



COMPARATIVE EVALUATION OF TENSILE BOND STRENGTH OF THREE DIFFERENT ELASTOMERIC IMPRESSION MATERIALS TO AUTO-POLYMERIZING ACRYLIC RESIN USING MANUFACTURER RECOMMENDED AND TWO UNIVERSAL TRAY ADHESIVES - AN IN-VITRO STUDY

Dental Science

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ABSTRACT

Background and Objectives: This study was conducted to evaluate and compare the tensile bond strength of three commercially available elastomeric impression materials to auto-polymerizing methyl methacrylate resin material, using manufacturer recommended tray adhesive and two different commercially available universal tray adhesives.

Methods: Three different elastomeric impression materials, viz. two addition silicone and one condensation silicone of putty viscosity were used in the study. Three paint on tray adhesives, that is, one manufacturer recommended tray adhesive and two universal tray adhesives were used. A total of 180 flat 10×10×10 mm³ specimens, were made from the auto-polymerizing methyl methacrylate custom tray material. They were divided into 3 groups of 30 each. Each group was further divided into following 3 subgroups of 10 each. A thin layer of tray adhesive was coated and dried. Elastomers were mixed according to manufacturer's instructions and applied between the two acrylic plates maintaining a gap of 2mm. The tensile bond tests were conducted after 24 hours for each specimen at a crosshead speed of 5 mm/min until adhesion failure occurred. The bond strength was calculated as the maximum force at failure divided by the surface area of each plate. The data was first analyzed with ANOVA followed by Post hoc Tukey HSD comparison test.

Results: In present study, for all impression materials tested, results obtained were as follows: TBS for Group 1 ranged from 0.242-1.619; Group 2 ranged from 0.221-1.272 and Group 3 ranged from 0.049-0.827 N/cm². All results were statistically significant with p<0.05.

Conclusions: This study showed that, the use of manufacturer recommended tray adhesive provides significantly higher bond strength values than those obtained with the universal tray adhesive tested.

KEYWORDS

Addition Silicone, Condensation Silicone, Tray Adhesive, Autopolymerizing methyl methacrylate resin, Tensile Bond Strength.

INTRODUCTION

Currently, there is an extensive variety of impression materials available for making accurate impressions of soft and hard tissues.¹ Elastomeric impression materials are among the most popular impression materials used in all aspects of Prosthodontics, widely used for fixed partial and implant supported prosthesis because of their excellent detail reproduction, dimensional accuracy and stability, and elastic recovery.² Even in complete denture Prosthodontics, heavy body putty silicone has been used for border moulding the custom trays in preference over low fusing compound.³

Hence, it is imperative that the impression material adheres to the tray because bonding of the impression to the tray is an important determinant of the accuracy of the impression and the resulting cast and further the definitive prosthesis.⁴ Impression material should be securely attached to the tray by adhesive, retentive holes or locking rims.⁵ In literature, tray adhesives were recommended to be used on all trays, even on those with perforations.⁶

Tray adhesives can be of two types –

- (1) Manufacturer recommended tray adhesives and
- (2) Universal tray adhesives.

Most of the clinicians use adhesives provided with the respective silicone impression material. However, when the adhesive provided by the manufacturer is exhausted, there is a tendency to use universal tray adhesives. However, commercially available universal adhesives are considered inadequate from the viewpoint of retaining the impression material on the tray without a form of mechanical retention such as perforations on the tray surface. Though many of the manufacturers recommend their universal tray adhesive to be used with any brand of vinyl polysiloxane impression material, there are not many studies to support this view.⁷ Furthermore, there are not many studies regarding use of tray adhesive with condensation silicone impression material of either same brand or with universal tray adhesive.

In the light of these facts, this study was planned to investigate the effectiveness of bonding of commercially available addition silicone impression materials of putty and medium consistencies and a condensation silicone of putty consistency to acrylic resin material using manufacturer recommended tray adhesive and two universal tray adhesives.

MATERIAL AND METHODS

Three commercially available polyvinyl siloxane impression materials, two of addition type of medium and putty viscosity and other one of condensation type of putty viscosity were used in this study (Table-1).

TABLE 1 – Types of Impression materials used in the study

Material	Consistency	Brand Name	Manufacturer
Addition Silicone (ASM)	Medium viscosity	Aquasil monophase	Dentsply
Addition Silicone (ASP)	Putty viscosity	Aquasil regular putty	Dentsply
Condensation Silicone (CSP) with activator	Putty viscosity	Precise-D Precise-C	Dentsply

Three types of tray adhesives were used in the study. One of them was manufacturer recommended tray adhesive for each impression material (MRTA) and other two were commercially available universal tray adhesives (UTA - 1 and UTA - 2) (Table-2).

