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CASE STUDY

AN IN VITRO STUDY TO ASSESS DIFFERENT DRYING TIMES OF POLYVINLYSILOXANE TRAY ADHESIVE TO ACHIEVE OPTIMAL TENSILE BOND STRENGTH WITH AUTOPOLYMERIZING ACRYLIC RESIN TRAY MATERIAL

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ABSTRACT

Background: The maximum tensile bond strength between acrylic special tray and silicone impressions is achieved when adhesive is allowed to dry for a longer period of time, usually 15 minutes. This delays the impression making procedure. **Aims and Objectives:** This study tested the tensile bond strength of tray adhesive on special trays using warm air to dry and hence decrease its drying time. **Materials and Methods**: 48 test specimens were prepared with autopolymerizing acrylic resin. The study groups considered in this study were - **Group 1:** 15 min (control) (normal drying), Group 2: 1 minute (with warm air drying), **Group 3:** 2 minutes (with warm air drying) and Group 4: 3 minutes (with warm air drying). Statistical Analysis: The one-way ANOVA was used to test the null hypothesis that there is no significant difference in mean tensile bond strength among the four study groups. **Results and Conclusion**: It was found that there was no change in tensile bond strength between adhesive and impression when air at 35 degree Celsius was blown from a distance of 10 cms for 2minutes: This study suggests a new technique to reduce drying time of tray adhesive considerably without compromising tray- impression bond strength.

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INTRODUCTION

Polyvinyl siloxane impression materials, commonly referred to as Addition Silicones, are widely used in Fixed Prosthodontics, Operative Dentistry, Removable Prosthodontics, and Implant Dentistry (Chee, 1992). Addition Silicone impression materials are most accurate when used with custom trays. They are primarily secured to the impression trays by tray adhesives. It has been found that maximum tensile bond strength between acrylic special tray and silicone impressions is achieved when adhesive is allowed to dry for a period of usually 15 minutes [(2).] This delays the impression making procedure and consumes clinical chair side time. Various methods have been used to shorten the drying time of tray adhesives without compromising bond strength. As many dentists depend entirely on tray adhesives for retention of the impression material to impression tray, it is obvious that the strength of the bond is of vital importance for the accuracy of the impression and subsequent model. Addition Silicone impression materials have excellent rheological properties. Their reproduction of oral surface details is unsurpassed.

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They also have the best elastic recovery of all available impression materials because they have the least permanent deformation in compression induced during removal. There is virtually no by-product in the polymerization reaction and hence these impressions are also dimensionally stable. Addition Silicone elastomeric impression material does not bond chemically to acrylic tray surface. So if it has to be retained, tray adhesives have to be applied to the inner surface and to the borders of the tray (Asgar, 1971). Auto polymerizing acrylic resin is used to fabricate custom tray for making impressions and record bases for complete dentures. When impression tray is removed from the oral cavity, it causes a tensile force stress on the elastomer/tray interface (Wilson, 1963). To withstand the stress generated during the removal of the set material, there should be a tight seal between the elastomeric impression material and the tray, or else the material will be pulled away (Maruo *et al*., 2007). Various authors have studied the tensile bond strength of elastomeric material and tray adhesive and have recommended a minimum drying time of 15 minutes (Seema Munjal, 2014) but very few authors have studied the different drying times of polyvinlysiloxane tray adhesive to achieve optimal tensile bond strength with autopolymerizing acrylic resin tray material.

Hence, this study was undertaken to assess different drying times of polyvinlysiloxane tray adhesive to achieve optimal tensile bond strength with autopolymerizing acrylic resin tray material.

MATERIALS AND METHODS

Forty eight cuboid auto polymerizing polymethylmethacrylate (PMMA) acrylic resin specimens (15 x 15 x 20 mm) were fabricated, they were divided into 4 groups of 12 samples each. The study groups were - Group 1: 15 minutes (control) (normal drying), Group 2: 1 minute (with warm air drying), Group 3: 2 minutes (with warm air drying) and Group 4: 3 minutes (with warm air drying). An eye hook was incorporated into each specimen to serve as the point of attachment to the universal testing machine (Fig.1) (Instron mode). The specimen surface was polished with a 320-grit silicone carbide paper to standardize the surface roughness (Fig.2). A piece of poly vinyl chloride pipe (PVC), 15 mm in diameter and 20 mm long, was used to house the impression material and it was perforated in multiple locations, providing additional mechanical retention.

