

COMPARISON STUDY OF THE SHEAR BOND STRENGTH BETWEEN POLYETHER AND ADDITION SILICONE IMPRESSION MATERIALS

Saad F. Oboudi

Physics Department, College of Science, Baghdad University.

Abstract

The impression material is used mainly in the area of removable partial and complete denture and in the construction of inlays, crowns and bridges. They are used also in dental laboratories for duplicating master casts.

Recent studies have evaluated the bond strength of selected impression materials. This research was performed to study the shear bond strength of impression materials to tray by testing forty samples, each of which consisted of two blocks of acrylic with the impression material sandwiched between them. Tray adhesive was used to increase adhesion between impression material and custom tray. Also this research showed that by the use of perforation impression materials adhere firmly to the impression trays. Therefore perforation - adhesive combination gave acceptable results.

Experimental results indicated that polyether impression material showed higher shear bond strength values to cold-cure acrylic than addition silicone impression material for both control and perforated samples without adhesive application. The shear mean bond strength values of polyether to the tray material after adhesive application were decreased. While, the shear mean bond strength increased significantly when addition silicone was used with the adhesive and with the combination samples.

Keywords: impression material, shear bond strength, adhesive material.

Introduction

The need to make accurate impressions is fundamental to the practice of prosthodontics. This requires the clinician to know which tissues to include in the impression and to consider the impression materials used to record them [1].

Elastomeric impression materials are among the most popular materials used in dentistry. They are required where severe undercuts are present and/or where superior dimensional stability is required for the impression. It is essential that these impression materials adhere firmly to impression trays [2,3]. Many methods have been used to increase the bond strength between the tray and the impression material, such as perforations. Mechanical retention however by using perforations is difficult to achieve at the periphery of the tray and where the handle joins the tray [4,5]. Also these perforations are not so effective in the palatal region where the tray is stressed in tension. Hence to increase the retention in this area and prevent detachment of the material or its distortion during removal it was useful to use chemical

adhesives [6]. Samman and Fletcher found that perforation-adhesive combination gives acceptable results [7].

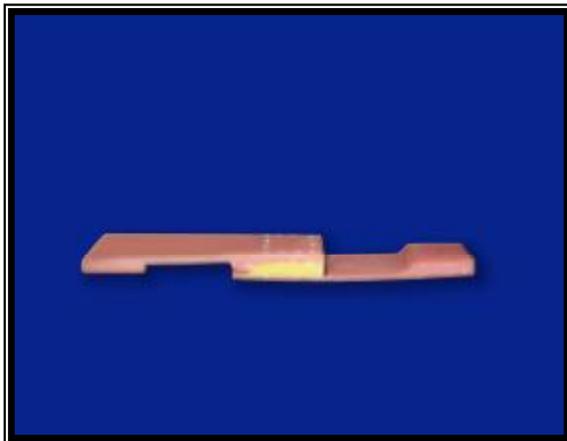
It has also been demonstrated that Adhesion of elastomeric impression materials to the impression trays is an important factor that can affect the accuracy of cast restoration [8]. It is important that the impression materials do not debond from the tray during impression removal to avoid distortion.

[9] Have indicated that bond at the walls of the tray is stressed in shear force, while the palatal region is stressed in tension. Therefore they recommend that the shear bond would be stronger if the walls of the trays were perforated. These perforations however are not so effective in the palatal region where the tray is stressed in tension. Hence to increase the retention in this area and prevent detachment of the material or its distortion during removal it was useful to use chemical adhesives [7].

