



The effect of saturation by artificial saliva on the effectiveness of denture adhesives

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ABSTRACT

Purpose: of this examination was to evaluate the impact of saturation of adhesive materials by artificial saliva upon the generated bonding force.

Design/methodology/approach: Four selected types of denture adhesives have been chosen. Measurements of bonding forces of the materials of different degree of saturation by artificial saliva have been carried out by dynamometer. The stamp covered by denture adhesive was pressed against the glass with force of 30 - 40 N and then keeping perpendicular movement against the glass, the stamp was pulled off and the joining was broken. It has been assumed that the bonding force was the equivalent of maximal pulling off force obtained in the test. The samples of different degree of saturation by artificial saliva have been exposed to tests of extensibility in a device of own design. The final denture adhesives have been put on the complete denture. It was pressed down against the denture bearing area model and next the values of retention forces were determined on a universal testing machine.

Findings: Proper saturation of the samples by artificial saliva makes it possible to obtain approximate values of retention force for the majority of denture adhesives. However excessive saturation of adhesive materials can result in considerable reduction of their effectiveness.

Research limitations/implications: The samples are handmade as well as part of the measurements are carried out manually and this is justified by the specific clinical conditions.

Practical implications: Analysis of the impact of the level of saturation of denture adhesives by artificial saliva upon the generated bonding force highlights the need for individual selection of adhesive creams. The choice of material should be related to individual features such as secretion of saliva. It is advisable to introduce into clinical practice the option of adjusting the optimum saturation of particular denture adhesives by artificial saliva materials.

Originality/value: The presented research work results allow to combine the secretion of saliva with the effectiveness of denture adhesives.

Keywords: Denture adhesive; Complete denture; Adhesion; Denture retention

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PROPERTIES

1. Introduction

Adhesive creams are recommended for the patients with complete dentures who complain about the dentures weak retention and stability. Clinical indications for the use of denture adhesives are the complicated anatomic conditions (atrophic, hard denture bearing area), making the new denture more easily acceptable, psychological factors, neurological disorders or limited salivation [1-5]. Additional advantage of using denture adhesives is to prevent food from getting between the denture and mucosa. It is a great discomfort for denture users to get rid of small bits of food.

Adhesive materials are usually available as powders or creams. They are used for eliminating mental discomfort of the denture users who are afraid of sudden breaking off the denture from the denture bearing area due to the activity of mimic muscles, tongue and lips [6-11]. Such effect can be achieved by the growth of adhesion force, cohesion, inter-surface adapting to the tissue, the increase of viscosity of saliva and even partly substituting it, e.g. in the case of xerostomia [1]. Substances of that type form a tacky mass when they are mixed with saliva and they increase cohesion of the denture base to mucosa. Despite the fact that the absolute values of adhesion forces are relatively low, the examinations of the impact of adhesive materials upon the retention and stability of the moving denture, particularly in case of toothless maxilla in the process of chewing, swallowing and speaking, have revealed a significant improvement of all the mentioned activities up to eight hours after the denture adhesive was applied [12-14]. A positive effect of applying the denture adhesive upon retention of maxilla dentures can be observed on incisors while biting and there is a growth of the value of occlusion force as well [4, 12, 15-17]. The use of denture adhesives intensifies the effectiveness of chewing, facilitates more uniform transfer of occlusive load on the tissues of the denture bearing area, reduces irritations of mucosa which result from the contact stress and food which gets under the denture. It also stops the development of microorganisms under the denture [2, 17-20]. However it needs to be stressed that despite obvious advantages of applying denture adhesives, they should not be used too long [3]. In the case of insufficient secretion of saliva, reddening of mucosa may appear, there may also be unpleasant smell coming from the patient's mouth and the feeling of tingling sensation may appear [5]. It needs to be remembered that denture adhesives should not be used if the denture is damaged or it has some faults or if it is incorrectly fitted to the changed profile of denture bearing area. Some patients can also have problems with keeping their oral cavity or their denture clean so denture adhesives are not recommended.