A metal rod was inserted into 2 centred holes to provide additional retention for eyehook which was attached to the universal testing machine (Fig.3). Each specimen of Group 1 (consisting of 12 specimens) was coated with a thin layer of tray adhesive using the brush provided, allowing the solvent to evaporate or dry for 15 minutes (Fig.4). The impression material was automixed and dispensed into the PVC pipe (Fig.5). The perforated PVC pipe housing was then centrally placed in contact with the tray material so as not to allow extra material to leak out of the cylinder (Fig.6). The metal rod and hook were inserted at the open end of the cylinder. Acrylic resin specimens were positioned against the open cylinder end in contact with the VPS material, and the impression material was allowed to dry in accordance with manufacturer's recommendations. Similarly 12 samples were taken for Group 2, 3, 4 and coated with tray adhesive and allowed to set for 1minute, 2 minutes and 3minutes respectively, using a hair dryer to generate air at 35degree Celsius (Fig.7). Each specimen was then attached to the universal testing machine by means of metal hooks attached to the eyehooks in the tray specimen and the metal rod placed through the PVC pipe housing. Specimens were tested in tensile mode at a cross-head speed of 5 mm/min until separation failure occurred (Fig.8).The maximum force at which separation failure occurred was divided by the area of adhesion and recorded as the adhesive strength in MPa.

STASTISTICAL ANALYSIS AND RESULTS

The maximum load at break for each sample was attained. It was observed that Group 1, ranged from 36.780-60.01N, Group 2, ranged from 32.53- 44.35N, Group 3 ranged from, 31.57-73.9N and Group 4 ranged from 32.47-67.57N (Table 1). Then, tensile bond strength of each specimen was calculated using the formula, maximum load/unit area of contact and the descriptive of each group were tabulated and compared. The mean tensile bond strength of each group, was calculated and Group 3 which was air dried for 2 mins had the highest mean tensile bond strength of 0.22700 Megapascal (MPa) (Table 2 & 3). These descriptive were statistically analysed using one way ANOVA and followed by post hoc test for multiple comparison of groups. (Table 4 & 5).

DISCUSSION

The mean tensile bond strength showed significant difference in between the groups ($p < 0.014$). The Post hoc test showed significant difference between Group 2 and Group 3. The Group 3 which was air dried for 2 minutes obtained the maximum tensile bond strength which was comparable with Group 1 (15 minutes control). The tensile bond strength of a material is the maximum amount of tensile stress that it can take before failure, for example, breaking. A tensile stress is always accomplished by tensile strain (Arvind Shenoy, 2014).The bond strength between the elastomeric impression material and tray is increased by application of tray adhesives. Newer impressions like Polyether and Polysiloxanes set harder than Polysulphides and Condensation silicones. Due to their rigid property, they create more resistance for the impression tray to be removed from the mouth (Fehling, 1986). Polyvinyl Siloxane impression material exhibit the most elastic recovery, distortion on removal from the undercuts and it is virtually non-existent because these materials exhibit the lowest permanent distortion after excessive strain in compression (Arvind Shenoy, 2014). Bindra and Heath compared tensile bonding strength of two types of Additional Silicone impression materials and their tray adhesives by changing the combination of their manufacturing companies.

The results presented that changing the combination of the manufacturing companies showed higher bonding strength than in combination of the same manufacturing company, and concluded that using a tray adhesive and impression material combination of a same company does not always provide an ideal choice (Bindra, 1997). Dixon *et al*. compared tensile bonding strength of tray adhesives using three different tray materials. The results presented higher bonding strength with light curing tray resin than self-curing tray resin (Dixon, 1994). Overnight storage did not affect the bond strength adversely (Davis, 1976). Hee Yi *et al* revealed that at least 10 minutes is needed for Silfix-Aquasil, and 15 minutes for VPS Tray Adhesive-Imprint II, to attain an appropriate tensile bonding strength (Yi, 2009) . In addition, in the experiment performed by Peregrina *et al*, five types of tray adhesives were evaluated by using two types of tray materials and three types of polyvinylsiloxane impression materials. The results presented no significant difference in self-curing resin and light curing resin trays (Peregrina, 2000). Acrylic tray resin is composed of powder and liquid. Powder component contains Polymer - Poly (methyl methacrylate), Benzoyl peroxide initiator (0.2-0.5 %.) and Pigment (1% ground into polymer particles). Liquid component contains Methyl methacrylate, hydroquinone inhibitor (0.006 %.) and activator Dimethyl-p-toluidine. It is used to fabricate custom tray for making impressions and record bases for complete dentures. Tray adhesive drying times which have been reported by various authors. According to the study by Maruo *et al*, Reprosil and Exaimplant yielded extremely low values for drying times of 10 minutes or less ($P<0.05$), while Imprint II and Impregum were not influenced by drying time. Vinyl polysiloxane achieved the highest adhesive strength with bur-produced roughness, which was significantly higher than with air abrasion or no treatment ($P<0.05$), whereas polyether achieved the lowest value with bur-produced roughness ($P<0.05$). It was concluded that surface treatment of custom tray should be adapted to the type of impression material used to achieve optimum bond strength (Maruo *et al*., 2007). Various authors have recommended different drying time from 4-48 hours (Seema Munjal, 2014).