Experimental Work

The samples were constructed according to the method described by Wang et al. [10]. Rectangles of modeling wax approximately

(3 inch long, 1 inch wide and 0.2 inch thick) were made. The patterns were made with a square transverse handle (50 mm square area and 4mm thickness) to facilitate the sample attachment to the clamps of the testing machine and in order to make the direction of the pulling force parallel to the area tested as shown in Fig.(1). Forty samples were prepared; these samples divided in two groups each one of twenty samples that implicated for testing each impression material. Further subdivisions of the samples in four groups each one with five samples. The first one contained control samples (without adhesive and without perforations). The second group of samples was perforated only to study the effect of perforations on the bond strength. This was accomplished by using number 8 acrylic bur. Perforations were made at the borders of each specimen providing 4 perforations in each side of the square sample and a total of 12 perforations, with a 4-5 mm spacing between one perforation and another [11]. The third group contained samples with adhesive only, the adhesive was applied on the surface of the block before the application of the impression material. This was done by applying two drops of adhesive on each acrylic surface by the use of a medical dropper. Then spreading it evenly onto all the surface area of the blocks, whether were perforated or not, by the use of a clean brush and allow it to dry for 3 minutes according to manufacturer's instructions. The fourth group contained samples with combination of both adhesive and perforation.



(a)



(b)

Fig. (1): (a): Shear plates and the material is sandwiched between them.

(b): Instron machine holding a sample.

The shear bond strength between polyether and addition silicone impression materials and cold cure acrylic resin has been investigated. In this bond the direction of force will be parallel to the surface area tested. Van Noort R. [12] explained this phenomenon by stating that " If two slides held together by an interposing liquid it is difficult to separate them by pulling apart but separation is readily achieved by shearing the two slides apart, as the liquid has no resistance to such shearing action other than its viscosity".

The shear bond strength between acrylic and polyether impression material was superior and significantly higher than that for addition silicone impression material for both control and perforated samples without adhesive application. The shear mean bond strength between acrylic and polyether for control and perforated samples was 110.180 KPa and 127.080 KPa respectively Table (1).

While for addition silicone impression material the shear mean bond strength for both groups was 48.842 KPa and 66.214 KPa respectively. Table (3).

The shear mean bond strength between acrylic and addition silicone impression material after adhesive application for both adhesive and combination (adhesive and perforation) groups was superior to that for polyether adhesive and combination groups.

The application of tray adhesives in general is very important, not only as an aid for the retention of the impression materials to the trays but also to enhance the immediate accuracy and dimensional stability of the impression materials. This was proved by Ciesco et al, when he studied the effect of tray/adhesive systems on five impression materials [13].

The shear mean bond strength between acrylic and polyether for adhesive and combination (adhesive and perforation) samples was 74.176KPa and 93.300KPa respectively Table (1). While for addition silicone the shear mean bond strength for both groups of samples was 102.206KPa and 115.088 KPa respectively.

Table (3) these results agreed with those made by Wang et al. for a single material or for a multilayered material system during mechanical loading of the material [14]. Also Sulong and Derrick, Ellam and Smith indicated that shear bond strength values are less than tensile values[2,15]. This could be attributed to the mode and direction of force application.

One way analysis of variance (ANOVA) test was also performed between the groups and it showed a highly significant difference between the (control, perforation only, adhesive only, adhesive and perforation) samples for both impression materials used .Tables (2, 4). The t-test comparison between polyether and addition silicone shear groups was performed also and there was a highly significant difference between those groups concerning all variables used Table (5).

After shear test application the means of comparisons between all samples of the four groups for polyether and addition silicone including all variables are represented by Fig. (2).

Table (1)
Mean, standard deviation and coefficient of variance between (control, perforation only, adhesive only, adhesive and perforation) variables of polyether.

	Mean.(KPa)	S.D.	C.V. %	Min.(KPa)	Max.(KPa)
Control	110.180	7.108	6.451	100.00	117.70
Perforation only	127.080	11.690	9.198	111.10	142.20
Adhesive only	74.176	7.126	9.606	66.60	84.40
Adhesive and Perforation	93.300	9.555	10.241	80.0	102.20

Table (2)
ANOVA test between (control, perforation only, adhesive only, adhesive and perforation) variables of polyether.

	Sum of squares	D.F	Mean square	F	P-Value
Between groups	7715.602	3	2571.867	31.239	0.000
Within groups	1317.256	16	82.328		
Total	9032.857	19			

H.S: highly significant difference at level $P < 0.01$.

Table (3)
Mean, standard deviation and coefficient of variance between (control, perforation only, adhesive only, adhesive and perforation) variables of addition silicone.

