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ORIGINAL RESEARCH


# *In vitro* Retention Loss of Attachment-retained Removable Partial Denture

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## ABSTRACT

**Aim:** To investigate the importance of attachment types on the retention loss of extracoronal attachment-retained removable partial dentures depending on the usage period.

**Materials and methods:** In order to observe the retention loss of 5 different attachments (OT Strategy, OT Strategy-metal protected, Vario-stud-snap and Vario-soft 3 and ERA-RV) over time, attachment-retained partial dentures representing Kennedy II mod. I case were placed in a custom-made, retention test machine. For each minute, eight separating and joining movements were performed and retention values (Newton) of the attachments were recorded by computer. The retention tests implemented in 540,1080 and 2160 cycles. The data were evaluated statistically according to the two-way ANOVA and Tukey parametrical tests.

**Results:** The slide type attachment providing the best retention force was observed to be the most worn out by this process ($p < 0.01$) while the ball type attachments, which typically have the lesser retention force, showed less retention loss ($p < 0.01$).

**Conclusion:** It can be concluded that the retention attributes of the attachment-retained dentures were affected by the specific type of precision attachment as well as the usage period.

**Clinical significance:** Precision attachments with ball-type plastic matrices may be recommended for the clinical use due to their retention stability over time.

**Keywords:** Precision attachment, Removable partial denture, Retention.

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## INTRODUCTION

Removable partial dentures should demonstrate sufficient retention to resist reasonable dislodging forces during masticatory function. Retention for the removable partial denture is accomplished mechanically by placing retaining elements on the abutment teeth and by the intimate relationship that exists between denture bases and the major connectors with the underlying tissues. The clasps exert occlusal forces to the abutment teeth in order to provide retention and stability to the denture. It is important to note that excessive loading may jeopardize the abutment teeth. In addition, extracoronal attachments provide not only an esthetically pleasing result because of the lack of visible conventional clasps but also improve stress distrubition exerted by removable partial dentures on the abutment teeth.[1,2] Extracoronal resilient attachments that allow articular, rotational and friction movements consist of two components known as resilient and rigid. The rigid positive component (patrix) is placed generally on the crown restoration made upon abutment teeth while the resilient one is the negative component (matrix) usually incorporated into the removable prosthesis. While the patrix is generally composed of metal, the matrix is elastic and it generally made up of a prefabricated thermoplastic polymer. Additionally, extracoronal precision attachments are produced in ball or slide form.[3,4]

Thermoplastic polymers (polypropylene, polystrene, polyamid, nylon) are resilient materials showing high solidity, resistance against ambient conditions and humidity, flexibility, chemical reliability, and inherently posses less mechanical strength. Resilient attachments are generally produced of Nylon 11 (synthetic polyamide). The nylon 11 attachments are inexpensive, easily replaced and cause less wear and tear of the positive component. In addition, the carboxylic group chain of the Nylon 11 is much more dense than in other types of nylons. Therefore, it is easily observable that because of the reduced water absorption, resistance and flexibility are increased.[5,6] Furthermore, plasticizer elution from the polymers may increase wear on either the matrix or patrix components of the attachment, thusly may cause lower overall retention. In fact, the wear of these attachments create harmful forces on the supporting tissues negatively affecting the overall denture retention and stability. When this occurs, it is obligatory to change the polymeric components of the attachments because wear-induced loss of retention in attachment retained dentures pose a major clinical problem.[7,8] For this reason, the choice of an attachment type essentially depends on which design provides the best condition, i.e. the least wear, to ensure long functional life. As manufacturers offer patients to change polymeric component attachments after 2 years, it is inevitable to see its wearing in more long-term usage periods.

In literature, the wear and retention behavior of attachments has been examined by researchers using different *in vitro* conditions and various attachment types existing currently on the market.[9-13] This study was focused on the examination of retention forces of the ball and slide type attachments after wear testing. It was hypothesized that the shape of the attachment has a direct influence on retentive forces after simulated wear, that there would be differences in retentive properties between the types of attachments tested, and that wear simulation would influence retention performance of precision attachments.

## MATERIALS AND METHODS

A total of 35 epoxy resin mandibular Kennedy Class II mod. one model and five types of attachments (Fig. 1) were used in this study.

OT Strategy (OTS, Rhein 83, Bologna, Italy), which consists of a ball metallic patrix placed upon the crown while a polyamide matrix is incorporated in the denture base of the removable partial denture.

Metal protected OT Strategy (OTSM, Rhein 83, Bologna, Italy) which is the same as the OT Strategy previously discussed, with the only difference being that there is also a metal preserver under the matrix.

Vario-stud-snap (VSS, Bredent, Senden, Germany) which consists of a ball metallic patrix placed upon the crown while a polyamide matrix is incorporated in the denture base of the removable partial denture.

Vario-soft 3 (VS3, Bredent, Senden, Germany) which consists of a slide-type metallic patrix placed upon the crown and a polyamide matrix which is incorporated in the denture base of the removable partial denture.

