

A Comparative Analysis of the Effect of Three Types of Denture Adhesives on the Retention of Maxillary Denture Bases: An In Vivo Study

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Abstract There are many factors involved in the success of a good quality complete dentures, one of them is retention. There are some forcing situations where providing optimal retention may be a problem, in which use of denture adhesives is recommended. In the present study, primary and secondary impressions were made on 20 completely edentulous patients, master cast was fabricated. Master cast was duplicated; heat-cured denture base was fabricated. The retention test for control group, powder group, wafer group, paste group was done using a customized force sensor device. Readings was subjected to ANOVA followed by post hoc test. Results show that the retention force value of the paste group was the maximum, followed by powder group, wafer group and the least retention force value was observed with control group. Within the limitations of the study it can be concluded that the paste form of denture adhesive has the best retentive property compared to the powder and wafer.

Keywords Completely edentulous patient · Retention · Denture adhesives · Tension gauge

Introduction

Dentists have an important role to play in providing good quality complete dentures and in encouraging their edentulous patients to improve the quality of their diet. There are many factors involved in the success of a good quality complete dentures, one of them is retention. There are some forcing situations where providing desirable

(optimal) retention may be a problem [1]. Use of denture adhesives is recommended for enhancing the quality of retention in conditions such as immediate dentures, single complete denture, maxillofacial prosthesis like obturators and in patient's having poor neuromuscular control, poor ridge anatomy, dry mouth, and jaw relations. It may also be indicated in difficult and demanding patients with poor denture adaptation, and in socially active people such as public attorneys, actors and politicians [1, 2].

Retention is defined as “that quality inherent in the dental prosthesis acting to resist the forces of dislodgment along the path of placement”. Denture retention is defined as “the resistance in the movement of a denture away from its tissue foundation especially in a vertical direction”.

Denture adhesive is a material used to adhere a denture to the oral mucosa [3]. The use of denture adhesive provides comfort and additional confidence not only by increasing the adhesive and cohesive but also eliminating voids between the denture base and the basal seat. It is commercially available, non-toxic, soluble material, sticky in nature that can be applied over the tissue surface of the denture in order to enhance the quality of denture retention and thereby improving quality of denture stability too. They are available in different forms such as powder, paste/cream, foam and strips/wafer [1].

Among the various forms of denture adhesives the ease of application/use seems to be with the wafer form. Application of a product is not the only criteria; the efficiency of the material should also be known. Studies have been done in which the powder and paste forms have been compared but wafer form is not yet been tested, hence felt the need for the study.

The null hypothesis of this study is there is no effect of any of the three types of denture adhesives on the retention of maxillary denture bases.

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Materials and Methods

The study was done on 20 completely edentulous patients with the following inclusion and exclusion criteria (inclusion criteria—completely edentulous patients, fair to poor ridges, no undercuts, healthy mucosa and exclusion criteria—xerostomia, flabby ridges, poor neuromuscular conditions, palatal defects, unco-operative patients) after obtaining permission from the Institutional Ethics Committee, Sumandeep Vidyapeeth.

Primary impressions were made with irreversible hydrocolloid in edentulous stock metal trays. Secondary impressions were made with low fusing compound and zinc-oxide eugenol in custom fabricated tray using selective pressure technique and a master cast was poured. From the master cast, one cast was duplicated using agar in a hydrocolloid duplicating machine. The master cast was used to fabricate the denture and the duplicated cast was used to make denture base which was used for checking the retention. With the help of the digital vernier caliper, the distance between the two hamular notches were measured and was divided by two, marked on the posterior land area. This was considered to be the centre point where the hook was to be placed (Fig. 1). A sheet of base plate wax was adapted to the duplicated master cast. Anteriorly in the midline on the crest of the ridge, a wax block measuring 10mm × 10 mm was made to act as a fulcrum. The duplicated master cast was placed on the surveyor with the ridge plane parallel to the floor. The hook was placed with the help of the surveyor in the predetermined location (Fig. 2). The height of the hook and the wax block was made to lie in one plane. A groove was made in the centre of the wax block through which the copper wire was passed in a straight direction in the mid-line without injuring the patient's lips (Fig. 3). Flasking was done according to the method given by Morrow [4]. Long curing cycle was followed for acrylization



Fig. 1 Marking of the centre point for hook placement with the help of a vernier caliper

