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ORIGINAL RESERACH

Effect of Time and Method of Drying on Bond Strength of Tray Adhesives with Vinyl Polysiloxanes

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ABSTRACT

Aim: To establish an effective combination of drying time and drying method of the tray adhesive so that maximum bond strength can be achieved between impression tray and impression material.

Materials and methods: Cylindrical specimens of auto-polymerizing resin and addition silicone impression material were made. A total of 150 specimens were tested. They were divided into two groups Dentsply and GC. Each group was further divided into five subgroups:

- Drying with compressed air for half the time as recommended by the manufacturer
- Drying with air blower for half the time as recommended by the manufacturer
- Open air drying as recommended by the manufacturer
- Open air drying for 15 minutes
- Open air drying for 1 hour

The samples were tested for tensile bond strength using the universal testing machine. The results were subjected to statistical analysis.

Result: Open air drying as recommended by the manufacturer was better than drying with a blower or compressed air. There was no significant difference between open-air drying for 5 minutes and open-air drying for 15 minutes or 1 hour.

Conclusion: Open air drying as recommended by the manufacturer, i.e. 5min, showed good bond strength and drying for more than 5mins does not significantly increase bond strength.

Clinical significance: Tray adhesive should not be dried with compressed air or air blower. Tray adhesive should be applied and kept to dry according to the manufacturer's recommended time.

Keywords: Bond strength, Drying time, Polyvinylsiloxane, Tray adhesive.

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INTRODUCTION

A dimensionally accurate impression is important for the fabrication of any prosthesis because inaccurate impressions can compromise the fit, esthetics, and function of the restoration. Inaccurate impressions can be caused by insufficient rigidity of the impression tray, manipulation errors, wrong choice of material, separation of impression material from tray and shrinkage of impression material. Addition Silicone does not adhere chemically with the impression tray. While removing the impression from the mouth, a weak connection between impression material and the tray may lead to distortion of the impression. A tray adhesive can be beneficial in this regard.[1]

Separation of the impression from the underlying tray might occur during impression making procedure despite the use of tray adhesive. This could be attributed to the use of compressed air or blower for drying the adhesive. Hence in this study a combination of drying time and drying method of the tray adhesive has been described.

MATERIALS AND METHODS

The tensile bond strength between the impression material and the auto-polymerizing tray resin was to be evaluated after application of tray adhesive and subjecting it to various drying times and methods (Fig. 1).

For this 150 samples were made. They were divided into the following groups:

Each subgroup had 15 samples. Compressed air drying (Fig. 2) and drying with air blower (Fig. 3) was done for half the time as recommended by the manufacturer, i.e., 2.5 min. Open air drying was done as per the manufacturer's recommendation for 5 minutes. Auto-polymerizing resin blocks were fabricated and coated with tray adhesive and then allowed to dry. Polyvinyl siloxane was adapted on the other side of the block. These samples were later tested in the universal testing machine for tensile bond strength (Fig. 4). The load was applied at a crosshead speed of 0.5 mm/min. The maximum load at which the sample separated was recorded.

The mean bond strength of Dentsply and GC at different time intervals and methods was compared using one-way analysis of variance (ANOVA) and adjusted for multiple comparisons using Tukey's method. A p value less than 0.05 were considered to be statistically significant.

RESULTS

Table 1 shows that there was a statistically significant difference between groups as determined by one-way ANOVA (F = 14.26, p = <0.001).

