

Original Article

# Retention Evaluation of PEEK Telescopic Attachment in Two Implants Supported Palateless Maxillary Overdenture. An In-vitro Study

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## Abstract

**Objective:** The aim of this study is to evaluate the effect of different positions of two dental implants with polyether ether ketone (PEEK) telescopic attachment on the Retention of palateless maxillary overdenture.

**Methods:** Three edentulous maxillary models were fabricated from cold-cure polymethyl methacrylate resin. Each Model has received two implants as follows: Model 1 (one in each canine region), Model 2 (in right canine and left first premolar area), and Model 3 (in right canine and left second premolar area). One Palateless maxillary denture was constructed over each Model. Ready-made PEEK telescope attachments corresponding to implant abutments were embedded in the inner surface of these overdentures. Initial anterior, posterior, and central retention values of overdentures were estimated and compared with the Retention after 540 cycles of insertion and removal using a digital force gauge.

**Results:** The highest initial anterior retention value was recorded with Model 1, followed by Model 2 and then Model 3 (8.080, 7.460, and 6.980 N), respectively. On the other hand, the highest posterior and central retention values were recorded for Model 3 (11.060 and 10.680 N), and the lowest value was with Model 1 (9.18 and 9.660 N). The highest loss of secondary retention value was recorded with central retention value (24%), then anterior retention value (19%), and the lowest was recorded with posterior retention value (13%).

**Conclusions:** The implant location and distribution affect the retention value of palateless maxillary overdenture. Continuous insertion and removal of the prosthesis for daily hygiene practice lead to decreases in the retention values.

**Keywords:** *Overdenture, Attachment, PEEK telescopic attachment, Retention.*

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## Introduction

Today, implant-supported overdenture represents a reliable treatment option for both edentulous mandible and maxilla<sup>(1,2)</sup>. It has been evidenced by increased patient satisfaction, oral health-related quality of life, and improved mastication<sup>(3,4)</sup>. Maxillary implant-supported overdenture is a predictable treatment option for the edentulous maxilla when the Retention and stability of complete dentures are unsatisfactory<sup>(5)</sup>. Such overdentures are indicated in patients with compromised maxillary ridges, high lip line, thin mobile mucosa, and insufficient lip support, and patients with severe xerostomia (Sjogren's)<sup>(6-8)</sup>. Reduction of the palatal coverage offers several benefits for the patients, including an enhanced taste sensation, better control of the gag reflex, a positive effect on salivary flow rate, and even phonetic benefits. Also, it can be used in patients with large maxillary tori or bony exostoses<sup>(9-11)</sup>.

Denture retention is defined as a resistance of the denture to dislodgment in a vertical direction<sup>(12)</sup>. To enhance Retention and stability of the denture, various overdenture attachments systems can be used for implant-supported overdentures<sup>(13)</sup>. The most popular attachment systems are bar and clips, studs, magnets, and telescopic attachment<sup>(14)</sup>. Telescopic attachments consist of a primary coping (patrx), which is attached to the implant, and a secondary coping (matrix), which is contained within the fitting surface of the denture. Retention is achieved through frictional contact between its components<sup>(15)</sup>. There were different types of materials used for the fabrication of primary and secondary crowns, which are Chrome cobalt alloys, Gold alloy, Zirconia, and Polyether ketone (PEEK)<sup>(16-18)</sup>.

PEEK is a semi-crystalline linear polycyclic thermoplastic that has been proposed as a substitute for metals in biomaterials; it can also be applied to dental implant materials as a superstructure, implant abutment, or implant body. It is a noble material to use in prosthodontics. Due to its favorable chemical, mechanical and physical properties, it is used in producing fixed and removable prostheses<sup>(19)</sup>.

In assessing retention load, it has been reported that PEEK may be a suitable material for telescopic crowns construction, used as a primary and secondary crown with Zirconia and cobalt-chromium<sup>(20,21)</sup>.

The aim of this in vitro study was to assess the retention forces of ready-made secondary PEEK telescopic cap in different positions and distribution of two implant-supported palateless maxillary overdenture. Also, to evaluate the retentive force after 540 times insertion and removal cycles.

