Comparative evaluation of tensile bond strength of addition silicone impression material to different tray materials using different adhesive systems

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Abstract

Introduction: Accurate impressions are of utmost importance for a well fitting prosthesis. Use of custom tray and application of tray adhesives have been shown to provide best accuracy. But, there is a dearth of studies on cohesive and adhesive bond strength of tray adhesive to the light polymerizing and autopolymerising custom tray materials.

Aim & Objectives: Comparative evaluation of the tensile bond strength of addition silicone impression material to different tray materials using different adhesive systems.

Materials & Method: Addition silicone impression material was used along with universal paint on tray adhesive. 20 samples of auto polymerizing tray material were made. In 10 samples adhesive was not applied (AM GROUP 1) and in the remaining 10 samples adhesive was applied (AMC GROUP 2). Similarly, 20 samples of light polymerizing tray material were made. In 10 samples adhesive was not applied (LM GROUP 3) and in remaining 10 samples adhesive was applied (LMC GROUP 4). The samples were placed in Universal Testing Machine to evaluate the tensile strength. The values obtained were tabulated & pair t test statistical analysis was performed to obtain the results.

Results: The mean tensile bond strength was highest in Group 4 Light cure acrylic resin mechanical + chemical [LMC] (0.2694 MPa), followed by Group 2 Auto polymerizing acrylic resin mechanical + chemical [AMC] (0.179 MPa), Group 3 Light cure acrylic resin mechanical [LM] (0.1302 MPa), & lowest in Group 1 Auto polymerizing acrylic resin mechanical [AM] (0.101 MPa) respectively.

Conclusion: Application of tray adhesive increased the tensile bond strength between the tray and addition silicone impression material. Light polymerizing tray material with perforations and adhesive application showed highest tensile bond strength. The use of tray adhesive is highly recommended for making accurate impressions.

Keywords: Tensile Bond Strength, Adhesive Systems, Tray Materials.

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Introduction

Making an accurate impression is one of the most important objective in Prosthodontics. Various factors such as the selection of tray, type of impression material and the technique, mode of retention of impression material in the tray etc. influence the accuracy of an impression.[1]

Several impression materials are available for different clinical situations. In fixed restorations, a precise marginal fit is an important factor for longevity of the prosthesis as well as for the health of surrounding tissues.[1]

Elastomers refer to a group of rubbery polymers which are either chemically or physically cross linked. They can deform under stress within limits and recover from deformation when the applied stress is released. The rheological property of elastomeric impression materials plays a major role in high accuracy of impression.[2,3] Addition silicon impression material is considered to produce more accurate and consistent results than the other types of elastomers.[3] These materials are popular due to their excellent physical properties, handling characteristics, and dimensional stability.[3,4]

The impression techniques used for elastomeric impression are double mix two step impression, double mix single step impression and monophase impression. As per few studies and clinical experiences the two stage putty and wash impression technique is recommended for better accuracy as this allows an enhanced representation of the gingival sulcus and compensates for polymerization shrinkage of putty to a great extent.[1]

Impression can be made either in stock trays or in custom trays. Custom trays are believed to produce more accurate impression as compared to stock trays because they provide a uniform and desired amount of material thickness.[5,6] The materials commonly used for making custom trays are self-cure and light cure acrylic resins. The rigidity of the tray is important to gain full advantage of the physical properties of the impression material.

One of the pre requisites for making an undistorted impression is that the impression material should adhere firmly to the tray either mechanically or chemically or by both and should not come out of the tray while being removed from the mouth.[7]

Mechanical methods for retention of material in the tray include perforations and use of rim lock trays. Proper retention of impression will be affected by size and number of perforation and their location and distribution in the tray. Chemical methods include application of adhesives. The adhesive can be a conventional, universal adhesive or a manufacturer supplied adhesive. If the material pulls away from the tray during removal from the mouth, the completed impression may fail to return to its original shape and dimension, resulting in a distorted die, wax pattern and casting.[7]Therefore, a combination of mechanical and chemical methods have been suggested.

