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Comparison between Two Different Attachment Caps Used in Locator Attachments of Implant supported Overdentures (In-Vitro Study)

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ABSTRACT

Purpose: To compare different retentive cap material used in LOCATOR attachments, namely the nylon retentive cap versus PEEK retentive caps, and measure the loss of retention over a period of two years, through 2880 cycles of insertion and removal. ***Materials and methods:*** Two implants 3.8mm x 10.5mm were inserted into a clear epoxy resin cast, through a surgical guide, with the implants being 23mm apart. Two LOCATOR attachments with 5 mm gingival height were screwed to the implants, custom made nylon caps were fabricated as an exact replica of the PEEK retentive caps, then two dentures were constructed and pick up were done with both retentive cap materials. A hook was attached to the geometric center of both dentures, and measurement of the retentive forces was accomplished with a universal testing machine, and the data was recorded and analyzed. ***Results:*** The amount of retention achieved from PEEK retentive caps was twice that of the nylon retentive caps, indicating high statistical significance ($p < 0.001$) of the effect of the material and remained so throughout the repeated cycles with ($p < 0.001$), however both caps showed similar rate of retention loss throughout the study, but the amount of wear was statistically higher in the PEEK group throughout the cycles, except after 2880 cycles.

Conclusion: PEEK showed higher retentive properties throughout the cycles, but both materials showed similar rate of retention loss.

1. INTRODUCTION

Implant supported or implant retained overdentures introduced a solution to overcome those shortcomings through the various attachments, however, that lead to the rise of new problems related to these attachments. Both Meijer et al[1] and Raghoebar et al[2] found that when compared to complete denture, overdentures showed higher satisfaction rate even with patients that had undergone pre-prosthetic surgeries. Overdentures still has its drawbacks such as being bulkier when compared to regular dentures, and its need for increased inter-arch distance, the increased maintenance required for the supporting teeth, as well the maintenance required for the overdenture itself.[3]

LOCATOR attachments are a type of stud that consists of a male part, a metal socket with a replaceable nylon cap as the female part. The retention value is dependent on the female part of the attachment, specifically the nylon cap [4]. One of the key advantages of locator systems is their ability to be used with patients with limited-inter arch distances, and their ability to fix inter-implant angles up to 40°. [5] Another advantage of Locator is their ability to retain their retention value over time when compared to bar attachments despite having lower initial retention values. [6] However, LOCATOR showed significant loss of its retention values over time due to its nylon female part despite the initial retention of the color-coding of the cap. [7] Also, locators show a more rapid decline in retention value with angulated implants when compared with ball attachments. [8] In addition, locator implants showed significantly higher vertical bone loss than magnets after 1 year,[9] and showed greater peri-implant stresses when compared with either bar or ball attachments. [10]

Since PEEK promises higher mechanical properties when compared to Nylon, this study aimed to replace the Nylon component of LOCATOR attachments and measure the loss of retention over time when subjected to repeated cycles of insertion and removal.

2. MATERIALS AND METHODS

Class 1 mandibular edentulous (Mcgamy 1999, ACP [11]) mold was used to fabricate the edentulous cast. Clear Epoxy Resin (CMB Kemapoxy 150-3D Clear Epoxy Resin) was mixed according to manufacturer's instructions and poured into the mold to obtain a transparent edentulous template.

Figure (1) — Clear Epoxy Class 1 Edentulous Model

Scanning of the edentulous template was done by the aid of an intraoral scanner (Medit i700) to obtain an accurate 3D render of the template.

A fully limiting guide was designed using a computer software (RealGuide, 3diemme, Italy), with implant drilling sites 23 mm apart crossing the midline. Two 3.8mm in diameter x 10.5mm in length implants (BioHorizons, Tapered Internal) were used and the sleeves and guide fabrication were done accordingly. Implant drilling was done sequentially according to the manufacturer's instructions, and implant placement was finally done with a torque wrench adjusted to 30Ncm, and a final coat of epoxy resin was put on the surface of the implant fixtures to ensure proper bonding of the implant to the template.

