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EVALUATION OF THE RETENTION OF CONVENTIONAL VERSUS CAD/CAM FABRICATED EXTRA CORONAL ATTACHMENTS FOR REMOVABLE PARTIAL DENTURE (IN-VITRO STUDY)

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ABSTRACT

INTRODUCTION: When treating edentulisum, severely resorbed mandibular ridges are a prevalent issue. Attachments could be used to enhance retention. For removable distal extension prosthesis, extra coronal attachments enhance retention. During mastication and removal, micro and macro movement between the retentive surfaces of an attachment causes wear and reduces the retentive capacity over time. Using CAD/CAM technology, more accurate frameworks with improved retention should be expected.

OBJECTIVE: was to compare the retention of conventional and CAD/CAM fabricated extra coronal attachments for a removable partial denture.

METHODOLOGY: - Retention of four extra coronal attachments of different materials and methods of fabrication was evaluated. The attachments were divided into two different groups according to the material used and whether the attachment was fabricated using the conventional method or CAD/CAM technology. Using a Universal testing machine, the difference in retention was compared between the groups.

RESULTS: Data was collected, tabulated, and statistically analyzed using the appropriate test. In group I the mean force needed to dislodge the female clip before and after cyclic loading was 46.69N and 32.13N respectively and in group II the mean force needed was 59.07N and 42.44N respectively.

CONCLUSION: In comparison to conventional extra-coronal attachment, CAD/CAM fabricated extra-coronal attachment had a highly significant retentive force.

KEYWORDS: Retention, Extra coronal attachments, CAD/CAM, Removable partial denture.

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INTRODUCTION

Tooth fracture, trauma, periodontal or periapical disease are all causes of edentulism. Bone resorption and masticatory difficulties can occur as a result of tooth loss (1). Being edentulous causes difficulty in speaking and eating. A disability that has a negative impact on one's entire quality of life (2). When treating totally edentulous individuals, severely resorbed mandibular ridges are a typical concern, especially in older patients with limited adaptive skills, resulting in poor dentures. (3-4) Complete dentures have significant functional constraints, such as chewing problems and poor fit (5-7). Better results can be achieved by using two or more intraforaminal implants with attachments. (8) Treating edentulous patients with implant-retained dentures results in a prosthesis that is less painful, has fewer sore areas and is more comfortable to chew (9). Furthermore, patients would be able to eat a greater variety of foods with less trouble. (9)

The attachments are employed in the partial edentulous space treatment solution to improve the aesthetics and longevity of the

prosthesis. Moreover, At the end of the nineteenth century Parr, Peeso, and Chayes collaborated on the benefits of attachments for using fixed dentures with those of removable dentures. (10) The systems were either non-splinted attachments that were connected directly to the implant (magnet, ball, locator, telescopic) or splinted attachments that use a bar and a bar-clip attachment to splint the implants together (11).

Some patients prefer a fixed restoration in the anterior area but are ready to accept a removable prosthesis in the posterior. Because of substantial bone loss, implant placement in the posterior areas sometimes necessitates major surgical operations. Furthermore, the requirement for additional implants raises the entire therapy cost. (12)

The use of conventional or implant-retained fixed prosthesis is one of the therapy options for edentulism rehabilitation. However, due to loss of supporting tissues, medical reasons, and significant surgical protocol, as well as patient affordability, such prosthetic choices are not always possible (13). A well-constructed removable partial denture (RPD) was considered by several authors to be a cost-effective and acceptable alternative treatment option for partially dentate patients. (14)

Lost wax casting technique takes a long time and a great deal of skill. It could also lead to an increase in attachment mismatch and porosity. As a result, a growing number of labs and clinicians are turning to CAD/CAM technologies. (15). Inlays, Onlays, fixed, and even removable prostheses are increasingly being made with CAD/CAM technology. With the available software and scanners, the clinician can either scan the wax/plastic pattern and mill the attachment in the desired material with increased accuracy, bypassing the laboratory stages of casting. The clinician can also scan the patient's oral cavity and build a virtual model from which the attachment design is created and transmitted to the milling machine through the internet (16).

