“In vitro” wear behavior of extracoronal precision attachments

Elken Gomes Rivaldo
Wellington Cardoso Bonachela
Paulo Henrique Orlato Rossetti
Luis Carlos da Fontoura Frasca

ABSTRACT

The objective of this study was to evaluate the retentive ability and weight change of two extracoronal attachments after repeated insertion/removal cycles. Material and methods: Two extracoronal attachments were used, one with plastic inserts and the other one with conventional metal-alloy. Initial retentive ability was checked under a 20kgf load cell at 5mm/min. The weight of the fixed/removable pairs was verified with an electronic mass comparator. Fixed/removable pairs were tested with an insertion/removal cycling machine, for 5800 cycles (corresponding to 5 years) at a speed of 32 rpm speed. Insertion/removal cycles were performed under artificial saliva. Weight change and retentive ability of attachments were verified at baseline, six-month, one-year, two-year, three-year, four-year and five-year time intervals. The two-way ANOVA for repeated measurements test was used to verify possible interactions between precision attachment type and retentive ability/weight change over time. Statistically significant associations were found between attachment type and retentive ability over time (P=0.006). Metal-alloy group showed significant differences between baseline and first year (P=0.005), baseline and second year (P=0.001), and between baseline and five years (P=0.035) of insertion/removal cycles. In the plastic insert group, no significant differences were found over time. No statistically significant associations were found between precision attachment types and weight change over time (P=0.643). Initial retentive ability can not be standardized for both attachments; the metal-alloy showed better performance than the plastic insert after five years. Both attachments did not show weight change after five years of simulated use.

Keywords: Denture precision attachment, dental prosthesis, denture retention.

Elken Gomes Rivaldo – DDS, MSC, PhD. Department of Prosthodontics, School of Dentistry, Universidade Luterana do Brasil, Canoas, Rio Grande do Sul, Brazil.

Wellington Cardoso Bonachela – DDS, MSc, PhD. Department of Prosthodontics, School of Dentistry, Universidade de São Paulo, Bauru, São Paulo, Brazil.

Paulo Henrique Orlato Rossetti – DDS, MSc, PhD. Department of Prosthodontics, School of Dentistry, Universidade Sagrado Coração, Bauru, São Paulo, Brazil.

Luis Carlos da Fontoura Frasca – DDS, MSc, PhD. Department of Prosthodontics, School of Dentistry, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

Corresponding author: Elken Gomes Rivaldo. Rua Santa Vitória, 80/01, Bairro Tristeza. CEP 91920-350 – Porto Alegre, RS – Brazil. Tel./fax: 55 51 3241.3337. E-mail: elkenrivaldo@gmail.com

Stomatos	Canoas	Vol. 17	Nº 33	p.51-59	July/Dec. 2011

Comportamento de desgaste “in vitro” de encaixes de precisão extracoronários

RESUMO

O objetivo deste estudo foi avaliar a capacidade retentiva e a alteração do peso de dois encaixes extracoronários após repetidos ciclos de inserção e remoção. Materiais e métodos: Dois encaixes extracoronários foram usados, um com fêmea em plástico e o outro em metal. A capacidade retentiva inicial foi verificada em uma máquina de ensaio universal com célula de carga de 20kgf a velocidade de 5mm/min. O peso do conjunto macho/fêmea foi verificado com uma balança eletrônica. Os conjuntos macho/fêmeas foram testados em um simulador de ciclos por 5800 vezes (correspondendo a 5 anos) a uma velocidade de 32 rpm. Os ciclos de remoção e inserção foram realizados com saliva artificial. A alteração de peso e a capacidade retentiva dos encaixes foi verificada inicialmente e nos intervalos de tempo de 6 meses, um, dois, três, quarto e cinco anos. O teste ANOVA foi usado para verificar possíveis interações entre o tipo de encaixe e a capacidade retentiva/alteração de peso com o tempo de uso. Associação estatisticamente significativa foi encontrada entre o tipo de encaixe e a capacidade retentiva com o tempo de uso (P=0.006). O grupo metálico mostrou diferença significante entre o tempo inicial e o primeiro ano (P=0.005), tempo inicial e o segundo ano (P=0.001), e entre o tempo inicial e cinco anos (P=0.035) de inserção e remoção. No grupo com fêmea de plástico, não foram encontradas diferenças significativas. Associações estatisticamente significativas não foram encontradas entre os tipos de encaixes e a alteração de peso em tempo algum. (P=0.643). A capacidade retentiva inicial não pode ser padronizada nos dois encaixes; o grupo com fêmea em metal mostrou melhor performance retentiva que o grupo com fêmea em plástico após cinco anos. Ambos encaixes não mostraram alteração no peso após uso simulado de cinco anos.