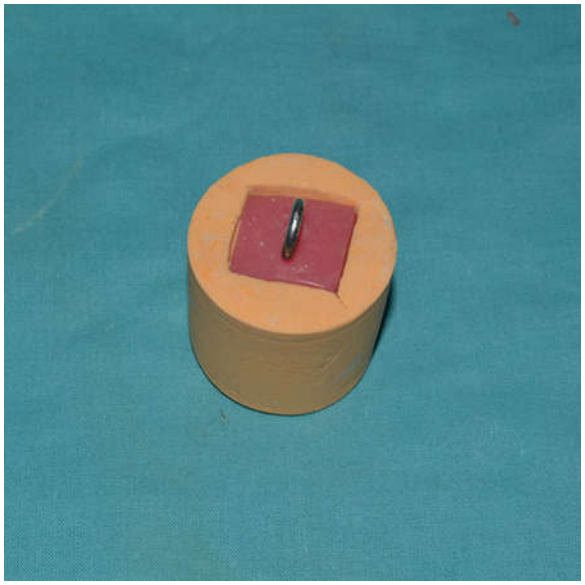

Fig. 1. An Eyehook Incorporated into the cuboid (PMMA) acrylic resin specimens

Fig. 2. The specimen surface polished with a 320-grit silicon carbide paper

Fig. 3. A metal rod inserted into 2centered holes to provide retention The specimen surface polished with a 320-grit silicon carbide paper

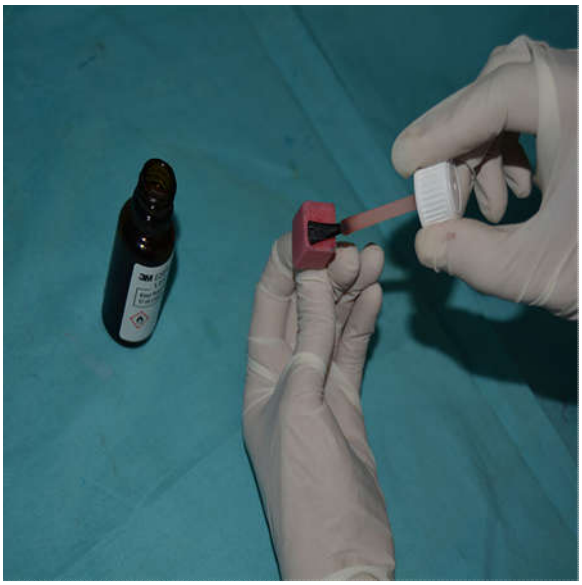

Fig. 4. Thin coat of tray adhesive applied on the surface of specimen

Fig. 5. Impression material automixed and dispensed into the PVC pipe

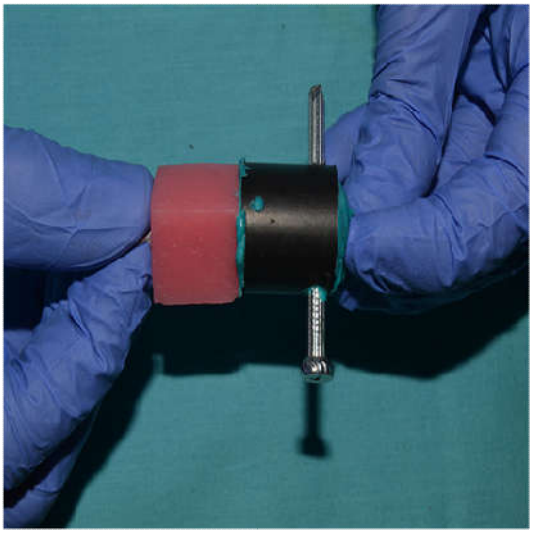

Fig. 6. Acrylic resin specimens positioned against the open cylinder end in contact with the VPS material