TABLE 2 – Type of tray adhesives used in the study

Material	Mode of application	Brand Name	Manufacturer
Manufacturer recommended tray adhesive (MRTA)	Paint on	Caulk	Dentsply Caulk, Miltord, De
Universal tray adhesive – 1 (GC UTA)	Paint on	GC Universal VPS	GC America Inc, Alsip, IL
Universal tray adhesive – 2 (Coltene UTA)	Paint on	Coltene	Coltene Whaledent

The tray material used was a commercially available auto polymerizing methyl methacrylate resin (DPI-RR Cold Cure, DPI, Bombay Burmah Trading Company Corporation, Mumbai, India).

Test specimens preparation: A total of one hundred and eighty flat, square, resin specimen (Figure - 1) were fabricated from commercially available auto-polymerizing methyl methacrylate resin using a metal mould (10.0×10.0×10.0 mm³) (Figure - 2). The specimens were divided into 3 groups each containing 30 pairs. Each group was further divided into 3 subgroups each containing 10 pairs of specimens.



FIGURE. 1 – Acrylic specimen FIGURE. 2 – Metal Mould

Two acrylic plates were fixed on a linearly movable stage by means of a grip mechanism already present in the UTM (Universal Testing Machine; Figure - 3). Both plates faced each other with a gap of approximately 5 mm between them.



FIGURE. 3 - Universal Testing Machine

A single thin layer of tray adhesive was applied using paint on method on each smooth surface and allowed to air dry for 15 minutes at room temperature ($32^{\circ}\pm 2^{\circ}\text{C}$ and $50^{\circ}\pm 10\%$ relative humidity). The impression material was mixed as manufacturer specifications and loaded into the gap between two plates.

The movable stage was then actuated 10 seconds after loading the impression material until the gap was reduced to 2 mm and the impression material was allowed to polymerize in accordance with manufacturer’s recommendation. Both plates with sandwiched impression material were removed from the stage and the excess impression material overhanging the plate was trimmed off. Specimen were stored at $32^{\circ}\pm 2^{\circ}\text{C}$ and $50^{\circ}\pm 10\%$ relative humidity 24 hours before testing procedure.

Tensile test

After allowing the residual inner strain to be released over a period of 24 hours, the plates were attached to a universal testing machine (Shimadzu, AG-IS). The tensile bond tests were conducted for each specimen at a crosshead speed of 5 mm/min., using a 100 KN load cell until adhesion failure occurred. The bond strength was calculated as the maximum force at failure divided by the surface area of each plate. The data were analyzed statistically using one-way analysis of variance (ANOVA) and Post hoc Tukey HSD for further comparison.

RESULTS

A one way ANOVA revealed significant difference between the three subgroups of Group - 1 i.e., ASM, ASP and CSP with the manufacturer recommended tray adhesive ($p<0.001$, $F=141.094$). Post hoc Tukey HSD comparison shows the tensile bond strength of ASM with MRTA was greater compared to ASP and CSP and statistically significant, while the tensile bond strength of ASP MRTA was greater than CSP but not statistically significant.

A similar pattern was seen when we evaluated and compared the tensile bond strength of three elastomeric impression materials to auto – polymerizing methyl methacrylate tray resin using GC UTA in Group - 2. A one way ANOVA revealed significant difference between the three subgroups of group 2 ($p<0.001$, $F=16.449$). Post hoc Tukey HSD comparison showed the tensile bond strength of ASM with GC UTA was greater and statistically significant with other two impression materials – ASP and CSP, here there was a change in pattern in which the tensile bond strength of CSP with GC UTA was greater than ASP with GC UTA but were not statistically significant.

A slight change in pattern was seen Group - 3 i.e., with Coltene UTA. A one way ANOVA revealed significant difference between the three

subgroups of Group - 3 ($p<0.001$, $F=6.722$). Post hoc Tukey HSD comparison showed the tensile bond strength of ASM with Coltene UTA was greater with other two impression materials and but statistically significant with ASP only. Here also, tensile bond strength of CSP with Coltene UTA was greater than ASP with Coltene UTA but were not statistically significant.