Palavras-chave: Encaixe de precisão de dentadura, prótese dentária, retenção em dentadura.

INTRODUCTION

A dental precision attachment can be generally defined as “A connector consisting of two or more parts. One part is connected to a root, tooth or implant and the other part to prosthesis” (1). Modern dental precision attachments were first introduced in dentistry by Dr. Herman Chayes as metallic patrix and matrix components. More recently, newer options include a plastic matrix insert that can be replaced without damage to abutment teeth or prosthesis (2). Nevertheless, their choice should be based on location, function, retention, space and cost. In terms of location, they can be divided into intra and extracoronal types (1, 2). Extracoronal devices are indicated in distal removable partial dentures for several reasons: the non-aesthetic appearance of clasps, normal crown contour maintenance, reduced interocclusal space, avoidance of root canal therapy, facilitated path of insertion for patients with reduced dexterity (1, 3-5), and the need for some resiliency between tooth and mucosal tissues (6, 7). Whenever possible, double abutting is recommended for intra and extracoronal precision attachments (8).

However, repeated insertion/removal of precision parts, as well as small displacements of a removable partial denture when subjected to occlusal forces, can modify initial precision attachment retention values (9, 10). Although several types of precision attachments are available in the market, there are few comparative studies on their retention and wear behavior (9-14). The knowledge of a precision attachment's retentive ability over time could prevent biomechanical damage to abutment teeth, alveolar bone and mucosa, improving patient comfort and esthetics.

The objective of this study was to evaluate the long-term in vitro retentive ability and weight change of two extracoronal precision attachments after repeated insertion/removal cycles. The study had two hypotheses: the first null hypothesis tested was that no changes in retention ability would be observed for both precision attachments and the second one was that no changes in weight change would be observed over time.

MATERIAL AND METHODS

Master cast fabrication

The upper member of a dental study model (Sem Limites, Minas Gerais, Brazil) was used to fabricate the master cast in this study. All maxillary posterior teeth and the left anterior teeth were removed. The maxillary right lateral and canine were prepared for complete crowns with a high-rotation speed bur (Extra torque 605, Kavo, Joinville, Brazil) according to the following characteristics: 135º circumferential chamfer finishing line, 6 degrees of convergence angle, 1.2 to 1.5mm of axial and occlusal reduction, respectively, and rounded line angles. The abutment teeth and edentulous spaces were then boxed with a polypropylene sheet, impressions made with a liquid industrial silicone material (Remasil, São Paulo, SP, Brazil), poured in autopolymerizing acrylic resin (Duralay, Reliance Dental Mfg. Co., Illinois, USA), invested and cast in Ni-Cr alloy (Wiron 99, Bego, Bremen, Germany) according to manufacturer's recommendations. The master cast was divested, cleaned with aluminum oxide 110µm particles (Duostar, Bego, Germany) finished with coarse and fine carburundum wheels (Pontas Shelbe Ltda., Petropolis, Rio de Janeiro, Brazil) and polished with abrasive rubber wheels (Cromox, São Paulo, SP, Brazil). The master cast was then attached to an acrylic resin base (Clássico, Artigos Odontológicos Clássico, São Paulo, Brazil) for infra-structure fabrication.

