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Retention and Wear Evaluation of Rigid Telescopic and Nova Loc Attachments for Two Implant-Supported Mandibular Overdentures (An in vitro study)

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ABSTRACT

To investigate and compare the changes in retentive forces and wear resistance of two attachment systems Nova-loc& telescope with different design and overlaying patrices over two un splinted implant supported mandibular over denture under short-term simulated function. Two models carrying a two-implant analogue with two different types of overlying patrices Telescope and Nova loc over which an acrylic complete denture was constructed with picked up corresponding matrices. The tensile forces were applied using a universal testing machine to evaluate retention force, and digital microscope was utilities to evaluate wear resistance. Evaluation of retentive force & wear resistance of telescopic and Nova-loc IODs was carried out at five-time intervals; at baseline and after they are subjected to cyclic loading under at 500, 1000, 1500 and 2000 cycles of repeated insertion and removal. Retentive values were recorded by using independent t-test which revealed the retention of the group I (Telescope) was significantly higher ($p<0.05$) than those of group II (Nova loc) at baseline & after exposure to different cyclic loading (500- 1000- 1500- 2000). Regarding the wear, comparison of wear (wear change) of both groups was performed by using t-test between mean difference which revealed that the group I (telescope) was significantly higher than group II (Nova-loc). Regarding to Telescope and Nova-loc systems have satisfactory retentive forces, However, short-term successful clinical use in implant overdentures. Nova loc attachments are promising to be successfully used in implant overdentures as the Telescopic coping attachments with satisfactory retention. However, the retention value of Telescope higher than Nova loc, the wear behavior of Nova-loc lesser than Telescope due to the peek material.

Keywords: Retention, Wear, Implant, Overdenture, Telescopic attachment, Novaloc attachment

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INTRODUCTION

Although prosthetic management with conventional complete dentures CCD has long been a valuable option as well as the treatment of choice for decades in order to rehabilitating of completely edentulous patients, various reports presented that some complaints can be accompanying the wearing of CCD. They are mostly related to stiffness of adaptation especially with mandibular dentures. Also, patient complaints include insufficient denture retention, poor stability, and frequent chewing difficulties causing low patient self-confidence, no or little satisfaction and, diminished quality of life.[1]

Mandibular Implant over denture IODs retained by two un splinted implants is considered to be the first treatment of choice in the rehabilitation of edentate patients, for patients who have technical problems with CDD, and in the cases in with the preservation of alveolar bone is requiring. Dental practioners utilizing over-denture attachments for improving the retention mechanism. The choice of implant non-splinted overdentures is required in many clinical situations. The use of implant non-splinted overdentures is necessary for simplifying the attachment system connecting the retained implant with the denture.[2]

Attachment systems are utilized with the dental implant to improve the values of overdenture's retention, the stability and support consequently, overdenture's longevity will extend for longer time. currently, wide forms of attachment systems are obtainable to join the Osseo integrated implants with final removal prosthesis. Some attachment systems can be used for splinting the dental implants such as bur attachment system, and other are employed with unsplinting dental implants.[3]

Recently Straumann Novaloc attachment system contains either a straight or 15-degree angled abutment. Both Straumann Novaloc abutment types are made of titanium, and covered with an amorphous diamond-like carbon (ADLC) material in order to improve the attachment components' resistance to wear by reducing the abutment roughness. The Straumann Nova-loc straight abutments are formed to be employed in clinical situations with angulations of up to 40- degree between implants because PEEK matrices overlaid on the abutments can house up to 40° prosthetic divergence between two abutments. The heights of these straight abutments with their gingival cuffs are ranging from 1 to 6.[4]

On the other hand, the Straumann Nova loc 15- degree angled abutment is formed to use in clinical situations with angulations of up to 60- degree between implants. These angled abutments are interconnected to the Osseo integrated dental implant using a prosthetic screw. The heights of these angled abutment with their gingival cuff are ranging from 2 to 6 mm. These angulated prefabricated abutments offer several advantages over the custom-made ones. They create a common path of insertion with divergent dental implants in lesser time and expenses.[5]