## Materials and methods

### Fabrication of study models

Three edentulous maxillary models (without ridge undercuts) were fabricated from cold-cure polymethyl methacrylate resin (Orthocryl Clear Acryl Resin- Dental Dentaaurum-Germany). The residual ridge and the palatal area of the acrylic resin model were covered by approximately 2 mm thick silicone resilient liner (Soft base-Bisico-Germany) to simulate edentulous mucosa<sup>(22)</sup>. In each Model, two of the one-piece compressive long neck (bendable) dental implants (Roott implants - TRATE AG - a Swiss-based company) 4.0 mm in diameter and 10.0 mm in length were placed in a different position. To indicate the exact location for each implant site, a maxillary denture was used as a surgical guide. Simultaneously, the parallelism of the dental implant was archived by using a dental surveyor<sup>(23)</sup>.

In Model 1, two dental implants were placed in canine regions; in Model 2, one dental implant was placed in the right canine and left first premolar region, while in Model 3, one dental implant was placed in the right canine and left second premolar region (Figure 1).

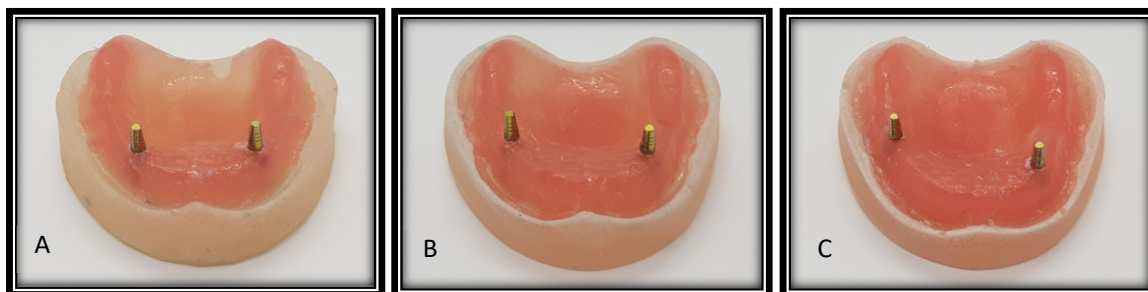


Figure 1: Position of dental implants; (A) Model 1, (B) Model 2, (C) Model 3.

### Impression technique

A primary impression was taken for each Model with their corresponding implants using a heavy body condensation silicone impression material (MAJOR - Prodotti Dentari S.p.A - Italy). After the Transfers (TRA, Roott - TRATE AG - a Swiss-based company) were placed on the implants, a secondary impression was taken with a special tray using addition silicone impression material (PD – President Dental – Germany) by single-step impression technique. Then the analogs were placed inside the transfer position in the impression then poured with dental stone (SHERAPLASTER-Type 3- SHERA-Germany).

### Telescopic attachment

Ready-made PEEK telescopic cap (PCE1, Roott - TRATE AG - a Swiss-based company) was used as a secondary coping, imbedded to the denture base. The abutment of the implant is regarded as a primary coping (7mm length, 3mm diameter, 5° tapers) (Figure 2).

### Maxillary overdenture fabrication

Three experimental palateless overdentures were constructed, one for each Model. Each overdenture was individually processed and polymerized. A conventional heat-polymerized processing technique was used<sup>(24)</sup>. The PEEK telescopic cap was embedded in the denture base. Four U-shaped stainless steel wire loops (0.9 mm diameter) with retentive tags were attached via cold cure acrylic resin to the denture's polished surface, palatal to canines and second molars. The U-shaped loops on both sides of the denture were connected with stainless steel wires (0.5 mm diameter) (Figure 3)<sup>(25)</sup>.