Infra-structure fabrication and precision attachment positioning

Infra-structures in this study were not cemented to their abutments, but were secured with a 1.2mm-diameter horizontal threaded perforation made at the mid-buccal portion of lateral and canine abutments with a universal bur M 1.4 at low-speed rotation (Firth Rixson Monroe, Rochester, USA). This was necessary to be able to test the retentive ability and weight change of the extracoronal precision attachments. Wax patterns (Degussa-Hulls, Guarulhos, Brazil) for the splinted complete crown restorations were made directly on the master cast. Mesial rest seat and lingual arm design were incorporated into the canine portion of the infra-structure with the aid of a milling machine (Frasgerat F1, Degussa, Essen, Germany).

Two extracoronal precision attachments were used in this study, with 10 samples per each group: The first group used plastic insert (PI) precision attachment (ROD, Servo Dental, Hagen, Germany) consisting of 4.0mm-height plastic burnout cylindrical patrix/matrix elements with a nylon insert (Figure 1A) and metal-alloy (MA) precision attachment (Microfix) (Odontofix, Ribeirão Preto, Brazil) consisting of 3.0mm-height metallic (nickel-chromium) cylindrical patrix/matrix elements (2, 10) (Figure 1B). Both are extracoronal, adjustable precision attachments being two of the most common connecting elements in use in Brazil (15). The patrix portions of both precision attachments were positioned distal to the canine and along the edentulous space with the aid of a paralleling device (Frasgerat F1, Degussa, Essen, Germany). All wax patterns were carefully removed, invested (Virovest, Bego, Petrópolis, RJ, Brazil), and cast with the same Ni-Cr alloy according to manufacturer's recommendations.

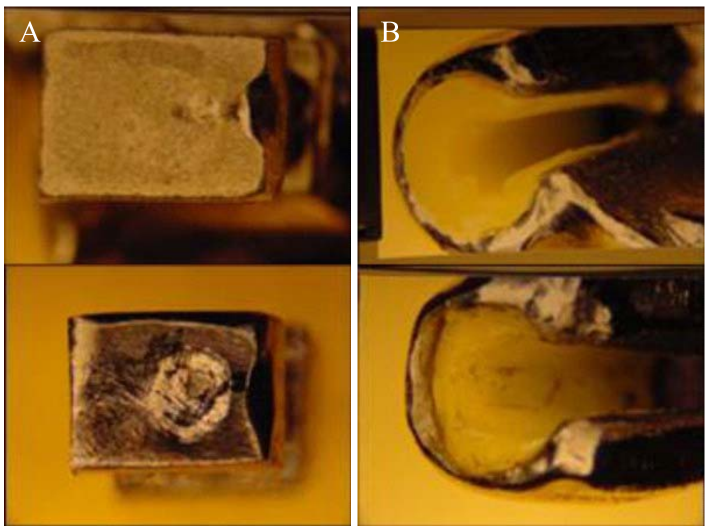

FIGURE 1. A) Plastic insert precision attachment, B) Metal-alloy precision attachment

The metallic infra-structures were initially adapted to the master cast using a uniform liquid disclosing agent (Occlu Plus Spray, Haver & Werken GmbH & Co, Germany) painted on their internal surfaces. After seating, crowns were internally inspected and interferences removed with a rotary instrument. The internal portions were then cleaned with alcohol and the seating procedure repeated until no detectable interferences were observed. Final adaptation was considered acceptable when no discrepancies were detected.

Superstructure fabrication

The removable part (superstructure) was waxed up including the matrix precision attachment part, lingual arm and mesial rest. The master model was then positioned in the milling device and two 20-mm plastic rods were attached to the mesial rest and the matrix part of the precision attachments. All superstructures were invested and cast in Ni-Cr alloy (Wiron 99, Bego, Germany). These rods serve as connecting jigs to the insertion/removal cycling machine. The lingual arm and the mesial rest of the superstructure were adapted to the infra-structure with a spray disclosing agent. The patrix part of PI precision attachment was finished with abrasive rubber wheel and felt disk embedded in polishing paste (Dentaurum, Medental, São Paulo, SP, Brazil). The nylon insert of the PI precision attachment was finally positioned with the aid of a paralleling device.

