)] – [12500 cycles (1 months) \ 37500 cycles (3 months)] & [Baseline \ 37500 cycles (3 months)]:

	Retention				
	Group C		Group P		p-value
	MD	SD	MD	SD	
Baseline \ 12500 cycles (1 months)	0.734	0.122	2.464	0.001	<0.0001* **(0.06)**
12500 cycles (1 months) \ 37500 cycles (3 months)	5.499	0.088	1.519	0.042	<0.0001* **(0.16)**
Baseline \ 37500 cycles (3 months)	6.233	0.034	3.982	0.041	<0.0001* **(0.39)**
% of change	-40.078%		-48.98%		

MD; mean difference SD: standard deviation P; probability level (significant < 0.05).
*significant difference

Discussion

The milled cobalt chromium framework showed higher significant retention values when compared to PEEK group at baseline, 12500 chewing cycles while at 37500 it was not significance. The reason for this result would mainly due to the higher modulus of elasticity of Co-Cr when compared to the PEEK framework which is of lower modulus of elasticity. The milled cobalt chromium framework was roughened by sintering and would depend upon the frictional fit and wedging with the primary coping ***(Abdelrehim et al., 2020)***, while the milled PEEK framework would depend upon the hydraulic adhesion. The friction and the wedging action of the milled Co-Cr would mainly be the reason for the greater retention values when compared to the milled PEEK framework.

The two frameworks showed a decrease in retention when subjected to the different chewing cycles, the milled PEEK framework showed a greater decrease (change) in retention only from baseline and 12500 cycles. Initially the milled PEEK framework showed a greater decrease in retention, because it seems that there was a strong hydraulic retention between the PEEK framework and the primary coping at base line. The ductility and low elastic modulus of PEEK resulted in good adaption that would improve the marginal fit of the PEEK. ***(Emarah et al 2020).*** The good adaptation and marginal fit would result in an initially strong retention through hydraulic adhesion which is influenced by the viscosity of the applied saliva, as well as the chamfer design, ***(Bayer et al 2012)***. while when subjected to 12500 chewing cycle it lost retention at a faster rate than cobalt chromium frame work due to its lower modulus of elasticity which comes in agreement with ***Größera et al 2014*** who stated that CoCr has high elastic modulus (200 GPa) in addition to being rigid and stable (280 HV 10) while, PEEK is ductile and soft (110 HV 5/20) and has less elastic modulus (4GPa).

When comparing the change in retention between the two groups after being subjected to 12500 and 37500 cycles the cobalt chromium framework showed a greater decrease in retention from 12500 cycle and 37500 cycle which was not significant. An explanation for this is that the milled chrome cobalt framework when subjected to 37500 cycles started to loose retention compared to the milled PEEK framework that has already lost most of the retention at 12500 cycle so that was the reason the change in retention was greater for the chrome cobalt framework.

CONCLUSION

Within the limitation of this in-vitro study, it can be concluded that the milled Co-Cr frameworks showed a statistically significant higher initial retentive values than PEEK frameworks up to an equivalent period of one month, after which retention of both frameworks became equivalent.

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