Impact of Locator Attachments with Different Retentive Insert Materials on Bite Force in Mandibular Implant Overdenture.

Original Article

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ABSTRACT

.**Purpose:** To evaluate the impact of locator attachments with different retentive insert materials on bite force in mandibular implant overdenture.

Materials and Methods: Eight completely edentulous patients were selected for this study. Each patient received two implants in the canine area of the mandible bilaterally. Patient grouping was performed as follow, group I: 4 patients received two locator overdenture attachments with nylon inserts, group II: 4 patients received two locator overdenture attachments with PEEK inserts. The bite force was measured with conventional complete denture, after 3 months of overdenture insertion and after 6 months using occlusal force transducer. The surface wear evaluation of PEEK and nylon inserts were done before pick-up, after 3 months and after 6 months of overdenture insertion using scanning electron microscope (SEM).

Results: There was significant difference between groupI(nylon insert) and groupII (PEEK insert).Overdentures loaded with PEEK inserts recorded significant increase in bite force values than nylon inserts after 3 months and 6 months of overdenture insertion($P<0.001$). Significant wear changes were shown with nylon inserts at (T3) and (T6) rather than PEEK inserts($P<0.001$).

Conclusion:PEEK inserts in locator attachments provide successful inserts instead of nylon ones providing better biteforce and wear resistence.

Key Words: implant overdenture, PEEK insert, locator, biteforce .

INTRODUCTION

Implant-supported overdentures have become popular as a standard of care for the treatment of edentulous mandible .Implant supported overdentures have been used in the rehabilitation of the edentulous lower jaw with excellent results.Completely edentulous patients can benefit from implant supported overdenture when they lose their teeth at an advanced age and are not capable of wearing mandibular denture or when, after having dentures for many years they begin to lose their motor skills and no longer able to wear complete dentures[1].

Locator attachment system is one of the most popular attachments with an optimized design and improved retention and stability. This system consists of a patrix and a matrix , using a dual retention approach with different retentive values. It is classified as a resilient universal hinge device, and is designed for limited inter-arch distances, enabling inter-implant angles to be fixed up to 40º. This attachment employs mechanical and frictional forms of retention, since the insert section of the nylon male component is slightly oversized compared to the inner ring of the female abutment. The external margin attaches simultaneously and completely within the shallow area at the outer margin of the abutment, while the central stud of the nylon male component insert press-fits inside the inner metal ring of the female abutment.The retention value of the Locator attachment depends on the patrix, composed of a metallic cap with a replaceable nylon element, and its cross-sectional strength is obtained through its dual retention feature [2].

Mechanical complications of the locator attachments are bound to increase with time in function, as with all technical equipment. The loss of retention over time has been confirmed due to excessive wear and increased maintenance requirements for the male inserts of the locater attachment which are made from nylon[3]. A modification in the attachment design along with an elioration of the attachment surface decreased the maintenance needs and enhanced its clinical performance. The locator attachments with polyetherketoneketone inserts have been presented and have important role on increasing the bite force and the wear resistance[4].

PEEK is used rather than nylon inserts due to the decreased the wear rate.PEEK material allows the absorption of

functional stresses and acts as stress breaker. PEEK is a very rigid material with a flexural strength of 140170- MPa . Furthermore, PEEK has good biocompatibility combined with low water solubility and high chemical and thermal stability.PEEK material reported high patient satisfaction with regard to retention and comfort.The superiority of PEEK material over the other materials made PEEK to be considered as a substitute for the other materials that used in dentistry.[5,6]

There is a lack of data, on the impact of different retentive insert materials on bite force due to the attachment surface wear. Hence, the purpose of this study was to evaluate the impact of locator attachments with PEEK versus nylon insert materials on bite force in mandibular implant overdenture and evaluation of surface wear occurs with different types of insert materials used.