The telescopic crown is also called as a double crown system It comprises of two crowns; primary telescopic coping or inner crown, and outer or secondary crown. The primary telescopic coping is fixed to the abutment or dental implant with permanent cement to an abutment while the secondary crown firmly attached to the detachable removal prosthesis.[6]

Retention of these telescopic crowns are provided from the fit between the secondary crowns on the primary crown. Güngör et al. (2004). The outer surface of the secondary crown can be shaped as the anatomic crown of the natural tooth, or be a simple coping without following anatomic landmarks.[7]

Furthermore, telescopic attachments are made-up in various forms like cylindrical crowns, conical crowns, resilient designs and modified designs to cover wide prosthetic clinical indications. Retention of removable prosthesis is considered one of the most elementary parameters influences on success & longevity of prosthodontic appliance as it extensively impinges on patient's oral functionality & satisfaction. Evaluation of the retentive force can be carried out either through subjective methods or objective methods.[8]

Universal testing machine UTM is mostly utilized for standard testing for the tensile and compressive strengths of the materials, components and structures. Wear is one of the worst harms of attachment systems used implant overdenture. It is frequently happened after period from its use causing reduction in prosthetic retention values. Detecting wear of different dental materials and measuring its rate either in clinical situations or in laboratory conditions are important to distinguish inappropriate material which may lead to rapid retention loss of implant overdenture.[9]

Nowadays, digital microscope considered one of the most versatile microscopes in the dental market, because it allows to observe a wide range of 3D objects, ability to find fine detail in the field of scope and having the shutter trigger on the base of the unit. This category considered a combination of a zoom microscope and 5MP digital camera.[10]

MATERIALS AND METHOD

Epoxy Resin Model Preparation:

A two readymade identical clear acrylic epoxy resin standing for a completely edentulous mandible with a class I (ACP classification), Duplication of the epoxy model was performed using laboratory addition silicon material in a metal duplicating flask, Mandibular trial denture bases with its wax occlusion block were constructed over the epoxy resin models after that, mandibular acrylic teeth were placed, organized and modified in accordance to compensatory curves (Wilson, monsoon, spee), Finally, duplication of the whole assembly trial denture base with its arranged & adjusted acrylic teeth over the epoxy resin model using silicon duplicating material inside metal duplicating flask were considered as a standard copy

for any denture needed in this study. Platooning of epoxy resin cast was performed anteriorly at canine-to-canine segment to enlarge the surface area to 5-mm diameter

Surgical Stent Fabrication

A readymade epoxy resin class-I (ACP classification) cast was used to fabricate surgical stent to standardize during drilling procedure of the models, Mandibular trial denture bases with its wax occlusion rim were constructed over the epoxy resin models after that, mandibular acrylic teeth were placed, organized and modified in accordance to compensatory curves (Wilson, monsoon, spee), The trial denture base with the set acrylic teeth was checked to epoxy cast to ensure its accuracy, stability & adaptation and to check the optimal determination of canine area before creating osteotomies in the epoxy model at these areas, The optimum area for implants' drilling into epoxy resin cast positioned at canines' area was marked by the setting of the acrylic of artificial teeth. In order to simulate the true distance between two natural canines, the inter-implant distance was equivalent 20 mm (each position was 10 mm away from the midline), Inter implant distance was calculated by digital caliber. Epoxy resin model was drilled at previously determined canine area utilizing tungsten carbide bur to develop an oversized bilateral parallel corresponding osteotomy, the size of each osteotomy was up to 4.1 mm diameter and 14 mm length. Then, each newly formed osteotomy was received root-form endosseous struman dental implant analogue The implant analogue class and size were tapered, bone-level implant, and 3.8mm-diameter and 12mm-length, the parallelism between the two osteotomies created in epoxy resin casts was verified by the aiding of the paralleling tools, Parallelism between the two implant analogues was ensured using a dental/milling surveyor (Ney Dental surveyor) during placement of implant analogue step. A latch rotary implant driver was attached to the dental/milling surveyor during analogues placement, Fixation of root-form implant analogues into epoxy resin models was performed by using self-cure acrylic resin, the final position of the implant analogue was verified so that the crestal module is flush with the level of the epoxy resin model.

Fabrication of The Mandibular Overdentures

Following the conventional techniques, steps of flasking and packing of the four mandibular trial denture bases were carried out using heat cure polymethyl methacrylate Finishing and polishing all aspects of the newly formed overdentures were performed using the conventional methods.