On comparison of all 3 groups, results were statistically significant in which tensile bond strength of all impression materials with MRTA being greater with GC UTA and Coltene UTA respectively ($p<0.001$, $F=6.477$). However, Post hoc Tukey HSD revealed no statistically significant difference with GC UTA. (Table - 3; Figure - 4)

TABLE 3 – Descriptive statistics comparing all groups

Type of Tray adhesives	n	Mean	Std. Deviation	ANOVA		Significant difference from*
				F Ratio	'p' Value	
MRTA	30	0.781	0.464	6.477	0.002	Coltene
GC India	28	0.603	0.361			-
Coltene	30	0.451	0.184			MRTA

Post hoc Tukey HSD



FIGURE. 4- Graphical statistics comparing all groups

DISCUSSION

On comparing ASM with all the 3 tray adhesives, MRTA and ASM combination showed better TBS, while out of two UTA, GC UTA was better and statistically significant. This showed that it is preferable to use MRTA in comparison to any UTA with ASM to achieve good bonding between the tray and impression material which is in accordance to previous studies.^{7,8}

We also observed that when we compared ASP with all tray adhesives, it again showed significantly greater TBS with MRTA compared to GC UTA and Coltene UTA. While, among two universal tray adhesives used, greater TBS was seen with GC UTA, but statistically not significant. Hence it was concluded that among two UTA used, GC UTA was better.

We observed a change in the above pattern in case of CSP where it performed similarly with all three adhesives. Although GC UTA showed overall greater tensile bond strength, it was not statistically significant.

It was also observed that among the two universal tray adhesives used, GC UTA provided greater TBS compared to Coltene UTA across all elastomeric impression material. It was again a significant observation, because GC UTA, which is basically recommended for VPS elastomeric impression materials and not specifically for condensation silicone impression materials, gave better results also with CSP though statistically not significant. Hence, this aspect needs further investigation.⁹

When the two putty materials were compared, we observed that CSP performed better than ASP especially with UTA which are in agreement with results of Chai JY et al.⁹

With regard to mode of failure, in all the groups tested, we observed adhesive failure between the tray adhesive and impression materials. This is in partial agreement with the study by Grant BE et al.¹⁰

Overall, combinations of elastomeric impressions and MRTA showed best results compared to UTA. Out of the two UTA, GC UTA gave constantly better results compared to Coltene UTA. Further investigation of GC UTA is required as it gave better results with CSP for which it was not indicated for use.

The results of the current study should however be considered in the light of a few experimental limitations. For example, the test protocol used in the current study employed flat specimens and did not attempt to mimic the clinical conditions imposed by the lateral walls of an impression tray as well as those by the teeth and alveolar ridges of a severe undercut. Saliva is one of the common contaminant of the adhesive material and this study did not include this influence.

There is also future scope for additional chemical analysis of various elastomeric impression materials and tray adhesive composition which appears necessary to answer some of the questions raised during this study. For example, further research is needed to investigate the effect of the film thickness of tray adhesive on TBS. In addition, further studies should be also conducted in vivo or conditions simulating clinical conditions. The reported data from previous studies showed that bond strengths of the adhesive agents supplied with the various elastomeric materials ranged from 211 kPa to 2129 kPa. Also, forces ranging from 224 N to 514 N were involved in removing impression-filled custom trays from an in vitro simulation model.^{11,12} This force is necessary to remove stiff impression materials such as polyvinyl siloxane from the mouth may be increased in the presence of severe undercuts, the shape of the clinical crown, and the spacing and angulations of teeth. Hence, the ideal amount of bond strength necessary for different viscosity and different types of elastomeric impression material to prevent detachment of the impression from the custom tray has not been quantified. Therefore, there is a need to determine a clinically relevant, ideal TBS value, so that in future, various material combinations can be tested with this value as a bench mark.

CONCLUSION

This in-vitro study was done for the comparative evaluation of tensile bond strength of three different elastomeric impression materials to auto – polymerizing acrylic tray resin using manufacturer recommended and two universal tray adhesives.

Within the limitations of this study, the following conclusions were drawn –

- Amongst the tray adhesives tested, MRTA yielded a higher TBS compared to UTA. This was especially evident with addition silicone of both viscosities. Hence, it is better to use MRTA for addition silicone of any viscosity.
- ASP showed good TBS across all tray adhesives, highest being with MRTA and no significant difference between GC and Coltene UTAs. Hence, if use of a UTA is warranted with ASP, any of the two tested UTA may be used.
- CSP bonds better with UTA in comparison to ASP. So, in clinical situations like for border molding procedure, CSP can be considered to be used in the custom tray by bonding with any UTA.
- Out of two UTA compared, GC UTA gave better TBS with all elastomeric impression materials. Hence, it can be used as an alternative to MRTA in situations where MRTA has been depleted.

Conflict of interest: No conflict of interest

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