



ISSN: 0975-833X

RESEARCH ARTICLE

COMPARATIVE EVALUATION OF TENSILE BOND STRENGTH OF DENTURE ADHESIVES AT DIFFERENT TIME INTERVALS- AN IN VITRO STUDY

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ARTICLE INFO

Article History:

Received 10th August, 2016
Received in revised form
10th September, 2016
Accepted 17th October, 2016
Published online 30th November, 2016

Key words:

Denture Adhesive,
Retention,
Powder adhesive,
Tensile bond strength.

ABSTRACT

Aim: The aim of this study is to evaluate the tensile bond strength of denture adhesives with respect to time interval of upto 12 hours.

Material and methods: 40 pair of cylindrical acrylic resin samples with flat ends was fabricated with the help of brass moulds for dimensions 20mm diameter and 20mm height. Commercially available denture adhesives such as Fittydent, Secure and Fixon in powder form were tested with artificial saliva. Tensile Bond strength was compared with respect to time interval of 5 minutes, 3 hours, 6 hours and 12 hours after the applications of the adhesive material in between cylindrical samples. Maximum tensile force before failure were examined and recorded in Newton (N) using universal testing machine.

Statistical analysis used: One way ANOVA and Tukey's post hoc test were applied.

Results: Fittydent, Secure and Fixon adhesives showed higher tensile bond strength compared to artificial saliva. Fittydent exhibited significantly greater tensile bond strength values than secure where as fixon having significantly lower values ($P < .001$). Higher tensile bond strength was recorded by all adhesives at 5 minutes time interval and decreased gradually thereafter with least values at 12 hours time interval.

Conclusion: All the 3 denture adhesives had the greater Tensile Bond Strength (TBS) than the control. Highest values obtained at 5 minute time interval and where values get declined and the lowest values found at 12 hours time interval. Within all denture adhesives, Fittydent showed significantly greater bond strength at all time intervals and fixon showing the least values throughout given time intervals.

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Citation: Dr. Jaykumar R Gade, Dr. Meetesh M Banik, Dr. Saumitra Nisal and Dr. Rupesh Vaidya, 2016. "Comparative evaluation of tensile bond strength of denture adhesives at different time intervals- An in vitro study", *International Journal of Current Research*, 8, (11), 42280-42283.

INTRODUCTION

The complete denture modality should provide desired degree of retention and stability to be considered as satisfactory and successful to the patient. Retention may be a problem in few of the situations like severely atrophied edentulous ridges, patients having lack of neuromuscular control including parkinsonism, severely abused/hypertrophied tissue covering the ridges, xerostomia, maxillofacial defects with inadequate tissue support. (Jagger and Harrison, 1996) So for enhancing the quality of retention in such situation, a denture adhesive is recommended. Denture adhesive continues to be extensively used by denture wearers with dentures as a means to enhance denture retention, stability and function. (Guang Hong and TH, 2010) In the US in 1980, 15% of denture wearers utilized denture adhesives. Wilson *et al.* (1990) reported in 1990 that 30% of denture wearers used, or had used, denture adhesive. Denture adhesive is a commercially popular because of its

nontoxic, soluble material of sticky nature which can be applied over tissue surface of the denture in order to enhance the denture retention and denture stability which ultimately improve the quality of the denture. They are available in powder, cream or liquid form. Many dentists view adhesive usage as a poor reflection of their clinical skills and prosthetic expertise. However, in occasional circumstances, patients often lean towards the use of denture adhesives for e.g., in conditions such as complicated prostheses— obturators, a single complete denture, immediate restorations, poor ridge anatomy and relations, dry mouth, the challenging and demanding patient, or in public figures like lawyers, actors, and politicians. They minimize the amount of denture movement, increases the denture retention in such situations. Thus in occasional situations, patients often lean towards the use of denture adhesives. (Chowdhry *et al.*, 2010) Shay explained the mechanism of action of adhesives in 1991. (Shay, 1991) These materials swell 50–150% by volume in the presence of water, filling the spaces between the prosthesis and the tissues. The properties of current adhesives depend upon the combination of both physical and chemical properties. Denture adhesives act by increasing the viscosity of saliva and of the interface between the dentures and mucosa, thus aiding peripheral

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sealing. (Grasso, 2013) However the retentive ability of these materials decreases over a short period of time after application. Literature is lacking in evaluation of current denture adhesive retention ability at different time intervals. So the present study was undertaken to evaluate the tensile bond strength (TBS) of three commercially available denture adhesive powders.