Figure (2) — Guide for Implant Placement

Two LOCATOR attachments (5mm Click-PEEK Locator attachments) 5mm gingival height with were screwed into the implants.

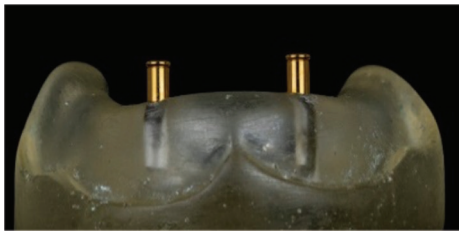

Figure (3) — Male LOCATOR attachments after screwing to implants

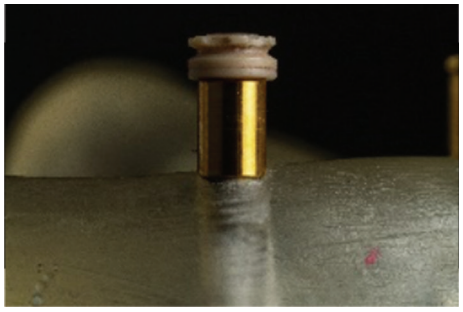

Figure (4) — PEEK retentive cap fitted on the Male attachment

In order to have an accurate comparison between the PEEK and the Nylon retentive caps, an exact replica of the PEEK retentive cap was made.

Addition curing silicon-based duplicating material (Replisil 22N) impression was taken for the metal male part of the LOCATOR and poured with Extra Hard dental stone Type IV(Zhermack)to produce a positive reproduction of the male part of the attachment system.

Figure (5) — Silicone impression of male part

Figure (6) — Stone replica of male part

Another impression was taken to the male part with the PEEK cap attached to it, to produce a sufficient space for the PEEK housing, to be replaced with Nylon. Blue inlay replacement wax was put into the created impression in the space created from the PEEK cap, creating a replica from wax of the PEEK retention cap. The wax model was attached to a sprue and inserted into a flask (Thermopress 400).

Wax elimination was performed, and a space was created which was then filled with a polyamide (Bredent bre.flex). Finishing and polishing was done using an ultrasonic cleaner to ensure the removal of excess investment material without damaging the Nylon caps.

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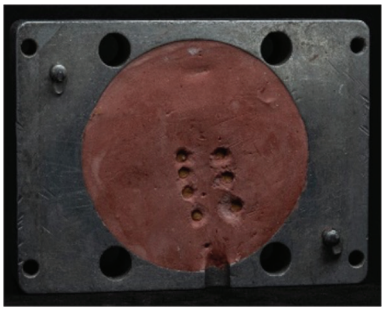

Figure (7) — Thermopress flask with space for Nylon injection

Two dentures were constructed to be used and were categorized into two groups according to the retentive caps that were incorporated into the fitting surface of the denture. Group 1 custom made nylon caps. Group 2 readymade PEEK caps. The following steps were done:

An irreversible hydrocolloid impression (Hydrogum, Zhermack) with a stock tray was taken to the already prepared epoxy model, with the LOCATOR attachments screwed to the implants, upon which the caps (Nylon or PEEK) was placed. Occlusion blocks followed by teeth setting, flasking and curing were done to produce the heat-cured acrylic dentures with holes already prepared opposite to the attachments for the pick-up stage. The flanges were reduced and trimmed.

Figure (8) — Finished heat-cured acrylic denture

The holes corresponding to the attachment was widened, a pick-up was made for the different caps using cold cure acrylic resin (Acrostone). The rubber spacer was first inserted under the caps, and the remainder of the attachment was sealed using Teflon. Excess acrylic from the pick-up was removed and the surfaces were finished and polished.