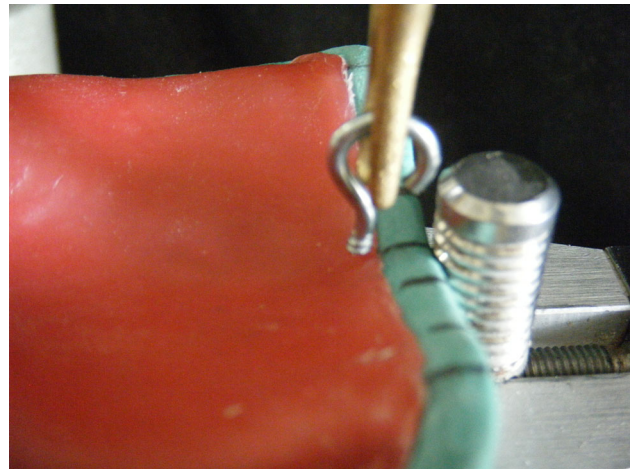


Fig. 2 Placement of the hook with the help of a surveyor

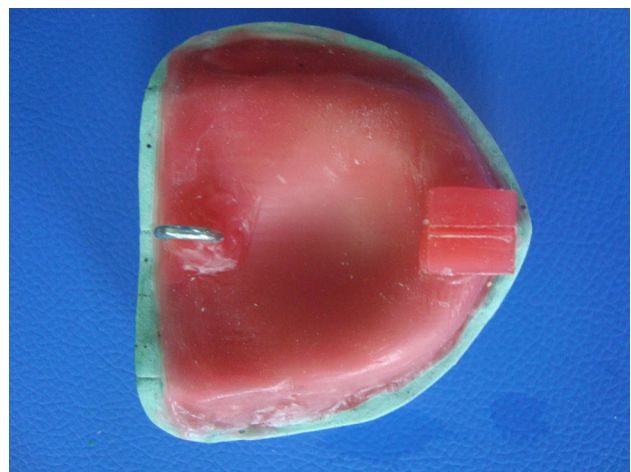


Fig. 3 Groove made in the centre of wax block

of the denture base and overnight bench cooling was done before deflasking. The denture base was stored in water for 17 d at room temperature before testing for retention.

Before testing the denture base for retention, the patients were trained to tell, when the denture base gets loose. Patient's head was stabilized on the head stabilizer of the OPG machine in order to keep it in a fixed position. The denture base without any adhesive was the control group, same denture base with Fixon powder was group I, group II was denture base with sea bond wafer and denture base with Fittydent paste was group III. Each group was tested in 20 patients by placing the denture base in the mouth for 3 min, respectively, after which the dislodgement of the denture base was tested (Fig. 4). Retention with each denture base was tested three times. In order to avoid bias by the principle investigator a post graduate student was asked to apply the adhesives on the denture bases and insert in the patient's mouth. For the powder form, denture base was wetted and Fixon powder was sprinkled over the impression surface of



Fig. 4 Materials used for testing retention and denture adhesives

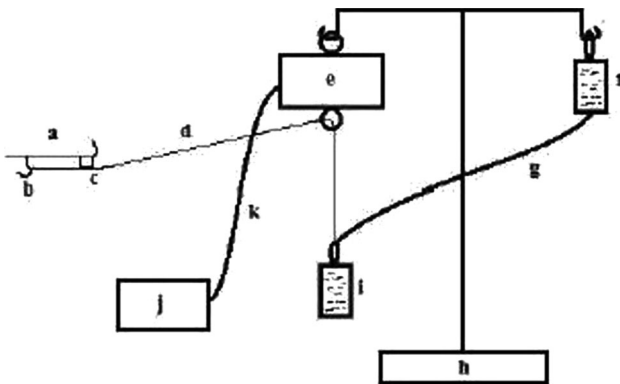


Fig. 5 Diagrammatic representation of testing apparatus *a* Denture base, *b* Hook, *c* Fulcrum, *d* Cooper wire, *e* Customized Force sensor (tension gauge), *f* Saline bottle filled with bottle, *g* Infusion tube, *h* I. V. stand, *i* Empty saline bottle, *j* Digital reading box, *k* Connecting wire

the denture base, for the paste form, the denture base was dried and bead size of Fittydent paste was applied on the incisor, molar and mid-palatine region and for the wafer form [5], the denture base was dried and the sea-bond wafer was dipped in warm water then placed over the impression surface of the denture base as per manufacturer’s instructions. One end of the 1 mm thick copper wire was attached to the hook and the other end was passed through the customized digital force sensor (tension gauge) to which an empty saline bottle was attached. Water in the form of weight was flown in the empty saline bottle through the infusion tube. The I. V. stand was placed at two feet distance from the OPG machine and the customized digital force sensor was kept 1 inch above the subject’s mouth level (Figs. 5, 6 7). The flow of water was stopped when the principle investigator observed the denture base loose contact first from the tissues and/or when the subject reported of lost contact of denture base. The result that was recorded in grams on customized digital force sensor was tabulated.



