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Comparison of the Retention of Conventional Dentures after the use of Common Adhesive Brands on Poor Denture Foundations. An *in vitro* Study

Comparación de la Retención de Dentaduras Convencionales con el uso de Marcas Comerciales de Adhesivos en Procesos Alveolares Deficientes. Un Estudio *in vitro*

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FLORES-LEÓN, J. Z. J.; DOMÍNGUEZ-PÉREZ, R. A.; RUÍZ-VALDEZ, H. E.; SÁMANO-VALENCIA, C.; LOYOLA-RODRÍGUEZ, J. P. & CASTRO-RUIZ, E. Comparison of the retention of conventional dentures after the use of common adhesive brands on poor denture foundations. An *in vitro* study. *Int. J. Odontostomat., 14(2)*:236-241, 2020.

ABSTRACT: There is no information about the possible impact in denture retention after the use of common denture adhesives (DAs) when poor denture foundations (PDF) are present. Moreover, there is a lack of information about which current formulation provides greater retention and for how long. Twelve models from edentulous patients with different ridge shape and border height were used and complete dentures were manufactured. Four different formulation brands of DAs were tested after 10 minutes and three, six, nine, and 12 hours of DA application using a universal testing machine. The Fittydent® and Fixodent® adhesives had the highest retention at 12 hours. The PDF group increased on average its retention by 400 %. However, the group presented lower retention compared to the good denture foundation group. In conclusion, DAs significantly increased denture retention. The PDF group were the most benefited with the application of DAs. The Fixodent® paste had the highest retention.

KEY WORDS: denture adhesives, retention, poor denture foundation, good denture foundation.

INTRODUCTION

It is believed that edentulism rates will remain constant or increase over the next decades (Douglass *et al*., 2002). Although there are many alternatives to implant treatment for edentulous patients (Doundoulakis *et al*., 2003), there are still circumstances in which a conventional complete denture is indicated, mainly in developing countries where it remains as the first choice of treatment due to the limited access to complete oral health care services.

The most common complaint of complete denture users is a nonretentive or unstable denture and particle accumulation under it (Siadat *et al*., 2008). Stability and retention are considered a basic and important requirement for the acceptance of a complete denture by the patient. The denture's performance is determined mainly by the retention [resistance in the movement of a denture away from its tissue foundation especially in a vertical direction (The glossary of prosthodontic terms: ninth edition, 2017)], which greatly depends on denture foundation, which is defined as the oral structure available to support a denture (Koshino *et al*., 2008).

It is well known that edentulous patients experience continuing resorption of the residual alveolar ridges over the years. The prosthetic replacement of the lost tissues will increase treatment problems causing extreme difficulties in the management of the dentures. Hence, poor denture foundation (PDF) is a serious prosthodontics problem (Atwood, 1971).

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It has been demonstrated that denture adhesives (DAs) significantly reduce movement (Grasso *et al*., 1994) and increase retention (Grasso *et al*.; Munoz *et al*., 2012). Different subjective [patient-based and quality-of-life outcomes (Kelsey *et al*., 1997)] and objective [(Kapur index, bite force to measure denture retention, stability and dislodgement (Tarbet *et al*., 1980) a measure of denture movement in function and masticatory performance (Kapur, 1967), electromyography, and kinesiography (Chew *et al*., 1985)] methods have been used to demonstrate the effectiveness of DAs.

A great majority of authors have concluded that DAs can provide a softening effect, reduce food particles collecting under the denture, and reduce local pressure points by helping in the distribution of occlusal forces over denture foundation (Tarbet *et al*.). Additionally, DAs can improve function and increase food chewing force. However, until now, it was not well known if denture retention has benefits and if these equally apply to PDF and good denture foundation (GDF). Moreover, there is a lack of information about which current DA formulation provides greater retention and for how long. Hence, the aim of this study was to evaluate the retention of well-fitting dentures after 10 minutes, and three, six, nine, and 12 hours of the application of some common DAs in two groups of simulated denture foundations (PDF or GDF) under controlled laboratory conditions *in vitro.*

MATERIAL AND METHOD

Sixty-three maxillary ridge gypsum models from edentulous patients who received treatment at the Dental School of the Faculty of Medicin at the Universidad Autónoma de Querétaro were examined. Twelve were selected according to their ridge shape and height, two of every kind (Table I). The models were subsequently classified into two groups, GDF group with a sum score ≥4 and a PDF group with a sum of score ≤3.