During removal of impression material from the mouth, the bond between the impression material and the tray is highly stressed in both tension (base of trays) & shear (side of trays). Therefore, the tray adhesive must have sufficient cohesive and adhesive strength to resist these stresses.[7,8]This depends on the properties of the adhesive agents and the resin tray material.

Several methods are used for application of tray adhesive and include liquid paint-on method, spray on method and self-stick adhesive system. The conventional or liquid paint-on adhesive method is most commonly used. Each class of elastomeric impression materials has its own specific adhesive for application on impression trays. Failure to adequately apply adhesive material to the tray and not following the manufacturer's directions could compromise the retention of impression material.[9,10,11,12]

In routine practice it has been observed that most of the practitioners do not use tray adhesives and rely on mechanical retention alone, which may compromise the accuracy of impression.[7]

Review of literature reveals that there is a dearth of studies on cohesive and adhesive bond strength of tray adhesive to the light polymerizing and auto-polymerizing custom tray material. Therefore, this study was undertaken to evaluate the tensile bond strength of impression material to different tray materials using different adhesive systems.

It was hypothesized that none of the factors being considered have a bearing on the outcome of this study.

Aim & Objectives

This was an in vitro study which aimed to evaluate the tensile bond strength of impression material to different tray materials with different adhesive systems.
The objectives were:-

1. To compare the tensile bond strength of polyvinyl siloxane impression material with two different tray materials i.e. auto polymerizing resin and light polymerizing resin tray material.
2. To compare the type of bond failure of light polymerizing tray material and auto polymerizing tray material.

Materials and Method

The study was carried in the following manner:

1. Preparation of master die
2. Preparation of test samples
   a. Auto polymerizing acrylic resin tray material.
   b. Light polymerizing acrylic resin tray material.
3. Testing of the samples.

For standardization, a stainless steel assembly was fabricated which had two parts. There was an upper assembly of 3.5X3.5cm and depth of 4mm (Fig. 1) and a lower assembly of 2.5X2.5 cm (Fig. 2). The lower assembly had the vertical wall of 2mm, so that when the sample (custom tray material) which was prepared in this mould, it had 2mm depth to accommodate the impression material. The assembly was so machined, that, when the two parts were assembled together, it provided space to be filled by the tray material and produce a tray of 2 mm thickness and 2 mm border height. Two such trays were required to make one sample that produced 4mm thickness of impression material.

Fig. 1: Mould assembly: upper component

Fig. 2: Mould assembly: lower component

The custom tray resin (DPI, India) was mixed according to the manufacturer's recommendation. After the material reached dough stage, it was packed into the mould and pressed with a lubricated glass slab so that the material flowed inside the mould completely and excess flowed out. A stainless steel hook with threads was pressed in the centre approximately 1mm inside the acrylic resin. Hooks facilitated holding of the sample in universal testing machine for evaluation of bond strength. After polymerization, holes were drilled in all the trays for mechanical retention.20 trays were painted with tray adhesive (Aquasil, Dentsply) and allowed to dry for 10min before making impression. For making impression, two trays were filled with the impression materialand were held undisturbed to allow complete polymerisation of the material which produced one test sample. 10 such samples were prepared for both Group 1 and Group 2.

The visible light cure denture base resin (WP dental, Germany) was packed inside the mould and a hook attached as for auto polymerizing acrylic resin. The assembly was placed inside the VLC polymerization unit and polymerized for 12 min. 40 such trays were placed and stored at room temperature for 24 hours. After polymerization, holes were drilled in all trays for mechanical retention. 20 trays were painted with tray adhesive (Aquasil, Dentsply) (Fig. 3) and allowed to dry for 10 min before making impression. For making an impression, two trays were filled with the impression material and were held undisturbed to allow complete polymerisation of the material which produced one test sample. 10 such samples were prepared for both Group 3 and Group 4 (Table 1).