MATERIAL AND METHODS

Eight complete edentate patients were selected from the outpatient clinic of Prosthodontics Department with regard to the following selection criteria: all patients have adequate bone width and thickness for dental implant and bone density of type D3 at least verified by cone beam CT (CBCT), one year at least after last extraction, covered with even thickness, firm healthy mucosa, normal maxillomandibular relation, adequate restorative space verified by putty index method. Patients with parafuncional habits, smoking, alcohol administration, systematic disorders affecting bone were excluded from this study.

-For all patients, complete dentures were fabricated at first by conventional method. After one month of denture wearing to allow denture settlement, mucosa supported sterolithographic surgical guide was fabricated aided by CBCT planning software (Figure1a). After local anesthesia, two implants (12mm length and 4 mm diameter) were inserted in the mandibular interforaminal region bilaterally using the flapless surgical approach(Figure.1b). The mandibular denture was relieved over implant sites and the implants were left submerged for 3 months according to the standardized two-stage protocol to allow for implant osseo-integration.

The patients were classified into 2 groups according to type of attachment insert:

Group I: where the mandibular implant overdenture was retained by Locator attachment with nylon retentive male inserts.

Group II: where the mandibular implant overdenture was retained by Locator attachment with PEEK retentive male inserts.

Small crestal incisions were made at canine regions bilaterally and cover screws were removed from the internal hex of implants and healing abutments were placed instead for two weeks. Healing abutments were removed and the locater abutments were attached to the

implants intra-orally. Direct functional pick up of the locater metal cap to the denture fitting surface was accomplished by self-cure acrylic resin (Figure. 2(a,b)). Blue nylon insert was placed into each locater abutment using locater insertion tool in groupI(Figure.3a), PEEK insert was placed in group II(Figure 3b).Measurement of biteforce was done at T0(conventional complete denture) , T3 (after 3 months of overdenture insertion) and T6 (after 6 months of overdenture insertion). Evaluation of wear of the retentive inserts was done at T0 (before pick up),T3(after 3 months of overdenture insertion),T6(after 6 months of overdenture insertion) -Biteforce measurement was done using occlusal force transducer (Figure.4)

-Evaluation of wear of the retentive inserts was done by SEM.(scanning electronmicroscope). The inserts were prepared to be evaluated with scanning electron microscope (SEM) by coating with gold using Hummer VI deposition system for about 1.01.5- minutes of sputtering(Figure.5(a,b)). Samples were studied using electron microscope (JOEL-JSM-6510LV) at 25X, 150X magnification power. Evaluation of surface changes (wear) was done by using Computer Assisted digital image analysis (Digital morphometric study)

(Figure 6 - 11). The resultant images were analyzed on Intel® Core I3® based computer using Video Test Morphology® software with a specific built-in routine for pixel statistics. -Significance of the obtained results was judged at the 5% level.

RESULTS

• Table (1) shows the statistical analysis of biteforce between T0, T3and T6 for group I and group II.

• Results show statistical significant increase in biteforce in groupII than groupI with advance of time at significance level p<0.001.

• Table (2) shows the statistical analysis of biteforce between groupI&groupII

• There was statistically significant difference between both groups at different observation times (p <0.001). Significant reduction of biteforce was noted in both groups after six months with increased reduction in groupI rather than groupII at T3 ,T6.

• Table (3) shows the statistical analysis of wear between different observation periods within group I and group II.

• Results show statistical significant increase in wear in groupI rather than group II with advance of time at significance level p <0.001.

• Table (4) Comparison of Wear between groups within T0, 3M & 6M time periods.

• Results show significant difference in wear between groupI& II within T0,T3,T6 where(P< 0.001 ,P=0.017 in (T0-T3),(T3-T6) respectively).