Fig. 6 Testing apparatus

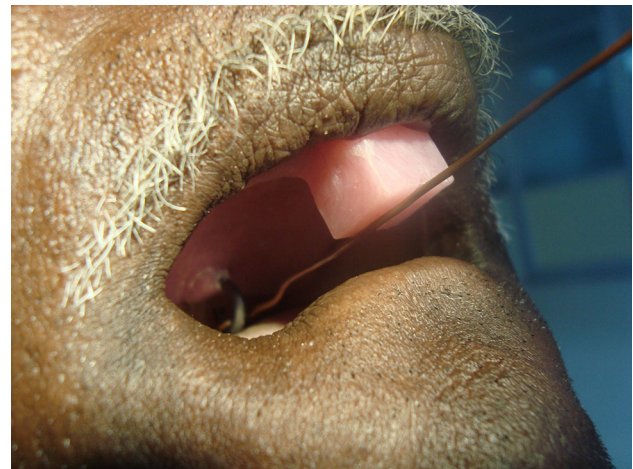


Fig. 7 Intraoral photo showing denture base in patient’s mouth and copper wire passing from hook outside mouth

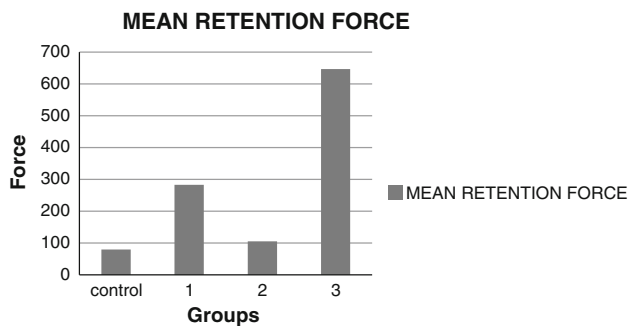
All the denture adhesives were tested for retention on the same day. The retention values of the control group and the three test groups of all the subjects were tabulated and subjected to statistical analysis.

Results

Table 1 shows descriptive statistics of all the three groups in which the mean retention force for control group is 79.10 g, group I is 282.55 g, group II is 105.25 g and

Table 1 Descriptive statistics

Groups	N	Mean (grams)	S.D.	Std. error	95 % Confidence interval for mean		Min	Max
					Lower bound	Upper bound		
Denture base (control)	20	79.10	10.40	2.325	74.54	83.66	65	95
Denture base with powder (test group I)	20	282.55	22.03	4.92	272.9	292.2	250	315
Denture base with wafer (test group II)	20	105.25	5.05	1.13	103.04	107.46	98	116
Denture base with paste (test group III)	20	646.2	38.15	8.53	629.48	662.92	599	710
Total	80	278.27	14.65	1.64	275.06	281.48	65	710

**Graph 1** Mean retention force**Table 2** Summary statistics of one way ANOVA

Source of variation	Sum of squares	df	Mean square	F	p value
Between groups	4,099,908.25	3	1366636.08	635.23	0.000
Within groups	39,413.71	76	518.60		
Total	4,139,321.96	79			

group III is 646.2 g. The minimum and maximum retention force values along with their SD for all the three groups are 65–95 ± 10.40 g, 250–315 ± 22.03 g, 98–116 ± 5.05 g, 599–710 ± 38.15 g, respectively.

Graph 1 shows the comparison between all the four groups in which group 3 (paste form) shows the highest mean retention force value and the control group shows the lowest mean retention force value. The mean values of all the four groups were subjected to one way analysis of variance (ANOVA) to determine the statistical level of significance. Table 2 shows the one way ANOVA statistics in which a highly statistical significance among all the four groups. $p = 0.000, < 0.05$. To evaluate which group comparison yielded the statistical significance, a post hoc test (Tukey test) was performed. Table 3 shows when the control group is compared with group I it gives a mean difference of –203.45. This means group I shows significant increase in retention compared to the control group.