	Mean. (KPa)	S.D.	C.V. %	Min.(KPa)	Max.(KPa)
Control	48.842	5.659	11.586	95.50	108.80
Perforation only	66.214	11.260	17.005	108.80	126.60
Adhesive only	102.206	10.419	10.194	60.00	75.50
Adhesive and Perforation	115.088	7.766	6.747	82.22	91.11

Table (4)
ANOVA test between (control, perforation only, adhesive only, adhesive and perforation) variables of addition silicone.

	Sum of squares	D.F	Mean square	F	P-Value
Between groups	14235.092	3	4745.031	57.921	0.000
Within groups	1310.770	16	81.923		
Total	15545.862	19			

H.S: highly significant difference at level $P < 0.01$.

Table (5)
Comparison between polyether and addition silicone concerning (control, perforation only, adhesive only, adhesive and perforation) variables.

	Mean.(KPa)	S.D.	T test.	P-value.	Sig.
Control Polyether	110.180	7.108	15.095	0.000	H.S.
Control Addition Silicone	48.842	5.659			
Perforation Polyether	127.080	11.690	8.385	0.000	H.S.
Perforation Addition Silicone	66.214	11.260			
Adhesive Polyether	74.176	7.126	-4.965	0.001	H.S.
Adhesive Addition Silicone	102.206	10.419			
Perforation and adhesive Polyether	93.300	9.555	-3.957	0.004	H.S.
Perforation and adhesive Addition Silicone	115.088	7.766			

H.S: highly significant difference at level $P < 0.01$.

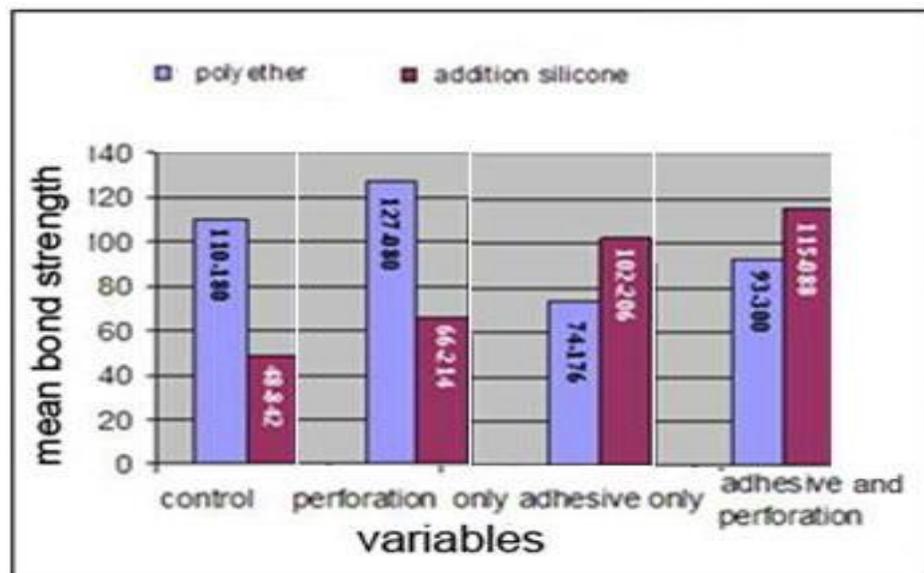


Fig. (2) : Histogram representing the means of comparisons between polyether and addition silicone including (control, perforation only, adhesive only, adhesive and perforation) variables..

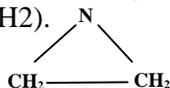
Discussion

In this study the influence of all the variables have been studied practically to find the effect of these variables on the retention of the impression materials to the trays. So each variable will be discussed separately.

Concerning the two types of impression materials that means the polyether and the addition silicone, the shear bond strength between the addition silicone material and the acrylic sample without the application of any adhesive material was significantly lower than that with polyether. Tables (1, 3) this could be related to the following explanations.

Morrison and Boyd Suggested tow reasons for the high bond strength.

The structure of polyether material contains Aziridine ring in its structure. This ring is unstable and usually opens during the setting process to form (N-CH₂-CH₂).