Denture adhesive applied on the surface of the denture directed to the base, ought to be properly hydrated in order to make it more effective. The influence of the level of hydration by artificial saliva of selected denture adhesives on the value of generated bonding force has been presented in the paper. The level of hydration has been defined indirectly by testing the consistence of the creams and it has been expressed as their extensibility, i.e. the elongation needed for pulling off a given sample of adhesive. The extensibility of denture adhesives is a natural measure of their ability to seal the space between the denture and mucosa in the process of chewing. When the adhesive layer gets broken by the movement of denture then the action of the cream is stopped. The obtained examination results on the

samples have been combined with the results of examinations on phantoms which were carried out on physical models of the denture and the denture bearing area.

2. Materials and experimental procedure

At the first stage of laboratory examinations bonding forces and extensibility of the samples have been tested. Four types of denture adhesives have been used: Protefix, Protefix with aloe, hypoallergenic Protefix (Queisser Pharma GmbH & Co, Germany) and Corega (Glaxo Smith Kline, The United Kingdom).

The samples have been prepared by squeezing from the tube about 0.2 g of a given type of cream (1 cm long strap) and next, artificial saliva has been added. Artificial saliva Mucinox (Parnell Pharmaceuticals, USA) based on natural mucin coming from plants was used in the experiment. The samples of different level of saturation by artificial saliva have been made. The amount of cream was measured by the number of doses released from the feeder (from one to four) and one dose was releasing about 0.25 g of the denture adhesive. A dynamometer equipped with a polished stamp of 24 mm diameter was used for measuring the bonding force. A glass (smooth surface) 5 mm thick was the opposite surface and it was firmly fixed to the base. Denture adhesive mixed uniformly with artificial saliva was put on the table (Fig. 1) and it was pressed against the glass with force of 30-40 N and next keeping perpendicular direction of the movement against the glass, the table was pulled off. It has been assumed that the bonding force was the equivalent of maximal pulling off force obtained in the test. Since the samples were handmade and the way of carrying out measurements was quite specific, the test was repeated fifteen times for every type of denture adhesive with a particular level of saturation by artificial saliva. (AV) average value and (SD) standard deviation from the average value have been calculated.

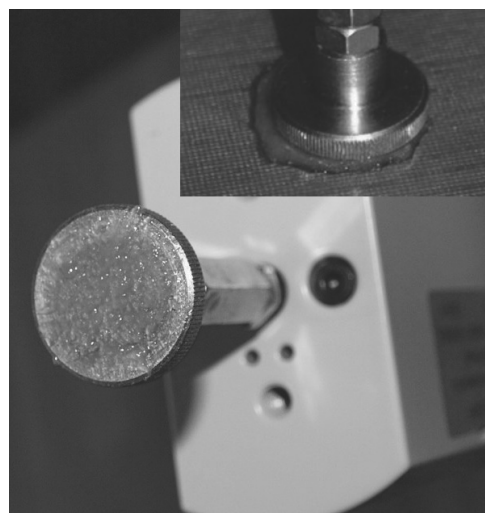


Fig. 1. Presentation of the mode of carrying out the measurements of bonding force: a polished stamp with a spread film of properly wetted denture adhesive fixed to a dynamometer and (top right corner) a stamp covered with adhesive cream pressed against glass

Extensibility of the samples made of different types of adhesive creams with different level of saturation by artificial saliva has been tested in a device designed by the research team. The device allows to define the length to which a gluey sample can be extended until it breaks. A digital slide caliper (Gedore, Germany) has been used as a supporting structure of the device. The precision of reading was high – up to 0.01 mm. Cover plates for carrying out the experiment have been fixed coaxially on the extension arms. A cylinder of 9 mm diameter was the top cover plate and a cylinder of 10 mm diameter was the bottom cover plate. The covers were adjusted in such way so that the polished contact surfaces could be perfectly adherent to each other. In the course of examination the nest was filled excessively with denture adhesive rarefied by artificial saliva and then the contact surfaces were pressed down (which helped to get rid of the excessive mixture). Next the excess of mixture of the denture adhesive and artificial saliva was removed by tissue paper and the process of slow pulling off the sample was started (Fig. 2). The pulling off action was stopped immediately when the sample got broken and the length at which the breaking occurred was read. The results of measurement was given in millimeters. The test has been carried out fifteen times for every type of denture adhesive of a given level of saturation by artificial saliva. AV and SD have been calculated for the series.



