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An comparative evaluation of tensile bond strength of polyvinyl siloxane impression material to tray material using three different tray adhesive: An *in vitro* study

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Abstract
Elastomeric impression materials are the materials of choice in Prosthodontics for its better surface detail reproduction. Vinyl polysiloxane cannot give an accurate reproduction of the tissues if there is separation of impression materials from the tray which may results in a distorted impression leading to poor final restorations. Hence, a tray adhesive needs to be applied to the tray to obtain an accurate and consistent impression. The purpose of the study was to evaluate the compatibility of impression materials to acrylic materials using three different tray adhesive, by determining the tensile bond strength. Acrylic samples were fabricated from a metal die which was milled as per specifications of which putty impressions were made to fabricate the acrylic samples. On the finished and polished samples tray adhesives of 3 different brands were applied as per the group divided. The samples prepared were subjected to test for tensile bond strength on a digitalized UTM. The results obtained were statistically analyzed. The highest tensile bond strength was shown by 3M followed by Denstply, and Coltene tray adhesive.

Keywords: Autopolymerising resin, polyvinyl siloxane, tray-adhesive

Introduction
Due to the ease of manipulation, high dimensional accuracy, excellent detail reproduction and multiple pouring of the cast from a single impression vinyl polysiloxane (VPS) impression materials are the material of choice for impression making. In the recent era vinyl polysiloxane (VPS) impression materials are among the most popular non-aqueous elastomeric impression materials used in dentistry [1].

Polyvinyl siloxane impression materials have applications in a variety of indirect procedures carried out in dentistry. Due to favorable handling properties, good acceptance by the patient and excellent physical properties of polyvinylsiloxane have resulted in their popularity [3]. The polyvinyl siloxane impression materials are addition reaction silicone elastomers which were first introduced in the 1970s. Since that time and especially in the past decade, these materials have gained in their popularity and account for a large share of the impression material market. Polyvinyl siloxanes have applications in fixed Prosthodontics, operative dentistry, and removable prosthodontics and implant dentistry [2]. The materials are dispensed in the form of two paste system (a base and an accelerator) which can be hand spatulated or auto dispensed from a dual cartridge along with an automixing gun, and mixed in equal quantities for application. They have achieved a high level of dentist and patient acclimatization as they are clean, odourless and tasteless [4]. The accuracy of an impression material is dependent on the dimensional stability of the same. There are a number of possible causes responsible for dimensional changes in elastomeric impression materials. All rubber polymers do contract slightly during polymerization as a result of reduction in spatial volume as they cross-link during setting of the impression material. If the setting reaction produces a byproduct or if an accelerator component is liberated, then the set volume is further decreased. Some impression materials like the polyethers are less hydrophobic and can absorb and then even lose water if they are placed in wet or varying humid environments [1]. Changes in temperature can also add to varying changes in the final dimensions of the impression material. Polyvinyl siloxanes show the smallest dimensional changes on setting of all the elastomeric impression materials.

The majority of this shrinkage is due to continued polymerization occurring within the first three minutes of removal of the impression from the mouth. Thus, Impression materials must have sufficient strength to allow removal from a gingival sulcus without tearing. Tear energy is the amount of energy required to sustain a tear through a material, and is of great importance in thin intrasulcular or interproximal areas acting as potential undercuts [5]. Elasticity is the inherent property to all the elastomeric impression materials as they are polymers with highly flexible kinked segments that allow freedom of movement. Under a load, the flexible kinked segments of these polymers will uncoil allowing the movement. Upon removal of the load, an ideal elastomer will exhibit complete elastic recovery and return to its prestressed configuration [2]. The degree to which this occurs is a measure of the elastic recovery of the material. Permanent deformation occurs when a polymer is elongated beyond the point where elastic recovery is possible. Permanent deformation is associated to the degree of cross-linking of the polymer strands, temperature, and the rate of stress applied [1]. The ideal impression material should exhibit maximum energy absorption with minimal distortion occurring. However, it is also desirable that the material tears rather than deforms past a critical point such as at the margins. Polyvinyl siloxanes does deform at much slower rates and tears at points of less permanent deformation than do the other elastomeric materials [3]. Polyvinyl siloxanes are frequently reported to be the most ideally elastic impression materials because they exhibit better elastic recovery and less permanent deformation as compared to other elastomers.