Hence the nitrogen atom in the (N-CH₂-CH₂) structure contains three sites available for binding with other atoms or molecules also the nitrogen atom size is small which makes this bond much easier. In addition both acrylic and polyether impression material contains polar hydrophilic groups (C=O) and non-polar hydrophobic groups (CH₃), and since the interaction between these groups is high, therefore the shear bond strength will be increased accordingly [16].

Van noort in 2002 attributed this to the fact that when two surfaces are in close proximity secondary forces of attraction arise through dipole-dipole interaction between polar molecules [12]. This explains the strong shear bond between polyether as an impression material with the acrylic before adhesive application. Table (1).

In addition Morrison and Boyd explained the low shear bond strength between addition silicone and acrylic resin as the silicone atom in addition silicone structure is bonded from three sites, leaving only one site available for binding with acrylic. Also the size of silicone atom is large which makes this bonding slightly difficult [16].

Furthermore the silicone impression material predominantly contains non-polar

hydrophobic (CH₃) groups and since the acrylic contains both polar hydrophilic and non-polar hydrophobic groups, so only the non-polar groups of both materials will interact with each other making the shear bond slightly weaker. These results agree with Davis et al. who found that the shear bond strength of polyether was greater than that for silicones using custom acrylic trays [17].

The effect of tray perforation while measuring the shear bond strength it was noticed that when these perforations were added the shear bond strength increased between both impression materials i.e. the polyether and the addition silicone and the acrylic samples Tables (1, 3). This apparently is related to the fact that the perforation will serve to lock the impression materials to the surfaces of the acrylic trays. A perforated surface may provide more surface area to be in contact with the impression material. Moreover the excess impression material is forced out of the holes during the process of making impressions, therefore minimizing the displacement of the soft oral tissues [11].

The shear bond strength of polyether decreased after the application of the adhesive Table (1).due to the difference in the composition of the adhesive and the impression material. Application of adhesive may form a layer that will block the interaction between functional groups of both acrylic resin and the impression material, and since the adhesive contains Silicone (Si) in its structure, this makes the adhesive having non-polar hydrophobic groups. While the polyether impression material contains mostly polar hydrophilic groups which are predominant, so no strong interaction will occur between both adhesive and polyether [18].

When addition silicone was used, the bond strength significantly increased after the application of the adhesive material Table (3). This process may be due to the interaction between the non-polar hydrophobic groups (CH₃) present in the structure of both the adhesive and the impression material. Also both adhesive and silicone impression material contain silicone (Si) in their structures, which makes them nearly similar and allow the adhesive solvent dissolve the impression

material, penetrate into it and chemically react with it (Like dissolve like) [18].

Conclusion

For control samples (without adhesive and without perforations) the mean bond strength values were higher for polyether impression material than that of the addition silicone impression material.

The adhesive application significantly decreased the bond strength values for polyether impression materials, while significantly increased the bond strength for addition silicone impression material.

Perforations significantly increased the bond strength values for both impression materials used.

Combination of both adhesive and perforations significantly increased the bond strength for addition silicone impression material, while for polyether impression material using combination gave average bond strength which is less than bond strength values use perforations alone and more than bond strength values using adhesive alone.

This could be explained by the fact that when the adhesive by itself did not work with polyether effectively, the mechanical retention that was gained using the perforations increased the bond with the application of the adhesive giving average bond strength.

