

Denture adhesives' effect on retention of prostheses in patients with xerostomia

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Abstract

Background. Patients with xerostomia have difficulties using dentures. Application of denture adhesives (DAs) can improve the stabilization of prostheses.

Objectives. The aim of the study was to determine the retention capability of complete maxillary dentures in patients with xerostomia, determined with and without the use of prosthetic DAs.

Material and methods. This study evaluated the retention force of prostheses in a group of 60 patients diagnosed with xerostomia. Completely edentulous patients were classified into groups and all used the same kind of DAs during the study. The evaluation was performed 1, 3 and 6 h after application.

Results. All patients had poor retention of maxillary dentures without DAs. Maxillary denture retention was much better when DAs were used. The majority of the DAs used were most effective in terms of retention after 1 h. Denture adhesives in the form of glue had the best retention in this study of patients with xerostomia.

Conclusions. The results of the present study revealed the impact of DAs on average retention forces in complete maxillary denture patients with xerostomia. Patients affected by a reduced secretion of saliva have difficulties using prosthetics. In some cases, such use becomes impossible because of a complete lack of retention. The application of DAs could be a solution in these cases. Denture adhesives in glue form had the best retention during the study for patients with xerostomia.

Key words: denture adhesives, patients with xerostomia, retention of prostheses

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Introduction

Two of the conditions determining the success of prosthetic treatment are good retention and stability. The retention of prostheses is influenced by a number of factors, in particular, cohesion, adhesion, atmospheric pressure, capillary force, and the viscosity of saliva. The mutual interaction of these factors contributes to the force which holds prostheses. However, the current view is that the most essential components are capillary force and the density of the liquid layer. The 2 primary factors are the surface tension of the liquid layer (between the prosthesis and the mucous membrane) and the friction which occurs during the flow of liquid in capillary spaces, on both mating surfaces between the liquid and the prosthesis. One condition for the occurrence of these forces is a layer of saliva in the space between the prosthesis and the oral mucous membrane.^{1–3}

Patients affected by reduced saliva secretion have difficulties using a complete maxillary dentures. In some cases, these devices cannot be used because of a complete lack of stability and retention caused by a lack of saliva. A solution in these cases is to apply denture adhesives (DAs), which facilitate the maintenance of prostheses. There is quite limited research targeting the effectiveness of DAs in patients with xerostomia, although this affects a relatively large group of individuals. Especially among geriatric patients, there are evident symptoms of dryness of the mouth and dentures adaptation can be difficult.^{4–6}

Xerostomia may appear as a single illness – initially caused by a salivary gland dysfunction – or as one of the symptoms of a systemic disease. Another reason for the almost entire disappearance of saliva secretion may be the physiological processes of aging causing changes in the saliva secreting function. In elderly patients, involution of the oral mucous membrane and the related salivary glands appears. Decreased saliva production usually develops between the ages of 50 and 70 years (in most cases, in females during and after menopause). Many authors show no relationship between aging and a reduced secretion of saliva, but we must remember that involution degenerates and atrophies the whole body, including the salivary glands. The dynamics of this process are different. This is due to many factors, both external and internal. Age as a factor does not affect the secretion of saliva. However, it is important to note that aging itself is not the only reason for the appearance of xerostomia symptoms, but that other systemic diseases and some types of medication can cause it as well. Xerostomia is a subjective complaint of dry mouth, whereas hyposalivation is an objective decrease in salivary flow. The subjective oral dryness can be assessed by questionnaire (e.g., with the use of Fox's test), by clinical examination (e.g., the Challacombe score) and by measurement of the salivary flow rate (sialometry diagnosing salivary dysfunction). Sometimes, cases of xerostomia have been described in patients with a normal salivary flow rate.

Xerostomia vera is diagnosed on the basis of a clinical examination and standard sialometry tests. The most commonly used tests measure the unstimulated salivary flow rate (u-SFR), the stimulated salivary flow rate (s-SFR), the level of endocrine secretion of the parotid glands (PAR), and the secretion of the palatal salivary glands (PAL). The normal values of u-SFR and s-SFR are 0.3–0.6 mL/min and 1–2 mL/min, respectively; u-SFR values <0.1 mL/min and s-SFR values <0.2–0.5 mL/min indicate a reduction in the function of the salivary glands.⁷

In the literature, there are very few studies of DA effectiveness in patients with xerostomia, although this affects a relatively large proportion of them.^{7,8}

The aim of this study was to estimate the retention capability of prosthetic DAs in complete maxillary denture patients with previously diagnosed xerostomia.