### Retention evaluation process

Before retention evaluation, artificial saliva (SALIVEZE™-WYVERN MEDICAL LTD-UK) was applied to the models and the inner side of the overdentures framework to mimic the oral environment (between every ten insertions and removal to maintain the moisture of the surface)<sup>(26)</sup>. A digital force gauge estimated retention (Nextech DFS500, Push-Pull Gauge, Peak/Track Mode, Invert Display, Pass/Fail) use to record maximum dislodging forces (Figure 4)<sup>(27,28)</sup>. The digital force gauge was attached to the upper portion of the stand, and the Model was stabilized to the stand base by screw. The hook of the strain gauge device was attached to withdrawal loops of anterior, posterior, and central wires to measure overdenture anterior, posterior, and central retentions, respectively. The digital force gauge was slowly lifted by rotating the stand until the denture base was dislodged, and the peak value was recorded in Newton as a retention value<sup>(23,29)</sup>.

Five measurements (maximum dislodging force) were recorded for each site (anterior, posterior, and central). The average of the five readings was calculated, and the mean value was used to represent initial Retention. Each overdenture was inserted and removed (540 times in central crossing point) to simulate six months of overdenture use (assuming three daily removals and insertions for oral hygiene). Another five measurement was performed, and the mean was used to represent final Retention<sup>(30)</sup>.

For oblique (non-axial) dislodging force: two types of rotational dislodgements were investigate; first, anterior

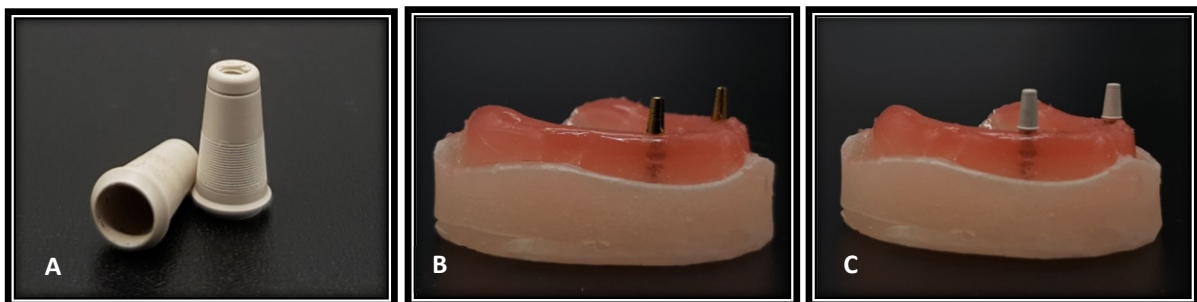


Figure 2: (A) PEEK telescopic cap, (B) Abutment of the implant, (C) PEEK telescopic cap placed on the implant abutment.



Figure 3: (A) Anterior and posterior centrally looped wires. (B) Two diagonal wires meet in a crossing point.

rotational dislodgement, when a stainless steel wire connecting two hooks left and right canines, and the centrally looped wire was attached to the digital force gauge. Second, posterior rotational dislodgement, when a stainless steel wire connecting two hooks on left and right second molars and the centrally looped wire was attached to the digital force gauge<sup>(23,31)</sup>. For vertically (axial) dislodging force: two diagonal wires meet in a crossing point to measure central Retention (Figure 3).

### Statistical analysis

SPSS (ver. 22.0) software (SPSS Inc.) was used for statistical analysis. One-way ANOVA testing was applied for determining the difference between the means of the Models, and a Paired sample t-test was applied for determining the difference between initial and secondary retention value, where the significance alpha level was set at  $p < 0.05$ .

## Results

### Primary Retention

One-way ANOVA test revealed statistically significant differences in the anterior, posterior, and central retention values between the Models. The highest initial anterior retention value was recorded with Model 1 (8.080 N) and the lowest with Model 3 (6.980 N). On the other hand, as implant position placed posteriorly, the highest posterior and central retention values were recorded for Model 3 (11.060 N and 10.680 N) and the lowest value was with Model 1 (9.18 N and 9.660 N) (Table 1).