Table (1) : Comparison of bite force in newton(N) between observation periods within groups

		T0	3M	6M	P value
Bite force in (N)	**Nylon**	70.78±3.03	101.50±1.20	96.62±1.76	<0.001*
	Post-hoc		P1=<0.001*	P2=<0.001* P3=<0.001*	
	PEEK	70.38±.57	149.00±2.00	147.43±2.04	<0.001*
			P1=<0.001*	P2=<0.001* P3=<0.001*	

Data expressed as mean±SD
SD: standard deviation
P: Probability   *: significance <0.05
Test used: Repeated measures ANOVA followed by post-hoc tukey
P1: significance between T0 & 3M
P2: significance between T0 & 6M
P3: significance between 3M & 6M

		Nylon	PEEK	t	P value
Bite force in newton(N)	**T0**	70.78±3.03	70.38±.57	.367	0.71
	3M	101.50±1.20	149.00±2.00	-57.663	<0.001*
	6M	96.62±1.76	147.43±2.04	-53.258	<0.001*
	(T0-T3)	30.73±2.06	78.63±2.16	-45.352	<0.001*
	(T3-T6)	-4.88±1.35	-1.57±.35	-6.709	<0.001*

Data expressed as mean±SD
SD: standard deviation
P: Probability   *:significance <0.05
Test used: Student's t-test(Unpaired)

Table(3): Comparison of wear between observation periods within groups.

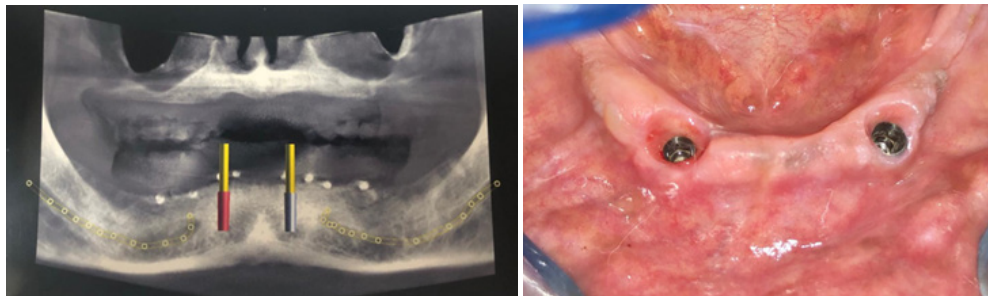|		T0	3M	6M	P value
Wear (surface topography Analysis)	**Nylon**	216.17±26.69	146.51±8.82	123.82±10.68	<0.001*
	Post-hoc		P1=<0.001*	P2=<0.001* P3=<0.001*	
	PEEK	209.30±14.45	176.99±9.27	165.60±7.42	<0.001*
			P1=<0.001*	P2=<0.001* P3=<0.001*	

Data expressed as mean±SD
SD: standard deviation
P: Probability   *:significance <0.05
Test used: Repeated measures ANOVA followed by post-hoc tukey
P1: significance between T0 & 3M
P2: significance between T0 & 6M
P3: significance between 3M & 6M

Table(4) : Comparison of Wear between groups within T0, 3M & 6M time periods.

		Nylon	**PEEK**	**t**	**P value**
Wear (surface topography analysis)	**T0**	216.17±26.69	209.30±14.45	.640	.533
	3M	146.51±8.82	176.99±9.27	-6.739	<0.001*
	6M	123.82±10.68	165.60±7.42	-9.087	<0.001*
	(T0-T3)	-69.65±21.95	-32.31±7.01	-4.585	<0.001*
	(T3-T6)	-22.69±11.16	-11.39±3.80	-2.713	0.017*

Data expressed as mean±SD
SD: standard deviation
P:Probability   *:significance <0.05
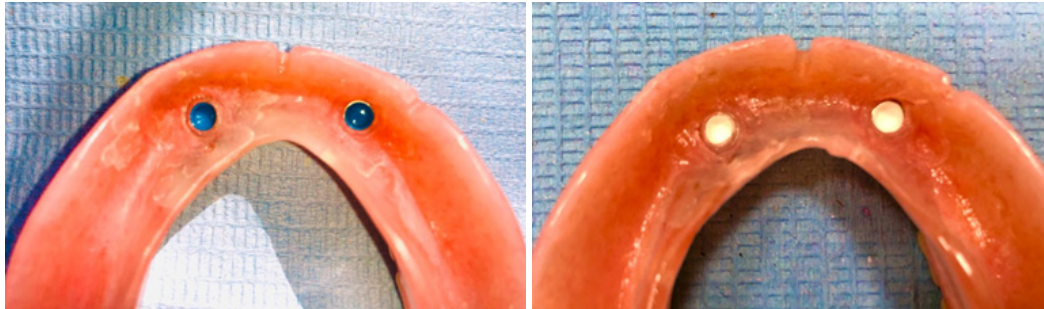Test used: Student's t-test(Unpaired)

Figure(1) a: CBCT showing the predetermined location, inclination, and depth of canine implants.
b: 2 implants were placed in the canine region.

a: Pick up of the two locater attachment.