However all these properties would be rendered useless if the material detaches from the tray while its retrieval from the oral cavity if it engages in some undercut area. The bond strength of impression material to custom resin tray is very important in the impression of removable prosthesis, and retention of the elastomer rubber impression material to custom resin tray is obtained with use of tray adhesives [3]. Therefore tray adhesive plays an important role in the accuracy of impression. Before adding the elastomer rubber impression material to the custom resin tray, tray adhesives have usually been recommended to be applied not only for the inside of the custom tray but also for surface of border molding materials of the tray border

To encounter this issue and to get the recommended benefit of the impression material various tray adhesives have been introduced to strengthen the bond between tray and impression material which withstand the stresses and prevent the detachment of impression material from the tray during withdrawal from the oral cavity [4]. More accurate and consistent impressions are obtained when adhesives are employed.

The adhesives recommended for silicone impression materials in its composition has poly (dimethylsiloxane) and ethyl silicate where Poly (dimethylsiloxane) adheres to the silicone impression material, whereas ethyl silicate forms hydrated silica that bonds with tray material physically leading to an accurate and consistent impression and preventing the detachment of the impression material from the tray [1].

The use of a custom tray may have a significant effect as well and offers an advantage by providing a uniform thickness of impression material to improve the accuracy of the working cast. Any material used to make custom trays must be dimensionally stable over time and must not permanently deform during the impression making procedure or as the impression is being retrieved from the oral cavity materials should have good tear resistance [2].

The bond between the impression material and the tray is essential and is achieved either by means of mechanical retention or chemical adhesion or both. Mechanical retention is by means of undercuts or perforations on the tray and chemical adhesion is by means of using a tray adhesive.

Before placing the elastomeric rubber impression material on the custom resin tray, tray adhesives have usually been recommended to be applied not only for the inside of the custom tray but also to the surface of border molding materials of the tray border [4].

Material and Methodology

The aim of the study was to evaluate the tensile bond strength of vinyl polysiloxane to tray material (poly methyl methacrylate) using three different tray adhesives (Coltene, 3M, Dentsply).

Fabrication of master die

A stainless steel metal plate having dimensions of 30 mm × 5 mm in dimensions was milled in such a way so as to obtain a disc of dimensions 20 mm × 2 mm. The rest of the metal plate extensions had been utilized to facilitate the grip of the sample while they were subjected for testing.

The stainless steel die was used to prepare a putty mold to make tray specimens. The obtained molds were used to prepare samples. The materials used as tray samples.

Preparation of Test Samples

The two discs samples were and finished and polished for each tray adhesive used. Two strokes of tray adhesive each of Coltene, 3M, and Dentsply were applied on the set of acrylic samples with a brush on each disc and were allowed to dry for their respective recommended time.

Once the two trays were ready, they were loaded with impression material to be tested and were carefully placed in metal box to maintain the even thickness of impression material.

The proportioning of the impression material and mixing process was carried out as per the manufacturer's instruction.

Sample Testing

All the specimens were subjected to testing for tensile bond strength using a digitized Universal Testing machine.

There was a loop attached to the sample. The loop so attached engaged the hook in the universal testing machine the pulled the samples apart for measurement of the tensile bond strength. The metal rod and hook were inserted at the open end of the cylinder, and the impression materials were allowed to polymerize in accordance with manufacturers' recommendations. Each sample 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, and specimens were tested in tensile mode at a cross-head speed of 5 mm/min, using a 2500-kg load cell set at full-scale load until separation failure occurred. The maximum force at which separation failure occurred was divided by the area of adhesion and recorded as the adhesive strength in MPa. The failures were classified as occurring at either the adhesive/impression material interface, the impression adhesive/tray material interface, or as a mixed failure occurring at both interfaces. The digital data so collected was analyzed statistically for results.

The sample size and grouping of the test samples were as follows.

- Sample Size n=45
- Group A-Samples with 3M VPS tray adhesive (15)
- Group B-Samples with Dentsply Caulk tray adhesive (15)
- Group C-Samples with Coltene tray adhesive (15)

Results

The study evaluate tensile bond strength of auto polymerizing tray materials and medium body addition silicone impression material after application of three different tray adhesives on tray materials.