Initial weight and retentive ability of the precision attachments

The initial weight of the fixed/removable pairs was verified with an electronic mass comparator (CC 3300 Sartorius, Sartorius AG, Germany, series 70903192) (13). Five measurements were taken for each pair and the mean used for statistical analysis. The reading error was 0.001g. The initial retentive ability was then measured in a vertical direction with a Versat Universal Testing Machine (Model 500, 1053 series, Panambra Industrial e Técnica SA, São Paulo, Brazil) under a 20kgf load cell and cross-head speed of 5mm/min. Five measurements were taken and the mean retentive ability used for statistical analysis.

Insertion/removal cycling machine

Fixed/removable pairs were tested with an insertion/removal cycling machine, for 5800 cycles (corresponding to 5 years) at a speed of 32 rpm speed (15) (Figure 2). Each pair was immersed in artificial saliva (saliveze, Wyvern Medical Limite, Herefordshired, United Kingdom) for one hour to simulate lubrication found in the oral cavity. Each pair was then positioned in an insertion/removal cycling machine which was vertically directed. Artificial saliva (8 drops/min) was applied throughout the insertion/removal test (10).

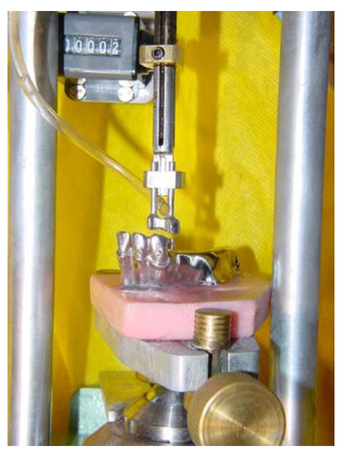

FIGURE 2. Insertion/removal cycling apparatus.

Weight change and retentive ability of extracoronal precision attachments were verified at baseline, six-month, one-year, two-year, three-year, four-year and five-year time intervals. The number of cycles for each test period was calculated on the basis of average values in the literature (10). Stereomicroscope analysis (Olympus SZ 11, Tokyo, Japan) of the precision attachments at baseline and five-year simulation periods provided information on wear conditions (10).

Statistical analysis

The Kolmogorov-Smirnov and the Levenne tests (α=0.05) were used to verify normality and equal variance for each group, respectively. The two-way ANOVA test for repeated measurements (α=0.05) was used to verify possible interactions between precision attachment type and retentive ability/weight change over time. The Tukey test (α=0.05) was used to identify which groups had statistically significant differences.

RESULTS

Means and standard deviations for retentive ability and weight change over time are shown in Tables 1 and 2, respectively. Statistically significant interactions were found between precision attachment type and retentive ability over time (P=0.006). In the MA group, the Tukey test revealed differences between baseline and first year (P=0.005), baseline and second year (P=0.001), and between baseline and five years (P=0.035) of insertion/removal cycles. In the PI group, no significant differences were found over time. No statistically significant interactions were found between precision attachment types and weight change over time (P=0.643).

Stereomicroscope analysis of both precision attachments can be found on figures 3 and 4. Two examiners blinded to the study were calibrated in relation to morphological changes on the inner and outer part of precision attachments. Considerable changes were verified in patrix/matrix parts.

TABLE 1. Retentive ability (Newtons) over time for extracoronal precision attachments

	Time period						
Type	**Initial**	**6 mo**	**1yr**	**2yrs**	**3yrs**	**4yrs**	**5yrs**
Plastic insert (N)*	4.1 (±0.3)	5.2 (±0.4)	4.1 (±0.4)	6.5 (±0.5)	5.5 (±0,5)	6.5 (±0.4)	6.0 (±0.6)
Metal-alloy (N)	6.0 (±0.5) [a,b,c]	9.2 (±0.5)	12.6 (±0.6)[a]	10.9 (±0,5) [b]	9.3 (±0.6)	8.4 (±0.6)	9.6 (±0.6) [c]

*N = Newtons
same small letters in rows represent statistically significant differences (P<0.05)

TABLE 2. Weight change over time for extracoronal precision attachments.