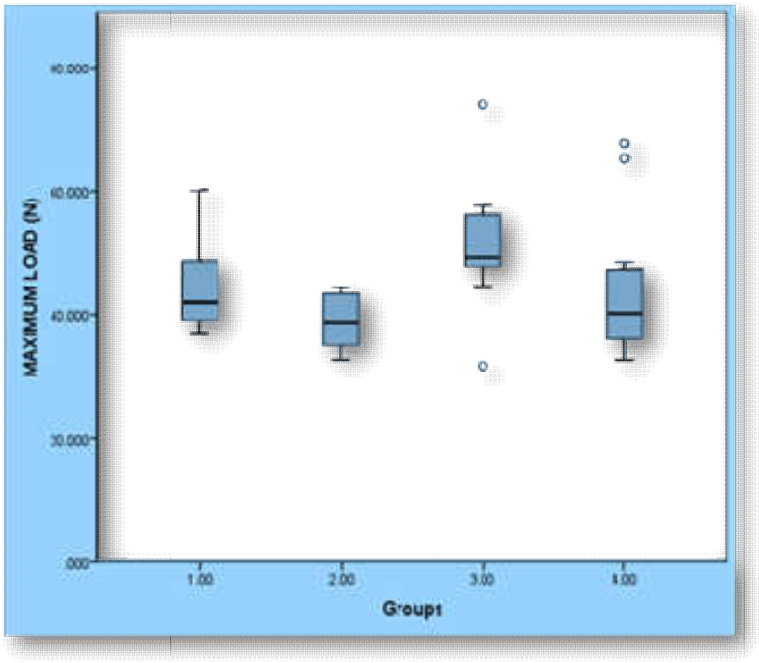

Table 1. Box plot showing maximum load at break

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
TENSILE BOND STRENGTH (MPa)	1.00	12	.19725	.031551	.009108	.17720	.21730	.163	.267
	2.00	12	.17317	.019126	.005521	.16101	.18532	.145	.197
	3.00	12	.22700	.044130	.012739	.19896	.25504	.140	.328
	4.00	12	.19608	.050939	.014705	.16372	.22845	.144	.300
	Total	48	.19838	.041890	.006046	.18621	.21054	.140	.328

Table 2. Tensile bond strength calculated

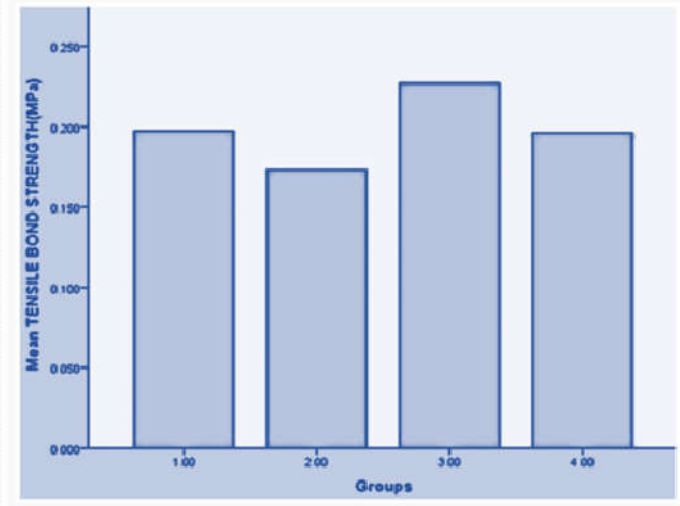

Table 3. Comparison of mean tensile bond strength of each grou

Table 4. Statistical analysis done using ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
TENSILE BOND STRENGTH (MPa)	Between Groups	.018	3	.006	3.961	.014
	Within Groups	.065	44	.001		
	Total	.082	47			