### Secondary Retention

There was a statistically insignificant difference in secondary anterior Retention in different positions of

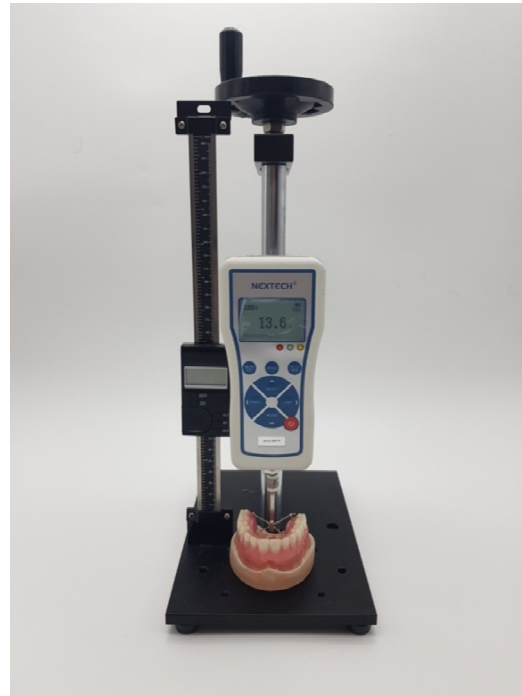


Figure 4: Digital force gauge and the model attached to test stand.

Two implant-supported overdenture among the three models ( $p > 0.05$ ), while there was a significant increase in posterior and central retention value ( $p < 0.05$ ) (Table 2). The highest secondary posterior and central retention values were recorded for Model 3 (9.460 N and 8.52), and the lowest value was with Model 1 (7.900 N and 7.060 N).

### Comparison of initial and secondary Retention

As shown in Table 3, there was a statistically highly significant difference between initial and secondary retention value ( $p < 0.001$ ) as there was decreasing in the amount of anterior, posterior, and central retention values of two implants supported overdenture after 540-time insertion and removal. The overall highest loss of retention value was recorded with central retention value (24%), then anterior retention value (19%), and the lowest loss of retention value was recorded with posterior retention value (13%).

## Discussion

The telescopic attachment has several advantages as axial force transmission and rigid splinting action, long-term patient satisfaction, better marginal adaptation, and easy to perform routine oral hygiene<sup>(32-34)</sup>; while the disadvantages are complex laboratory procedures,

Table 1: Comparison of initial retention value (in Newton) between different positions of two implant-supported overdenture.

		N	Mean $\pm$ SD	p-value
Initial anterior Retention	M1	5	8.080 $\pm$ 0.4147	0.001
	M2	5	7.460 $\pm$ 0.2966	
	M3	5	6.980 $\pm$ 0.2950	
Initial posterior Retention	M1	5	9.180 $\pm$ 0.3701	$\leq$ 0.001
	M2	5	10.220 $\pm$ 0.3834	
	M3	5	11.060 $\pm$ 0.5857	
Initial central Retention	M1	5	9.660 $\pm$ 0.4561	0.026
	M2	5	9.980 $\pm$ 0.6760	
	M3	5	10.680 $\pm$ 0.3834	

Table 2: Comparison of secondary retention value (in Newton) between different positions of two implant-supported overdenture.

		N	Mean $\pm$ SD	p-value
Secondary anterior Retention	M1	5	5.660 $\pm$ .2881	0.065
	M2	5	6.100 $\pm$ .6083	
	M3	5	6.420 $\pm$ .4207	
Secondary posterior Retention	M1	5	7.900 $\pm$ .7348	0.003
	M2	5	9.220 $\pm$ .4712	
	M3	5	9.460 $\pm$ .5273	
Secondary central Retention	M1	5	7.060 $\pm$ .4827	0.001
	M2	5	7.320 $\pm$ .4817	
	M3	5	8.520 $\pm$ .4970	

difficulty in achieving esthetics and additional cost to the patient<sup>(32)</sup>. To overcome the disadvantage of conventional telescopic attachment, in this study, ready-made PEEK telescopic attachment was used. This type of telescopic attachment has several advantages over the conventional telescopic attachment as it is a cost-effective, simple laboratory procedure, less time consuming, and simple repairing procedure.