Figure(3) a: Changing the plastic cap with nylon insert.
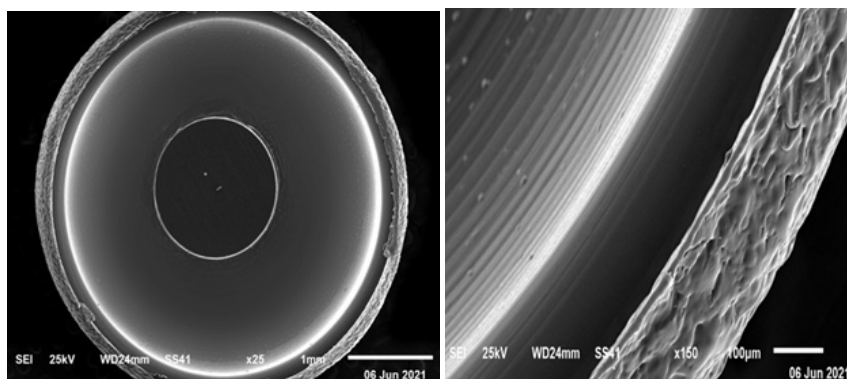b:changing the plastic cap with PEEK insert.

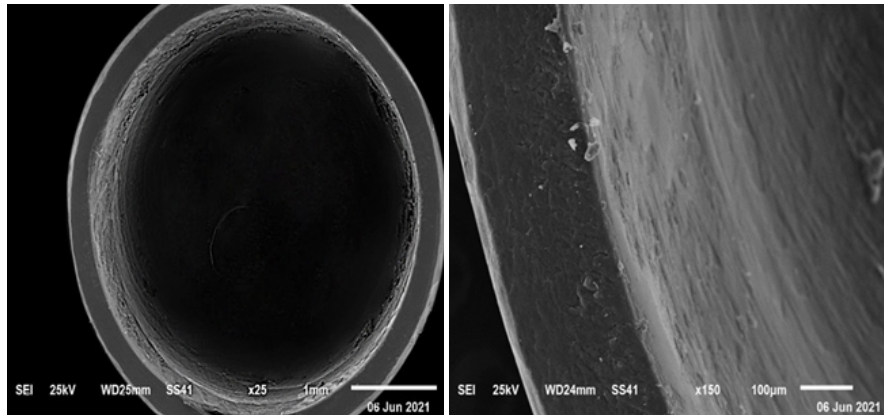**Figure (4)**:measurement of bite force by occlusal force transducer GM10.

Figure(5)a: Hummer VI sputter deposition system for coating insulation SEM samples.
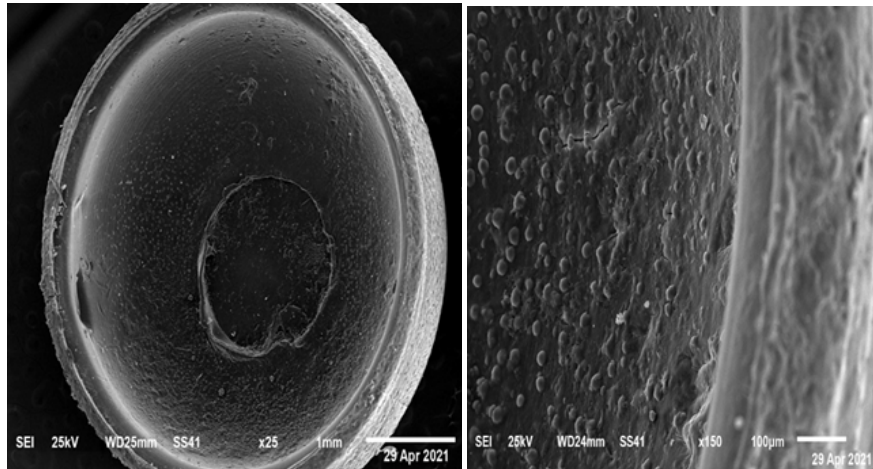b: Samples coated with gold for SEM.