	Time period						
Type	**Initial**	**6 mo**	**1yr**	**2yrs**	**3yrs**	**4yrs**	**5yrs**
Plastic insert (g)	5.0654 (±0.02)	5.0657 (±0.04)	5.0512 (±0.03)	5.0679 (±0.02)	5.0652 (±0.03)	5.0657 (±0.02)	5.0658 (±0.03)
Metal-alloy (g)	5.1348 (±0.08)	5.1491 (±0.07)	5.1298 (±0.06)	5.1310 (±0.05)	5.1186 (±0.06)	5.1372 (±0.05)	5.1614 (±0.07)

DISCUSSION

Retentive ability increased significantly over time in the metal-alloy precision attachment group. Retention provided by precision attachments may be related to comfort, satisfaction, chewing ability, as well as adequate distribution of occlusal loads to, and preservation of abutment teeth in patients with removable partial dentures.

This in vitro investigation evaluated and quantified changes in retention ability and weight change over time. Metal-alloy and plastic inserts precision attachments have been reported to preserve supporting teeth and alveolar bone ridges when associated with at least two splinted abutments (8, 10, 14). It is difficult to evaluate precision attachments´ effects on treatment longevity based solely on in vitro results since other factors such as continuous ridge resorption, changes in saliva flow and composition, and occlusal considerations may affects its long-term success (9, 10, 14).

The number of insertion/removal cycles per day was set according to the minimum number of patient hygiene periods, as well as, cycle frequency and the use of artificial saliva one hour before the simulation period (9, 10, 14). Perhaps, the absence of weight change in both groups could be attributed to the protective and lubricant action of saliva (12). In this way, different values are found in dry simulation tests (12, 13).

Baseline retention values obtained in this study (Table 1) showed lack of standardization for both precision attachments. This result is similar to that found in other studies (9, 10, 12-14). Even a skilled laboratory technician can not guarantee similar conditions.

After six months, an initial increase in retention was noted in both groups, with stabilization of retention values achieved after two years of use. In plastic insert group, this finding could be a result of water sorption, since samples were constantly in artificial saliva. Moreover, maintenance of retention forces may be explained by longitudinal grooves and scores generated during use, which can be seen with a stereomicroscope (Figure 3). These features could also explain increase in the retention forces (9, 10). In the metal-alloy group, an increase in the retention “click” was found during cycling. This can be attributed to fatigue in the spring that supports the dimple in the matrix component, as well as by changes in the contact surface between patrix/matrix parts verified under stereomicroscope (Figure 4). In contrast, precision attachments have been found in another study to provide similar or higher retention in paraxial directions and less retention in axial directions after wear simulation (16).

Lack of precise fit in the interaction between removable partial dentures and their corresponding restored abutments/attachments is sometimes a clinical problem found after significant wear periods. Use of plastic insert allow easy and economic replacement of worn matrix components. However, the metal-alloy precision attachment showed better performance (final retentive capacity) than the plastic insert type.

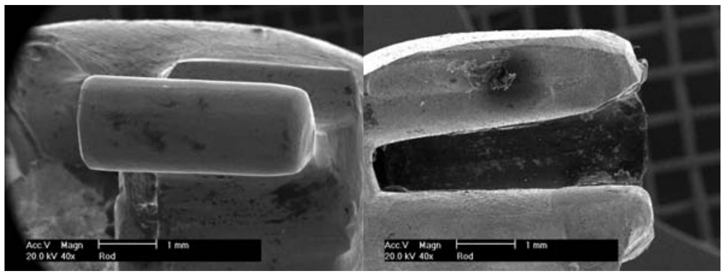

FIGURE 3. Stereomicroscope analysis for metal-alloy precision attachment. White arrows indicate wear between patrix/matrix after 5 years of simulated use.