Fig. 3: Adhesive application on the resin tray material before adding the impression material

Table 1: Study groups

All the test samples were grouped as below:
1. Auto polymerizing acrylic resin mechanical [AM]
2. Auto polymerizing acrylic resin mechanical + chemical [AMC]
3. Light cure acrylic resin mechanical [LM]
4. Light cure acrylic resin mechanical + chemical [LMC]

All specimens (10 of each group) were placed in Universal Testing Machine (Instron) for evaluating tensile bond strength of each group. The test was carried out in tensile mode at a cross head speed of 5mm/min, using a 980N load cell set at full scale load until separation failure occurred(Fig. 4). The maximum force at which separation failure occurred was divided by the area of adhesion and recorded as adhesive strength. The mode of adhesive 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.

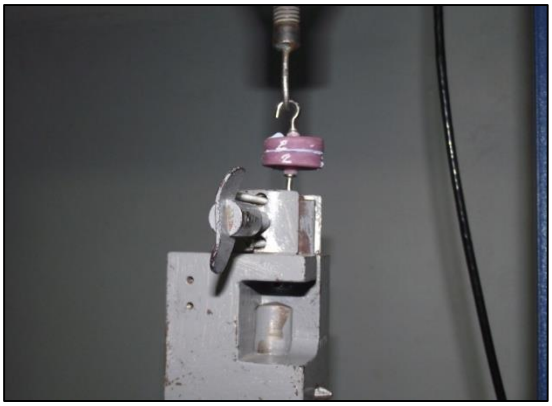
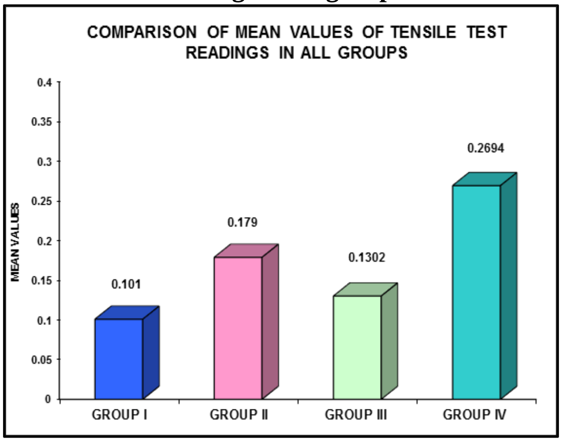


Fig. 4: Testing of samples for bond strength by Universal Testing Machine

Results

The values of the tensile bond strength (Mpa) and mean± SD of all the samples of all the four groups was tabulated (Graph 1). It was observed that the samples with mechanical plus chemical retention showed higher tensile bond strength as compared to mechanical alone. Group 4 showed the maximum bond strength followed by Group 2 and Group 3, whereas, Group 1 had the least bond strength.

Graph 1: Comparison of mean values of tensile test readings in all groups



A comparison of bond strength among the four groups was carried out by means of unpaired-t test (Tables 2-7). The tensile bond strength of auto polymerizing acrylic resin combination retentive system showed significant difference in comparison with the light polymerizing mechanical retentive system.

Table 2: Comparison of mean values of tensile test readings between Group 1 and Group 2

Group I (n=10)	Group II (n=10)	Unpaired 't' test value	'p' value	Result
Mean ± SD	Mean ± SD			
0.101 ± 0.0028	0.179 ± 0.0017	82.22	p<0.01	Highly significant

Table 3: Comparison of mean values of tensile test readings between Group 1 and Group 3

Group I (n=10)	Group III (n=10)	Unpaired 't' test value	'p' value	Result
Mean ± SD	Mean ± SD			
0.101 ± 0.0028	0.1302 ± 0.0018	29.20	p<0.01	Highly significant

Table 4: Comparison of mean values of tensile test readings between Group 1 and Group 4

Group I (n=10)	Group IV (n=10)	Unpaired 't' test value	'p' value	Result
Mean ± SD	Mean ± SD			
0.101 ± 0.0028	0.2694 ± 0.0020	168.14	p<0.01	Highly significant

Table 5: Comparison of mean values of tensile test readings between Group 2 and Group 3