ERA-RV (ERA, Sterngold, Attleboro, USA), extracoronal resilient attachment since it is different from the other precision attachment types, it consists of a polyamid patrix which is incorporated in the denture base of the removable partial denture while the metallic matrix is set upon the crown.

**Fig. 1:** Precision attachment types

### Preparation of Attachment Retained Crowns and Metal Frameworks

After the wax models of the crowns were set up on the abutment teeth, either the patrix or the matrix was placed on the proximal surfaces using a parallelometer. Afterwards, the crowns were casted with Cr-Co dental casting alloy.

The metal crowns were set up on the abutment teeth, the available laboratory copings of the matrix components were placed on the model (Fig. 2).

Major and minor connectors, blocks on edentulous areas and other supporting, stabilizing and retentive components were produced using modeling wax. Afterwards, using the same casting metal alloy, denture specimens were prepared. A metal plate (10×40×3 mm) with a screwing system in the middle was soldered between the right and left blocks.

Matrix of attachments were supplied on the spaces done by copings at the inner surface of the denture. A silicon material of fluid consistency was placed between model and metal framework in order to imitate the oral mucosa regularly found in a typical patient's mouth (Fig. 3). For each attachment type, a total of 35 partial denture specimens were prepared by repeating the same procedure that was just described.

### Insertion–removal Procedure

The equipment shown in Figure 4 was designed to carry out the retention testing. Inside of the reservoir of the test device, three models having dentures on were screwed in along with a carboxymethylcellulose based on artificial saliva (Cekol 2000, Noviant, Holland) kept at a temperature of 36.5°C in order to supply a lubricating medium for the experiment. For each minute, 8 seperating and joining movement were performed during the retention tests.

**Fig. 2:** Crowns and attachment. Vario-stud-snap, ball metallic patrix placed upon the crown and polyamide matrix incorporated in the denture base

**Fig. 3:** Attachment-retained metal framework

**Fig. 4:** Test machine

Removal values at 540, 1080 and 2160 cycles were recorded for each attachment to simulate the usage periods of 6 months, 1 year and 2 years, respectively (n = 7). Comparisons according to attachment types and the insertion-removal cycles were evaluated statistically according to the two-way ANOVA and Tukey parametrical tests.

## RESULTS

Mean retention forces and standart deviation values of attachment types measured by Newton (N) are remarked on Graph 1 according to the testing cycles. Dentures were removed from the model by approximately 12 to 35 N, varying according to the attachment types.

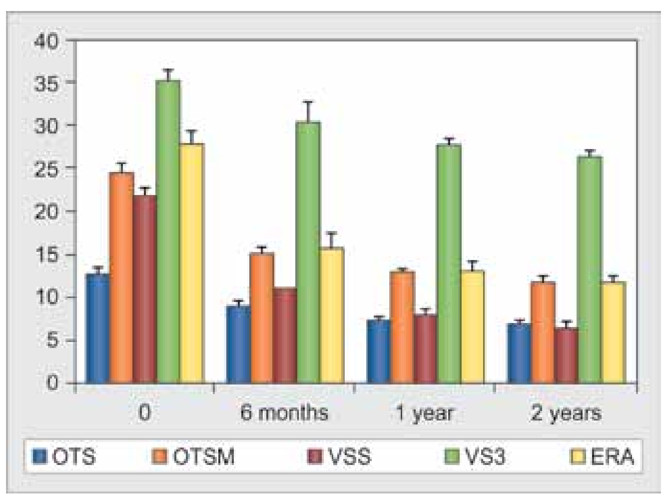
### Comparison of the Attachment Types

According to the values reported for initial retentive forces on Graph 1, VS3 (slide) was found to have the highest amount of retention force in comparison with other attachments while the OTS (ball) was found to have the lowest. VSS (ball) showed less retention than both OTSM (ball) and ERA. In each of the different attachment-retained dentures, the retention force was observed to be similar to the beginning values as the testing cycles were increased.

Statistically significant differences were detected in the retention values of attachments after 6 monthly cycles ($p < 0.01$). However, there was no statistically significant difference in the final retention values at the end of the 1 yearly cycles ($p > 0.01$). On the other hand, OTS showed significantly less decrease in its retention compared to the other attachment types at the end of the 2 yearly cycles ($p < 0.01$).

### Influence of Cycle Period

The insertion-removal cycles adversely affected the retention values of the attachments. Retention of the attachment-retained dentures was decreased as the duration of the testing period increased. Each attachment type showed a rapid fall of the retentive force at the end of the first 6 months (540 cycles). However, the reduction rate of the retaining force was more moderated when the testing lenght passed from 1 year (1080 cycles) to 2 years (2160 cycles).




**Graph 1:** The mean and SD retention values (N) according to the usage periods

A significant effect was found in each testing period of the dentures with VS3 and ERA in accordance with the formula; 6th month > 1st year = 2nd year ($p < 0.01$). However, while observing the retention of the dentures with OTSM, OTS and VSS, time-dependent loss of retention was found to be best expressed by the following formula; 6th month >1st year>2nd year ($p < 0.01$).

