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# Comparison of Effect of Horizontal and Vertical Retention Grooves on Acrylic Teeth and Denture Base Bond: An In Vitro Study

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## ABSTRACT

**Aim:** The present in vitro study was performed to evaluate the bond strength of acrylic resin teeth with and without retention grooves processed with three different heat cure acrylic denture base materials and also to compare the bond strength of central and lateral incisors to denture base.

**Materials & Method:** A total number of 180 Ivostar teeth comprising of 90 maxillary central incisors and 90 lateral incisors were selected to bonded to three different heat cure denture base resins namely Trevalon, Lucitone 199 high impact, and SR Triplex hot. These teeth were divided into three groups of 60 each. Group A, no surface modifications done. Group B, horizontal grooves 2mm deep and 2mm wide made on ridge lap. Group C, vertical grooves 2mm deep and 2mm wide cut into the ridge lap surfaces of the teeth. A rectangular stainless steel mould of dimensions 8X10X20mm with a $45^0$ taper to the long side was made and used to make the specimens. 10 samples of each of central and lateral incisors of each group were processed with three different heat cure acrylic resins. The specimens were placed on a universal testing machine- Instron. A point force was applied by a steel pin tip of 1.5mm diameter at an angle of $45^0$ to the long axis of the tooth on the palatal surface, until fracture occurred at a crosshead speed of 0.5mm per minute. The fracture load was measured and recorded by a monitor in ($Kg/cm^2$) for all specimens. Values were subjected to ANOVA, Tukey's multiple post hoc procedures and T test.

**Results:** Results revealed statistically significant difference in bond strengths between all the groups. The mean bond strength value with vertical grooves i.e. Group C was 28.05$Kg/cm^2$ as compared to the horizontal grooves i.e. Group B (24.33$Kg/cm^2$) and in control group A(20.26$Kg/cm^2$) in central incisors. And in lateral incisors the mean bond strength values of group A, group B, Group C being 17.49, 21.79, 25.62$Kg/cm^2$ respectively.

**Conclusion:** Within the limitations of the study, the results showed that the bond strength was superior for the teeth with vertical grooves when compared to the horizontal grooves and which was further superior to teeth without any grooves on its ridge lap surface.

**Keywords:** Bond strength, retentive grooves, denture base resins, acrylic teeth.

## INTRODUCTION

The loss of teeth is a psychologically devastating experience to patients whether young or old since they are handicapped both in terms of appearance as well as function, and their replacement by artificial substitutes is vital to normal life. Polymethyl methacrylate (PMMA) has

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Fig 1: Tooth with horizontal groove.

Fig 2: Tooth with vertical groove.

Fig 3: Stainless steel mould.

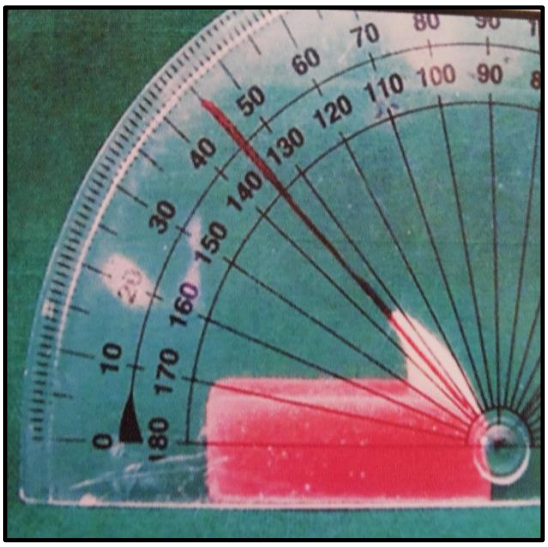


Fig 4: Wax specimen.

Fig 5: A steel tip of 1.5 mm diameter.

Fig 6: Fractured test specimen.

been used in fabrication of dental prosthetic devices for almost 78 years now, since their introduction by Harold Veron in 1937.[1]

Artificial acrylic teeth have long been used in the fabrication of complete dentures. More recently, with the increased use of implant therapy,

**Table 1: Results of one way ANOVA for mean values of bond strength between groups.**

| Materials | Source of variation | Sum of squares | Degrees of freedom | Mean sum of squares | F-value | P-value |
|---|---|---|---|---|---|---|
| Trevalon | Between groups | 227.97 | 2 | 113.99 | 16.9083 | 0.00001* |
| | Within groups | 82.02 | 27 | 6.74 | | |
| | Total | 409.99 | 29 | | | |
| Lucitone 199 | Between groups | 370.66 | 2 | 85.33 | 16.5732 | 0.00001* |
| | Within groups | 301.93 | 27 | 11.18 | | |
| | Total | 672.59 | 29 | | | |
| SR triplex hot (ivoclar) | Between groups | 338.41 | 2 | 169.21 | 28.2915 | 0.00001* |
| | Within groups | 161.48 | 27 | 5.98 | | |
| | Total | 499.90 | 9 | | | |

*p<0.05

**Table 2: Results of one way ANOVA for mean values of bond strength between the materials.**

| Groups | Source of variation | Sum of squares | Degrees of freedom | Mean sum of squares | F-value | P-value |
|---|---|---|---|---|---|---|
| Group A | Between materials | 5.57 | 2 | 2.79 | 0.4609 | 0.6356 |
| | Within materials | 163.17 | 27 | 6.04 | | |
| | Total | 168.74 | 29 | | | |
| Group B | Between materials | 36.23 | 2 | 18.11 | 1.3516 | 0.2758 |
| | Within materials | 361.85 | 27 | 13.40 | | |
| | Total | 398.08 | 29 | | | |
| Group C | Between materials | 8.71 | 2 | 4.35 | 0.9760 | 0.3897 |
| | Within materials | 120.42 | 27 | 4.46 | | |
| | Total | 129.12 | 29 | | | |