Fig. 2. Examination of extensibility of a sample of denture adhesive rarefied by artificial saliva

The examinations on phantoms have been carried out at the final stage of tests. A model of complete denture and denture bearing area has been made. A half millimeter film of Ufi Gel P (Voco GmbH, Germany) silicone used for making soft liners of the dentures has been applied in order to simulate mucosa. The examinations have been carried out on Zwick testing machine (Zwick GmbH & Co, Germany). The model of denture bearing area has been fixed to a table mounted in the machine. A flexible connector fixed in the denture in the area of incisors and in the jaws of a testing machine was used for loading the denture. A test stand used for examinations has been presented in Fig. 3. Samples made of one of the four denture adhesives have been made

directly before each examination. 4 cm of denture adhesive have been squeezed out of the tube, artificial saliva has been added to make the mixture homogeneous. The amount of artificial saliva to be used was defined by previous test results carried out on the samples. The surface of the model of denture bearing area and the denture has been wetted by artificial saliva and the denture adhesive has been put in five places (equal doses). The denture has been pressed hard against the denture bearing area for about 5 s (at the same time the possible excessive amount of the mixture has been squeezed out). The initial load of 0.5 N was used in order to level possible clearance on the flexible connector. Tensile force was applied in the test until the denture was thrown off the denture bearing area. The displacement and force before the denture was thrown off the denture bearing area have been registered during the test. The test has been repeated ten times for each sample of denture adhesive and the mean value of force which threw off the denture from the denture bearing area has been calculated for particular types of adhesive creams.



Fig. 3. A test stand for phantom examinations

3. Results and discussion

The examination results of bonding forces obtained for particular types of adhesive creams of different level of saturation by artificial saliva have been presented in Table 1. The test results of extensibility measurements for the same kind of samples have been presented in Table 2. The dependences of bonding force and extensibility of particular types of denture adhesives in the function of the level of saturation of the samples by artificial saliva have been presented on the diagrams (Fig. 4 and Fig. 5). Protefix mixed with three doses of artificial saliva featured the highest mean value of force (15.60 N), Corega and Protorex with Aloe mixes with four doses of artificial saliva had slightly worse

results (about 13 N). The mean value of force, measured for hypoallergenic Protefix was considerably lower than the one in the examined types of denture adhesives and it was about 8 N. It is worth noticing that the values of standard deviations are significantly high – about 20 % up to even 55 % higher than the determined mean values. Extensibility of the examined samples became higher when saturation by artificial saliva was increased and in the case of Corega and Protefix with aloe the growth was gradual. Examination results of the measurements of retention forces carried out on phantoms have been listed in Table 3. Exemplary curves presenting the dependence of force which pulls off the denture from the displacement preceding the actual pulling off the denture from the model of denture bearing area have been

presented in Fig. 6. Proper saturation of the samples by artificial saliva made it possible to obtain quite similar values of retention forces for three types of denture adhesives, whereas the results for hypoallergenic Protefix were definitely poor. If the saturation of the samples by artificial saliva was too low then the value of retention forces was quite insignificant (up to 2 N) and if the saturation was too high these values were insignificant as well. This phenomenon has been presented in Fig 7. However it should be underlined that both above described cases of the tests have been carried out additionally (for comparison) and they were not taken into consideration while calculating the mean values of retention forces.

Table 1.

Average values (AV) of bonding forces with standard deviations (SD) for four types of denture adhesives of different level of saturation by artificial saliva

Amount of artificial saliva, dose	F, N							
	Protefix		Protefix with aloe		Protefix (hypoallergenic)		Corega	
	AV	SD	AV	SD	AV	SD	AV	SD
1	13.67	4.36	8.37	1.49	5.45	3.043	9.16	2.81
2	13.87	4.11	8.31	2.51	7.92	2.33	8.74	2.78
3	15.60	4.41	7.23	3.35	8.27	2.77	9.08	3.33
4	9.52	2.96	13.31	3.55	7.82	3.13	13.09	2.95