References

- [1] Smith P. W., Richmond R., and McCord J. F. : The design and use of special trays in prosthodontics , Guidelines to improve clinical effectiveness. Br Dent J 1999; 187 (8).
- [2] Sulong M. Z., and Setchell D. J. : Properties of the tray adhesive of an addition polymerizing silicone to impression tray materials. J Prosthet Dent 1991; 66 (6): 743-747.
- [3] Flinn R.A and Trojan P.K.: Engineering Materials and their Applications. 4th edition, John Wiley & Sons, New York, 1990. 20.
- [4] Leung K. C., Chow T. W., Woo E. C., and Clarke R. K.: Effect of adhesive drying time on the bond strength of irreversible hydrocolloid to stainless steel. J Prosthet Dent 1999; 81 (5): 586-590.
- [5] Salem N. S., Combe E. C., and Watts D. C.: Mechanical properties of elastomeric impression materials. J Oral Rehabil 1988; 15: 125-132.
- [6] Wilson H. J. and Smith D. C.: Alginate impression materials.Br Dent J 1963; 1:20-26.
- [7] Samman J. M. and Fletcher A. M.: A study of impression tray adhesives. Quint Inter 1985; 4: 305-309.
- [8] Grant B. E., and Tjan A. H.: Tensile and peel bond strengths of tray adhesives. J Prosthet Dent 1988; 59 (2): 165-168.
- [9] Wilson H. J. and Smith D. C.: The bonding of alginate impression materials to impression trays. Br Dent J 1963; 1: 291-295.
- [10] Wang R. R., Nguyen T., and Boyle A. M. the effect of tray material and surface condition on the shear bond strength of impression materials. J Prosthet Dent 1995; 74 (5): 449-454.
- [11] Carr A. B., McGivney G. P., and Brown D. T. : McCrackens' removable partial prosthodontics, 11th edition, The C.V. Mosby Co. St.Louis 2005.
- [12] Van Noort R. : Introduction to dental materials. Principles of adhesion. 2nd edition. Mosby St Louis.2002.
- [13] Ciesco J. N., Malone W. F., Sandrik J. L., and Mazur B. : Comparison of elastomeric impression materials used in fixed prosthodontics . J Prosthet Dent 1981; 45 (1): 89-94.
- [14] Wang R. R., Nguyen T., and Boyle A. M. : the effect of tray material and surface condition on the shear bond strength of impression materials. J Prosthet Dent 1995; 74 (5): 449-454.
- [15] Ellam A. H., and Smith D. C. : The relative effectiveness of adhesives for polysulphide impression materials. Br Dent J 1966; 120 (1): 135-138.
- [16] Morrison R. T., and Boyd R. N. : Study guide to organic chemistry. 6th edition.Longman Co. 1996.
- [17] Davis G. B., Moser J. B., and Brinsden G. I.: The bonding properties of elastomer tray adhesives. J Prosthet Dent 1976; 36 (3): 278-285.

[18] Carey F. A.: Organic chemistry.3rd edition, McGraw-Hill Companies, USA.1996.

الخلاصة

تستعمل مادّة الطبعه بشكل رئيسي عند صناعة طقم الأسنان الجزئي والكامل القابل للفصل (المتحرك) وفي بناء البطانات والتيجان وجسور الاسنان, كما تستعمل أيضاً في مختبرات الأسنان لنسخ القوالب الرئيسية.

لقد أجريت دراسات عديدة لحساب قوة الربط لمواد الطبعه المختارة. في هذا البحث تم دراسة القوة الرابطة للقصّ لمادة الطبعه إلى صينية الطبعه وذلك بفحص أربعون عينة حيث ان كل عينة مكونة من صفيحتين من الاكريل محصورة بينهما مادة الطبعه.

استخدمت مادة لاصقة لزيادة الالتصاق ما بين مادة الطبعه وصينية الطبعه. كما بينت الدراسة أنّ تنقيب صينية الطبعه يؤدي الى زيادة التصاق مادة الطبعه إلى صينية الطبعه. لذلك فان استخدام التنقيب والمادة اللاصقة معا أعطى نتائج مقبولة.

أظهرت النتائج ان قيم القوة الرابطة للقصّ لمادة البولي ايثر مع صفائح الاكريل هي اعلى من القوة الرابطة للقصّ لمادة السيليكون لكل من عينات المقارنة وعينات التنقيب فقط وبدون استخدام المادة اللاصقة. اما بعد استخدام المادة اللاصقة وجدنا ان القوة الرابطة للقصّ لمادة البولي ايثر مع صينية الطبعه اصحت اقل, بينما زادت القوة الرابطة للقصّ بشكل ملحوظ لمادة السيليكون لكل من عينات المادة اللاصقة فقط و عينات المادة اللاصقة والتنقيب معاً.