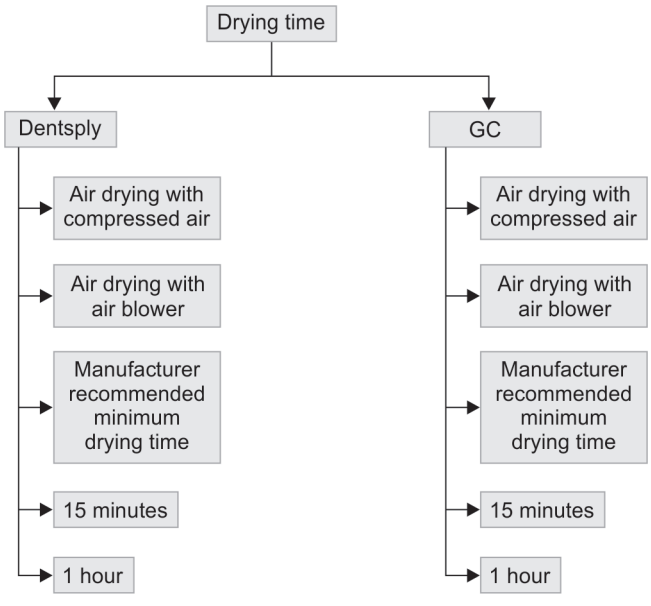

Fig. 1: Material and methods

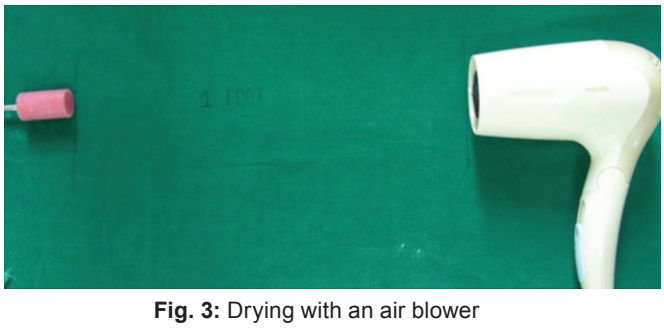

Fig. 3: Drying with an air blower

A Tukey post-hoc test revealed no statistically significant difference in bond strength between air drying with compressed air (50.2 ± 11.9) and blower (60.90_± 15.6). Bond strength was significantly higher for open-air drying for 5 minutes (74.08 ± 20.1), Open air drying for 15 minutes (75.3 ± 12.3) and for open-air drying for 1 hour (86.6_± 9.8) when compared to compressed air drying for 2.5 min (50.2 ± 11.9).

There was a significant difference between drying with a blower (60.9 ± 15.6) and drying in open air for 60 min (86.6 ± 9.8).

Open air drying for 5 minutes was better than drying with a blower or compressed air. There was no significant difference between open-air drying for 5 minutes and open-air drying for 15 minutes or 1 hour.

Table 2 shows that there was a statistically significant difference between groups as determined by one-way ANOVA (F = 33.35, p = <0.001).

Table 2 shows the comparison of various subgroups of GC specimens. A Tukey post-hoc test revealed that bond strength due to air drying with compressed air (34.74 ± 10.45) was significantly higher than the bond strength due to air drying with a blower (23.9 ± 3.6). Bond strength was significantly higher for open-air drying for 5 minutes (50.3 ± 9), Open air drying for 15 minutes (53 ± 7.9) and for open-air drying for 1 hour (50.4 ± 9.6) when compared to compressed air drying for 2.5 minutes (34.7 ± 10.4).