Attachment's Placement:

Nova- Loc Group: {Model 1 was represented the implants analogue with Nova-loc attachments}.

The two Nova-loc Straumann attachments were tightly twisted into the implant analog in manual manner by using the Straumann Screwdriver, Then, a ratchet was utilized to accomplish the torque of the nova-loc attachment to 35Ncm, A piece of rubber dam was put around the attachment to avoid the deluge of the acrylic resin over the prepared surface of the cast. Moreover, the Nova-loc processing spacer (A white mounting collar spacer ring) was placed around each abutment to create the space needed.

A PEEK denture cap (white, light retention approx. 750g) was positioned onto each abutment and was pressed down to guarantee their engagement to the abutment.

Telescopic Group: {Model 2 was represented implants analogue with telescopic attachments}

Two 5, 5 mm-wall height, telescopic abutments (struman) were used, over those abutments two telescopic coping were attached. At first, the telescopic copings were designed in wax pattern using conventional methods then, the designed wax patterns were burnt out and casted into cobalt chromium alloy, each outer surface of telescopic copings was subjected to sandblasting process to ensure its mechanical interlocking with the pickup resin.

Pick-Up of The Attachments:

The overdenture was put on the model and the sites of the attachments were marked by a flowable composite. Relieving of the attachments position was achieved by the flowable composite mass until the overdenture became a fully seated., Creating two holes (vents) into the lingual surface of each overdenture matching up to the attachment's places were performed using a fissure bur for permitting the excess of self-cure acrylic resin used in pickup of the attachments' caps and metal copping to be escaped out, The cast model was coated with glycerin while the fitting surface of the overdenture was lined by a separating medium, Mixing of cold-cure polymethyl methacrylate (PMMA) was accomplished in accordace to the manufacturer's instructions. The mix was only placed on the relieved areas of the fitting surface of the overdenture when it reached to the dough stage. Then, it was left to be a completely set, Finishing and polishing of the acrylic resin was thoroughly performed.

Pick Up of Nova- Loc Attachment:

The overdenture was seated over the cast model to pick-up the attachments' caps. After setting, the PEEK matrix came out with the overdenture. Then, the protruding part of the cap's sleeve as well as the excess materials were eliminated using a scalpel. Applying of pressure indicating paste on the fitting surface of each overdenture was utilized to identify any pressure area, Finally, Finishing and polishing of the acrylic resin was thoroughly performed, These steps were repeated with the other over denture in all Nova- loc group

Pick up of Telescopic Attachment:

The overdenture was seated over the model to pick-up the attachments' metal copping, after setting, the metallic copping came out with the overdenture. Then, the protruding part of the copping as well as the excess materials were eliminated using a scalpel, applying of pressure indicating paste on the fitting surface of each overdenture was utilized to identify any pressure area, Finally, Finishing and polishing of the acrylic resin was thoroughly performed. These steps were repeated with the other over denture in all telescope group.

Determining the Geographic Center of the Lower Arch:

After the needed mandibular IODs retained by two unsplinted implants have been completely created, they were prepared for the retention tests. The relative geometric center of each overdenture was determined on the cast model by four lines. The exacting lines were drawn and extended on the cast model in the following sequence

Line (1): It was drawn to connect two- points at the apices of the retromolar pads of both sides of the cast model,

Line (2): It was drawn anteriorly & parallel to line (1). It passed through the crest of the anterior ridge and the two canine positions of the complete edentulous cast model,

Line (3): It was drawn to pass through the mid line of the cast model. It perpendicularly intersected the both lines (1) and (2). After that, a point which was located on line (3) in the center between both lines (1) and (2) was called point (a),

Line (4): It was drawn to pass through point (a). It was extended on the model cast to be parallel to lines (1) and (2). This line was used to assist in the setting of the lingual brackets. The hook of the universal testing machine put in proper position which was perpendicular to the relative geographic center. A wrought wire ring was joined with the hook from one side connected to three wrought wires. Their ends were then stick to the mandibular overdenture by self-cured acrylic resin at its polished surface, lingual to midline and to both second molars**.**

Retention and Wear Evaluation:

Retention Measurements by Universal Testing Machine:

A servo-hydraulic universal testing machine was used to evaluate the retention of each examined overdenture. During evaluation, the universal testing machine applied successive dislodging forces running at a crosshead speed of 5 mm/min, During testing, the servo-hydraulic universal testing machine exerted both fatigue and tensile strengths on each examined overdenture seated over its cast model, The upper section of the testing machine which applies pull force was connected to the polished surface of overdenture though testing hook as well as the triple orthodontic wire because of this testing hook is always encircled with a special device present in upper vertical machine arm to measure the retention value of the tested samples, The value of retention force of each sample was recorded at baseline and

after; 500, 1000, 1500 and 2000 insertion and removal cycles at jaws simulator device, Data of the load required to dislodge each overdenture was recorded in Newton by computer software ,After each interval, all samples were fixed in the two metallic devices in the universal testing machine and the maximum retention force values were an average of five measurements taken at each interval.

Chewing simulator:

In order to complete the retention and wear test, insertion and removal cycling technique was executed utilizing a programmable logic-controlled equipment (4 station multimodal ROBOTA chewing simulator)integrated with thermo-cyclic protocol operated on servo-motor, Robote chewing simulator consists of four chambers imitating vertical and horizontal movements concomitantly in a thermodynamic condition with particular strength of bite and number of cycles. Each chamber includes an upper Jacob's chuck and a lower plastic sample-holder. The upper Jacob's chuck can be tautened using the screw so it is considered as an antagonist holder. While, the lower holder receives the examined samples. Therefore, the cast model of each examined overdenture was placed & fixed to the lower holder at first. Then, the examined overdenture was seated properly on its fixed cast model and was connected to the upper component of the chewing simulator with triple orthodontic wire (0.5 mm).

The machine able to place of the overdenture to its programmed terminal position and induce subsequent overdenture removal from its abutment, it was employed to simulate the insertion and removal of each examined overdenture, the test temperature was sustained at room temperature (25 ± 2 ◦C) during all different cycling periods, The number of insertion and removal cycling was programed on 500, 1000, 1500 and 2000 cycles for each examined overdenture to represent the clinical use of 3,6, 9 & 12 months according to the literature. Insertion and removal cycles were acted upon along the long axis of the IODs' implants.

Wear Evaluation by Microscope (Digital Microscope).

Digital microscope with a built-in camera was employed to photograph the examined attachment samples, this microscope was connected with an IBM compatible personal computer. During examination the microscopic power of magnification was adjusted to 120×

The images of the examined attachment samples were captured at a resolution of 1,024 × 1,280 pixels, By means of Microsoft Office Picture Manager software, the areas of roughness in images of the examined attachment samples were identified, measured and cropped to 350 × 400 pixels in to order to standardize all images of the different examined samples, Careful analysis roughness areas in cropped final images were carried out using WSxM software. 3D image of the surface profile of each examined attachment sample was acquired via a digital image analysis system

During capturing the digital photographs of attachment sample (Nova loc caps & secondary

copping of telescope), every shot was taken considering the wear surface of the attachment sample parallel to the base of the used microscope, The Surface Area was measured as starting the distance between the inner and the outer boundary of the cap of nova loc and coping of telescopic attachments, The Perimeter was measured as the entire length of the outer boundary of the cap of Nova loc and the coping of telescopic attachments. Also, The Diameter was measured the extension of a line that touches two points on the edge of the outer boundary of the cap passing through the center. of nova loc and coping of telescopic attachments, these points were demarcated. Moreover, the value of surface area, perimeter and diameter of each wear surface of the different attachment samples was calculated digitally in square micrometers (μm2) using the 3D Viewer Software which was automatically added up in the used digital microscope.