## DISCUSSION

Long-term clinical success of removable partial dentures, without creating harmful effects on supporting teeth and tissues, depends on the ideal denture plan and the selection of suitable attachment type. Extracoronal attachments are frequently preferred as opposed to clasps when indicated. However, the loss of retention in the dentures is inevitable due to the wear of the polymeric components of the attachments over time. Therefore, it is necessary to carry forward the research on the factors that actually cause the retention loss of attachment-retained denture.

In the previous *in vitro* studies, wear and retention of precision attachments were investigated by either placing the attachments on acrylic blocks or placing them at the ends of a mechanical wear device. These tests were carried out without taking into consideration the denture components and the effects of oral environment.[8,14-16] Although posterior clasps are the auxiliary components of the dentures contributing to stabilization, and reciprocation, oral mucosa also significantly affects the supporting capacity during function.

Human saliva, ensures the integrity of oral mucus like tissues with mucin and its electrolytes as well as possessing the viscoelastic characteristics of glycoproteins and acting as a lubricant. The increase of friction coefficient between saliva-enamel, -metal or -porcelain highlights the importance of the properties of saliva used during *in vitro* retention testing.[18,19] Artificial saliva containing carboxymethylcellulose as an alternative to human saliva can be used as a spray form or stored in a container.[8,9,13] Moreover, it is noteworthy that the resilient silicon layer placed under the denture absorbs forces similar to oral soft tissues during laboratory testing. In addition, usage cycles of attachments can be monitored either monthly or yearly.[16-21]

Present study was conducted in an artificial saliva environment and attachment-retained dentures with all structural components suitable to Kennedy class II mod. one case. In previous studies, it was generally preferred to examine the attachment types composed of either metal-metal or metal-polymer structure without taking into consideration the differences in their designs.[22-24]

Thermoplastic components of the attachments can exhibit viscoelastic behavior. However, plastic deformation appears when the stress occurs continuously along with the natural loss of elastic behavior. Additionally, thermoplastic polymers tend to degrade in liquid environment because of the elution of plasticizer substances.[6,23]

Retention differences of slide (VS3), ball (OTS, VSS, OTSM) and ERA attachment, indicating the differences of retentive force, may affect the attachment selection according to the denture plan. Holts et al[15] reported that polymeric attachments showed the greatest retention force after 10.000 cycles when compared to prefabricated metal-metal precision attachments. They proposed that this result arose due to the more homogeneous structure of prefabricated polymeric attachments. Wichmann and Kuntze[8] observed that polymeric precision attachments were less worn out than the metal ones according to scanning electron microscopy analysis after 10.000 cycles.

Retention of slide type attachment (VS3) statistically being more than the other types indicated that the shape of the attachment significantly affected the attachment retention during long-term function. Furthermore, retention attributes of OTSM and ERA, statistically being higher than VSS and OTS, underlined the importance of attachment shape and protecting metal elements.

It was stated that precision attachments without metal protection provided less retention values when compared with the metal-protected ones at the end of 2000 cycles.[24,25] However, in this study, as the retention of precision attachments without metal protection was found stable during testing, it was considered to be less worn out after cycling process.

The retention of OTSM (ball) was determined superior than OTS (ball). This result was thought to be due to the effect of metallic components that support rotational movements. However, metal-protected precision attachments, not being able to withstand the same force during the usage period was attributed to the increased wear of the attachments.

The decrease in the retention of VS3 (slide) and OTS (ball) at the end of the 6 months cycles was higher than the retention obtained at the end of 1 and 2-year cycles. However, wear of ball shaped (VSS and OTS) attachments at the end of 6 months stayed at a stable level. This result revealed that the frictional movement was more abrasive than the rotational movement of the attachments.

In Berg and Caputo's research,[26] the stress distribution on the precision attachments of the attachment-retained partial dentures was examined with a photoelastic stress analysis method which consisted in applying vertical and horizontal forces at the result rest and/or splinting the abutment teeth. Their study showed that the presence of rests and/or splinting the abutment teeth was not effective in reducing the stress distribution.

In the present study, higher retention values were obtained in comparison with the other similar studies. This is due to the taking into account the auxiliary functions of denture components and the use of a more effective *in vitro* test environment. This result ultimately shows the importance of implementing the denture components with precision attachments within *in vitro* circumstances.

## CONCLUSION

Within the limits of this study, the following conclusions may be drawn:

- The structure and design (slide or ball) of the extracoronal attachments are important factors for the retention properties.
- The greatest retention loss of the attachments occurs during the first 6 months of service in all tested plans.
- The structural elements of dentures significantly affect the retention of attachment-retained removable partial dentures.
- Polymeric components of attachment are to be changed after 1 year of clinical usage.

### Clinical Significance

Extracoronal attachments composed of a thermoplastic polymer provide distinct advantages, such as having changable partials and low costs as opposed to metalic attachments. In terms of the retention properties of the attachments, ball-type plastic matrices seem to be recommendable for clinical use.

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