Material and methods

The study consisted of 60 patients with previously diagnosed xerostomia: 52 women and 8 men aged 63–77 years. The inclusion criteria were complete maxillary edentulism and partial or complete mandibular edentulism. Patients with previously diagnosed xerostomia were referred to the Department of Prosthodontics at the Wrocław Medical University, Poland. An interview with the patients was done to determine the frequency of dryness of the mouth. Prior to qualifying for the study, decreased salivary flow was confirmed. During subsequent visits, 3 tests were carried out to assess salivary secretion during 1 min in total rest (u-SFR).

The DAs used in the study included the following:

1. Adhesive seals: Secure[®] (Johnson & Johnson, New Brunswick, USA) (based on agar). Lot No.: 4L027. Weight of one seal: 250 mg.

2. Adhesive seals: Protefix[®] (Queisser Pharma, Flensburg, Germany) (71 g viscose–cellulose and 29 g alginate sodium). Lot No.: OA5269010. Weight of one seal: 570 mg.

3. Adhesive powder: Protefix[®] (Queisser Pharma, Flensburg, Germany) (alginate sodium, menthol and sodium chlorophyll in cupric salts). Lot No.: 029091. Weight of one seal: 30 g.

4. Glue for dentures: Fittydent[®] (Fittydent International GmbH, Vienna, Austria) (sodium carboxymethylcellulose, polyvinyl acetate, denatured alcohol, petrolatum, hydroxypropylcellulose). Lot No.: 280605. Contents: 40 g.

5. Glue: Blend-a-dent Extra Stark[®] (Wick Pharma, Greensboro, USA) (poly maleic acid methoxyethylen –2.7:1, 302 mg Calcium-Zinc Salt, 192 mg carmellose natrium). Lot No.: 81311. Contents: 40 mL.

6. Adhesive cream: Corega Fix&Fest[®] (Block Drug Company Inc., Jersey City, USA) (copolymerisat methylvinylether maleic acid, sodium magnesium zinc salt, carboxymethylcellulose sodium salt). Lot No.: 01164A. Contents: 40 mL.

Sixty denture wearers with healthy oral tissues were referred to the Wrocław Medical University, Department

of Prosthodontics, for construction of maxillary and mandibular dentures. They were the subjects of this study. The experimental protocol was approved by the Ethical Review Committee of the University. The patients received conventional complete maxillary and mandibular dentures and the treatment followed a standardized protocol.

This study evaluated the retention force of prostheses in a group of 60 patients diagnosed with xerostomia. In the 1st stage of the study, there were new additions to the prosthetic devices: acrylic complete maxillary dentures and partial or complete mandibular dentures. After a 3-week period for initial adaptation, the new prostheses were assessed for their stability and retention.

In order to measure the force required to pry the complete maxillary denture from the denture base, a dynamometer was used. Measurement of force was performed using an FG-5000 Digital dynamometer with an RS 232 interface from LUTRON (Coopersburg, USA) (units of measurement: grams [g]/ounces [oz], resolution: 1 g/0.05 oz, minimum reading: 3 g/0.15 oz, accuracy: 0.2% + 1 digit). It assessed the size of the force in grams and the spread of screws placed between the 2nd premolar and the 1st molar of the complete maxillary denture. This corresponded to the prosthesis as the site of application of the force. The force was applied until the retention was broken between the prosthesis and the denture base. Before initiating, the appropriate tests determined whether the mucous membranes were affected, i.e., not inflamed, irritated or abraded. Measurements of the retention were carried out first without the use of DAs, the dentures were rinsed with distilled water, and then DA was used, after 3 h and after 6 h. The patients were divided into 6 groups according to the type of DA. Twenty patients used 2 different kinds of adhesive seals, 10 patients used adhesive powder, 20 patients used 2 different types of adhesive glue, and 10 patients used adhesive locking. The adhesives were applied according to the manufacturers' instructions. Before measuring the force, the head of the patient was fixed in the same position. Reference points were cranial landmarks and the horizontal positioning of the occlusal surface.

Statistical analysis

Analysis of the variability of measurements for benchmarks depending on the application of DAs and materials was done using analysis of variance (ANOVA).

Measurements for benchmarks between groups (materials) were compared with Tukey's test least significant difference (LSD) (post hoc test).

Results

The average results of dynamometric testing of the retention forces of complete upper prostheses without adhesives in all groups were as follows: Secure seals – 1187 g, Protefix seals – 1150 g, Blend-a-dent glue – 1070 g, Protefix powder – 1145 g, Fittydent glue – 1301 g, and Corega cream – 1370 g.

