ORIGINAL RESEARCH

Comparison of Tensile Bond Strength of Elastomeric Impression Material to Different Tray Materials in Different Surface Conditions: An *in vitro* Study

[1]Seema Munjal, [2]Sumit Munjal

ABSTRACT

Optimum bond between elastomeric material and custom tray decides accuracy and success of any prosthesis. Specimens of specific dimensions were made of DPI pink acrylic and MP SAI green tray acrylic resin and subjected to different surface treatments, namely sand papering, sandblasting and grooving; whereas control kept smooth. The 3M VPS adhesive was then applied, allowed to dry and 3M ESPE Express^{TM} material then manipulated and allowed to set. All the study specimens were evaluated on Instron tensile testing machine for bond strength of tray adhesive between (i) elastomeric and different custom tray materials; and (ii) elastomeric and different surface conditions of trays. The sandpapered specimens of DPI acrylic resin were analyzed using ANOVA, one way classification Snedector's 'F' test Newman- Keul test and showed least strength in the range 5.84 to 6.06 kg/cm^2 and sandblasted MP SAI resin specimens showed highest strength in the range 7 to 7.72 kg/cm^2. Also grooved group showed increase in strength compared to control in both materials tested. It was concluded that sandblasting is the best acceptable method and sandpapering should be avoided.

Keywords: Tensile bond strength, Elastomeric impression material, Custom tray materials.

How to cite this article: Munjal S, Munjal S. Comparison of Tensile Bond Strength of Elastomeric Impression Material to Different Tray Materials in Different Surface Conditions: An *in vitro* Study. J Orofac Res 2014;4(1):15-20.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

Among the presently available impression materials, elastomeric impression materials are more common in use especially in Prosthodontic treatment for making final impression. This is due to their added advantage like consistency, permanent deformation, strain in compression, flow, shore hardness, and tear strength. As per the American Dental Association Specification No. 19, the material must be able to reproduce fine details of 25 microns or less.[1] Custom made acrylic trays are generally used to make elastomeric impression.

The main disadvantage of elastomeric impression material is that it does not bond to tray material. So, to achieve a bond, a tray adhesive is applied to the inner surface and to the borders of the tray.[2] It has been noted that when the impression tray is removed from the dental arch tensile forces stress the elastomer/tray interface.[3] To withstand the forces and stresses generated during the removal of set impression from the oral cavity, there must be complete-not partial-not inadequate-adhesion of the impression material to the custom tray; otherwise, the impression material will be pulled away or separated from the tray.[4]

Ciesco JN, Malone WF, Sandrick JL, Mazur B et al[5] found that the immediate accuracy and dimensional stability of five impression materials were improved, when a custom tray applied with tray adhesive was used. Various authors have studied the tensile bond strength of elastomeric impression material to a custom tray material with the help of an adhesive and all recommended adhesive drying time of 15 minutes prior to impression material loading.[6-11]

But, very few authors have studied regarding the effect of tray materials and surface conditions on the bond strength of elastomeric impression material to the tray. Hence, this study was undertaken to test the bond strength of a commercially available polyvinylsiloxane impression material with its tray adhesive to two commercially available custom tray materials in different surface conditions of custom tray.

MATERIALS AND METHODS

Two split metallic master dies were fabricated in the form of key and keyway. Each die consisted of three plates; the upper, the middle and the lower plate. When all the three plates were assembled, a square mould space of 1 inch × 1 inch with a depth of 7 mm in the center of middle plate was formed (Fig. 1). The upper plate consisted of two slit plates which when joined together had a hole in the center to facilitate fixation of aluminium hooks. Further, the keyway

[1,2]Reader

[1]Department of Prosthodontics and Crown and Bridge, Dr BR Ambedkar Institute of Dental Sciences and Hospital, Patna Bihar, India

[2]Department of Periodontics, Institute of Dental Studies and Technologies, Modinagar, Uttar Pradesh, India

Corresponding Author: Sumit Munjal, Reader, Department of Periodontics, C-125, Golf View Apartments, Saket, New Delhi-110017, India, e-mail: ssmunjal@yahoo.co.in

consisted of two projections and a slot and the key consisted of three slots. The key had one projection that snugly fit into the slots of the keyway and other two projections on each plate that contacted the opposite plate to ensure stability.

