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Comparative evaluation of tensile bond strength of different forms of denture adhesives at different time intervals. – an in vitro study

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Abstract:
Background*: For the patient's complete denture method to be deemed successful and satisfactory, it must offer the appropriate level of stability and retention. In certain cases, such as significantly atrophied edentulous ridges, patients with Parkinsonism or other neuromuscular control disorders, highly abused or hypertrophied ridge-covering tissue, xerostomia, and craniofacial abnormalities with insufficient tissue support, retention may be a concern. Therefore, a denture adhesive is advised to improve the quality of retention in such a condition.*
Materials and Methods*: Total 50 pairs of cylindrical samples will be fabricated from heat polymerised acrylic resin and clear acrylic resin of same size having dimension of diameter 20 mm and height 20 mm. Group A was a saliva substitute (Control group) and Group B , C, D & E (Experimental groups) were different forms of denture adhesive's Tensile bond strength was checked by Intergroup and Intragroup comparison at different time intervals.*
Results*: Group B, C, D and E adhesives showed higher tensile bond strength compared to Group A. Group B showed significantly greater tensile bond strength values where as Group C had significantly lower values. Higher tensile bond strength was recorded by all adhesives at 5 minute time interval and decreased gradually thereafter with least values at 12 hours time interval.*
Conclusion: *All the 4 denture adhesives had the greater Tensile Bond Strength (TBS) than the control group. 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, Group B significantly showed greater bond strength at all time intervals and Group C showed the least values throughout given time intervals.*
Key Word*: Denture Adhesive, Retention, Tensile bond strength, Time intervals*

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I.Introduction

Denture adhesives, fixatives, and adherents were first used in the late 18th century, which is roughly when modern dentistry first emerged. Prior to the 19th century, there is no mention of adhesives or fixatives in the dental literature. There was no mention of the usage of adhesives because it appears they were not part of the dentist's toolkit. An apothecary combined vegetable gums to create a substance that absorbed moisture from saliva and expanded to a mucilaginous substrate that stuck to the mouth mucosa and denture, which is how adhesives or fixatives were made in the 19th century. In terms of adhesives, the first patent was granted in 1913 Denture adhesives have become more and more popular over time, and because they enhance dentures' fit, comfort, chewing ability, and performance, these manufactured goods are crucial to prosthetic dentistry. Denture adhesives fill the crevices between the tissues and the prosthesis by swelling 50–150% by volume when water is present. Current adhesives characteristics are a result of a combination of their chemical and physical components; saliva enhances the adhesive's viscosity, which increases the effort needed to remove the prosthesis from the tissue surface. In order to create temporary adhesive bonding between the denture which is usually made of PMMA and the oral mucosa that supports the denture, denture adhesives are needed. When the patient takes out the denture at the end of the day, an adhesive failure from the tissue contact is the ideal failure outcome because it prevents the uncomfortable sensation of residue remaining on the oral tissue. The ratio of cohesive to adhesive strength determines the mechanism of failure. Adhesive failure is the term used to describe

the situation where the locus of failure happens at an interface. Conversely, a cohesive failure occurs in the bulk of the adhesive. Denture adhesives have become more and more popular over time, and because they enhance dentures' fit, comfort, chewing ability, and performance, these manufactured goods are crucial to prosthetic dentistry. In order to create temporary adhesive bonding between the denture which is usually made of PMMA and the oral mucosa that supports the denture, denture adhesives are needed. When the patient takes out the denture at the end of the day, an adhesive failure from the tissue contact is the ideal failure outcome because it prevents the uncomfortable sensation of residue remaining on the oral tissue. The ratio of cohesive to adhesive strength determines the mechanism of failure. Adhesive failure is the term used to describe the situation where the locus of failure happens at an interface. Conversely, a cohesive failure occurs in the bulk of the adhesive.

II.Aims & objectives

AIM: The aim of this study is to evaluate the tensile bond strength of different forms of denture adhesives with respect to different time intervals up to 12 hours.

OBJECTIVES:

1. To measure the tensile bond strength without denture adhesives by using only artificial saliva with respect to different time intervals of 5 mins, 3 hrs, 6 hrs and 12 hrs.
2. To measure the tensile bond strength with denture adhesives in paste and powder forms with respect to different time intervals like 5 mins, 3 hrs, 6 hrs and 12 hrs.
3. To compare the tensile bond strength of control group and experimental groups.

4. To compare the efficacy of four different forms of commercially available denture adhesive in relation to their retentive ability.