After applying the adhesives, the maximum results of dynamometric testing of the retention forces of complete upper prostheses in the particular groups were as follows: Secure seals – 2590 g (3 h after application), Protefix seals – 1812 g (1 h after application), Blend-a-dent glue – 3459 g (1 h after application), Protefix powder – 2162 g (1 h after application), Fittydent glue – 3360 g (1 h after application), and Corega cream – 3182 g (1 h after application).

The results of measurements of the retention force of complete maxillary dentures in patients with DAs, with and without the use of DAs, are shown in Table 1.

The average values of dynamometrically measured retention in the study groups are shown in Fig. 1. A comparison of the dynamometric measurements testing retention capability between groups (materials) is shown in Table 2.

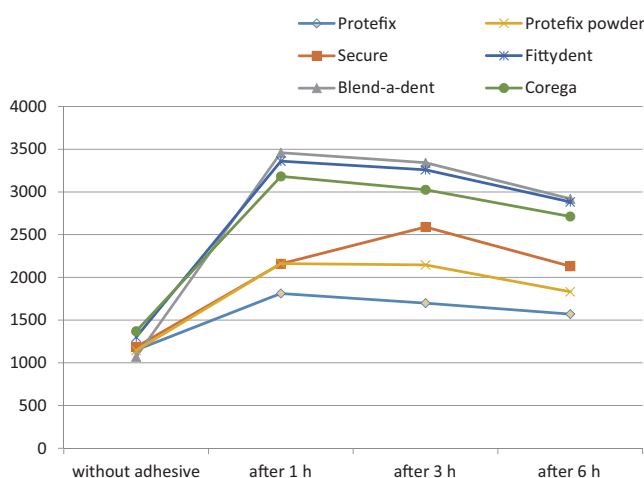


Fig. 1. Average dynamometrically measured values of retention in the analyzed groups

Discussion

In the literature, there are very few research reports of the effectiveness of DAs after application, especially in patients with xerostomia. They often consist of a survey evaluating the subjective opinion of the patients or exploring the magnitude of the incisal bite force.^{8,9}

In recent years, Oliveira da Rosa et al. presented “Current trends and future perspectives in the development of denture adhesives: An overview based on technological process monitoring and systematic review”. The aim of that paper was to systematically review the articles and patents with regard to DAs in order to obtain a scientific

Table 1. The results of dynamometric testing of retention effectiveness of complete upper prostheses after applying adhesives

Adhesives/ Application→	Average measurement of dynamometer [g]			
	without adhesive in groups	1 h after application	3 h after application	6 h after application
Secure seals	1187	2159	2590	2131
Difference*	–	972	1403	944
Protefix seals	1150	1812	1699	1571
Difference*	–	662	549	421
Blend-a-dent glue	1070	3459	3342	2920
Difference*	–	2389	2372	1850
Protefix powder	1145	2162	2146	1832
Difference*	–	1017	1001	687
Fittydent glue	1301	3360	3259	2883
Difference*	–	2059	1958	1582
Corega cream	1370	3182	3026	2713
Difference*	–	1812	1656	1343

* refers to the difference in prosthesis retention with adhesive material and without.

Table 2. A comparison of dynamometric measurements of the retention effectiveness between groups (materials). The values of the probabilities p marked in bold differ statistically significantly ($p < 0.05$)

Patient and group	Without adhesive	1 h after application	3 h after application	6 h after application	Total
1 : 2	0.574	0.000	0.000	0.000	0.000
1 : 3	0.523	0.957	0.000	0.000	0.000
1 : 4	0.087	0.000	0.000	0.000	0.000
1 : 5	0.082	0.000	0.000	0.000	0.000
1 : 6	0.007	0.000	0.000	0.000	0.000
2 : 3	0.939	0.000	0.000	0.000	0.000
2 : 4	0.025	0.000	0.000	0.000	0.000
2 : 5	0.232	0.000	0.000	0.000	0.000
2 : 6	0.001	0.000	0.000	0.000	0.000
3 : 4	0.021	0.000	0.000	0.000	0.000
3 : 5	0.263	0.000	0.000	0.000	0.000
3 : 6	0.001	0.000	0.000	0.000	0.000
4 : 5	0.001	0.081	0.210	0.221	0.950
4 : 6	0.296	0.002	0.001	0.000	0.005
5 : 6	0.000	0.000	0.000	0.000	0.006

1 – Secure; 2 – Protefix seals; 3 – Protefix powder; 4 – Fittydent; 5 – Blend-a-dent; 6 – Corega.