The next polymer and monomer of DPI pink cold cure and MP SAI green tray acrylic resin was proportioned according to the manufacturer's instruction and was placed in the 1-inch square space of master dies. The upper plate was then closed. The whole assembly along with a specially constructed jig to apply pressure was placed in a hydropress and gradual pressure (30,000 N) was applied for 10 minutes in order to get a uniform surface and the screws of master dies were tightened. After this aluminium hooks were placed through the center hole in the die to later facilitate the attachment of the test specimen to the tensile testing machine. The excess material which came out through the center hole was removed. The cured test specimens were then recovered from the die after 1 hour and the borders were smoothened with the help of a sand paper. The test specimens were then stored in water at room temperature for 24 hours to minimize the distortion (Fig. 2).

Likewise a total of 80 pairs (40 pairs each of DPI pink and MP SAI green tray resin) test specimens were prepared following the same method. Twenty pairs of test specimens were prepared by roughening using a 80 grit sand paper. Twenty pairs were prepared by using a sandblasting machine for 1 minute. Twenty pairs were prepared by making horizontal and vertical grooves. The rest 20 pairs of test specimens were kept smooth as a control group (Figs 3 to 6). The specimens thus made were grouped as follows:

- *Group A*: DPI pink cold cure acrylic resin-smooth.
- *Group B*: DPI pink cold cure acrylic resin-sand papered.
- *Group C*: DPI pink cold cure acrylic resin-sand blasted.
- *Group D*: DPI pink cold cure acrylic resin-grooved.
- *Group E*: MP SAI green tray acrylic resin-smooth.
- *Group F*: MP SAI green tray acrylic resin-sand papered.
- *Group G*: MP SAI green tray acrylic resin-sand blasted.
- *Group H*: MP SAI green tray acrylic resin-grooved.

A single layer of the 3M VPS adhesive was applied on the inner surface of the specimens with a supplied brush and allowed to dry for 15 minutes. A required amount of equal length of 3M ESPE Express^{TM} impression material