Table I. Scoring method used to classify denture foundations in two general groups.

Ridge Shape (Score)	Border height	Total Score
Flat (1)	Low (1)	2
	High (2)	3
V-Shaped (2)	Low (1)	3
	High (2)	4
U-Shaped (3)	Low (1)	4
	High (2)	5

Good denture foundation (GDF) with a sum score of ≥4
Poor denture foundation (PDF) with a sum score of ≤3.

Every gypsum model was duplicated in acrylic resin (Nic Tone Heat Polymerized, MDC dental, Guadalajara, México) and a complete denture was manufactured following the conventional technique by the same dentist and laboratory technician at the multidisciplinary laboratory of dental research, medical faculty of the Universidad Autónoma de Querétaro, México.

Four different formulation brands of DAs [Corega Ultra®, Stafford-Miller (Dungarvan, Ireland); Corega® (Powder), Stafford-Miller (Dungarvan, Irland); Fixodent Original® (Paste), Procter & Gamble (Gross-Gerau, Germany); Fittydent® (Paste), Fittydent International (Vienna, Austria)] were tested. In order to calculate and standardize the amount of paste and powder adhesive used for each denture, which depended on the denture size and instructions of every DA manufacturer, approximately 1 cm strips of DAs were applied at the anterior, middle of the hard palate, and right and left middle region of the posterior segments. The strips were then recollected and weighed on an analytical balance and registered. The same amount of paste/powder was applied in each denture in every test.

To perform retention tests in the vertical plane, every complete denture and its respective maxillary ridge acrylic model was attached to a universal testing machine (CMS Metrology). One ml of synthetic saliva (Panagiotouni *et al*., 1995) was sprayed inside the denture as well as in the maxillary ridge acrylic model. The corresponding amount of paste or powder was then applied on the denture and it was pressed in place with a 2 kg brass weight for 15 seconds. An extra 1 ml of synthetic saliva was sprayed when the powder was applied. All complete dentures and their corresponding adhered maxillary ridge acrylic models were placed in an incubator at 36 °C and 95 % humidity while the experimental time period was fulfilled in order to simulate intraoral conditions.

Every retention measurement was made with a testing crosshead speed of 1mm/minute. The force required to pull the denture apart was measured [Newtons (N)] and recorded. Each DA was tested 3 times in each of the 12 dentures during five time periods: 10 minutes, and three, six, nine, and 12 hours after DA application. Between tests, the dentures and the maxillary ridge acrylic

models were cleaned with an aqueous solution of detergent under running water and then dried by hand with a paper towel. The denture and acrylic maxillary ridge cleaning was of high importance due to the effects that product residuals might have caused.

All experimental procedures were done at room temperature of 23 °C ± 2 °C and relative humidity of 50 % ± 10 %. Retention was expressed in terms of the force necessary to separate the denture from the maxillary ridge acrylic model when a thin film of DA and synthetic saliva was interposed.

Statistical analysis. Quantitative data are expressed as mean, standard deviation, and range. For the determination of variable distribution, a Kolmogorov–Smirnov test was applied. To detect statistical differences among groups repeated measures ANOVA test was employed and the Tukey's post hoc test. The Student's t-test was applied when comparing the two groups. Statistical significance was set at $p<0.05$ employing GraphPad Prism V3.0 (GraphPad Software, San Diego, CA).

RESULTS

All tested DAs significantly improved denture retention compared to those with no DA application

Table II. Comparisons of the retention (in newtons) divided by the quality of the denture foundations (Poor Denture Foundation or Good Denture Foundation).