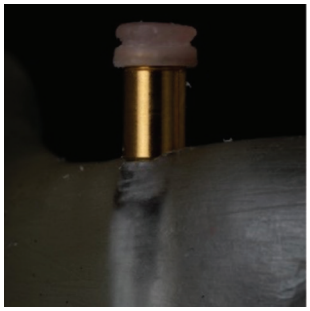

Figure (9) — Custom Nylon Cap over Locator

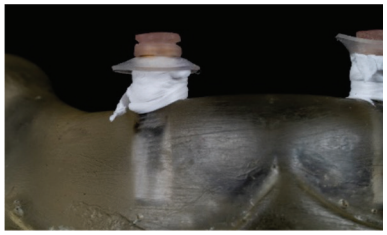

Figure (10) — Blocking undercuts for Pick-up

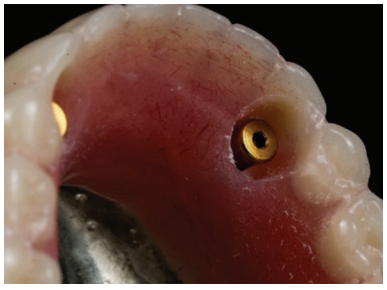

Figure (11) — Prepared denture for Pick-up

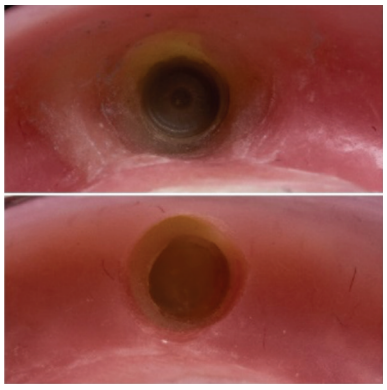

Figure (12) — Final Pick-up for PEEK and Nylon caps

Figure (13) — Finished Denture with steel hook

A round steel hook was attached the to the denture tongue space at the midline, centered between the two attachments according to the geometric centers of the attachments, to be used during the measurements of the retention.

The Epoxy model was secured to the base of a Universal Testing Machine (Model 3345, Instron, England) with 500 N load cell. A loose stainless-steel wire was winded around the hook and fastened to the universal testing machine. Dislodgement force was measured as overdentures were lifted

upward at 50 mm/min crosshead speed. Linear dislodgement slide was carried out, perpendicular to the occlusal plane, and the forces were recorded using a compatible computer software (Bluehill Universal, Instron, England).

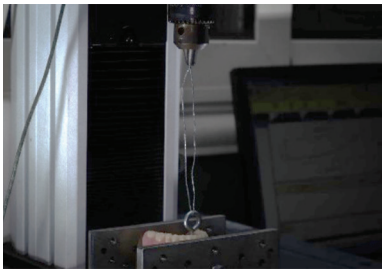

Figure (14) — Universal Testing Machine recording dislodgement forces

Ten Pulls were performed for each denture initially before any cycles of insertion and removal to measure the initial maximum retentive forces of both the PEEK and the Nylon caps.

Cycles of insertion and removal were performed to the overdentures, and the forces were recorded again at 360, 720, 1440, and 2880 cycles which simulated insertion and removal over a period of 3 months, 6 months, 12 months, and 24 months, respectively.

3. RESULTS

Data presented as mean and standard deviation (SD). Data explored for normality using Shapiro-Wilk test. Maximum load (N) data showed a parametric distribution. Two-way ANOVA used to show the different materials and cycles on the maximum load (N) followed by multiple comparison with Bonferroni adjustment. One-way ANOVA used to compare between tested cycles within each material followed by Tukey HSD for percentage of change in the maximum load. Additionally, Independent t-test used to compare between the materials for each cycle.

The significance level was set at $p < 0.05$.

1- Effect of tested materials on the maximum pulling load (N)

Table (1)

Mean and standard deviation of maximum load (N) for different tested materials.