Group II (n=10)	Group III (n=10)	Unpaired 't' test value	'p' value	Result
Mean ± SD	Mean ± SD			
0.179 ± 0.0017	0.1302 ± 0.0018	69.01	p<0.01	Highly significant

Table 6: Comparison of mean values of tensile test readings between Group 2 and Group 4

Group II (n=10)	Group IV (n=10)	Unpaired 't' test value	'p' value	Result
Mean ± SD	Mean ± SD			
0.179 ± 0.0017	0.2694 ± 0.0020	116.72	p<0.01	Highly significant

Table 7: Comparison of mean values of tensile test readings between Group 3 and Group 4

Group III (n=10)	Group IV (n=10)	Unpaired 't' test value	'p' value	Result
Mean ± SD	Mean ± SD			
0.1302 ± 0.0018	0.2694 ± 0.0020	167.34	p<0.01	Highly significant

Discussion

Impressions are indispensable to the practice of dentistry. Accuracy and dimensional stability of the impression are of utmost importance in prosthodontics especially in the field of fixed prosthodontics where the restoration has to be placed on unyielding hard tooth structure. Amongst latest elastomeric impression materials, addition silicone is believed to produce most accurate and dimensionally stable impressions.[11]

In accordance with the study undertaken, the highest tensile bond strength [0.2694MPa] was recorded for the VLC (visible light cure acrylic resin) material (Group 4), that had mechanical perforations and chemical adhesive application. The tensile bond strength achieved with VLC mechanical retention system (Group 3) was considerably less [0.1302 MPa] as compared with the combination group of VLC (Group 4) and auto polymerizing acrylic resin (Group 2). The reason for these results could be attributed to the holes which favor the shear strength than the tensile bond strength so that the combination group of VLC has better tensile strength than the mechanical group alone. The results were also in accordance with the studies referred.[13,14,15,16,17]

The tensile bond strength of auto polymerizing combination group was second best to the VLC combination group [0.17MPa]. The auto polymerizing resin with mechanical retention alone showed the least tensile bond strength [0.1MPa] amongst all the groups. In comparison with the combination retention system and the mechanical system, the light polymerizing acrylic resin had better tensile strength than the auto polymerizing acrylic resin group as the light curing tray shows less polymerization, better dimensional stability and the solvent of the adhesive created more micro porosities in the light cure resin than the auto polymerizing resin.[1] It was postulated that there is a better adherence of polyvinyl siloxane impression material to visible light cure acrylic resin as compared to auto polymerizing acrylic resin tray material.

The results obtained in this study were compared with the other studies by Pujya et al[18], Payne et al [19], Dixon et al[20], which however suggested the bond strength of 0.55-0.97MPa. The difference could possibly be the result of different brands of polyvinyl siloxane impression material in the solvent of impression adhesive.[1] Vinyl polysiloxane compared with studies by Peregrina[19], Grant B[13], Sulongwzs[16], Chee[4]showed similar results (0.20- 0.21).

The tensile bond strength of auto polymerizing acrylic resin combination retentive system showed significant difference in comparison with the light polymerizing mechanical retentive system. The tensile bond strength of light polymerizing combination system showed the maximum strength, followed by auto polymerizing combination system. Light polymerizing mechanical showed third best bond strength, whereas, auto polymerizing acrylic resin, purely mechanical, showed least bond strength.

Conclusion

Light polymerizing acrylic resin trays with a combination of perforations and application of tray adhesive demonstrated the highest tensile bond strength. Auto polymerizing resin trays with perforation alone were least retentive of the impression material.

Application of tray adhesive significantly improves the tensile bond strength of both the tray materials. VLC trays were approximately 30 -50% more retentive than the auto polymerizing acrylic resin. The maximum bond failure with auto polymerizing acrylic resin was of adhesive type occurring at the junction between the tray material and the adhesive. The maximum bond failure with light polymerizing acrylic resin was of cohesive type occurring within the adhesive itself. A perforated custom VLC tray with application of appropriate adhesive is therefore recommended for routine use.

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