PDF	Corega Ultra® Paste	Fittydent® Paste	Fixodent Original® (n=6)	Corega® Powder (n=6)	p-value*
10 minutes	12.81 ± 2.33 (9.45 - 16.20)	14.77 ± 4.86 (8.15 - 19.90)	13.92 ± 1.93 (12.65 - 17.70)	12.33 ± 1.90 (9.52 - 15.32)	0.1895
3 hours	14.36 ± 5.04 (9.90 - 24.10)	12.92 ± 3.87 (8.22 - 16.96)	14.21 ± 1.38 (12.99 - 16.70)	14.14 ± 4.82 (10.32 - 23.54)	0.5737
6 hours	13.33 ± 4.73 (8.9 - 22.35)	13.41 ± 3.35 (9.22 - 17.03)	17.59 ± 2.12a (15.44 - 21.20)	14.22 ± 5.47 (9.33 - 24.66)	0.0378
9 hours	15.20 ± 2.44 (12.55 - 19.45)	16.03 ± 4.10b (12.55 - 21.89)	19.73 ± 2.23c (17.54 - 23.41)	15.65 ± 2.82 (12.52 - 20.21)	0.0012
12 hours	12.22 ± 1.80 (10.43 - 14.95)	17.56 ± 2.99 (15.88 - 20.55)	25.16 ± 2.10d,e (22.21 - 28.43)	13.38 ± 1.35 (11.43 - 15.00)	<0.0001
p-value*	0.1366	0.0007	<0.0001	0.1948	
GDF	Corega Ultra® (n=6)	Fittydent® (n=6)	Fixodent® (n=6)	Corega® Powder (n=6)	p-value*
10 minutes	23.06 ± 3.83 (17.43 - 25.95)	23.54 ± 3.35 (19.21 - 26.90)	21.71 ± 1.96 (18.50 - 23.45)	20.38 ± 7.42 (6.49 - 26.76)	0.2716
3 hours	23.28 ± 3.11 (19.28 - 26.34)	19.01 ± 2.44f (15.80 - 22-12)	21.48 ± 2.31 (17.99 - 23.87)	23.34 ± 2.04 (20.32 - 25.92)	0.0004
6 hours	23.12 ± 3.00 (19.21 - 25.98)	19.24 ± 2.97g (14.05 - 22.03)	22.69 ± 3.00 (19.80 - 26.98)	23.65 ± 3.40 (18.78 - 27.88)	0.0067
9 hours	24.17 ± 2.32h (20.54 - 26.39)	24.05 ± 3.59 (19.32 - 27.88)	30.52 ± 5.50i (23.33 - 38.65)	25.87 ± 2.41j (22.98 - 29.65)	0.0149
12 hours	20.04 ± 3.38 (17.50 - 26.33)	25.08 ± 3.83 (20.53 - 30.33)	36.56 ± 6.73k,l (26.33 - 44.65)	21.01 ± 3.80 (17.90 - 27.98)	0.0016
p-value*	0.0187	0.0158	0.0004	0.1090	
Global PDF	13.58 ± 3.46 (8.99 - 24.10)	14.94 ± 4.00 (8.15 - 21.89)	18.12 ± 4.58m (12.65 - 28.43)	13.94 ± 3.56 (9.33 - 24.66)	<0.0001
Global GDF	22.73 ± 3.27 (17.43 - 26.39)	22.18 ± 3.99 (14.05 - 30.33)	26.59 ± 7.30 (17.99 - 44.65)	22.85 ± 4.44 (6.49 - 29.65)	0.0030
p-value**	<0.0001	<0.0001	<0.0001	<0.0001	

a Fixodent vs Fittydent: $p<0.05$; b Fittydent 9hs vs 6hs: $p<0.05$; c Fixodent vs Corega-Paste, Fittyden, Corega-Powder: $p<0.05$; d Fixodent vs Corega-Paste, Fittyden, Corega-Powder: $p<0.05$; e Fixodent 3hs vs 6hs, 6hs vs 9hs, 9hs vs 12hs: $p<0.05$; f Fittydent vs Corega-Paste; Fittydent vs Corega-powder: $p<0.05$; g Fittydent vs Fixodent; Fittydent vs Corega-Powder: $p<0.05$; h Corega-Paste 9hs vs Corega-Paste 12hs: $p<0.05$; i Fixodent vs Fittydent: $p<0.05$; j Corega-Powder 9hs vs Corega-powder 12hs: $p<0.05$; k Fixodent vs Corega-Paste, Fittyden, Corega-Powder: $p<0.05$; l Fixodent 12 hs vs Fixodent 9 hs: $p<0.05$; m Fixodent vs Corega-Paste, Fittyden, Corega-Powder: $p<0.05$. *Repeated measures ANOVA and Tukey´s post hoc test. ** Student´s t-test.

(baseline). The obtained means of retention from the 12 dentures without DA was 5.38 ± 3.03 N, whereas, in the study groups (n=6), the GDF's retention was 7.90 ± 0.68 N and for PDF was 2.89 ± 2.16 N.