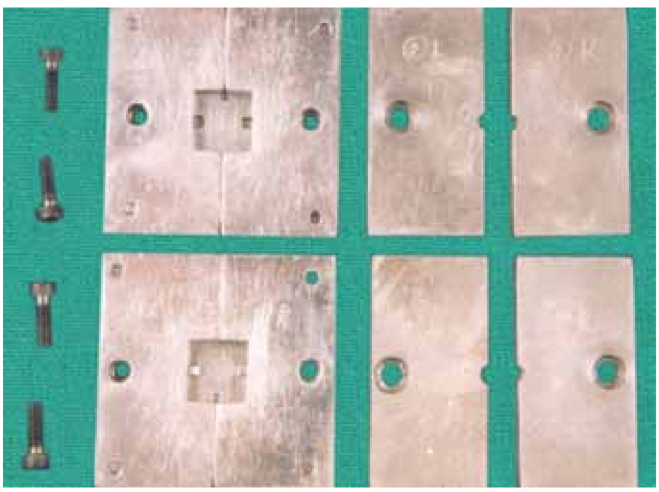


Fig. 1: Master dies used for making specimens

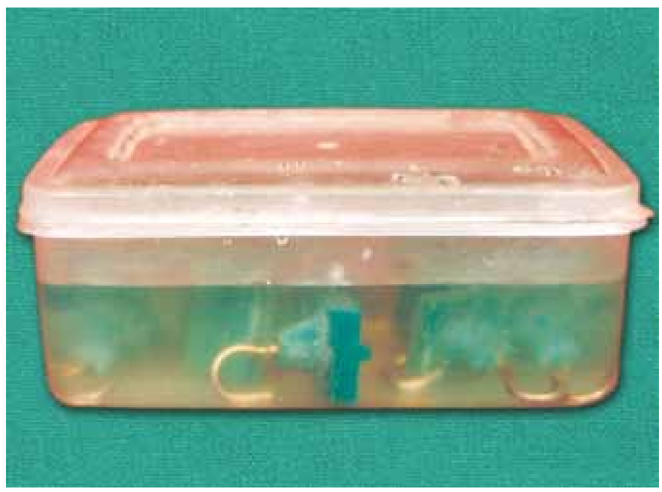


Fig. 2: Specimens stored in water

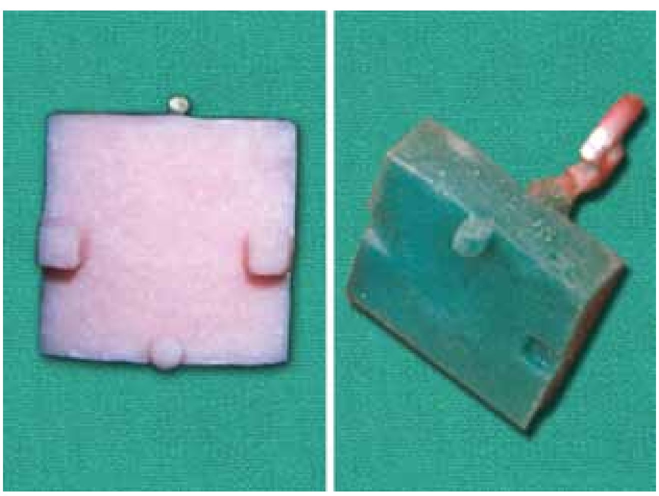


Fig. 3: Specimens in groups A and E

Fig. 4: Specimens in groups B and F

Fig. 5: Specimens in groups C and G

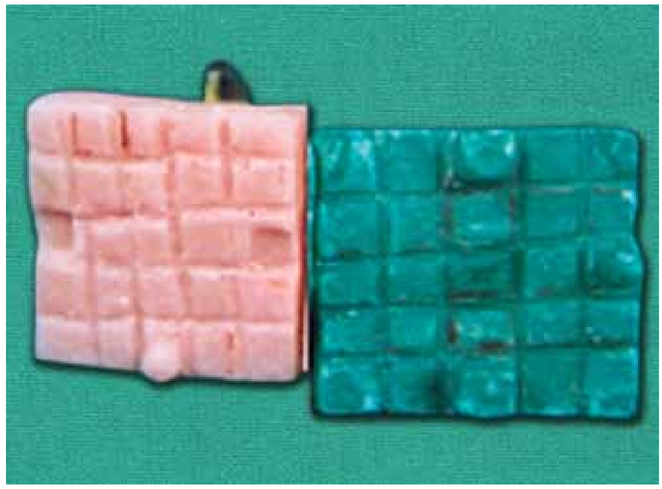


Fig. 6: Specimens in groups D and H

Fig. 7: Specimens tested in Instron machine

was mixed as directed by the manufacturer to obtain a homogenous mix and was placed between the key and the keyway of the specimen. Once the later were centered, the arrangement was held under pressure with the help of elastic bands for 10 minutes allowing the impression material to set followed by the excess removal. For each specimen, fresh elastic bands were used.

The above test specimen with the impression material were mounted in the Instron tensile testing machine [Hounsfield (UK), Textile Department, BIET, Davangere, Karnataka], using the hooks as shown in the (Fig. 7). Once positioned, a load was applied at a cross-head speed of (1 inch/minute) to test the tensile bond strength. The amount of load applied to pull the test specimens apart were noted from the scale in kg/cm^2.

RESULTS

The present study was conducted to test the tensile bond strength of one elastomeric impression material adhesive system to two different types of autopolymerizing trays in four different surface conditions as named smooth, sand papered, sand blasted and grooved.

The standard statistical techniques like analysis of variance (ANOVA), one way classification (SNEDECOR'S 'F' test) and studentized range test (Newman – Keul) were used for the analysis.

Table 1 shows the mean tensile bond strength of elastomeric impression material to two different tray materials in four different surface conditions.

Table 2 shows result of one-way ANOVA. The results obtained shows that the tensile bond strength of test specimens between different groups were highly significant when compared to within group difference ($F = 99.65$, $p < 0.001$).

Table 3 shows the difference in tensile bond strength between different groups using Student-Newman-Keul's Test. This test was used for the simultaneous comparison between different groups.

Graph 1 shows mean tensile bond strength between elastomeric impression material/adhesive system and the two autopolymerizing resins.

Graph 2 shows the mean tensile bond strength of elastomeric impression material/adhesive system to different surface conditions of DPI pink cold cure acrylic resin.