III.Materials and methodology

4 adhesive groups and 1 control group were used. For experimental groups, denture adhesive material and artificial saliva were sandwiched between heat polymerized pink acrylic cylinder and heat polymerized clear acrylic resin cylinder. For the control group cylinders was coated with only a thin layer of artificial saliva. For five groups ten pairs each were formed from the samples. Denture adhesives were placed along with artificial saliva as a medium, while in the control group artificial saliva was applied alone.

Study Design:
Study Location: Bhoomi lab, Surat, Gujarat.
Study Duration: 1 day
Sample size: Total 100 (50 pairs)
Sample size calculation: Heat cure acrylic resin samples were used. Sampling done with f-test ANOVA sampling: A total of 50 pairs of cylindrical samples were used, divided into 5 Groups, 10 samples in each group.
Subject & selection method: Total 50 pairs of cylinders. 50 samples of heat polymerized acrylic resin & 50 samples clear acrylic resin were made.
ARMAMENTARIUM:

- Metal cylindrical mould
- Sandpaper
- Metal hooks
- Universal tensile testing machine
- Humidifier
- Digital vernier caliper
- Weight assembly

Materials

SR. NO	GROUPS	FORMS	MATERIALS	MANUFACTURERS
1	Group A	-	Artificial saliva	ICPA,INDIA
2	Group B	Paste form	Calcium/ Sodium PVM/MACopolymer + Carboxy methyl Cellulose(Pasteform)	GSK,Slovenia
3	Group C	Paste form	Gantrez (PVM/MA Copolymer) +CelluloseGum(Paste form)(GroupC)	Global Dent PVT LTD, India

4	Group D	Powder form	Sodium Carboxy Methyl Cellulose +	OEM manufactures, India
			Sodium Methyl Paraben (Powder form)	
5	Group E	Powder form	Sodium Carboxy Methyl Cellulose + Calcium/ Sodium PVM/MACopolymer (Powderform)	GroupPharma, India
6	-	-	Heatcurepinkacrylic Resin	Dentsply, India
7	-	-	Heatcureclearacrylic Resin	Dentsply, India

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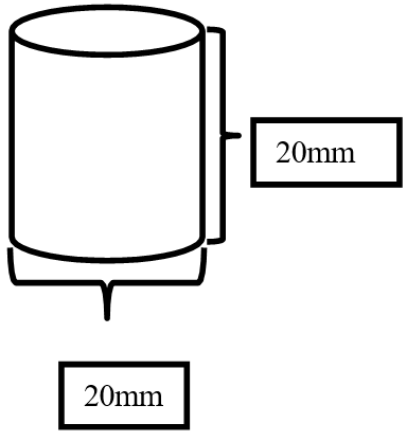
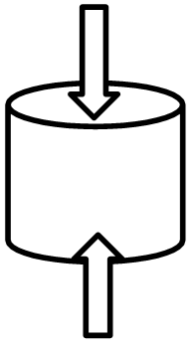


- For accurate fabrication of each sample,a metal die was used.
- The test cylinders were packed,processed and cured.
- After the fabrication of samples, dimensions were checked with a digital vernier caliper.
- Flattened ends were smoothened by using sandpaper for the final test surface.
- Metal hooks were attached at the ends to hold it during testing.



METHODOLOGY

- 4adhesive groups and 1 control group were used.
- For experimental groups, denture adhesive material and artificial saliva were sandwiched between heat polymerized pink acrylic cylinder and heat polymerized clear acrylic resin cylinder.
- For the control group cylinders was coated with only a thin layer of artificial saliva.
- For five groups ten pairs each were formed from the samples. Denture adhesives were placed along with artificial saliva as a medium, while in the control group artificial saliva was applied alone.
- As per the findings of Chew's (1990) study, 0.20 g of the adhesive was applied to the denture base resin cylinders for the test groups. Regarding the group under control, the on one flat end of the acrylic resin cylinder a small layer of artificial saliva was applied and the other side was left dry.
- (Haraldson et al., 1979) For 30 seconds, a force of around 12 N (1.2 kgs) was exerted over the samples to mimic a light occlusal force.

- After being fully hydrated in sealed containers, the cylinders were kept in a humidifier at 37 degrees Celsius for 5 minutes, 3, 6, and 12 hours before the examination of the samples. Then specimens were debonded in tensile mode at a pace of 10 mm per minute.
- After that, the maximal force before failure was determined. The samples were thoroughly cleaned using tap water and antibacterial soap, and then dried by using a paper towel.
- For every measurement, the same test cylinders were utilized.
- A mean value was determined after each test was conducted ten times.
- TBSwasusedasthedependentvariabletomeasuretheindependentvariables, adhesives, and time.
- Intragroup comparison was checked using repeated measures ANOVA.
- Intergroup comparison was checked using one-way ANOVA with post hoc Bonferroni test.