CAD/CAM fabrication eliminates the need for impressions, casting, and finishing. When comparing to the traditional laboratory procedures, alloy casting and investing is more precise due to the milling machine's accuracy and the scanner's accuracy (17). It also permits the ability to design the implant placement based on prosthodontic constraints. (18)

Non-precious alloys were the material of choice in the past. Non-metal conceptions, on the other hand, are gaining popularity for a variety of reasons, including the patient's rising aesthetic needs, the law in some countries, and the possibility of material incompatibility. (19) Zirconium oxide and Polyetheretherketone are two of the most often utilized materials today (PEEK).

Zirconium oxide is extremely strong, has a high aesthetic value, and is well tolerated by the mucosal membrane, making it ideal for implant prosthesis therapy. (20)

The retentive value of CAD/CAM produced attachments and traditional casted attachments is compared in this study. The difference in precision is reflected in the difference in retention.

The null hypothesis is that neither the material used nor the process of fabrication will affect the retention.

MATERIALS AND METHODS

Study design

Two abutments were fixed on the implants, the model and abutments were then scanned and a reduced form fixed partial denture was designed with CAD/CAM software and two extra coronal ball attachment was inserted at the distal ends virtually. Two groups were assessed in this study with group 1 using the conventional fabrication method for the nickle chromium (Ni Cr) fixed partial denture with 2.2mm attachment size and group 2 using milling of zirconium disc with 2.2mm attachment size on which a partial denture was constructed.

For each group, a 14 prefabricated plastic female clip was inserted into the fitting surface of the denture base. Then the amount of retention was tested for each group separately. Then the data was collected and analyzed using One Way ANOVA and followed by Tukey's test.

Preparation of the models:

Closed tray impression copings were fixed onto the implants present in the standard educational model (Straumann, Basel, Switzerland) on which a pick up impression was performed and two implant analogs were attached to the impressions copings. The impression was poured using clear acrylic resin to fabricate a model with two dummy implants placed at the cuspid area (Fig.1).

Two abutments (Straumann, Basel, Switzerland.) were fixed on the implants, the model was sprayed to decrease the reflective surfaces. The model and abutments were then scanned with a bench scanner (InEos X5, Sirona Dental Systems, GmbH, Bensheim, Germany) to produce a virtual model. A reduced form fixed partial denture was designed with CAD/CAM software Inlab SW 20 (CEREC, Sirona Dental Systems, GmbH, Bensheim, Germany) with standardized

measurements including the removable partial denture (RPD) components preparations. A VSK-SG attachments (Bredent VKS-SG, Miami, USA) of size 2.2mm were attached bilaterally to the distal end of the cuspids retainers (Fig.2).

Fabrication of the extra coronal attachment:

Conventional method (Group 1):

A VSK-SG attachments (Bredent VKS-SG, Miami, USA) of size 2.2mm were inserted bilaterally to the digital framework proposal. The whole assembly was milled with KATANA Wax Disc (Kuraray Noritke Dental Inc. Miyoshi, Japan)(Fig.3), invested and casted in Ni Cr alloy (Luoyang Beiyuan Special Ceramics Co, Ltd., Henan, China), finishing and polishing were done according to manufacture instructions then the ceramic build-up was done. The fixed partial denture was then cemented on the abutments with resin cement (RelyX, 3M ESPE, St. Paul, USA).

CAD/CAM Designed (Group 2):

A VSK-SG attachments (Bredent VKS-SG, Miami, USA) of size 2.2mm were inserted to the digital framework proposal bilaterally. Then the whole assembly was milled from Zirconium Oxide disc (Katana Multi-Layer Monolithic Zirconia, Kuraray Noritake Dental Inc. Miyoshi, Japan.) then the ceramic build-up was done(Fig.4). The fixed partial denture was then cemented on the abutments with resin cement (RelyX, 3M ESPE, St. Paul, USA).

Fabrication of the removable partial denture:

A removable partial denture of lingual bar as major connector (kennedy class I) was constructed with the conventional method for the two groups, gaining its retention from the attachment and its indirect retention from the cingulum rest present on the cuspids (Fig.5).

For each group, a prefabricated plastic female clip was secured into the fitting surface of the denture base. fourteen female clips were assigned to each group (Fig.6).