Initial retention values may indicate clinical predictability and performance and facilitate patient acceptance of prosthesis. It has been reported that the retention value from 5 to 7 N was sufficient to stabilize overdentures during a long-term function to achieve good patient satisfaction<sup>(34)</sup>. In this study, the initial

retention values for two implants supported palateless maxillary overdenture were above the range of accepted effective retentive force for overdentures, ranging from 6.98 to 11.06 N.

Model 1 showed a significantly greater mean of anterior retention value than Model 2, and then Model 2 showed a significantly greater mean of anterior retention value than Model 3. This logical result is attributed to the relation of the dental implants position and the point of force application within the models. In Model 1, the two dental implants were closer to the point of force application than the dental implants in Model 2 and then Model 3<sup>(35)</sup>.

Table 3: Comparison means of initial and secondary retention values (in Newton).

	Initial retention Mean $\pm$ SD	Secondary retention Mean $\pm$ SD	p-value	Percentage of retention value loss
Anterior Model 1	8.080 $\pm$ 0.4147	5.660 $\pm$ .2881	< 0.001	19%
Anterior Model 2	7.460 $\pm$ 0.2966	6.100 $\pm$ .6083		
Anterior Model 3	6.980 $\pm$ 0.2950	6.420 $\pm$ .4207		
Posterior Model 1	9.180 $\pm$ 0.3701	7.900 $\pm$ .7348	< 0.001	13%
Posterior Model 2	10.220 $\pm$ 0.3834	9.220 $\pm$ .4712		
Posterior Model 3	11.060 $\pm$ 0.5857	9.460 $\pm$ .5273		
Central Model 1	9.660 $\pm$ 0.4561	7.060 $\pm$ .4827	< 0.001	24%
Central Model 2	9.980 $\pm$ 0.6760	7.320 $\pm$ .4817		
Central Model 3	10.680 $\pm$ 0.3834	8.520 $\pm$ .4970		

On the other hand, regarding the posterior and central Retention, Model 3 showed significantly greater posterior and central retention values than that of Model 2. Then Model 1 showed the least amount of posterior and central retention value. Also, this may be attributed to the proximity of posterior implants in Model 3 (second premolar area) to the point of force application than in the other models. This result was concomitant with the study by Scherer et al., who stated that the posterior Retention was increased when the implant location was placed distally<sup>(36)</sup>. And also is agreed with the study of Michelinakis et al., who reported that interim plant distance could affect the Retention of two implant-supported overdenture<sup>(37)</sup>.

Secondary retention values were significantly decreased after 540-time insertion and removal that simulated six months period of time; this result agrees with the finding of Emera et al., who used PEEK as primary and secondary crown and also with the study of Minagi et al., they used an Ag-Au-Pd alloy for the coping and telescope of a crown<sup>(20,38)</sup>. The overall decrease in retentive values were (19%, 13%, and 24%) for anterior, posterior, and central, respectively. This decrease in retention value after the multiple insertion and removal may be related to some plastic deformation that may happen in PEEK telescopic cap, or it may be related to some wearing of the inner side of the PEEK telescopic cap with the implant abutment as a result of the frictional force that occurs between this two different materials<sup>(39)</sup>.

While our results are in disagreement with the finding of the study of Schubert et al., they used CAD/CAM-fabricated PEEK secondary telescopic crown and zirconia primary crown<sup>(40)</sup>. This dissimilarity possibly may be related to different materials and manufacturing variations. Despite the decrease in retention value after 540 times insertion and removal, the secondary retention in this study are still larger than the minimum retention value that was reported (5–7 N) to achieve good patient satisfaction<sup>(34)</sup>.

## Conclusions

Based on this in vitro study, it can be concluded that:

- Dental implant locations and distributions can affect the value of Retention.
- Anterior retention value was decreased when dental implants with PEEK telescopic attachment were placed more distally. Simultaneously, the posterior and central retention values were increased when the dental implant placed more distally.
- Continuous insertion and removal of the prosthesis for daily hygiene practice lead to decreased retention value. More loss of Retention was observed in central Retention.

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