Table 5. Statistical analysis done using Post hoc test

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
TENSILE BOND STRENGTH(MPa)	1.00	2.00	.024083	.015684	.426	-.01779	.06596
		3.00	-.029750	.015684	.244	-.07163	.01213
		4.00	.001167	.015684	1.000	-.04071	.04304
	2.00	1.00	-.024083	.015684	.426	-.06596	.01779
		3.00	-.053833*	.015684	.007	-.09571	-.01196
		4.00	-.022917	.015684	.469	-.06479	.01896
	3.00	1.00	.029750	.015684	.244	-.01213	.07163
		2.00	.053833*	.015684	.007	.01196	.09571
		4.00	.030917	.015684	.214	-.01096	.07279
	4.00	1.00	-.001167	.015684	1.000	-.04304	.04071
		2.00	-.022917	.015684	.469	-.01896	.06479
		3.00	-.030917	.015684	.214	-.07279	.01096

Fig. 7. Tray Adhesive allowed to set using a hair dryer

Fig. 8. Each specimen was then attached to the universal testing machine

Samman JM and Fletcher AM recommended 10 minutes drying time for Silicone impression materials (Samman, 1985). Previous literature reported that the material adhesive combination supplied by the manufacturer might not necessarily be the best. Universal adhesives have now started to replace the manufacturer's adhesive (Ashwini, 2014).

Most dentists follow the manufacturers' instructions, but problems are often encountered where clinical circumstances dictate departure from standard operating procedures. According to Davis *et al*, the bonding of the elastomer to itself generally exceeded the adhesive bond strength of the elastomer to acrylic resin tray material (Davis, 1976). According to

William R Hoger *et al*, drying time variances of 15 minutes to 72 hours did not significantly affect the tray adhesive bond strengths. However, drying times of less than 15 minutes reduced the bond strength values for polysulfide materials to a custom acrylic resin tray with the appropriate adhesive (Hogans, 1992). Heeyi *et al*, revealed that at least 10 minutes is needed for Silfix-Aquasil and 15 minutes for VPS Tray Adhesive-Imprint II to attain an appropriate tensile bonding strength (Yi, 2009). To obtain an accurate impression, the impression material must be securely attached to the tray. If the material is not secured to the tray firmly, while retrieving it from the mouth, it will result in improper impression and therefore produce a distorted die, wax pattern and casting (Bomberg, 1988). An adhesive is a tenacious and sticky substance (The Glossary of Prosthodontic terms, 2017). The adhesives used for silicone impression materials contain polydimethyl-siloxane or a similar reactive silicone and ethyl silicate. Polymethylsiloxane of adhesives bonds to the silicone impression material whereas ethylsilicate forms a hydrated silica that bonds to the impression tray material physically. The volatile solvent in the form of ethyl acetate reacts with the autopolymerising tray material to create microporosites on the tray material so that the adhesive physically and mechanically bonds with it (Phillips, 1982). The tray adhesive used in this study also contained ethyl acetate, poly (dimethylsiloxane) and naphtha. For a Universal Tray adhesive the surfaces of the impression tray must be oil-free, clean and dry. A thin layer of adhesive must be applied to the surfaces that come in contact with the impression material. The tray adhesive used in this study is VPS tray adhesive from 3M which is viscous orange in colour (Stober, 2010). In this study, the statistical analysis confirmed that there is no significant differences in tensile bond strength among Group1, Group 3 and Group 4 and significant differences were found between Group 2 (1 minute) and Group 3 (2 minutes). Group 3 which was air dried for 2 minutes attained maximum tensile bond strength of 0.227Mpa which was comparable to Group 1 (15mins control group) with bond strength of 0.196Mpa. The nature of forces in the mouth is dynamic. The tensile bond strength carried out in this study utilized static loading of the specimens. The difference between the room and mouth temperature and presence of saliva which might affect the surface detail reproduction of impression material were not simulated in this study. Thus, an in vivo study is needed to overcome these limitations.

Conclusion

It has been found that maximum tensile bond strength between acrylic special tray and silicone impressions is achieved when adhesive is allowed to dry for a longer period of time, usually 15 minutes. This delays the impression making procedure. In the system evaluated, it was found that there was no change in tensile bond strength between adhesive and impression when air at 35° C was blown from a distance of 10 cms for 2 minutes, 3 minutes and 15 minutes normal drying. Thus this study therefore suggests a new technique to reduce drying time of tray adhesive considerably without compromising tray-impression bond strength, thus saving valuable chair-side time.

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