Figure (6): Nylon inserts were captured with 25,150 magnifications at (T0).
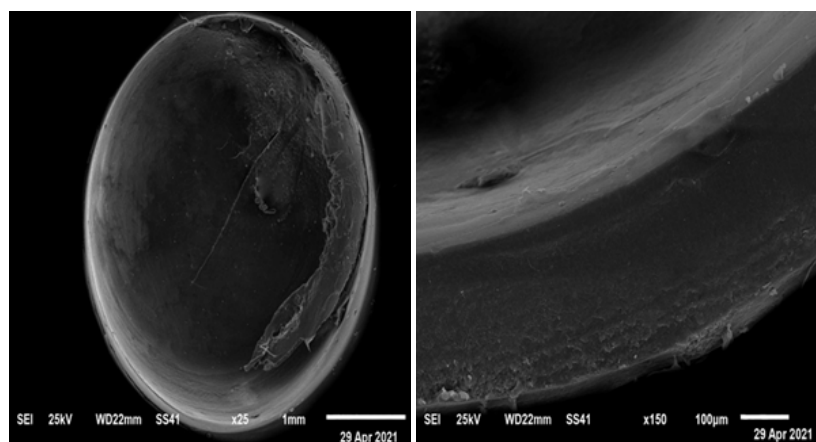
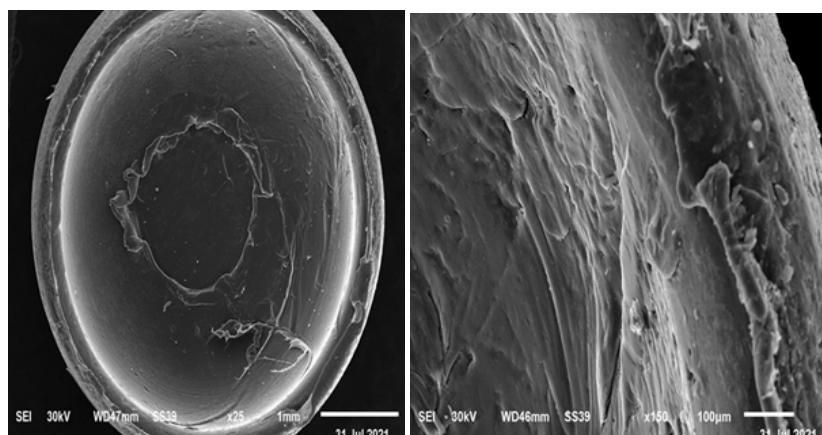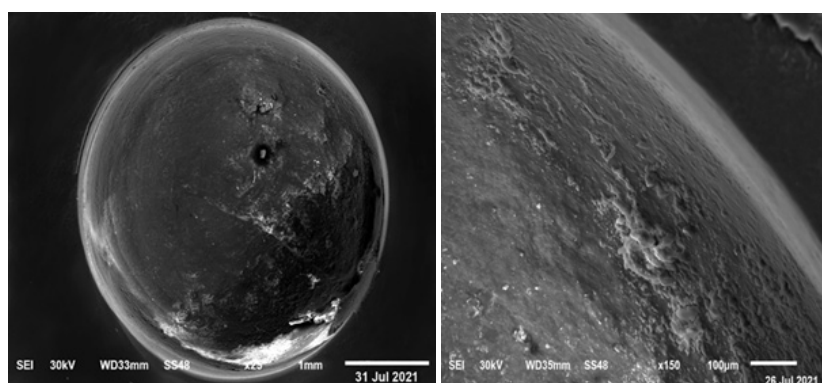**Figure(7) :** PEEK inserts were captured with 25,150 magnifications at (T0).