Testing the retention:

The metallic RPD was secured to the fixed partial denture. The whole assembly was fixed on the universal testing machine (Shimadzu, Universal Testing Machine, AG-X Plus, Japan.). A universal testing machine was used in this study with a cross head speed of 5mm/min to imitate the speed of dislodgment of the denture clinically. A cyclic tension-compression test was performed to simulate insertion and removal of the partial denture. The assembly was subjected to 1095 number of cycles resembling 1 year. The force needed to dislodge the partial denture was measured before and after the tension-compression cycles. The difference indicates the loss of retention due to usage (Fig.7). (21)

STATISTICAL ANALYSIS

Normality was checked using Shapiro Wilk test, box plots, and descriptives. Retention force was normally distributed and presented using mainly Median, Inter Quartile Range (IQR), and Minimum and Maximum values, in addition, to Mean, Standard deviation (SD).

Groups were compared regarding Retention force using One Way ANOVA and followed by Tukey's test with Bonferroni correction.

Percent change in tension force before and after the thermocycling process was calculated according to the following formula: [(readings after – readings before) / readings before)] x 100. Significance level was set at P value of 0.05. All tests were two tailed. Data were analyzed using SPSS for windows version 23.

Figure (1): Duplicated model used for testing.

Figure (2): A reduced form fixed partial denture was designed with CAD/CAM software.

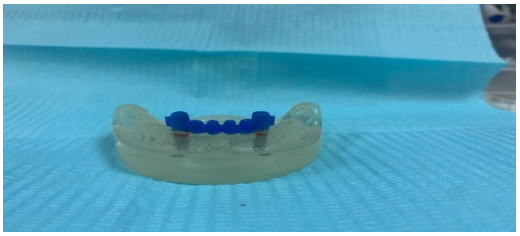

Figure (3): Fixed partial denture framework milled with KATANA Wax.

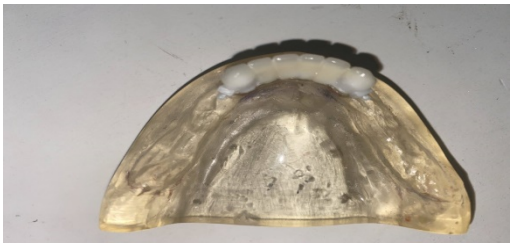

Figure (4): Group 2 was milled from Zirconium Oxide.

Figure (5): Fabrication of the removable partial denture.

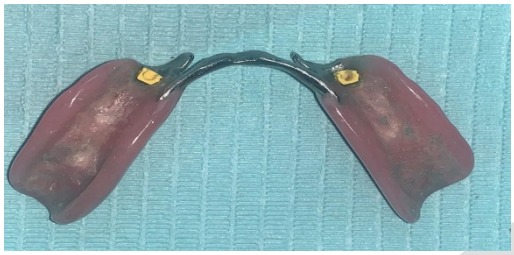

Figure (6): Prefabricated plastic female clip was secured into the fitting surface of the denture base

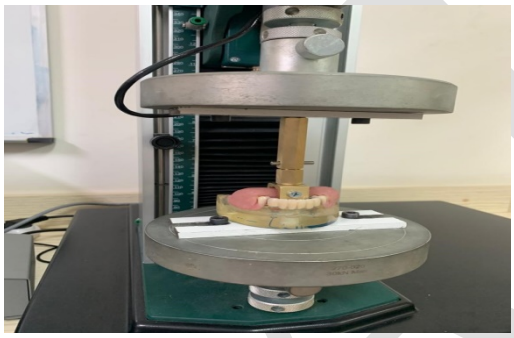

Figure (7): Testing for retention with universal testing machine.

RESULTS

The mean force was calculated and compared between the groups. The mean force needed to dislodge the removable partial denture for group I (Ni Cr Conventional ball attachment size 2.2mm) was 46.69N with the minimum value being 44.50N and the maximum value being 49.90N after cyclic loading the mean force needed to dislodge the RPD was 32.13N with the minimum value being 30.10N and the maximum value being 33.90N. The mean force needed to dislodge the removable partial denture for group II (Zirconium CAD/CAM ball attachment size 2.2mm) was 59.07N with the minimum value being 56.10N and the maximum value being 61.00N after cyclic loading the mean force needed to dislodge the RPD was 42.44N with the minimum value being 40.00N and the maximum value being 44.50N (Table 1, Figure 8).