Graph 3 shows the mean tensile bond strength of elastomeric impression material/adhesive system to different surface conditions of MP SAI green tray acrylic resin.

DISCUSSION

The addition polymerizing silicone impression material is the most recent development in rubber elastomers. Not only they are odour free, clean and very easy to mix, but also the working and setting times are quite short. Other advantages include permanent deformation and curing shrinkage are minimal and dimensional stability is excellent.[12] Although stock trays were predominantly used to make impressions, a custom tray with a relief of 2 to 3 mm is recommended for accurate registration of oral structures in that they provide uniform thickness of the impression.[4,13,14] Further, the

Table 1: Polyvinylsiloxane impression material/adhesive system of mean and standard deviation of tensile bond strengths in different subgroups

Subgroups	*Tensile bond strength (kg/cm²)*		
	Mean	*SD*	*Range*
DPI pink cold cure acrylic resin test specimens—smooth (A)	6.21	0.22	5.94-6.54
DPI pink cold cure acrylic resin test specimens—sand papered (B)	5.96	0.09	5.84-6.06
DPI pink cold cure acrylic resin test specimens—sand blasted (C)	7.03	0.12	6.86-7.2
DPI pink cold cure acrylic resin test specimens—grooved (D)	6.32	0.2	6.04-6.66
MP SAI green tray acrylic resin test specimens—smooth (E)	6.58	0.19	6.26-6.88
MP SAI green tray acrylic resin test specimens—sand papered (F)	6.04	0.08	5.92-6.2
MP SAI green tray acrylic resin test specimens—sand blasted (G)	7.46	0.22	7-7.72
MP SAI green tray acrylic resin test specimens—grooved (H)	6.91	0.16	6.64-7.17

Table 2: Comparison of subgroups and within groups 1 and 2

Source of variation	*Sum of squares*	*Degrees of freedom*	*Mean sum of squares*	*F-value (variance ratio)*	*p-level*
Between groups	19.81	7	2.83	99.65	$p < 0.001$
Within groups	2.05	72	0.03		
Total	21.86	79			

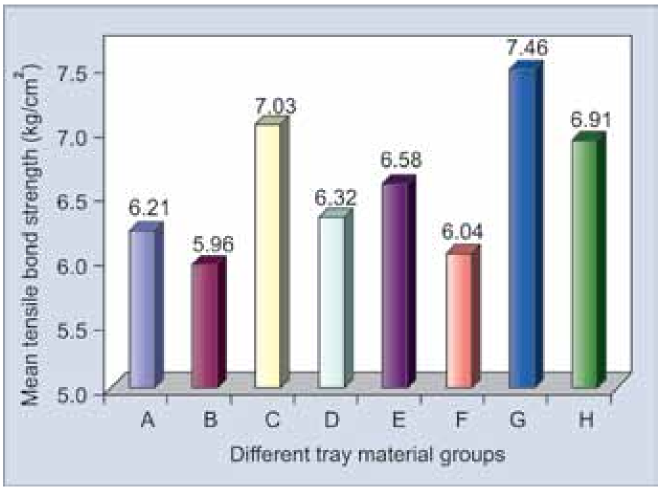
One-way ANOVA; $F = 99.6$, $p < 0.001$, HS: Highly significant