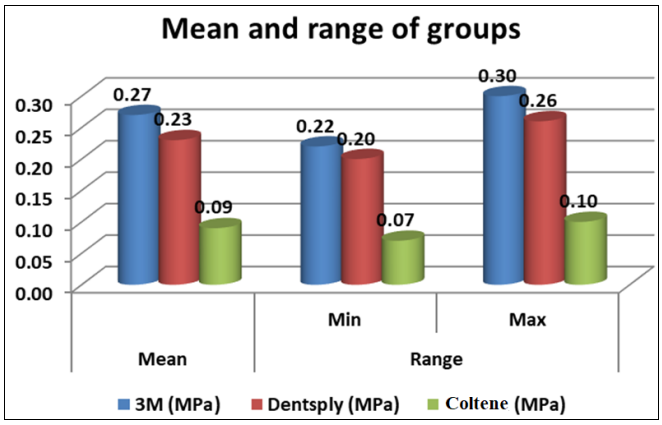
The highest tensile bond strength was shown by 3M followed by Denstply, and Coltene tray adhesive

Table 1: Mean, range and 't'-test value of groups

Group	Mean	Range		±SD	'F' value	'p' value
		Min	Max			
3M (MPa)	0.27	0.22	0.30	0.02	432.5	0.000 HS
Dentsply (MPa)	0.23	0.20	0.26	0.02		
Coltene (MPa)	0.09	0.07	0.10	0.01		

Table 2: 't' values between groups

Group	Mean	Mean	't' value	'p' value
3M (MPa) & Dentsply (MPa)	0.27	0.23	4.56	0.000 HS
3M (MPa) & Coltene (MPa)	0.27	0.09	25.89	0.000 HS
Dentsply (MPa) & Coltene (MPa)	0.23	0.09	30.71	0.000 HS



Graph 1: mean and range of different group

The data so obtained was statistically analyzed using t-test and unpaired t-test for inter and intra group comparisons which showed highly significant results. Thus this inference can be drawn that the highest bond strength was of 3M followed by Dentsply and Coltene.

Discussion

Impressions are an integral part of prosthodontics. Elastomeric impression materials are the impressions materials of choice in dentistry for its excellent properties including better surface detail reproduction. Out of the elastomers available, vinyl polysiloxane represents the state of art impression material in prosthodontics, but even these materials cannot give an accurate reproduction of the tissues if there is disengagement of impression materials from the tray which may results in a distorted impression leading to poor final restorations made from such impressions [7].

Hence, tray adhesives rectify these issues and are to be applied to the tray to obtain an accurate and consistent impression. The purpose of the study was to evaluate the compatibility of three different impression materials to three different tray acrylic materials using tray adhesive, by determining the tensile bond strength [8].

Retention of the impression material to custom tray resin ultimately depends on the ability of the adhesive solvent to resolve tray resin. The high specificity of the tray material and the impression material combination obtained in this study is an important clinical consideration [6].

Recently available adhesive in their composition consist of methyl acetate as a solvent along with that a conjoint monomer that bonds with booth the impression material and the tray material react with the molecular networks in polyvinyl siloxane and to chemically bond with both the elastomeric impression and the acrylic tray materials [9]. These reactive adhesives are purported to provide effective retention of the impression material which does not rely on mechanical retention. If these adhesives provide better impression retention to the tray than that provided by conventional adhesives, a more reliable method of retaining the impression material to the tray can be achieved. A custom tray enhances accuracy by allowing a uniform thickness of impression material [2].

With The use of a custom tray it has a significant effect as well and it offers an advantage by providing a uniform thickness of impression material to improve the accuracy of the working cast. Any material used to make custom trays must be dimensionally stable over time and must not permanently deform during the impression making procedure or as the impression is being retrieved from the oral cavity (materials should have good tear resistance [1].

The application of the adhesives were recommended to be used in all trays, even those with perforations that aid for mechanical retention. Rapid retrieval of impression from the mouth increased the retention between the tray and the impression materials, as did removal in a vertical rather than oblique direction. Also, in general, between the tray and impression material retention decreased with increase in flexibility of the impression materials [10].

The bond between the impression material and the tray is essential which is achieved by the means of mechanical retention or chemical adhesion or both. Mechanical retention is by manifested by the presence of undercuts or perforations on the tray and chemical adhesion is by means of using a tray adhesive which forms a bond with the impression material and with that of the tray material [11].

The study evaluate tensile bond strength of auto polymerizing tray materials and medium body addition silicone impression material after application of three different tray adhesives on tray materials [12].

The highest tensile bond strength was shown by 3M(0.27±0.02) followed by Dentsply (0.23±0.02), and Coltene (0.09±0.01)tray adhesive as per statistical analysis.

Conclusion

From the results of this study, it was suggested that tray adhesives for silicone rubber impression material are effective for impression modeling plastics for border molding within the limits of study to evaluate tensile bond strength of auto polymerizing tray materials and medium body addition silicone impression material after application of three different tray adhesives on tray materials. The highest tensile bond strength was shown by 3M followed by Dentsply, and Coltene tray adhesive.

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