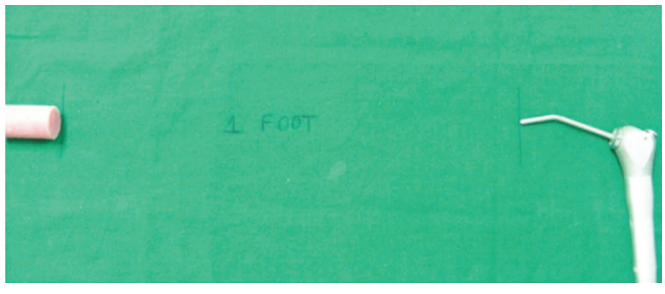

Fig. 2: Drying with compressed air

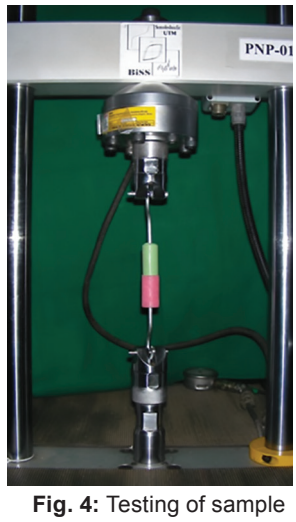

Fig. 4: Testing of sample

Table 1: Comparison of mean bond strength of various subgroups of dentsply

Comparison	*Mean difference*	*Std. error*	*p value*
Compressed air 2.5 *vs* Air Blower 2.5	–10.66667	5.26941	0.401
Compressed air 2.5 *vs* Open air 5 minutes	–23.84000*	5.26941	0.001 (Significant)
Compressed air 2.5 *vs* Open air 15 minutes	–25.04667*	5.26941	0.001 (Significant)
Compressed air 2.5 *vs* Open air 60 minutes	–36.37333*	5.26941	0.000 (Significant)
Air Blower 2.5 *vs* open 5 air minutes	–13.17333	5.26941	0.194
Air Blower 2.5 *vs* open air 15 minutes	–14.38000	5.26941	0.127
Air Blower 2.5 *vs* open air 60 minutes	–25.70667*	5.26941	0.000 (Significant)
Open air 5 min *vs* open air 15 minutes	–1.20667	5.26941	1.000
Open air 5 min *vs* open air 60 minutes	–12.53333	5.26941	0.238
Open air 15 min *vs* open air 60 minutes	-11.32667	5.26941	0.338

*Statistically significant

Table 2: Comparison of mean bond strength of various subgroups of GC

GC	*Mean difference*	*Std. error*	*p value CC*
Compressed air 2.5 *vs* Air blower 2.5	10.82667*	3.09893	0.022
Compressed air 2.5 *vs* Open air 5 minutes	–15.60000*	3.09893	0.000
Compressed air 2.5 *vs* Open air 15 min	–18.26667*	3.09893	0.000
Compressed air 2.5 *vs* Open air 60 minutes	–15.68000*	3.09893	0.000
Air Blower 2.5 *vs* Open air 5 minutes	–26.42667*	3.09893	0.000
Air Blower 2.5 *vs* Open air 15 minutes	–29.09333*	3.09893	0.000
Air Blower 2.5 *vs* Open air 60 minutes	–26.50667*	3.09893	0.000
Open air 5 minutes *vs* Open air 15 minutes	–2.66667	3.09893	0.945
Open air 5 minutes *vs* Open air 60 minutes	–0.08000	3.09893	1.000
Open air 15 minutes *vs* Open air 60 minutes	2.58667	3.09893	0.951

*Statistically significant

There was a significant difference between drying with a blower (23.9 ± 3.6) and drying in open air for 5 min (50.3 ± 9) drying in open air for15 min (53 ± 7.9), drying in open air for 60 min (50.4± 9.6).

Open air drying for 5 minutes was better than drying with a blower or compressed air. There was no significant difference between open-air drying for 5 minutes and open-air drying for 15 minutes or 1 hour.

DISCUSSION

Accurate impressions are a mainstay in prosthodontics. Addition silicone is widely used impression material. Its tray adhesive is weaker than those of polysulfide, polyether, and condensation silicone.[2] The forces exerted on impression material while retrieval is reported to be around 36.3 N with a metal tray/elastomer combination and 19.9 N with the same material used in a plastic tray.[3] They are also more while using rigid impression material, when soft or hard tissue undercuts are present and when dealing with multiple implant fixtures with varying angulations.[4] A rigid tray with less bulk of impression material and undercuts greater than 10° resulted in higher stresses.[5] Polymerization shrinkage also exerts a force.

The bond between impression material and impression tray can be achieved either by mechanical or chemical means. Mechanical measures include roughening the tray and creating perforations. This will ensure better locking of the impression with the impression tray making it difficult for it to get separated.