IV.Result

Data were collected from total 100 samples (50 pairs) and compiled into an MS Office Excel worksheet and was subjected to statistical analysis using an appropriate package of SPSS software version 25 for Windows (SPSS Inc, Chicago, IL). Data normality was checked by using the Shapiro-Wilk test. Quantitative data was expressed in mean and standard deviation respectively. Intergroup comparison of parameters between the 4 groups was done using One Way ANOVA followed by Bonferroni test. An intragroup comparison was done using Repeated Measures ANOVA. Keeping alpha error at 5%, and Beta error at 20%, Power at 80% $p \leq 0.05$ will be considered statistically significant.

One-way analysis variance(ANOVA): To test the equality of means (more than two means)of advancing contact angle ANOVA was used. ANOVA is general method for studying sampled data relationships. ANOVA signifies whether difference of values between group is significant or not.

Repeated measures ANOVA: Tests whether there are statistically significant differences in three or more dependant samples.

Bonferroni post hoc test: Used to correct the experiment wise error rate when using multiple‗t'test or as posthoc procedure to correct the family wise error rate following analysis of variance (anova).

Level of significance: ―P‖ is level of significance. $P>0.05$ then the result is not significant and if $p \leq 0.05$ then result is significant.

Each test of each group was performed10times and the average value was counted in Newton (N) unit:

Group A its average value at **5 mins** was 4.76N,at **3Hrs** -3.82N,at **6Hrs** -3.03N and at **12 Hrs** it was 1.85 N.

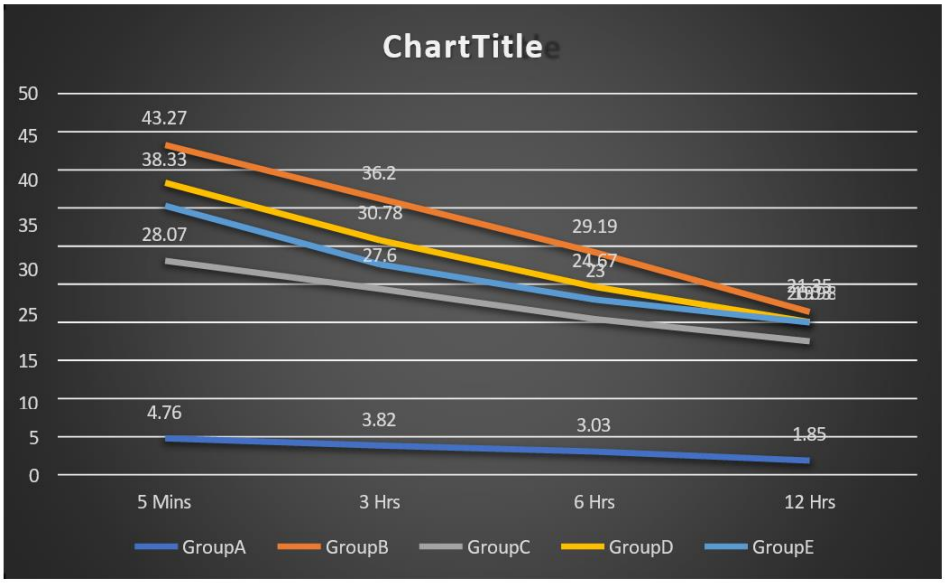
Group B its average value at **5 mins** was 43.27 N, a t**3Hrs**-36.2N,at**6 Hrs**-29.19 N and at **12 Hrs** it was 21.35 N.

Group C its average value at **5mins** was 28.07N,at**3Hrs**-24.38N,at**6Hrs**-20.42Nand at**12 Hrs**it was17.5 N.

Group Ditsaveragevalueat**5mins**was38.33N,at**3Hrs**-30.78N,at**6Hrs**-24.67Nand at**12 Hrs**it was20.03 N.

Group E its average value at **5 mins** was 35.3 N, at **3 Hrs** - 27.6 N, at **6 Hrs** - 23 N and at **12 Hrs** it was 19.98 N.

Tensile bond strength (N) means of artificial saliva and 4 denture adhesives products at various time intervals.



The 4 denture adhesives Group B,C,D and E have been statistically similar at 5 Mins time intervals but continued to drop with increased time.

Group B and Group D showed a consistent and significant drop in TBS values up to 12-hours intervals, whereas Group C and E showed a severe drop in TBS at 3mhours and then gradually decreased till 12 hours intervals.