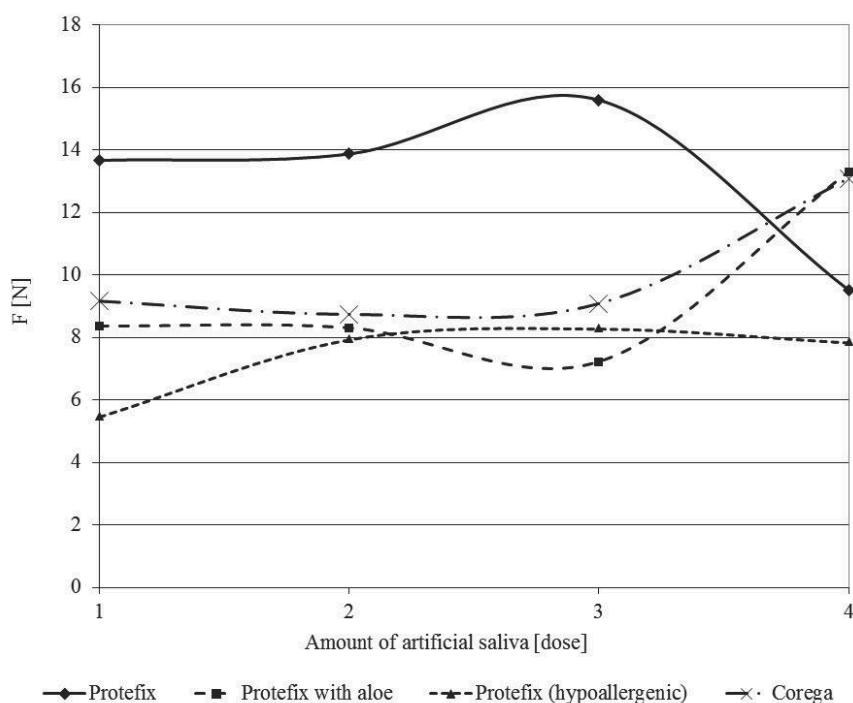


Fig. 4. The impact of saturation of the samples by artificial saliva upon the average values of registered bonding force

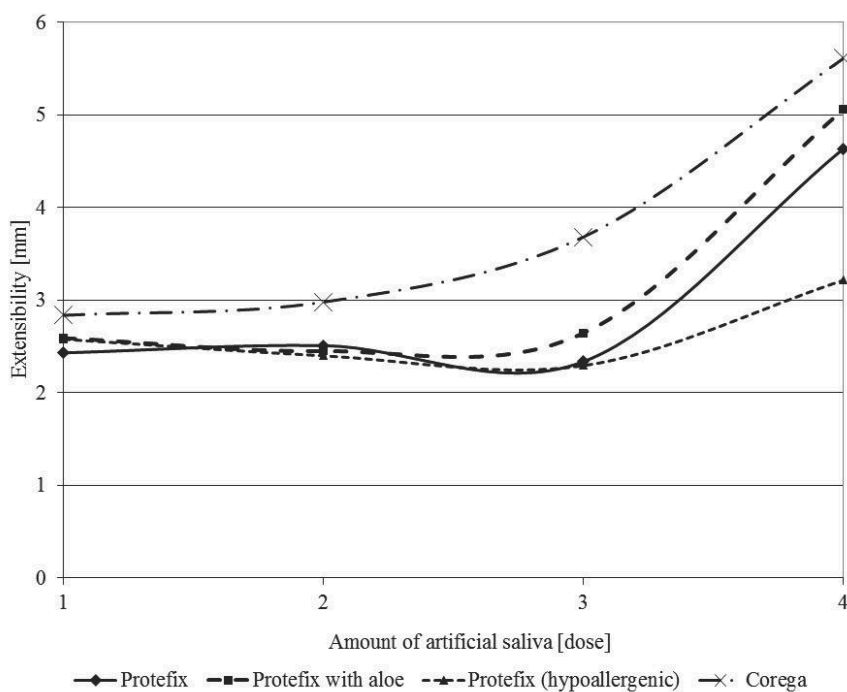


Fig. 5. The impact of saturation of the samples by artificial saliva upon their extensibility

Table 2.

Average values (AV) of extensibility with standard deviations(SD) for four types of denture adhesives of different level of saturation by artificial saliva

Amount of artificial saliva, dose	Extensibility, mm							
	Protefix		Protefix with aloe		Protefix (hypoallergenic)		Corega	
	AV	SD	AV	SD	AV	SD	AV	SD
1	2.43	0.56	2.59	0.54	2.58	0.25	2.84	0.45
2	2.51	0.47	2.45	0.56	2.40	0.41	2.98	0.37
3	2.34	0.39	2.64	0.71	2.29	0.47	3.68	0.31
4	4.64	0.76	5.06	0.53	3.22	0.62	5.61	1.07

Table 3.