When the control group is compared with group II it gives a mean difference of –26.15. This means group II shows significant increase in retention compared to control group.

When the control group is compared with group III it gives a mean difference of –567.10. This means group III shows significant increase in retention compared to control group.

When group I is compared with group II it gives a mean difference of 177.30 with. This means group I shows significant increase in retention compared to group II.

When group I is compared with group III it gives a mean difference of –363.65 with. This means group III shows significant increase in retention compared to group I.

When group II is compared with group III it gives a mean difference of –540.95. This means group III shows significant increase in retention compared to group II.

On the basis of the results obtained the denture base with Fittydent paste (group III) shows maximum retention force followed by the denture base with Fixon powder (group I) and then denture base with sea-bond wafer (group II). The least retention force was observed with the control group.

Discussion

Retention in a denture not only enhances its stability, but also helps to meet the various psychological problems encountered by the patient during the learning or the re-educating period. Such psychological problems might include the fear, apprehension, and embarrassment caused by unsatisfactory denture retention. Thus, retention supplementing stability will achieve a finished denture which satisfies the physical, physiologic and psychological needs of the patient [6]. In an extremely compromised situation e.g. geriatric patient with severely resorbed alveolar ridge covered by abused tissues pose a serious threat of inadequate retention, and thus demands the use of an alternative mechanism to encounter such adverse situations. Search in literature has revealed the use of mechanical devices like

Table 3 Summary statistics of post hoc test (Tukey test)

Primary group	Compared group	Mean difference	Std. error	p value	95 % Confidence interval	
					Lower bound	Upper bound
Denture base (control)	Denture base with Fixon powder (group I)	-203.45*	5.447	0.0001	-214.47	-192.42
	Denture base with sea-bond wafer (group II)	-26.15*	2.58	0.0001	-31.38	-20.91
	Denture base with Fittydent paste (group III)	-567.10*	8.84	0.0001	-584.99	-549.20
Denture base with Fixon powder (grp I)	Denture base with sea-bond wafer (group II)	177.30*	5.05	0.0001	167.06	187.53
	Denture base with Fittydent paste (group III)	-363.65*	9.85	0.0001	-383.59	-343.70
Denture base with sea-bond wafer (grp II)	Denture base with Fittydent paste (group III)	-540.95*	8.60	0.0001	-558.36	-523.53

* The mean difference is significant at the 0.05 level

wires, springs, suction discs, suction chambers, use of magnets and undercuts for providing required retention to prosthesis. Above devices increases the retention but complicates the situation by causing further damage to the tissues of the foundation. Therefore, denture adhesives being commercially available, non-toxic, soluble material of sticky nature and having ability to hold a denture in position has emerged as an acceptable solution to meet the challenges of retention in such patients [1]. No such in vivo study has been conducted where they have compared the powder, paste and wafer form of adhesive.

The degree of retention is dependent on biologic and physiologic properties of a complete denture and the denture-bearing and surrounding tissues. Quantifying retention forces of a complete denture can be carried out with three types of methods: subjective methods, methods with clinical more or less objective criteria, and nearly entire objective methods using measurement equipment. The subjective and most of the methods with clinical criteria are not or little reliable. However, for epidemiological research the methods with clinical criteria are very pragmatic. Of all objective methods using measurement equipment, like the gnathodynamometer are proven to be reliable [7]. Hence in this study an objective method of testing retention was chosen by using a digital customized force sensor.

Many factors influence denture retention, such as size, shape, and material of the denture base; age and health of the patient; character of the mucosa; denture experience; quality and quantity of saliva; time of day; water sorption by the denture base; and seating of the denture in the mouth [8]. All these factors were taken into consideration during the study. Patients having flabby, traumatized mucosa, bony undercuts and patients giving a history of xerostomia were excluded from the study because saliva helps in adhesion and cohesion which are the factors of retention [9]. Patients with healthy mucosa were include in the study, so character of the mucosa was also taken into

consideration for all patients. Denture experience is taken into consideration when a subjective analysis is to be done, but this study is an objective type where denture experience does not matter. The size and shape; age and health of the patient was also same, since all the three test were done in the same patient.