and technological overview of this material. A search for studies published between 1960 and 2014 was conducted in seven databases: Medline (PubMed), Web of Science, Lilacs, Ibex, the Cochrane Library, Scielo, and Scopus. Additionally, the following patent databases were screened: USPTO, EPO, JPO, INPI, the Derwent Innovations Index, Patentscope, and Questel Orbit. Data was tabulated and analyzed with Microsoft Office Excel 2013 (Microsoft, Redmond, USA) and Questel Orbit (Questel, Paris, France). A total of 54 articles and 78 patents were included in the analysis. The largest number of patents ($n = 19$) were filed by Procter and Gamble (Cincinnati, USA). Furthermore, in vivo studies were the most prevalent ($n = 30$) and the

types of adhesive most frequently studied were creams or powders ($n = 14$). It was possible to identify the current scientific and technological development of DAs, in which patents filed in many underdeveloped countries were mostly foreign-owned. Moreover, recent advances in such materials have been related more to presentation than to the additional effects of DAs.¹⁰

Kumar and Thombare conducted an in vivo study which was similar to our research. They published a comparative analysis of the effect of various DAs available on the market, studying the retentive ability of maxillary dentures. For measurement of retention, 5 patients who fulfilled the criteria described above and experienced minimal

retention were selected for the study. It was planned to fabricate 5 denture bases for each patient, making a total of 25 denture bases. A specially designed apparatus, based on the principle stated by Skinner, was created and used to measure the values of denture retention for each base with and without DAs. In this study, 4 DAs, readily available and commonly used by patients, were evaluated for their effect on enhancing the quality of denture retention. The retention values obtained with adhesives are more than twice than those of dentures alone. The paste form established its superiority over powdered DAs and provided double the retention values of powdered adhesives. The values of retention recorded in this study are in agreement with our observations, although they refer to different materials and to healthy patients without xerostomia.¹¹

In 2009, Pradies et al. presented a clinical study comparing the efficacy of 2 DAs in complete denture patients. The aim of their study was to compare the efficacy of 2 denture adhesives in edentulous patients wearing complete maxillary and mandibular dentures. Twenty-four edentulous patients were treated with complete dentures following a standardized protocol. Resistance to dislodgement of both dentures was measured in simulated functional movements by means of a gnathometer and a dynamometer. These outcome measurements were assessed first without the adhesive and then after 2 successive 2-week periods of using a randomly assigned denture adhesive in a crossover experimental design. The adhesives used were a standard one (Kukident Classic) and a new adhesive with a similar formulation but different physical characteristics (Kukident Pro). The dynamometer results showed highly significant differences between the maxillary and mandibular dentures in both the non-adhesive group and in the 2 adhesive groups ($p \leq 0.0001$). Similarly, highly significant differences were found when any of the adhesive groups were compared to the non-adhesive group ($p = 0.0001$). The patient's subjective evaluation was very favorable for both adhesives. The study confirmed the predicted and expected improvement in the stability and retention of well-fitting, complete dentures with the adjunctive use of adhesives. The observed and recorded improvements of the new adhesive compared to the traditional one were not statistically significant.¹²

Similar research was conducted by Polyzois et al. The purpose of this study was to investigate the effect of 4 commercially available DAs on the incisal and premolar dislodgement forces of maxillary complete dentures by using an electronic and disposable gnathodynamometer and to analyze the measured incisal forces for differences. This study was conducted with 12 complete maxillary denture wearers. Four commercially available DAs (Super Corega[®], Corega Ultra[®], Super Corega Powder[®], and Fittydent Cationic[®]) were investigated. The testing protocol and sequence included baseline measurements from an electronic and disposable gnathodynamometer without adhesives (control)

for previous and new dentures, followed by replications of measurements with the 4 adhesives. The highest dislodgement forces were recorded in 2 sites between the central incisors and the left 2nd premolars. To estimate the effect of the different adhesives on the dislodgement forces, the data were analyzed by 2-way and 3-way ANOVA, and to estimate the similarity of the 2 devices, Bland–Altman and Mountain plots were used. The ANOVAs indicated significant differences between adhesives ($p < 0.05$), denture types ($p < 0.05$) and biting sites ($p < 0.05$) with both devices. The Bland–Altman and Mountain plots indicated little similarity between the 2 devices. It was concluded that DAs increase the denture dislodgement forces, but with differences among them. The 2 devices do not highly agree with each other, but each one alone is useful in estimating dislodgement forces in clinical practice and research.¹³