Table 3: Difference in tensile bond strength in different subgroups

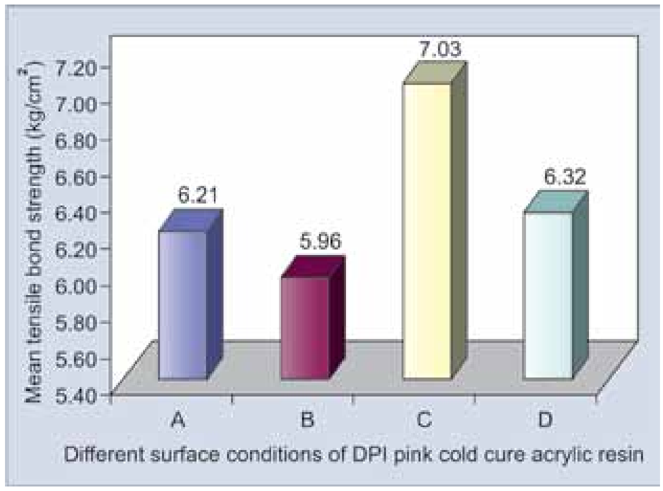
Subgroups compared	*Mean difference*	*Significance*
DPI-smooth—sandpapered	0.25	p < 0.05 (S)
DPI-smooth—sandblasted	0.82	p < 0.01 (S)
DPI-smooth—grooved	0.11	NS
DPI-smooth—MP SAI-smooth	0.37	p < 0.01 (S)
DPI-smooth—MP SAI-sandpapered	– 0.17	NS
DPI-smooth—MP SAI-sandblasted	1.25	p < 0.01 (S)
DPI-smooth—MP SAI-grooved	0.7	p < 0.01 (S)
DPI-sandpapered—sandblasted	1.07	p < 0.01 (S)
DPI-sandpapered—grooved	0.36	p < 0.01 (S)
DPI-sandpapered—MP SAI-smooth	0.62	p < 0.01 (S)
DPI-sandpapered—MP SAI-sandpapered	0.08	NS
DPI-sandpapered—MP SAI-sandblasted	1.5	p < 0.01 (S)
DPI-sandpapered—MP SAI-grooved	0.95	p < 0.01 (S)
DPI-sandblasted—grooved	– 0.71	p < 0.01 (S)
DPI-sandblasted—MP SAI-smooth	– 0.45	p < 0.01 (S)
DPI-sandblasted—MP SAI-sandpapered	– 0.99	p < 0.01 (S)
DPI-sandblasted—MP SAI-sandblasted	0.43	p < 0.01 (S)
DPI-sandblasted—MP SAI-grooved	– 0.12	NS
DPI-grooved—MP SAI-smooth	0.26	p < 0.01 (S)
DPI-grooved—MP SAI-sandpapered	– 0.28	p < 0.05 (S)
DPI-grooved—MP SAI-sandblasted	1.14	p < 0.01 (S)
DPI-grooved—MP SAI-grooved	0.59	p < 0.01 (S)
MP SAI-smooth—sandpapered	– 0.54	p < 0.01 (S)
MP SAI-smooth—sandblasted	0.88	p < 0.01 (S)
MP SAI-smooth—grooved	0.33	p < 0.01 (S)
MP SAI-sandpapered—sandblasted	1.42	p < 0.01 (S)
MP SAI-sandpapered—grooved	0.87	p < 0.01 (S)
MP SAI-sandblasted—grooved	– 0.55	p < 0.01 (S)

*Newman-Keul's range test: $p < 0.05$, $p < 0.01$; S: Significant; NS: Non significant
[least significant difference = 0.24 ($p < 0.05$) = 0.29 ($p < 0.01$)]

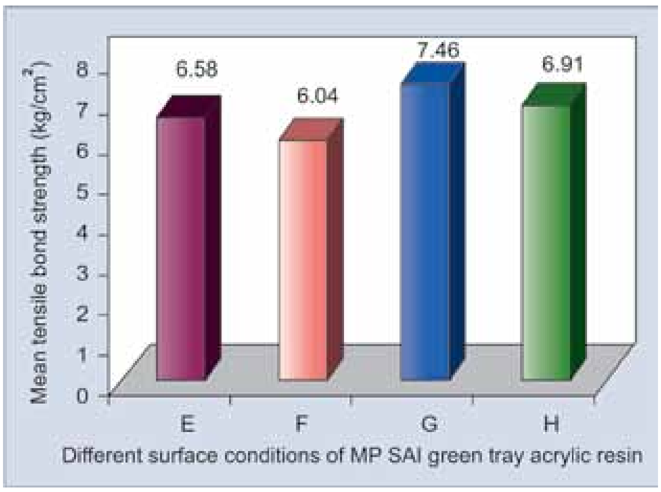
impression making is easier and less obstructive than with the stock tray.[15,16] The main disadvantage of elastomers is that they do not bond to tray material. But the dimensional stability of elastomeric impression material is substantially elevated when they are bonded to an acrylic resin tray. Permanent distortion occurs when the impression material does not adhere to the tray. So, some form of retention of the impression material to the tray is desirable.