MATERIALS AND METHODS

Total 40 pair of cylindrical samples was fabricated from heat polymerised acrylic resin (Dentsply Intl. Inc.) and counter clear acrylic resin (Dentsply Intl. Inc.) of same size having dimensions of diameter 20 mm and height 20 mm. For accurate fabrication of each sample, a standardized brass metal die was used. (Fig. 1) The internal diameter was 20 mm and the internal height was kept 22 mm which was more than required to be reduced during finishing and polishing upto 20 mm height. Respective lids were also made.



Fig. 1. Customised brass metal cylindrical mold

These test cylinders were packed, processed and cured. After fabrication of samples, dimensions were checked with a digital vernier caliper. Flattened ends were smoothed by using 320-grit silicon carbide paper for the final test surface. A metal hook was attached at the other end to hold it during testing. (Fig. 2)



Fig. 2. Fabricated sample pairs with attached metal hook

Three denture adhesives namely Fitty dent (Dr. Reddy's Lab. Ltd., Hyderabad), Secure (Group Pharma. Ltd., Mumbai) and

Fix-on (ICPA, Mumbai) in powder form were used for testing. The samples were divided in 4 groups 10 pairs each. In three different groups, denture adhesives were placed along with artificial saliva as a medium whereas in control, artificial saliva alone was used. (Table 1)

Table 1. Composition of artificial saliva

Carboxymethyl cellulose	10.000 (g/l)
Sorbitol	30.000 (g/l)
Potassium chloride	1.200 (g/l)
Magnesium chloride	0.843 (g/l)
Calcium chloride	0.146 (g/l)
Dipotassium phosphate	0.342 (g/l)
pH	7.2

For the test groups, the denture base resin cylinders were coated with 0.20 g of the adhesive, in accordance with a study by Chew (Chew, 1990). For the control group, the acrylic resin cylinder was coated with a thin layer of artificial saliva on flat end, and the other side was left dry. To simulate a gentle occlusal force, approximately 12 N (1.2 kg weight) of force over the samples was applied for 30 seconds. (Haraldson et al., 1979) The cylinders were placed in sealed containers with 100% hydration, after then in a humidifier at 37°C for 5 minutes, 3 hours, 6 hours and 12 hours until testing. Then the specimens were debonded in tensile mode at a rate of 10 mm per minute by using the testing machine (Company: Star Testing System, India. Model No. STS 248). The maximum force before failure was then calculated. The specimens were washed clean with anti-bacterial soap and tap water, dried by hand using a paper towel and then were air dried. The same test cylinders were used for all measurements. Each test was repeated 3 times with respect to time period, and a mean value was calculated. (Table 2) The independent variables- adhesives and time were measured with dependent variables- TBS. The data obtained of 3 adhesive groups, control, and 4 intervals of time were evaluated as one way ANOVA within subject factors and the significant differences in variability was examined using Tukey's post hoc test. Statistical analysis was done with Statistical Package for the Social Sciences (SPSS version 20, IBM, USA).

RESULTS

The retention of various commercially available denture adhesive materials was tested. Adhesive powders when used in conjunction with artificial saliva increased the retention exponentially against artificial saliva alone. One way ANOVA within subject factors and at 4 different time intervals was applied. Significant differences were found between the adhesives when compared with the control. ($P < .001$) (TABLE 2)

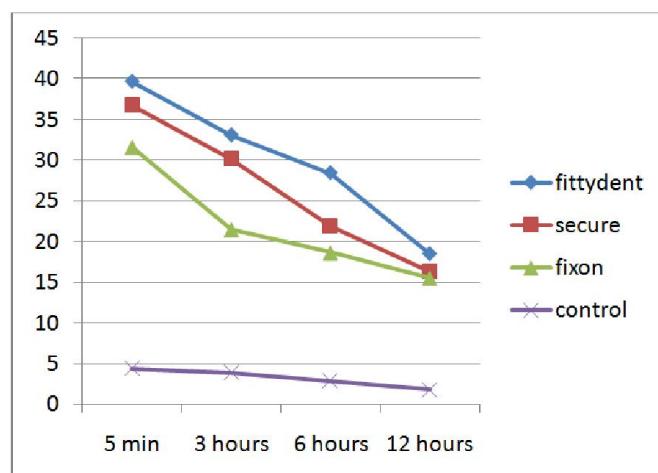
Table 2. Summary table analysis showing F value and P value

Source	Contrasts	Mean Square	F	P
Adhesive	Fittydent vs control	9786	5798.63	< .001
	secure vs control	7419	8426.47	< .001
	fixon vs control	5897	3267.82	< .001
Time	3 hours vs 5 min	612	349.45	< .001
	6 hours vs 5 min	794	415.57	< .001
	12 hours vs 5 min	898	613.35	< .001
Error		23	0.237	

The 3 denture adhesives have been statistically similar at 5 minute time interval but continued to drop with increased time.