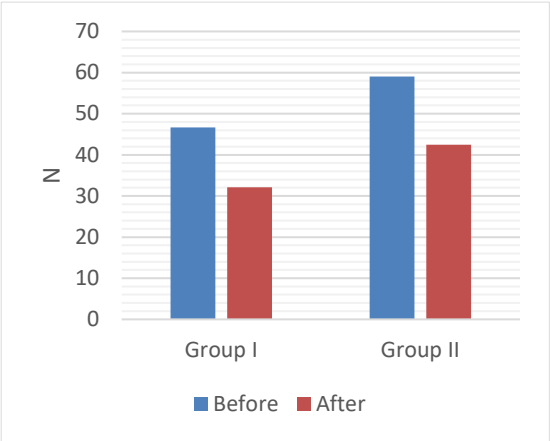

Figure (8): Comparison of retention between the study groups.

Table 1: Comparison of retention between the study groups

		Group I (n=7)	**Group II (n=7)**	**Test (*P* value)**
Before	Mean (SD)	46.69 (1.78)	59.07 (1.72)	1068.186 **(<0.001*)**
	Median	47.10	59.60	
	Min - Max	44.50 – 49.90	56.10 – 61.00	
After	Mean (SD)	32.13 (1.62)	42.44 (1.42)	602.328 **(<0.001*)**
	Median	31.70	42.30	
	Min - Max	30.10 – 33.90	40.00 – 44.50	
Test (*P* value)		40.385 **(<0.001*)**	32.831 **(<0.001*)**	
% Reduction	Mean (SD)	31.19 (1.87)	28.14 (1.87)	8.219 **(0.042*)**
	Median	32.06	27.59	
	Min - Max	28.66 – 32.96	25.34 – 30.97	

*Statistically significant different at p value <0.05

DISCUSSION

Removable dentures are still a big part of dentistry, due to the increasing number of edentulous population (22). However, this traditional treatment has been found to have

numerous flaws and is often unappealing to patients. Complete dentures have a variety of issues, ranging from instability and poor retention to trouble chewing and grinding food (23). Patient satisfaction was examined by Cune et al (24) on eighteen edentulous patients who were treated with implant overdentures. Ball and bar attachments resulted in higher patient satisfaction in this study. The retention of the detachable prosthesis is an important and major predictor of patient satisfaction (25). It's still up for debate which method of attachment delivers the highest retention (26). According to studies, the more retentive the denture is, the more effectively the patient can use it for mastication and speech. It also improves one's self-esteem and confidence (27-29).

In this study, a universal testing machine was used with a cross head speed of 5mm/min to imitate the speed of dislodgment of the denture clinically. A cyclic tension-compression test was performed in this study to simulate insertion and removal of the partial denture. (21). Using CAD/CAM technology for fabrication produces frameworks and attachment produces a superior precision to conventional casting techniques In this study, there was a significant difference in the retentive forces between the two groups before and after cyclic loading. This study also showed a significant difference in the retentive forces between the CAD/CAM fabricated extra coronal attachment versus that fabricated conventionally. The CAD/CAM extra coronal attachment showed higher force than the conventional method due to the higher precision of the CAD/CAM. This higher precision makes the female clip fit more accurately to the attachment hence, making it more difficult for the partial denture to be detached from the attachment. Studies asserted that the precision of the CAD/CAM produced framework is so precise that it fits intimately onto its corresponding abutment. (27-29). In this study there was a significant difference in the retentive forces between the CAD/CAM fabricated zirconium attachment versus that conventionally fabricated Ni Cr attachment. The CAD/CAM ball attachment showed 12.38N higher force than the conventional attachment before cyclic loading and 10.31N difference after cyclic loading. This significant difference can be attributed to the higher precision of the CAD/CAM technology. This higher precision allowed the female clip to fit more intimately onto the ball attachment, therefore needed a higher pull force to be separated. This assertion is in line with an experiment published by Sven Rinke et al (30) who claimed that the precision of CAD/CAM created framework is so high that it fits perfectly with a great degree of intimacy onto its matching abutment exactitude (27-29).

CONCLUSION

The retention of CAD/CAM manufactured attachments was nearly double that of conventional casted attachments. This increase in force is due to the milled attachments being more precise. This enhanced retention will be advantageous in the long run.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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