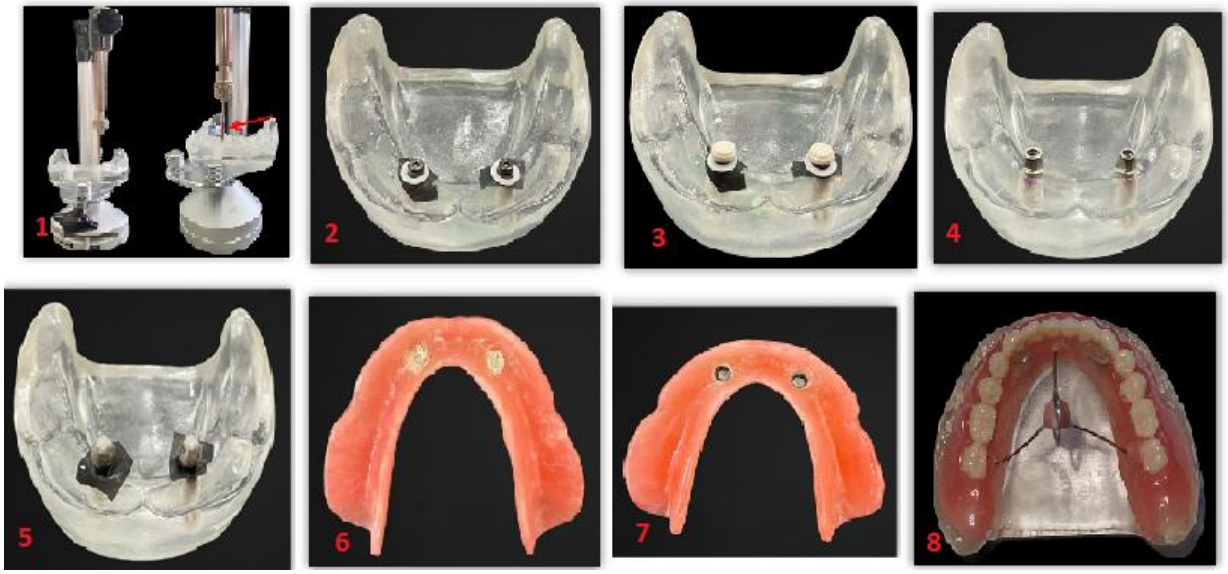

Figure 1: Represent all the following

1- Implant Analogue Placed by The Milling Surveyor, 2- Nova- Loc Attachment with The Processing Spacer, 3- Peek Matrix Attached to the Nova-loc Attachments, 4- Epoxy Resin Model with Two Telescopic Abutments, 5- Two Telescopic Coping After Sand Blasting, 6- Peek Matrix Came out With the Overdenture, 7- The Metal Copping Came Out with the Overdenture After Setting & 8- geographic center

RESULTS AND DISCUSSION

Retention

Comparison between telescopic & nova-loc group regarding retention was performed by using independent t-test which revealed that retention of telescope group was significantly higher ($P<0.05$) than Nova-Loc group at baseline only, while there was insignificant difference between them in others, as presented in table (1).

Table 1: Comparison between telescopic and nova-loc groups regarding retention:

	Retention				
	Telescope		Nova-loc		p-value
	M	SD	M	SD	
Baseline	23.322	3.725	14.318	1.464	0.004*
(500 cycle)	14.044	2.216	11.756	1.173	0.14
(1000 cycle)	9.364	1.513	8.412	1.300	0.39
(1500 cycle)	7.972	2.193	7.070	1.682	0.52
(2000 cycle)	6.718	1.464	6.594	1.765	0.86

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

Wear

Area:

Comparison between mean difference of wear (wear changes) of both groups was performed by using independent t-test which revealed that telescope was significantly higher than Nova-Loc group regarding all intervals except (baseline\ 3 months) & (9 months\12months) interval as there was insignificant difference between them. as presented in figure (2).

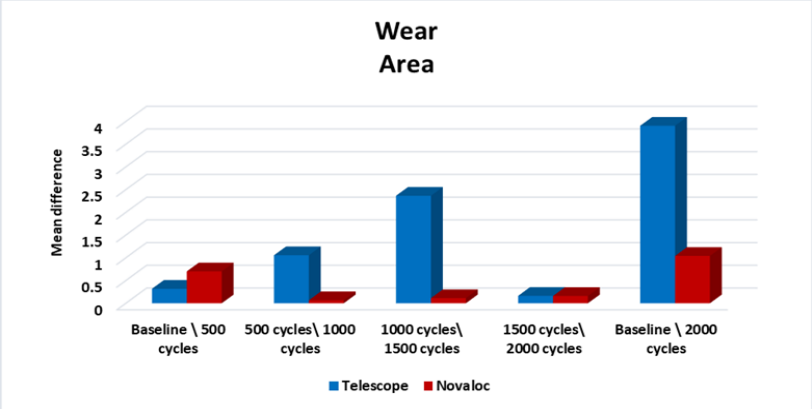

Figure 2: Mean difference of wear – area of both groups

Perimeter:

Comparison between mean difference of wear (wear changes) of both groups was performed by using independent t-test which revealed that telescope group was significantly higher than Nova-Loc group regarding all intervals except (baseline\ 3 months) interval was insignificantly lower. as presented in figure (3).