Fittydent and secure showed a consistent and significant drop in TBS values upto 12 hours interval, whereas Fixon showed a severe drop in TBS at 3 hours and then gradually decreased till 12 hours interval (Graph 1). Fixon demonstrated least values compared to other denture adhesives during the initial 5 min time interval and thereafter.

All 3 adhesives had the greatest TBS at the 5-minute interval and the lowest at the 12- intervals. Artificial saliva alone showed significant lowest and similar values at all given time intervals.



Graph 1. Tensile bond strength (N) means of 3 denture adhesives and control with 4 time intervals for 12 hours

DISCUSSION

Complete dentures constitute a standout within the most essential treatment modalities in Prosthodontics. An effective retention and stability shape a significant necessity and are crucial to the success of the removable prosthesis. In this way, improving retention and stability is of considerable interest in Prosthodontics. Methods to deal with the issue, all through the years have included overdentures, implants, and also denture adhesives. Regardless of the fact that adhesives are regularly applied by denture wearers and promoted commercially, dental practitioners have been average to recognize their place in prosthetic dentistry as a method to enhance denture retention, stability and function. They view adhesive usage as a poor reflection of their clinical skills and prosthetic expertise. This might be due to a lack of confidence in the results obtained, the suggested iatrogenic concerns of such products, or worry that patients may supplant sufficient denture maintenance with various commercial adhesives (powders, creams, and especially cushions). (Ekstrand *et al.*, 1993) Patients wearing ill- fitting dentures with the help of a adhesive might encounter deterioration of the denture-bearing structures. Nevertheless, patients with well-fitting dentures may utilize denture adhesives successfully, in light of the fact that it gives them an additional security and increased comfort without bringing about disintegration of the denture-bearing areas. (Kapur, 1967) The benefits, drawbacks, proper use, and misuse of denture adhesives are some of the areas that the dentist should discuss with the patient before recommending a denture adhesive. Studies performed by Trabet *et al.* (1980) shown the role of denture adhesive in retention and stability by counting denture dislodgements with and without denture adhesive with

standardised quantity of food. Results showed a significant decrease in dislodgement when an adhesive was used. In the present study also, the denture adhesive resulted in a significantly higher retentive force than artificial saliva. In several studies carried out on efficient medium of denture adhesive form, demonstrated a greater retention for paste form than powder form. As proven by Chew (1990), Ghani and Picton (1994) also supported the same result. In present study, only powder form of denture adhesive was selected so as to compare available popular denture adhesive in market. Three powder forms of adhesives were tested in present study namely Fittydent, Secure and Fixon in vitro condition. Analysis of the results so received indicated that there was a significant variation in the values of retention with the use of these powder adhesives, (Table 3) but it verified the fact that "Denture adhesives undoubtedly improve the quality of Denture retention".

Significant differences were found within the 3 denture adhesives and the control artificial saliva. Present study also confirmed that all the adhesives tend to lose their efficacy as time progressed. Results were in agreement with in-vitro studies conducted by Chew (1990), Kore *et al.* (2013) and DeVengencie *et al.* (1997) suggesting that adhesive is more efficient at initial placement then reduces over time because of loss of adhesive material. In present study, factors that are related to in vivo conditions were the denture base material, artificial saliva and denture adhesive, but the values of the results obtained are not accurate to in vivo conditions value as the presence of natural saliva, keratinized resilient mucosa, muscle movement and intaglio surface of denture base to close adaptation with broad tissue supporting area are some of the missing factors that strongly affect the adhesive bond strength values. Denture adhesive do not function the same way when they are bonded to acrylic resin as compared to keratinised resilient mucosa. This is one of the limitations of this study. However Kore *et al.* (2013) stated that the value of the in vitro study do however serve to examine and compare recently available and newly developed denture adhesive for the purpose of validating future clinical studies. The highest value of TBS among the denture adhesives were recorded immediately after application of the adhesive and gradually diminished and ending with similar values at 12 hours after application. This peak was consistent with previous reports of Kore *et al.* (2013), Chew (1990) and Grasso (2013). Artificial saliva had a consistent result with time and is considered so as control group.

Conclusion

Within the limitation of the in vitro study, the following conclusions were formulated:

1. All the 3 denture adhesives had the greater TBS than the control, which indicates the efficiency of the adhesive powders tested.
2. Significant values were obtained with Fittydent and Secure compared to Fixon and artificial saliva alone. Fittydent exhibiting the greatest TBS values compared to other adhesives.
3. Highest TBS values were recorded at 5 minute of adhesive application. With increased time intervals TBS values were not consistent until the final 12 hour time interval, when all values of denture adhesives were uniformly low.

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