Table II shows the comparison of retention on poor or good denture foundations, where GDF showed higher values compared to PDF. The Fixodent® adhesive presented the greatest retention. Both Fittydent® and Fixodent® had the highest retention at 12 hours, while the Corega® products (powder and paste) had the highest at 9 hours, but decreased significantly after 12 hours. Table III shows the percentage in which the retention increased in general and divided by groups considering the baseline (retention presented by each of the dentures without DA). In general, the PDF group showed an increase in its retention by 400 % on average while those that were already retentive (GDF group) only increased to a mean of 200 %. Although the percentage of retention was much higher in the PDF group, the retention achieved was always lower compared to the GDF group.

Table III. Percentage of increase on retention of every denture adhesive in general and divided by the quality of the foundations considering the baseline (without DA application).

Complete Group	Corega Ultra® (n=12)	Fittydent® (n=12)	Fixodent Original® (n=12)	Corega® (Powder) (n=12)
10 minutes	232%	254%	229%	202%
3 Hours	248%	195%	230%	247%
6 Hours	228%	202%	273%	250%
9 Hours	264%	271%	365%	284%
12 Hours	198%	294%	421%	218%
Total	234%	243%	314%	240%
Poor Denture Foundation (PDF)	Corega Ultra® (n=6)	Fittydent® (n=6)	Fixodent Original® (n=6)	Corega® (Powder) (n=6)
10 minutes	342%	410%	381%	326%
3 hours	396%	346%	391%	388%
6 hours	360%	363%	508%	391%
9 hours	425%	454%	581%	440%
12 hours	322%	506%	769%	362%
Total	365%	416%	526%	381%
Good Denture Foundation (GDF)	Corega Ultra® (n=6)	Fittydent® (n=6)	Fixodent Original® (n=6)	Corega® (Powder) (n=6)
10 minutes	191%	197%	174%	157%
3 hours	194%	140%	171%	195%
6 hours	180%	143%	187%	199%
9 hours	205%	204%	286%	227%
12 hours	153%	217%	362%	165%
Total	185%	180%	236%	189%

DISCUSSION

A DA can be an effective aid to denture care. It can improve retention and stability, ensuring adequate function and emotional security. The ideal DA should be nontoxic, nonirritating, odorless, tasteless, and biocompatible with the oral mucosa. Also, DAs should have a neutral pH as well as to be easy to apply and remove with no potential to cause damage to either denture material or other dental restorative materials (Zhao *et al*., 2004).

DAs are now recognized as adjuncts to denture treatment, but some decades ago they had a negative outlook, implying they were used to cover inadequacies of denture fabrication (Grasso, 1996). Their application is still discouraged when used as a substitute for good clinical practice (ill-fitting dentures). However, it is a reality that even a well-fitting denture may present problems of retention with PDF. This is a recognized

complex problem that affects millions of people around the world due to the continuing reduction of their residual ridges over the years (Atwood).

Several DAs formulations have been on the market in the last decades (Kulak *et al*., 2005). Their formulas have been modified several times in order to meet the ideal properties, which is mainly to increase stability and retention of dentures so that denture wearers can apply a force increment during mastication, thus needing less chewing strokes to reach deglutition (Kapur; Tarbet *et al*.).

In the present study, the retention of well-fitting dentures was evaluated in a simulated maxillary ridge acrylic model attached to a universal testing machine using four current DAs. The first measurement of retention was made 10 minutes after the DA was applied. This time interval was selected due to unclear instructions of almost every fabricant, which only states: "wait a few minutes before eating". In general, it was found that the measurements performed after 10 minutes and those performed after three hours were very similar. This indicated that indeed, 10 minutes is sufficient for hydration of the material and to achieve retention. Maximum retention was observed at nine hours (Corega® products) and 12 hours (Fittydent® and Fixodent®). Other studies have reported a peak of retention of dentures with DA at three to five hours suggesting that the reduction in retention could be caused by the loss of DA from the denture due to their solubility in saliva (Swartz *et al*., 1967; Kanapka, 1984). This could be true since it was not present in this *in vitro* model.