Graph 1: Mean tensile bond strength of elastomeric impression material/adhesive system in different groups



Graph 2: Mean tensile bond strength of elastomeric impression material/adhesive system to DPI pink cold cure acrylic resin in different surface conditions of custom tray



Graph 3: Mean tensile bond strength of elastomeric impression material/adhesive system to MP SAI green tray acrylic resin in different surface conditions of custom tray

Several methods[17] of adhesion that involve liquid paint and mechanical means may be used.

They include: (1) Bonding with an adhesive material; (2) Use of perforations; and (3) a combination of these two methods. The conventional or liquid paint-on adhesive method is most commonly used.[18] Some of newer impression materials (polyether and polysiloxanes) set harder than the material used earlier (polysulfide and condensation silicones). This lower flexibility creates more resistance when impression and tray are removed from the mouth over the undercuts.[19,20]

The polysulfide and polyether adhesives provide the highest bond strength of the materials to impression trays. The silicone base impression material, including the condensation reaction and most of the addition reaction materials have lower bonding values to the adhesive material.[17,21] But in another study,[22] the bond strength of addition silicone material/adhesive was significantly higher than that of the polysulfide material/adhesive. The reason, it is said that the tensile forces stress the tray material impression interface.[3] The adhesive must be applied thoroughly and complete drying of the adhesive must be accomplished before making an impression. However, there are other factors which also effect the bond strength of impression material/adhesive system. They are material used for making custom trays and surface condition of custom tray used. Although the strength of various impression material/adhesive systems have been studied and studies have been done on the length of time required to allow the tray adhesive to dry before making an impression but very few studies have been done on the effect of custom tray material and surface condition of custom tray on the bond strength of impression material/adhesive system.

In the present study, two common materials used to prepare custom trays in routine practice DPI pink cold cure acrylic resin and MP SAI green tray acrylic resin were grouped into smooth (control), sand papered, sand blasted and grooved. The highest mean tensile bond strength of polyvinylsiloxane impression material to DPI pink cold cure acrylic resin seen in sand blasted condition was 7.03 kg/cm^2. Whereas the highest mean tensile bond strength of polyvinylsiloxane impression material to MP SAI green tray acrylic resin seen in sand blasted condition was 7.46 kg/cm^2. Polyvinylsiloxane impression material/adhesive system in both of the autopolymerizing resins in sand papered condition showed a minimum mean tensile bond strength of 5.96 kg/cm^2 for DPI pink cold cure acrylic resin and 6.04 kg/cm^2 for MP SAI green tray acrylic resin.

In all the specimens tested, the least value was seen in the sand papered specimen because the use of 80 grit sand paper causes the smoothening of tray surface and so mechanical retention is reduced. This is contradictory to a study by Mohd. Sulong MZ, Setchell DJ[11] which showed an increase in bond strength of acrylic resin specimens made rough with 80 grit silicone carbide paper. They stated that the mechanical roughening of surface increases the surface area. The results were more or less seen in line with the findings by Wang RR, Nguyen T, Boyle AM[23] where the greatest bond strength was seen when the tray surface was abraded with aluminium oxide before the tray adhesive was applied.

Specimens in the grooved condition also showed an increase in tensile bond strength compared to control group because grooves increases the surface area of the test specimens. Similar results were seen in the study by Payne JA, Pereira BP[24] where they found increased adhesion of the impression to resin tray when roughening of the tray with carbide bur was done prior to application of tray adhesive. However, different results were seen in the study by Payne JA, Pereira BP[25] where surface roughness of Hydrotray thermoplastic resin specimens with tungsten carbide bur resulted in significant reduction in bonding strength to monophasic addition impression material. Specimens made with MP SAI green tray acrylic resin showed higher tensile bond strength in comparison to DPI pink cold cure acrylic resin in all the conditions probably because the former has a higher filler content (French chalk).

CONCLUSION

Within the limitations, the following conclusions were drawn from the study.

In all of the surface conditions, tensile bond strength of polyvinylsiloxane impression material/adhesive system showed higher bond strength with MP SAI green tray acrylic resin when compared to DPI pink cold cure acrylic resin.

Polyvinylsiloxane impression material/adhesive system in the surface condition produced after sand papering, showed weakest bond strength to both MP SAI green tray acrylic resin and DPI pink cold cure acrylic resin.