Results of measurements of retention forces for dentures fixed to the denture bearing area of a phantom model by denture adhesives saturated by artificial saliva

Retention force, N							
Protefix		Protefix with aloe		Protefix (hypoallergenic)		Corega	
AV	SD	AV	SD	AV	SD	AV	SD
12.24	3.74	10.39	2.98	7.98	1.96	11.93	3.21

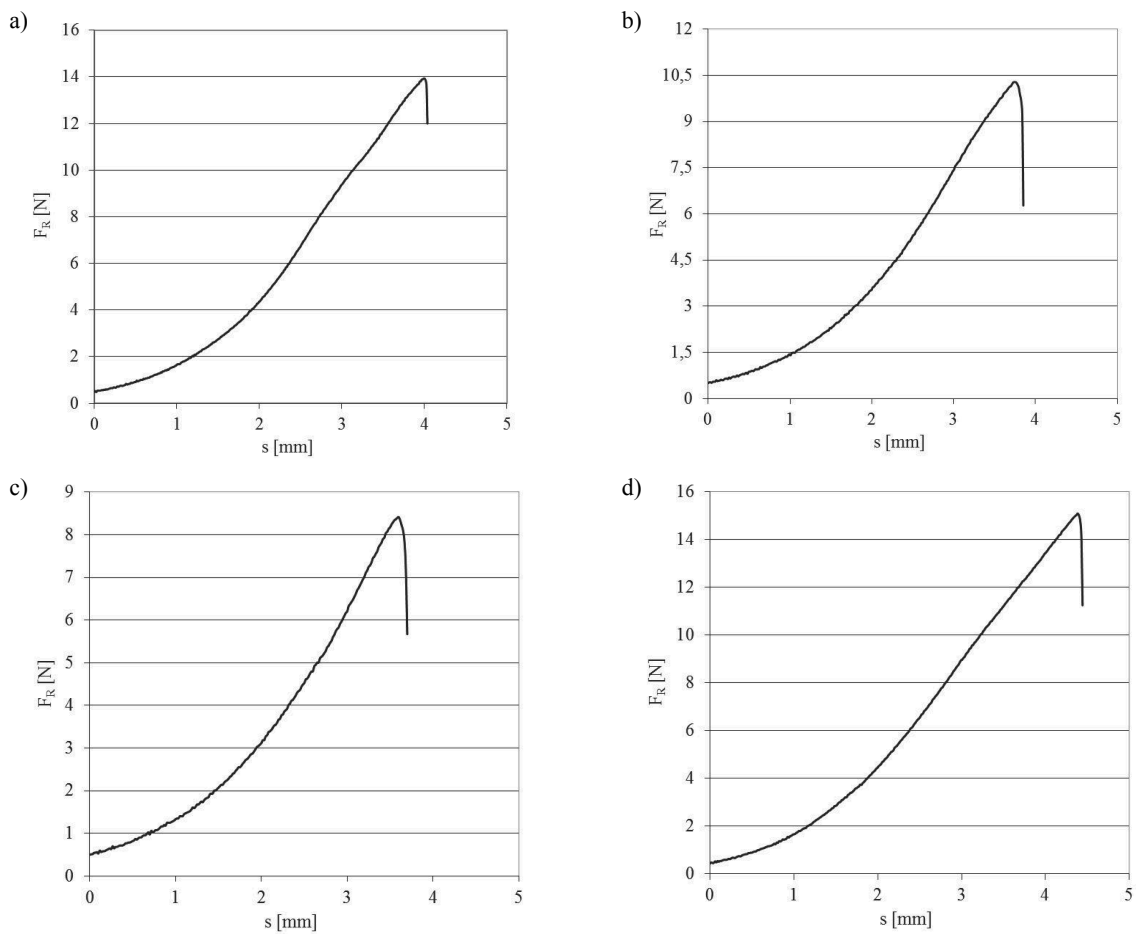


Fig. 6. Exemplary curves presenting the dependence of (F_R) retention force from the displacement preceding the moment of throwing off the denture (s) from the phantom model of a denture bearing area for: a) Protefix denture adhesive, b) Protefix with aloe, c) hypoallergenic Protefix, d) Corega