After the tray is fabricated, the spacer wax has to be eliminated. Use of a wax knife leaves some residue on the tray surface. This compromises the bond between impression material and the impression tray. We should use a tin foil or an aluminum foil between the spacer wax and impression tray when it is curing. This makes it easier to separate the spacer wax from the impression tray without leaving any residue. This, in turn, will help in enhancing the bond strength.

Cleaning the tray of saliva, use of light polymerized trays and cleaning with alcohol can increase bond strength.[6-9]

Chemical measures include the use of a tray adhesive. Tray adhesives of silicones are relatively weaker.[10] A tray adhesive consists of a solvent and an adhesive. Adhesive for polysulfide impression materials consists of butyl rubber or styrene and acrylonitrile dissolved in a volatile solvent such as chloroform or a ketone.[11]

The tray adhesive for silicone impression materials has polydimethylsiloxane or other reactive silicone, and ethyl silicate. Polydimethylsiloxane sticks to the silicone impression material whereas ethyl silicate forms hydrated silica that bonds to the impression tray material physically. A solvent like a methyl acetate dissolves the tray and bonds with it. The retention depends on the ability of the solvent to dissolve the tray.[1,12-14]

The solvent must evaporate completely to expose a layer of adhesive to bond with the impression material. As a result, the tray adhesive is left to dry for some time before the impression material can be loaded. Drying

time has been known to affect the bond strength. Various studies have been performed to identify the optimum drying time. For polysulfide impression adhesive 15 minutes of drying time has been recommended.[12] For addition silicone 10 min drying time[13] or 7–15 minutes,[14] is recommended. Forty-eight hours drying time was shown to give significantly higher bond strength than 10 minutes.[7] A study on adhesive for irreversible hydrocolloid demonstrated that drying for more than 5 minutes of reduced bond strength owing to over evaporation of the solvent.[15]

In this study, various drying time and mode of drying were tried to identify the best possible combination of drying time and mode of drying, so that maximum strength in a minimum amount of time is achieved. Clinicians try drying the tray adhesive with compressed air in an attempt to achieve faster drying. So, it was incorporated to study its effect. Some clinicians fear that compressed air might push the tray adhesive off the tray because of the force, so the use of an air blower was tried. Manufacturer recommended drying time was added to check its efficiency. A drying time of 15 minutes is followed by many clinicians thus it was included and a drying time of 1 hour was assessed to check the effect of prolonged drying on the tray adhesive. Thus five groups were tried- drying with compressed air for half the time as recommended by the manufacturer, drying with air blower for half recommended drying time, open air drying according to the manufacturer's recommended drying time, open air drying for 15 minutes, and open-air drying for 1 hour. Use of a custom tray ensures most accurate impressions. Cold cure acrylic was used because it is the most common material used for fabrication of custom tray. It was poured in the mold and the open surface was cured against a glass slab to eliminate the effect of contamination of wax on the surface. The hooks were incorporated exactly in the center, as an off-center placement would create an error in the measurement of tensile forces. The tray adhesive was then applied on the free surface of the acrylic specimens. A single coat of tray adhesive was applied. It was then allowed to dry as per the groups. Addition silicone was automixed with the help of an automixing gun and was injected into the mold. A custom tray is used with a multiple mix technique, in which heavy body comes in contact with the tray. Thus heavy body elastomer was used in this study. The samples were then tested for tensile bond strength.

It was found that open-air drying according to the manufacturer's recommended drying time was better than drying with compressed air or air blower for half the recommended drying time except for drying with air blower with Dentsply tray adhesive, where the bond strength was less but not significant. There was no significant difference in bonding strength between open-air drying for manufacturer's recommended drying time, open air drying for 15 minutes or open-air drying for 1 hour.

Thus it is evident that drying with compressed air or with air blower for reduced time is not effective and should not be practiced. It may be because the solvent evaporation is not complete or the time required for ethyl silicate to form hydrated silica and bond mechanically to the tray surface is insufficient. There was no significant difference in bond strength after drying of tray adhesives after 5 minutes. It may be because evaporation of the solvent is almost complete in 5 minutes and the reaction of ethyl silicate with tray surface is almost over.