		Nylon		PEEK		p-value
		Mean	SD	Mean	SD	
Maximum pulling Load (N)	Baseline	30.1	0.8	63.0	1.2	<0.001*
	360	22.4	0.2	43.2	1.0	<0.001*
	720	17.3	0.3	34.1	1.4	<0.001*
	1440	14.3	0.2	27.2	0.4	<0.001*
	2880	10.5	0.2	22.5	0.3	<0.001*

*=Significant. NS=non-significant

2- Effect of tested materials on the percentage of decrease in maximum pulling load (N)

Table (2)

Mean and standard deviation of percentage of decrease in maximum load (N) for different tested materials

		Nylon		PEEK		p-value
		Mean	SD	Mean	SD	
% Of change	360	25.5%	1.6	31.4%	2.1	<0.001*
	720	42.6%	1.5	45.8%	1.9	0.001*
	1440	52.5%	0.8	56.8%	0.9	<0.001*
	2880	65.0%	1.3	64.2%	0.9	0.148 NS

*=Significant. NS=non-significant

4. DISCUSSION

A Class 1 edentulous mold was used as it presents the least amount of complications[11], and was poured and a model was created using epoxy resin as it simulates modulus of elasticity of the trabecular bone. [12]

The implants were placed 23 mm apart as it was found to be the optimum inter-implant distance for retention[13]

The LOCATOR attachments used was 5 mm in height to create adequate clearance from the ridge and decrease friction between the denture and the crest of the model.

The rationale behind these cycles is that an average denture wearer takes out his denture and insert it an average of four times per day, equating to 120 times per month. Hence, these cycles represent measurements at 3 months, 6 months, 1 year, and 2 years of use.[14]

The reason behind choosing Bredent bre.flex for the custom-made nylon attachment was that it contained the specific polyamide groups that makes up for nylon polymers, and hence was comparable in its properties.

Linear dislodgement was done 50 mm/min as it simulates the situation of pulling in the patient's mouth in the presence of a thin film of saliva.[15–18]

At the baseline, the amount of retention achieved from using PEEK caps was almost twice that of its nylon counterpart, with a mean value of 63N ±1.2 compared to 30.8 ±0.8, indicating high statistical significance ($p < 0.001$) of the effect of the material and remained so throughout the repeated cycles with ($p < 0.001$)

The amount of retention achieved with the custom made retentive cap is comparable to that of other studies conducted on pre-fabricated ones [15,17,19], but higher than the amount advertised by the manufacturer of LOCATOR white. [7] There are a few other studies however in which the retention value of locator white was higher.[14,20] The amount of retention derived from PEEK retentive caps is higher than the recommended amount according to literature[19], therefore while promising an increased service time, it might cost LOCATOR attachments their favorable stress distribution over implants[21,22], or could cause difficulty for the patient in the insertion and removal of their overdentures.

When comparing the rate of loss of retention, both materials showed a similar rate of retention loss throughout the entire study, but the amount of wear statistically higher on the PEEK retentive caps throughout the cycles, except after 2880 cycles, in which the percentage of retention loss on the Nylon caps was higher but indicating no statistical significance. (p =0.148 NS)

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This finding suggests that while the effect of the material itself affects the performance of the caps, wear of the metal attachment itself might contribute to the loss of retention over time. The discrepancies of the results might be due to several limitations of our study. Difference of the methodology in selection of epoxy mandibular models instead of acrylic blocks, the lack of saliva, the lack of thermocycling, the different geometric mean that could be used to evaluate dislodgement force and the conduction of the study in-vitro settings rather than in-vivo in the presence of soft tissue might affect the values of initial retention and the rate of wear, thus the rate of retention loss. The oral setting for overdenture presents a dynamic condition for overdenture with complex biomechanics that are difficult to replicate in in-vitro settings.

5. CONCLUSIONS

Within the limitations of this study, it was concluded that:

1. PEEK caps showed higher retentive values than nylon, due to its higher rigidity and flexural strength.
2. Both retentive cap materials, the nylon and PEEK, showed loss of retention after 2 years.
3. The rate of retention loss between PEEK and Nylon is similar, indicating that regardless of the material, wear of the male part might have an effect in the loss of retention.

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