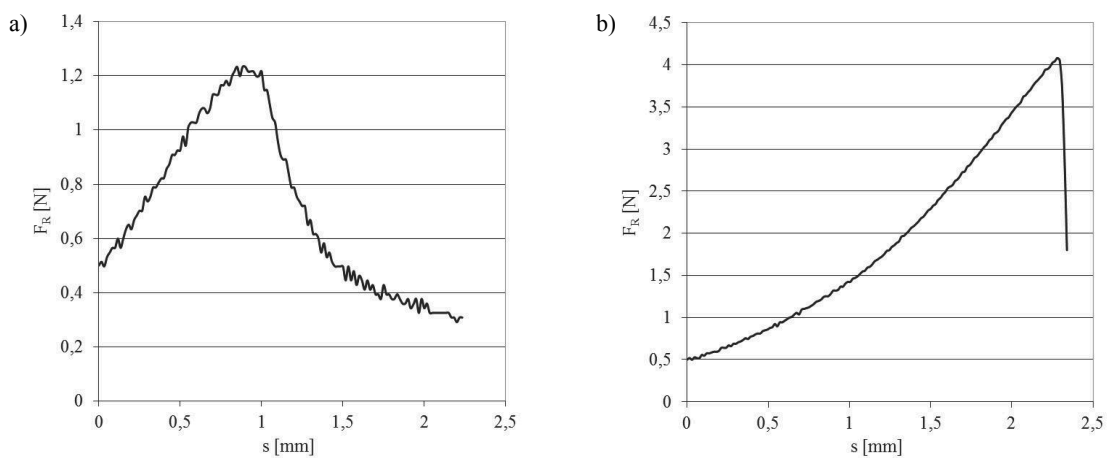


Fig. 7. Curves presenting the dependence of (F_R) retention force from the displacement preceding the moment of throwing off the denture (s) from the phantom model of a denture bearing area for Protefix denture adhesive at a) insufficient and b) excessive saturation of a cream sample by artificial saliva

4. Discussion and conclusions

The presented examination methodology enabled to analyse the possibilities of increasing the value of retention force of complete dentures by applying selected denture adhesives. On the basis of the carried out examinations it has been revealed that the level of saturation of denture adhesives by artificial saliva is the essential criterion of effectiveness of denture adhesives since the level of saturation is responsible for the consistence of the creams which in turn decides upon the level of extensibility. Extensibility is one of the most essential criteria of evaluating the effectiveness of denture adhesives. The movements of denture while chewing should not cause breaking of the film of denture adhesive in any case. For all examined creams, the maximum tested saturation by artificial saliva caused the increase of extensibility and only in the case of Corega the growing tendency was maintained for all applied doses for artificial saliva. The reaction of Protefix to any changes of the used amount of artificial saliva was the lowest. The examined adhesion forces for Protefix had the best bonding properties in the tested group when the level of saturation by artificial saliva was low. These properties reached the highest values when three doses of artificial saliva have been added to the cream and when four doses have been added they decreased by about 30%. It means that in practice, Protefix is the most effective when the secretion of saliva is moderate, whereas Corega is the most effective when the secretion of saliva is high.

Phantom examinations revealed that if the quantity of artificial saliva added to the denture adhesive is too small, the proper action of the cream is not possible and it does not intensify denture's retention (Fig. 7). However if the denture adhesive is adequately saturated by saliva its consistence is homogeneous and gluey then the retention of dentures is significantly improved and so the action of creams is optimal. On the basis of the examinations of bonding forces and extensibility it can be stated that the spectrum of proper wetting of denture creams seems to be quite wide. Excessive saturation of the denture adhesive by saliva reduces its effectiveness despite the fact that the extensibility of the samples increases. Unfavorable changes of rheological properties of the material are to be blamed for that. While examining the bonding forces in specific conditions this phenomenon was considerably less clear to see (three doses of Protefix vs. four doses of artificial saliva). The planes which were 'pulled off' were parallel to each other and they were perpendicular to the direction of the acting force - that is why they were considerably difficult to pull off (a dominating role of adhesion). Since the examinations on phantoms have been carried out in conditions which are very close to those in oral cavity, hence the action of pulling off was quite intensive (compare Fig. 6a and Fig. 7b) because rarefying the denture adhesive enabled it to 'skid off' the denture bearing area.

The presented results of laboratory examinations proved that it is highly recommended to carry out clinical tests which should concentrate on the dependence between saliva secretion and the effectiveness of denture adhesives. It is also advisable to consider introducing into clinical practice the system of controlling the optimum saturation of particular denture adhesives by artificial saliva.

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