Limitations of the Study

In this in vitro study acrylic specimens were used instead of the impression tray. Hence further research is needed to establish the effect of drying time on the bond strength between the metal tray and putty elastomer. While drying with compressed air or air blower, the 3-way syringe and the air blower was kept at a distance of 1 foot. The results may have been different if the distance would have been more or less. Only tensile bond strength was tested in this study; the effect of drying time on shear bond strength also needs to be evaluated. The effect of interchanging the brands of tray adhesive also may be studied.

CONCLUSION

This study was conducted to evaluate the effect of drying time and mode of drying on the bond strength of tray adhesive to vinyl polysiloxane. Within the limitations of this study, the following conclusions were drawn after the results were analyzed:

Open air drying according to manufacturer's recommended drying time i.e., 5 minutes, gives good bond strength and drying for more than that does not significantly increase bond strength.

REFERENCES

1. Ona M, Takahashi H, Sato M, Igarashi Y, Wakabayashi N. Effect of reactive adhesives on the tensile bond strength of polyvinyl siloxane impression materials to methyl methacrylate tray material. Dent Mater J 2010;29(3):336-340.
2. Grant BE, Tjan AH. Tensile and peel bond strengths of tray adhesives. J Prosthet Dent 1988;59(2):165-168.
3. Sotiriou M, Hobkirk JA. An *in vivo* investigation of seating and removal forces associated with recording impressions in dentate patients. J Prosthet Dent 1995;74(5):455-462.
4. Payne JA, Pereira BP. Bond strength of two nonaqueous elastomeric impression materials bonded to two thermoplastic resin tray materials. J Prosthet Dent 1995;74(6): 563-568.

5. Collard EW, Caputo AA, Standlee JP, Trabert KC. Dynamic stresses encountered in impression removal. J Prosthet Dent 1973;29(5):498-506.
6. Wang RR, Nguyen T, Boyle AM. The effect of tray material and surface condition on the shear bond strength of impression materials. J Prosthet Dent 1995;74(5):449-454.
7. Dixon DL, Breeding LC, Brown JS. The effect of custom tray material type and adhesive drying time on the tensile bond strength of an impression material/adhesive system. Int J Prosthodont 1994;7(2):129-133.
8. Abdullah MA, Talic YF. The effect of custom tray material type and fabrication technique on tensile bond strength of impression material adhesive systems. Journal of Oral Rehabilitation 2003;30(3):312-317.
9. Dixon DL, Breeding LC, Bosser MJ, Nafso AJ. The effect of custom tray material type and surface treatment on the tensile bond strength of an impression material/adhesive system. Int J Prosthodont 1993;6(3):303-306.
10. Bomberg TJ, Goldfogel MH, Hoffman W Jr, Bomberg SE. Considerations for adhesion of impression materials to impression trays. J Prosthet Dent 1988;60(6):681-684.
11. Chai JY, Jameson LM, Moser JB, Hesby RA. Adhesive properties of several impression material systems: Part II. J Prosthet Dent 1991;66(3):287-292.
12. Davis GB, Moser JB, Brinsden GI. The bonding properties of elastomer tray adhesives. J Prosthet Dent 1976;36(3):278–85.
13. Peregrina A, Land MF, Wandling C, Johnston WM. The effect of different adhesives on vinyl polysiloxane bond strength to two tray materials. J Prosthet Dent 2005;94(3):209-213.
14. Cho GC, Donovan TE, Chee WW, White SN. Tensile bond strength of polyvinyl siloxane impressions bonded to a custom tray as a function of drying time: Part I. J Prosthet Dent 1995;73(5):419-423.
15. Leung KC, Chow TW, Woo EC, Clark RK. Effect of adhesive drying time on the bond strength of irreversible hydrocolloid to stainless steel. J Prosthet Dent 1999;81(5):586-590.