Figure(8) : Nylon inserts were captured with 25,150 magnifications at (T3).

Figure (9): PEEK inserts were captured with 25,150 magnifications at (T3).

Figure (10): nylon inserts were captured with 25, 150 magnifications at (T6).

Figure (11): PEEK inserts were caputered with 25,150 magnifications at (T6).

DISCUSSION

During recording biteforce implant supported overdenture recorded significant increase in biteforce than conventional complete denture after 3 months and 6 months of overdenture delivery.Van Kampen and Bakke in 2002 reported that following stabilizing the dentures with mandibular implants, the edentulous individuals can do more muscular effort after 3 months or more months ,also they reported increase in Maximum bite force and muscle activity when they compared results before treatment with mandibular implants overdenture and after 3 months of treatment (from 41% to 58%,according to the attachment type)[7,8].

Mandibular Implant overdenture retained with Locator attachment played an important role in increasing the retention and the stability of the prosthesis and therefore the masticatory function of the patient[9].This with agreement with Helmy MA[10] who revealed that the maximum biting force recorded in mandibular overdenture retained by locator attachment was higher than that retained by ball attachment ,that may be attributed to the dual retention feature of the locator attachment that ensure long-lasting retention life and allow increase biting and muscle force.

The results of the clinical evaluation of this study demonstrated significant difference changes over the 6-months follow-up period. statistically significant differences were found with clinical parameters studied (biteforce and wear (surface topography analysis)) over the evaluation period. The values of biteforce were higher with PEEK inserts at all the evaluation periods. The values of wear were higher with nylon inserts at all evaluation periods.Comparison of biteforce within groups showed significant difference between different periods. GroupII with PEEK insert recorded higher biteforce in T3&T6 than nylon insert .This may be attributed to the high performance of PEEK material which is strong polymer , shock absorbent during chewing and has high resistance to abrasion and decay.Also, its elasticity might reduce the stress on the abutment teeth[11,12].

PEEK material seems to show stable retention load, less plastic deformation, and higher mean fracture loads which leads to increased neuromuscular adaptation[13].This finding was with agreement with the study of Gomaa A. [14]who evaluated the impact of CAD-CAM prepolymerized PEEK and Poly methyl methacrylate (PMMA) implant assisted overdentures on the chewing efficiency and bite force compared to the conventionally fabricated overdentures.

Biting force was assessed by a bite force transducer. The highest means of MBF were relevant to the CAD/CAM PEEK fabricated overdentures followed by CAD-CAM PMMA while the conventional heat cured PMMA recoded the lowest MBF. A highly statistical significant difference in the means of MBF between the three tested overdentures were evident ($P < 0.005$). In this study a significant reduction of bite force was noted in both groups after six months of overdenture insertion. The decreased bite force values may be due to surface changes ,wear of the retentive inserts and retention loss.

On the other hand , Van der Bilt and Van Kampen [15]evaluated the long term effect of mandibular implant treatment for 10 years after attachment application and found that bite force more than doubled but there is no significant changes in MBF after 10 years.

The current finding seems agree with Uludag et al. [16] who reported that all attachment systems demonstrated a decrease in retention over time.This may be due to wear simulation effects as postulated by Rutkunas et al[17]who concluded that mechanism of retention loss of resilient overdenture attachments can be explained by dimensional changes and surface alterations with advance of time. According to passia et al[18]and ludwig et al[19], all attachment systems exhibit some wear or deformation under functional loading or after many cycles of insertion and removal, which may be due to friction between the retaining abutment and its counterpart .Similar findings were reported by choi et al[20]

These results in concurred with Evtimovska et al[21]who explained that the reduction of the retentive capacity of the attachments attributed to the strain energy that absorbed during insertion and removal that may be divided into elastic (recoverable) and plastic (permanent) components. If permanent deformation occurs, a rapid loss of retention will be observed. The nylon retentive male insert showed decrease in biteforce and more wear changes with loss of retention after six months than PEEK inserts. This may be attributed to degradation of function and decrease in tensile strength ,and all of the tensile modulus which diminished the nylon insert material composition and design charecteristics which in turn affect the elasticity and the retention force compared to PEEK inserts[22].