For a 'typical' denture, saturation will take 17 d at room temperature [10]. In this study, the thickness of the denture bases were kept same by using one sheet thickness of baseplate wax and the monomer: polymer ratio was taken as per manufacturer's instructions, overnight bench curing was done, processed using long curing cycle, overnight bench cooling was done before retrieval of the denture bases. Denture bases for all the patients were constructed using heat-cure acrylic resin hence, material of the denture bases were same for all patients. Campbell [11] reported that water sorption increased the retention of acrylic resin dentures. All the denture bases for a subject were stored in water for the same length of time i.e. 17 days at room temperature, before being tested for retention.

Stephens et al. [12] reported that palatal tissue thickness varies with the time of day. All the three tests for a subject were completed in one appointment and time of the day for testing was kept same for all patients i.e. in the morning. The time of the day that the tests were done coincided with the time of the day that the secondary impressions were made to minimize the possible effects of diurnal changes.

Colon et al. [13] conducted a study regarding the area where force should e applied to study retention of complete denture. They placed hooks in three different locations i.e. in anterior part of denture base, in middle part of denture base and in posterior palatal area of denture base. According to this study, Maximum force was applied in anterior hook for the dislodgement of the denture base. The force applied on central hook was variable, but lesser than the force applied for anterior hook, Least force was needed for dislodgement of denture base when force was applied in posterior palatal area.

Use of the middle area where force is variable leads to misleading values and hence the central location was not used in this study. Further as the force applied in posterior palatal seal area to dislodge the denture base was the least it was chosen as the area to apply force in the present study. Further the posterior palatal region happens to show excessive movement in all functional and non functional movement it tends to be major area to affect loss of retention in maxillary denture, it was decided to use the posterior area for hook placement.

Objective methods used for testing retention have been tested in the laboratory on models and also clinically in the patients mouth. Skinner [14] in 1951 used a laboratory balance for applying the force for testing the retention on models. De Furio [15] in 1970 designed a precision machine in which Hanau face-bow and dynamometer was used to dislodge a maxillary denture base. Avant [8] in 1973 modified the testing machine by using a dial type push-pull dynamometer which was suspended from a scissors jack mounted on an upright frame. Hamrick [16] reasoned that an upward extraoral force to test the retention of maxillary dentures is closer to a functional situation than a downward intraoral force. Colon et al. [13] in 1982 used a modified Whipmix ear-type face-bow attached to a spring gauge which measured the force applied by the operator. Taking into consideration all the designs and principles of the various apparatus mentioned above. In this study we used a customized digital force sensor machine (tension gauge) which could measure the amount of weight in the form of water to dislodge the denture bases, as used in Skinner's apparatus [14]. To standardize the amount and rate at which the water flows in the container we used the I.V. infusion tube. As Avant [8] and Hamrick [16] suggested the force should be upward extraoral force and the anterior part of the maxillary ridge should serve as a fulcrum when force is applied, so in this study we kept the tension gauge 1 inch above the patient's mouth level so the force would be in an upward direction and an acrylic block was made in the center of the ridge in the anterior region which acted as a fulcrum, guided the copper wire to pass in a straight line and also protect the patient's lip from getting injured by the copper wire. The head stabilizer of the OPG machine was used to stabilize the patient's head in this study, instead of the head strap being attached to the whole framework as in case of De Furio's apparatus [15] which looks very bulky and complicated.

Studies done by Chew [17], Ghani and Picton [18] said that paste form of denture adhesives is more retentive than powder form. In vivo study conducted by Kumar and Thombare [1] also found that the paste form is more retentive compared to the powder form of denture adhesives which is also seen in the present study. The retention force values obtained in the previous study is more than the retention force values of the present study because they

have placed the hook in the center of the palate, where as in the present study it is placed at the posterior border.

In the present study the mean retention force value was the maximum in group III—646.2 g followed by group I—282.55 g and then group II—105.25 g. The least retention force was observed with the control group—79.10 g.

The reason for the paste form being more retentive can be due to its viscosity. The reason for the wafer form of denture adhesive to be less retentive compared to the other forms may be due to the thickness of the wafer.

Limitation and Further Research

In the present study retention of denture bases have been checked, which is a static record. For a better clinical study, the retention of dentures should be tested instead of denture bases and patient's feedback after a period of using the dentures with adhesives should also be considered. Future studies should be directed to measure the same in patients with poor neuromuscular control and dry mouth conditions.

Conclusion

Within the limitations of the study it can be concluded that the paste form of denture adhesive has the best retentive property compared to the powder and wafer form of denture adhesive.

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