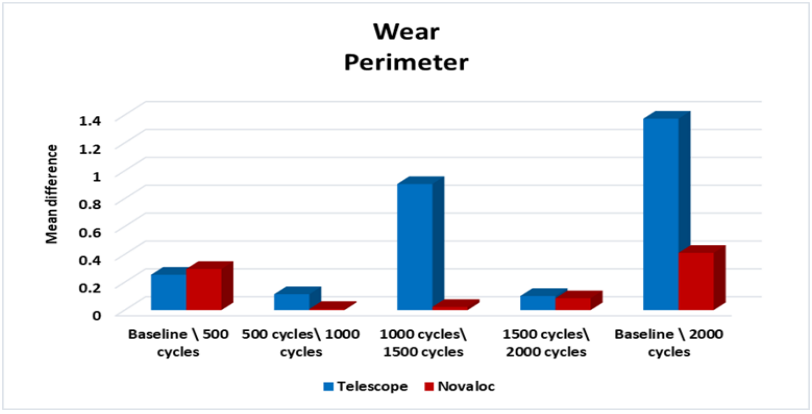

Figure 3: Mean difference of wear – perimeter of both groups

In this study, the fabricated implant-supported mandibular overdentures in reference to the McGill & York. consensus statement on IODs (A two implant overdenture must be the treatment of choice for all edentate mandible cases[11] Also, the selection of using two implants only for supporting the examined IODs was based on study which reported that higher quality, survival rate, besides they accomplish oral function & bring prosthetic satisfaction for patients. and sufficient stability can be straightforwardly achieved by two implants.[12,13]

Implants were seated bilaterally in the anterior zone of the mandible especially the canine region. The anterior area was chosen as Misch study concluded that this area showed high implant success rate when loaded by overdentures.[14.] Therefore, two non-splinted implants retained overdentures were used in this study, each overdenture has attachment system connecting the superstructure denture with the implants {Telescope attachment & Nova-loc attachment}.

The use of non-splinted implant overdentures is the necessity for simplifying the attachment system connecting the retained implant with the denture, despite many studies demonstrated that most attachments used with non-splinted implants have low wear resistance which directly decrease their retention value, so the clinician used to exchange the disposable part of attachments frequently in order to preserve functionality of non-splinted -implant overdentures**.** [14,15]

According to study by *Yunus, Saub,* that investigated the use of telescopic crown attachments in implant-supported dentures. results showed oral health related to quality-of-life OHRQoL was, improved patient satisfaction, and masticatory performance, peri-implant soft tissue response and implant stability were favorable.[16]

While the comparator group presented as an innovative attachment known as Nova loc (Insitut Straumann AG, Basel, Switzerland) is a recently introduced attachment system. The abrasion-resistant surfaces (Amorphous diamond-like carbon (ADLC) of these abutments are intended to have a positive influence on the wear behavior.[17]

Each implant analogue was 12 mm length and 3.8 mm diameter. the 12 mm length was chosen as it is considered as an adequate length to obtain optimum stress distribution around the implants, length of dental implant from10 mm to 14 mm is an important parameter which has a significant impact on its prognosis and the biomechanical load transmission.[14,18]

In order to evaluate & compare the change of retention force of each attachment system, the universal testing machine was used in this study because it's considered a vital element for retention measurement according to many researches**.** To standardize the forces, the epoxy resin model was locked each with the corresponding implant supported overdenture at lower fixed compartment of the testing machine & the machine was programmed to apply a tensile with pull out mode of force at a crosshead speed of 5 mm/min. Then, the principal

investigator recoded in Newton the tensile load which was able to dislodge each overdenture. [19,20]