In our study, the analysis of our results showed a difference in retention force depending on the use of DA. This applies to the entire group tested and to all the materials used. Differences in the average force in many cases are more than 2-fold. The most significant difference can be noted in the group of denture glues. The average value of the retention force without the adhesives was 1070 g and 1301 g. After the application of denture glue, in various periods of time the force was: 3459 g and 3360 g. Typically, the most powerful retention for these adhesives occurred in the 1st hour after application and fell gradually. The difference was 2389 g and 2059 g. The maximum retention force for both of the tested DAs was similar. For the cream adhesives dynamics of force distribution was similar. However, the retention force after DA application and use was not as significant as with the use of glue; it amounted to 1370 g without any preparation and 3182 g in the 1st hour. The difference in average force gradually decreased and reached 1343 g after 6 h. Dynamometric testing indicated increased retention forces of complete maxillary prostheses after applying powdered DAs compared to retention without the use of adhesives. In the evaluated group of patients, the original average strength of retention was 1145 g and after applying the adhesives it increased to 2162 g. This value gradually decreased and after 6 h it fell to 1832 g. There were also differences in retention force when it comes to the group of patients using adhesive seals. The average values varied between 1150 g without preparation to 2590 g after application. For the glue the maximum retention force occurred at the time of application. For the other two materials: creams, and powders, after 3 h.

Also, the difference in the retention strength for creams and powders was smaller than in the group of other tested adhesives. The comparison of the average values of retention force in complete maxillary dentures in patients with xerostomia showed a difference of 2388 g between the highest value recorded in the 1st hour after using glue adhesives and the measurements without DAs. The statistical analysis of the clinical trials in the test group of patients

with xerostomia using the studied adhesives demonstrated statistically significant differences ($p < 0.05$).

Synthetic materials presently dominate the DA market. The most popular and successful products are mixtures of salts of fast-acting (carboxymethylcellulose or CMC) and slow-acting (polyvinyl methyl ether maleate or Gantrez) polymers. In the presence of water, CMC hydrates and displays quick-onset ionic adherence to both dentures and the mucous epithelium. The original fluid increases its viscosity and the CMC increases in volume, thereby eliminating voids between the prosthesis and the basal seat. These 2 actions markedly enhance the interfacial forces acting on the denture. Polyvinylpyrrolidone (povidone) is another, less commonly used agent that reacts like CMC. Over a longer time period than necessary for the onset of hydration of CMC, Gantrez salts hydrate and increase in adherence and viscosity. The slow-acting Gantrez salts also display molecular cross-linking, resulting in a measurable increase in cohesive behavior. This effect is significantly more pronounced and longer-lasting in calcium zinc Gantrez formulas than in calcium sodium Gantrez. Eventually, all the polymers become fully soluble and washed out by saliva; this elimination is hastened by the presence of hot liquids. Denture adhesive distributed on the inside of the prosthesis must have a high degree of hydration for optimal effect. Thanks to the presence of carboxylic salt, CMC undergoes dissociation in the aquatic environment of the mouth. This is an instance of the ion adhesive force between the denture and the DAs and between the adhesives and the mucous membrane. The increased volume of DAs in the saliva and, as a result DAs, effectively fills voids between the palate and the denture foundation and increases the tension between these surfaces.^{12,14}

Denture adhesives are composed of less soluble salts than CMC; salts of Poly(vinyl methyl ether) hydrazine (PVM/MA) are longer, free up more slowly, and increase viscosity and adhesion. They also have cross-bonds, which increase cohesive strength. Ultimately, all the polymers contained in DAs become totally soluble and are rinsed away by saliva. A diet rich in hot foods or drinks quickens DA dissolution and leaching. By improving stability and retention, patients have increased bite force, improved efficiency of chewing, a more evenly distributed load on the basal bone, and a beneficial effect on the respiratory track. Tests have shown that DAs significantly improved the retention of dentures. In patients affected by xerostomia and other factors impeding the achievement of proper stabilization and retention of dentures, DAs may be a solution for this difficult situation.⁷

The fact that patients can frequently use a badly adjusted prosthesis over a long period of time thanks to the liberal use of DAs is not irrelevant to the status of the basal bone. There is no scientific evidence to confirm this claim, though. Because DAs have a semi-liquid or liquid consistency, like saliva, they are not capable of interacting with saliva to exert a force which can increase the alveolar ridge resorption process. There is, however,

an increased tolerance and adaptation to bad dentures which affect the basal bone. The use of DA to improve the retention of a broken or damaged prosthesis is absolutely contraindicated.

Conclusions

All patients had poor retention of their maxillary dentures without DAs.

The results of the present study revealed the impact of DAs on the average retention forces of complete maxillary dentures in patients with xerostomia.

The majority of DA used showed the highest retention ability after 1 h.

Denture adhesives in the form of glue had the best retention capability during the study for the patients with xerostomia.

In the analysis of the statistical results of the clinical trials in the test group of patients with chronic xerostomia using the studied preparations, the differences were statistically significant ($p < 0.05$).

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