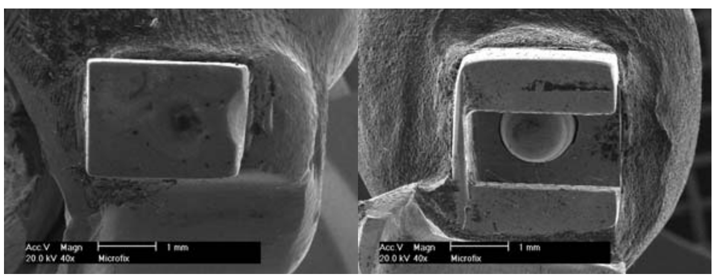

FIGURE 4. Stereomicroscope analysis for plastic insert precision attachment. White arrows indicate longitudinal grooves in patrix/matrix parts after 5 years of simulated use.

Many aspects related to the behavior of fixed/removable partial dentures still need to be studied since some patients can not be benefited from the use of osseointegrated implants. The knowledge of precision attachment's retentive ability over time could prevent biomechanical damage to abutment teeth, alveolar bone and mucosa.

CONCLUSIONS

Within the limits of this study, it can be concluded that metal-alloy precision attachments showed a greater increase in retentive ability compared to precision attachment with plastic inserts over time and both precision attachments did not show weight change after five years of simulated use.

REFERENCES

1. Shering-Lucas M, Martin P. Attachments for prosthetic dentistry: introduction and application. London: Quintessence Books. 1994.
2. Attachments International. Sybron Dental Specialties. Attachments International Sybron Dental specialties 2008 [cited 2008 10/01/2008]. Avaialbe at: www.attachments.com.
3. Burns DR, Ward JE. Review of attachments for removable partial denture design: 1. Classification and selection. Int J Prosthodont. 1990;3(1):98-102.
4. Burns DR, Ward JE. A review of attachments for removable partial denture design: Part 2. Treatment planning and attachment selection. Int J Prosthodont. 1990;3(2):169-74.
5. Jenkins G. Precision attachments. A link to successful restorative treatment. Berlin: Quintessence Publishing Co. 1999.
6. Berg T, Caputo AA. Comparison of load transfer by maxillary distal extension removable partial dentures with a spring-loaded plunger attachment and I-bar retainer. J Prosthet Dent. 1992;68(3):492-9.
7. Sadan A. Selection criteria for attachments. Pract Proced Aesthet Dent. 2005;17(9):590.
8. el Charkawi HG, el Wakad MT. Effect of splinting on load distribution of extracoronal attachment with distal extension prosthesis in vitro. J Prosthet Dent. 1996;76(3):315-20.
9. Holst S, Blatz MB, Eitner S, Wichmann M. In vitro wear of different material combinations of intracoronal precision attachments. Int J Prosthodont 2006.19(4):330-2.
10. Wichmann MG, Kuntze W. Wear behavior of precision attachments. Int J Prosthodont. 1999;12(5):409-14.
11. Besimo CE, Guarneri A. In vitro retention force changes of prefabricated attachments for overdentures. J Oral Rehabil. 2003;30(7):671-8.
12. Jung T, Borchers L. [Experimental study on the mechanical properties of precision connectors]. Dtsch Zahnarztl Z. 1983;38(11):986-9.
13. Koeck B, Grüner M, Werner BE. [Comparative study of commercially available attachments for axial cycles.]. Dtsch Zahnarztl Z. 1993;48(1):622-4.
14. Leung T, Preiskel HW. Retention profiles of stud-type precision attachments. Int J Prosthodont. 1991;4(2):175-9.
15. Rivaldo EG, Bonachela WC, Mezzomo E. Study of the performance in simulated use of extracoronal attachments tip stud (Microfix-Rod). Journal of Dental Research 2002. 81(B):133.
16. Rutkunas V, Mizutani H, Takahashi H. Influence of attachment wear on retention of mandibular overdenture. J Oral Rehabil. 2007;34(1):41-51.