It has been mentioned that a DA improves denture retention only if the primary properties of the complete denture such as retention, stability, and close adaptation of the denture base to the underlying tissues are acceptable. An ill-fitting complete denture will not become retentive with the mere use of a DA (Panagiotouni *et al*.); However, it has not been conclusively established whether the use of DAs increases the retention of well-fitting dentures when PDF exists. In this study, it was observed, as expected, that major retention was achieved in complete dentures from the GDF group. On the other hand, the PDF group was the most benefited with a retention increase of up to 700 % (Fixodent® at 12 hours when analyzing the percentage of retention considering the baseline). Nevertheless, even with this high increase, the PDF group did not achieve the retention as its counterpart, the GDF group. In summary, a well-fitting denture and GDF plus a DA are the best conditions, but a PDF definitely will get benefits with the DA application. This coincides with clinical reports where the effect of a DA on masticatory performance was more significant for denture wearers with PDF than with GDF (Fujimori *et al*., 2002). The DA application had a positive effect on all performance measures that were more significant for denture wearers with PDF (Munoz *et al*.).

All current DAs used in this study are similarly formulated on carboxymethylcellulose and their differences are based on the nonbonding synthetic agents, such as polyvinyl acetate, the copolymer of vinyl methyl ether or the maleic anhydride that extend the life of the DA effect, while the carboxymethylcellulose establishes cohesion between the denture and oral mucosa (Torres-Sánchez *et al*., 2017). Other components have been removed or added, such as zinc. This new product formula could influence previously established properties, including retention. All the DAs used in this study were free of zinc.

DAs should also be designed for easy denture removal, however, none of them are easy to remove from the inner surfaces of the complete dentures, which is consistent with a previous report (Kelsey *et al*.). It was also observed that compared to DA paste, DA powder is more complicated to apply uniformly, resulting in a thicker layer of DA between the maxillary ridge acrylic model and the complete denture.

Generally, dentists and researchers evaluate DAs using different criteria depending on the patient's individual needs and attitudes, as well as their expectation regarding their complete denture. It is complex to objectively evaluate the benefits of DAs in complete dentures. In this experiment, only retention in the vertical plane was tested, mouth conditions were simulated using artificial saliva, temperature, and humidity. The cruising speed of the universal testing machine was 1mm / minute since it has been proved to be the most appropriate testing procedure for bonding test in a similar experiment (Koppang *et al*., 1995). Our main limitation is that oral mucosa is different in nature and texture from the maxillary ridge acrylic model; it is highly unlikely that DAs perform in the same manner when bonded to keratinized mucosa as they do when bonded to the acrylic resin. Neither mechanical forces nor muscle movements were simulated, which undoubtedly have some effect on DA bond strengths. However, by examining these DAs under the same controlled and constant experimental conditions, it is possible to compare and evaluate their actual retention. It is likely that the same differences

will also be observed in the oral environment with value variation. *In vitro* investigations do, however, serve to evaluate and compare currently available and newly formulated DAs in order to validate future clinical trials.

CONCLUSION

Considering the limitations of this study, it can be concluded that DAs are useful in improving complete denture retention. Among the different DAs tested, Fixodent® paste had the highest retention. The PDFs were the most benefited with the application of DAs, however, even with that high increase, it fails to show the retention shown when using DAs in GDF.

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RESUMEN: No existe información acerca del posible impacto en la retención de dentaduras después del uso de adhesivos dentales comunes (DAs) cuando existen rebordes alveolares deficientes (PDF). Más aun, existe una falta de información acerca de cuál formula actual provee mayor retención y por cuanto tiempo. Doce modelos de pacientes edentulos con diferentes formas y alturas en sus rebordes alveolares fueron usados, y dentaduras completas les fueron realizadas. Cuatro diferentes fórmulas y marcas de DAs fueron evaluadas después de 10 minutos, tres, seis, nueve y 12 horas de que se aplicó el DA usando una maquina universal de pruebas. Los adhesivos Fittydent® y Fixodent® presentaron la retención más alta a las 12 horas. El grupo con PDF incrementó su retención hasta en un 400 %. Sin embargo, el grupo presentó menor retención cuando se comparó con el grupo que posee adecuados procesos alveolares. Los DAs incrementaron significativamente la retención de las dentaduras. El grupo PDF fue el más beneficiado con la aplicación de DAs. La pasta Fixodent® provee la más alta retención.

PALABRAS CLAVE: adhesivos dentales, retención, procesos alveolares deficientes, procesos alveolares adecuados.

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