The retention force evaluation test was performed at baseline & after 500, 1000, 1500 and 2000 insertion and removal cycles to record the retention force of attachment systems under laboratory conditions comparable to those which could be recorded in a clinical study at approximately 3, 6, 9 & 12 months of wearing the overdenture. Almost one year as the patient inserts and removes denture four times per day: one time after each meal for cleaning action and one before sleeping[21]

During simulating the oral function, the insertion and removal device executes vertical and horizontal movements concomitantly in a thermodynamic condition with particular strength of bite and number of cycles. This gives rise to wear and succeeding loss of retention of implant overdenture attachment systems. In order to achieve the study's objective from using jaws simulator, the number of cycles was regulated to 500, 1000, 1500 and 2000 cycles which represent the clinical use of 3, 6, 19 & 12 months according to the literature. The insertion and removal cycles in chewing simulator done in wet environment simulating the saliva {Isotonic 0,9% sodium chloride solution at 22 calicoes degree}[22]

For wearing evaluation, the digital microscope (Celestron, LLC., Torrance, CA, USA) was employed with a built-in camera to photograph the different attachment systems, The microscope offered a good resolution and accurate measurements of the traced wear facets the attachments. Wear evaluated at baseline & after they subjected to particular cyclic load (500, 1000, 1500 and 2000 insertion and removal cycles) at jaws simulator device. In order to capturing accurate digital photograph, the principal investigator kept the wear surface in each capture parallel to the base of the microscope.[23]

The results of this in-vitro study showed a statistically significant decrease in retention through the different loading cycles and after mechanical testing (p value equal 0.001), the retention loss of the attachments for IOD occurs due to the wear of the attachments occurring as a result of frictional contact between the two surfaces of the attachments during the insertion and removal cycles of the over dentures and load applied over both of them leading to retention loss. this scenario was a common finding in many investigations performed[24.]

The higher values were recorded with the telescopic group samples than those of Nova loc attachment group with statically significant differences these findings indicate that the micro mechanical frictional contact subsequently increase retention Regarding to various invitro study telescopic retainer or attachments have the highest retention value due to the micro mechanical frictional retention. [25.]

Also, the obvious reduction of retention values of the two groups but in telescope group retention value reduced more than the nova loc one this is due to the morphology, design of

attachments in addition to the matrices material which are made from PEEk (Nova loc group) and Metal (cobalt chromium alloy) (telescope group). This is totally related to the peek material prove it is worth to be better than metal in maintaining retention and this is based on research's which concluded that peek materials have advantageous characteristics e.g: excellent dimensional stability, easy processing, high rigidity, high tensile and flexural strength, superior chemical resistance to nearly all satisfactory mechanical, chemical and physical properties including good heat resistance and high dimensional stability [26]

In the present study the surface area wear value for the telescopic coping group was higher than Nova loc attachment group with statistical no significant differences in percentage of change recorded after 500 load cycles when it was compared to that were recorded at baseline, But after the group samples exposed to cyclic loads, there were significance different between telescopic coping groups and Nova loc attachment groups in all measurements of the percentage of change recorded after exposure to each different cyclic load. By the end surface area wear and perimeter value were reduced at all cycles due the effect of wear.

These results were in full agreement with Alsabeeha which enumerated in the conclusion of their review the design as one of the most effected factors can crucially influence on the wear feature of any attachment system[27] Moreover, these results are in accordance with Fromentin, which found that the distinct structural changes of attachment components characterized by deformation and deterioration are occurred depending material of attachment system after they exposed to simulated oral functions [(28).] Furthermore, the finding of this study regarding to the surface area wear of the examined groups agrees with analysis of *Khourazaty*, study considering the reduction of retention value of any attachment system reflects the deformity of its structural components. [29]

CONCLUSION

With respect with the limitation of this study: it can be concluded that: Both Telescope and Nova-loc systems have satisfactory retentive forces, However, short-term successful clinical use in implant overdentures, Nova loc attachments are promising to be successfully used in implant overdentures as the Telescopic coping attachments with satisfactory retention. However, the retention value of Telescope higher than Nova loc, the wear behavior of Nova-loc lesser than Telescope due to the peek material.

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