Group C demonstrated the lowest values compared to other denture adhesives during the initial 5-Mins time interval and thereafter. All 4 adhesives Group (B,C,D and E) had the greatest TBS atthe5Minsintervalandthelowest atthe12 Hrs time intervals. Group A alone showed significantly lower and similar values at all given time intervals.

V.Discussion

Denture adhesives are widely used as aids to retention and stability of dentures. It has been shown that using denture adhesive significantly reduces the displacement of the mandibular and maxillary dentures during chewing, biting and speaking. 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 a single complete denture, poor ridge anatomy and relations, the challenging and demanding patient, or in public figures like lawyers, actors and politicians. Denture adhesive act by increasing the viscosity of saliva and of the interface between the dentures and mucosa, thus aid in peripheral sealing.

Among the most important treatment options in prosthodontics, complete dentures stand out. Stability and successful retention make up a vital requirement and are essential to the detachable prosthesis's performance. In this sense, prosthodontist has a great deal of interest in enhancing stability and retention. Overdentures, implants, and denture adhesives have all been used as solutions to the problem over the years. Even while adhesives are widely advertised and frequently applied by denture users, dental professionals have not always been able to fully understand their role in using prosthetic dentistry to improve the function, stability, and retention of dentures. They believe that using adhesives is a poor representation of their prosthetic knowledge and clinical abilities. This could be because of a lack of faith in the outcomes, iatrogenic issues raised by these products, or fear that patients will use different commercial adhesives (powders, creams and especially cushions) in place of adequate denture care.

(Ekstrand et al, 1993) Patients who use adhesives to secure their ill-fitting dentures may experience denture-bearing components breaking down. However, Denture adhesives can be effectively used by patients who have well-fitting dentures since they provide them with enhanced comfort and security without causing the denture-bearing areas to disintegrate.

(Kapur, 1967) Before providing a denture adhesive to a patient, the dentist should go over the advantages, disadvantages, correct usage and misuse of the product.

Denture dislodgements with and without denture adhesive were counted in studies by Trabet et al. (1980) to demonstrate the function of denture adhesive in retention and stability. The application of an adhesive significantly reduced dislodgement, according to the results. The denture adhesive produced a noticeably stronger retentive force than fake saliva in the current investigation as well.

In the current investigation, artificial saliva Group A as control group and total of four adhesive materials were used in which two were paste types, Group B and Group C and two were powder types Group D and Group E were examined in vitro. Analysis of the obtained data revealed that the retention values varied significantly when different adhesives were used, but it also confirmed that "Denture adhesives unquestionably improve the quality of Denture retention."

The denture base material, artificial saliva, and denture adhesive were factors in the current study that are relevant to in vivo conditions, however the values of the presence of natural saliva, keratinized resilient mucosa, muscle movement, and the intaglio surface of the denture base to close adaptation with broad tissue supporting areaaresomeofthemissingfactorsthatstronglyaffecttheadhesivebondstrength values, which is why the results are not accurate to in vivo conditions values. When bonded to acrylic resin, denture adhesive behaves differently than when it is connected to keratinized robust mucosa. This represents one of the study's limitations.

Between the four denture adhesives and the artificial saliva used as a control, there were noticeable variations. Additionally, the current investigation verified that all adhesives eventually lose their effectiveness as Time went on. The outcomes corroborated with in-vitro research by Chew (1990), Kore et al. (2013), and DeVengencie et al. (1997), which suggested that glue is more effective when first placed but becomes less effective over time due to adhesive material loss.

However, according to Kore et al. (2013), the value of the in vitro research does help to compare and assess newly created and recently released denture adhesive in order to validate upcoming clinical research. Among the denture adhesives, the maximum TBS value was observed as soon as the adhesives were applied. It then progressively decreased and reached a similar value 12 hours later. This peak agreed with earlier findings from Grasso (2013), Chew (1990), and Kore et al. (2013). Artificial saliva is regarded as the control group since it produced consistent results throughout time.

VI.CONCLUSION

The following conclusions were drawn within the constraints of the in vitro investigation:

1. GroupAaloneshowedsignificantlylowerandsimilarvaluesatallgiventime intervals.
2. All four denture adhesive materials in paste and powder forms were also tested at different time intervals and all four adhesive groups showed greatest TBS values at 5 Mins intervals and the lowest at 12 Hrs intervals, at which point all denture adhesive values were uniformly low.
3. All four experimental groups revealed greater TBS values then the control group.
4. Group B showed the highest TBS values and Group C showed the lowest TBS values.

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