Consequently, attachment wear causes loss of retention in dentures retained with attachment which is a major clinical problem that required periodic follow up of implant assisted overdentures according to Chaffee and Felton[23].A statistically significant increase in wear was noticed with advance of time within groupI&II .Nylon inserts showed higher wear values than PEEK inserts at T3,T6.

The result of this study may be in accordance with Shastry, et al. [24] who showed that each additional time the Locator attachments retentive male inserts were removed from the abutments, an additional decrease in retention oc-

from the abutments, an additional decrease in retention occurred until retention plateaued after the sixteenth pulls. On the other hand, the results of the current study are in contrast to the finding of El Mekawy et al.[25] who found that After simulated period of three months, it was found that in clear and, blue retentive male inserts; there was insignificant change in wear with all cleansing solutions. Also, after simulated period of six months, it was found insignificant change in surface wear of clear retentive male inserts relative to one and three months with insignificance difference among different cleansing solutions. These finding indicates relatively stable wear pattern at three and six months relative to one month clinical simulation.

In addition , RM Emera[26] investigated and compared wear of telescopic attachments constructed from all zicronia, all PEEK and zirconia-PEEK telescopic attachments by evaluating surface changes using Scanning Electron Microscope (SEM) and concluded significant wear in all groups after simulating six months with lesser surface topography changes to all PEEK and all zircon attachments. This finding was with agreement with BC Spies[27]who suggested the use of an implant-supported overdenture with the receptor part of the bar milled from PEEK polymerized into a

zirconia framework for the rehabitation of an edentulous patient as the authors reported high patient satisfaction with function after 6 months .A statistically significant difference in wear was noticed between both groups with nylon inserts recording higher wear values than PEEK inserts.

This finding was in agreement with El Mekawy N. [28] who evaluated the surface changes of the locater attachment nylon parts after immersion in three different cleansing solutions using Scanning Electron Microscope (SEM) and concluded that the wear of blue nylon inserts in locator attachment increased significantly with water possibly requiring more frequent replacements. In addition ,Rutkunas et al. [29] investigated the wear characteristics of different attachment systems. They reported that locator attachments lost their initial retention between 21% and 62% after 15,000 cycles of wear simulation. Also, Gamborena et al, [30] reported that viscoelastic creep may contribute to the loss of retention, particularly of plastic contacting surfaces. When subjected to the same forces during function, plastic-lined attachments are more likely to undergo permanent deformation and creep, leading to more rapid loss of retention when compared to metallic components.

This study results also supported by Reda et al. [31] who reported that the rate of retention loss in overdenture attachments was higher in attachment types which comprised plastic parts within their components, rather than those totally made up of noble metals. On the other hand, PEEK has a good combination of stiffness, toughness and chemical resistance and greater strength weight ratio and high wear resistance than polymethyl methacrylate (PMMA) & composite resins. All these characteristics make PEEK a highly attractive material in medical and dental applications[32]. The current finding seems agree with Yue et al.[33]

who used an attachment system with angulated abutments and polyetheretherketone inserts to retain a maxillary overdenture and concluded that the PEEK matrices were more resistant to wear than inserts made from polyethylene. In addition , Wimmer et al. [34] found significantly higher wear resistance for PEEK than a nanohybrid composite and a poly methyl methacrylate material when loaded laterally and comparable wear of enamel antagonists. This was in agreement with Mangano et al. [35] who found 80% success rate for implant-supported overdentures when rehabilitated with a maxillary overdenture supported by 4 implants and CAD-CAM fabricated PEEK bar.

CONCLUSION

PEEK inserts in locator attachments provide successful inserts instead of nylon ones providing better biteforce and wear resistence.

RECOMMENDATIONS:

Further time is needed to monitor long time serviceability of PEEK inserts in locator attachment.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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