Polyvinylsiloxane impression material/adhesive system in sand blasted condition showed highest bond strength to both MP SAI green tray acrylic resin and DPI pink cold cure acrylic resin.

After making grooves in the test specimen, polyvinylsiloxane impression material/adhesive system showed increase in bond strength compared to controlled or smooth group with both the materials tested.

REFERENCES

1. Helvey GA. Elastomeric Impression Materials: Factors to consider. Comp 2011;32(8):58-59.
2. Asgar K. Elastic impression materials. Dent Clin North Am 1971;15(1):87-93.
3. Wilson HJ, Smith DC. The bonding of alginate impression materials to impression trays. Br Dent J 1963;115(3):291-294.
4. Maruo Y, Nishigawa G, Oka M, Minagi S, Irie M, Suzuki K. Tensile bond strength between custom tray and elastomeric impression material. Dent Mater J 2007;26(3):323-328.
5. Ciesco JN, Malone WF, Sandrick JL, Mazur B. Comparison of elastomeric impression materials used in fixed Prosthodontics. J Prosthet Dent 1981;45(1):89-94.
6. Davis GB, Moser JB, Brinsden GI. The bonding properties of elastomer tray adhesives. J Prosthet Dent 1976;36(3):278-285.
7. Nicholson JW, Porter KH, Dolan T. Strength of Tray Adhesives for Elastomeric Impression Materials. Oper Dent 1985;10(1):12-16.
8. Mac Sween R, Price RB. Peel Bond strength of five impression material tray adhesive. J Can Dent Assoc 1991;57(8):654-657.
9. Chai JY, Jameson LM, Moser JB, Hesby RA. Adhesive properties of several impression material systems: Part I. J Prosthet Dent 1991;66(2):201-209.
10. 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.
11. Mohd Sulong MZ, Setchell DJ. Properties of the tray adhesive of an addition polymerizing silicone to impression tray materials. J Prosthet Dent 1991;66(6):743-747.
12. Anagnostopoulos T, Tsokas K. Elastomeric impression materials. Hell Stomatol Chron 1990;34(2):117-124.
13. Bindra B, Heath JR. Adhesion of elastomeric impression materials to trays. J Oral Rehabil 1997;24(1):63-69.
14. Gordon GE, Johnson GH, Drennon DG. The effect of tray selection on the accuracy of elastomeric impression materials. J Prosthet Dent 1990;63:12-15.
15. Abdullah MA, Talic YF. The effect of custom tray material type and fabrication technique on tensile bond strength of impression material adhesive systems. J Oral Rehabil 2003;30:312-317.
16. Boulton JL, Gage JP, Vincent PF, Basford KE. A laboratory study of dimensional changes for three elastomeric impression materials using custom and stock trays. Aust Dent J 1996;41(6):398-404.
17. Bomberg TJ, Goldfogel MH, Hoffman W, Bomberg SE. Consideration for adhesion of impression materials to impression trays. J Prosthet Dent 1988;60(6):681-684.
18. Ellam AH, Smith DC. The relative effectiveness of adhesives for polysulfide impression materials. Br Dent J 1966;120(2): 135-138.
19. Fehling AW, Hesby RA, Pelleu GB Jr. Dimensional stability of autopolymerizing acrylic resin. J Prosthet Dent 1986;55:592-597.
20. De Araujo PA, Jorgensen KD. Effect of material bulk and undercuts on the accuracy of impression materials. J Prosthet Dent 1985;54(6):791-794.
21. Cullen DR, Sandrik JL. Tensile strength of elastomeric impression materials, adhesive and cohesive bonding. J Prosthet Dent 1989;62(2):142-145.
22. Hogans WR, Agar JR. The bond Strength of elastomer tray adhesives to thermoplastic and acrylic resin tray materials. J Prosthet Dent 1992;67(4):541-543.
23. 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.
24. Payne JA, Pereira BP. Bond strength of three nonaqueous elastomeric impression materials to a light-activated resin tray. Int J Prosthodont 1992;5(1):55-58.
25. Payne JA, Pereira BP. Bond strength of two nonaquous elastomeric impression materials bonded to two thermoplastic resin tray materials. J Prosthet Dent 1995;74(6):563-568.