**Table 3: Results of t test to compare the force (kg/cm2) required to de bond central and lateral incisor in three materials (Trevalon, Lucitone 199 and SR triplex hot (ivoclar)) in each group**

| Groups | Materials | Central incisor | | Lateral incisor | | t-value | p-value |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | |
| Group A | Trevalon | 20.63 | 2.64 | 17.75 | 2.23 | 2.6314 | 0.0169* |
| | Lucitone 199 | 23.21 | 3.10 | 21.65 | 4.38 | 0.9213 | 0.3691 |
| | SR triplex hot (ivoclar) | 27.32 | 1.90 | 25.66 | 3.81 | 1.2363 | 0.2322 |
| Group B | Trevalon | 19.65 | 2.82 | 17.35 | 1.96 | 2.1190 | 0.0483* |
| | Lucitone 199 | 23.95 | 4.45 | 21.92 | 2.43 | 1.2639 | 0.2224 |
| | SR triplex hot (ivoclar) | 28.26 | 2.41 | 25.65 | 4.72 | 1.5604 | 0.1361 |
| Group C | Trevalon | 20.50 | 1.79 | 17.37 | 2.00 | 3.6857 | 0.0017* |
| | Lucitone 199 | 25.83 | 3.28 | 21.81 | 2.97 | 2.8717 | 0.0101* |
| | SR triplex hot (ivoclar) | 28.59 | 1.99 | 25.57 | 4.41 | 1.9764 | 0.0636 |

*p<0.05

the use of these teeth and resin denture bases has further increased. In implant dentistry, acrylic teeth could be used in either implant-supported or implant tissue–supported dentures. One of the advantages of using resin denture teeth over porcelain denture teeth is resin's ability to chemically bond to denture base resins. Two processes affect the achievement of such a chemical bond. First, the polymerizing denture base resin must come into physical contact with the denture tooth resin. Second, the polymer network of the denture base resin must react chemically with the denture tooth resin polymer to form an interwoven polymer network. Mutual solubility or compatibility of two polymers is essential for the establishment of the interwoven polymer, and thus for the strength of the bond. Foreign materials interfere with the contact between the polymerising denture base resin and the tooth resin, thereby adversely affecting the bond strength.[6]

Repairs, as applied to dentures, can involve 2 modes of failure. (a) Fracture of the base, and (b) teeth debonding. Fracture of the base could be considered a 'fail-safe mechanism' as it may be brought about by natural resorption of the bone with the subsequent introduction of unbalanced forces and flexure in the denture base during function. However, debonding of denture teeth from the denture base is a major problem in prosthodontic practice, involving 22% to 30% of denture repairs particularly in the anterior region of dentures[1,7,8].In addition, as the implant-supported dentures improve the masticatory function, acrylic resin artificial tooth debonding from the denture base may be increased. Tooth detachment from the denture base resins may be attributed to several factors, including the direction of functional forces, the ridge lap area available for bonding with the base resin,[8]contamination of the denture teeth with wax or tin foil substitute ,[9,10,11] ridge lap modification, denture base resin dough stage at the packing time, method of polymerization of the denture base resin, and chemical treatment of the ridge. Contamination with tin foil substitute reduced the bond strength values in some studies[9,10,11] whereas there was no decreases in one study.[12] Several retention systems have been proposed in the literature for denture teeth, such as 1.macromechanical (pins or diatoric undercuts),2 micromechanical (high-energy abrasion),or 3.chemical adhesion methods(silanization).[13] Application of adhesive bonding agents or chemicals like dichloromethane to acrylic teeth have demonstrated an improvement in the bond strength values.[6,14,15]

Modification of the ridge lap area of the acrylic teeth demonstrated an increase in bond strength[6,16,17,18] whereas some other studies showed no obvious advantage.[7,10,12,14,19] Zuckerman concluded that mechanical modification to the acrylic teeth produced a stronger bond with denture base resin. [18] Moreover the ability of denture resins to retain resinous denture teeth also depends on the type of denture resin and the type of teeth and the form of mechanical modification done on the ridge lap surface of teeth. Hence the present study was undertaken to determine the effect of horizontal and vertical retention grooves cut into the ridge lap surface of acrylic resin teeth, on tooth denture base bond.

## MATERIALS & METHOD

A total number of 180 Ivostar teeth comprising of 90 maxillary central incisors and 90 lateral incisors were selected tobe bonded to three different heat cure denture base resins namely Trevalon, Lucitone 199 high impact, and SR Triplex hot. These teeth were divided into three groups of 60 each. Group A, no surface modifications done. Group B, horizontal grooves 2mm deep and 2mm wide made on ridge lap (Fig.1). Group C, vertical grooves 2mm deep and 2mm wide cut into the ridge lap surfaces of the teeth(Fig.2). A rectangular stainless steel mould of dimensions 8X10X20mm (JIST 6506,1989)(fig.3)with a $45^0$ taper to the long side was made and used to make the specimens . Acrylic tooth was placed and wax was melted and poured into stainless steel mould. After hardening wax block was retrieved from the mould(Fig.4)10 samples of each of central and lateral incisors of each group were processed with three different heat cure acrylic resins. The specimens were placed on a universal testing machine (Instron). A point force was applied by a steel pin tip of 1.5mm diameter (Fig.5) at an angle of $45^0$ to the long axis of the tooth on the palatal surface, until fracture occurred at a crosshead speed of 0.5mm per minute. The fracture load was measured and recorded by a monitor in ($Kg/cm^2$) for all specimens. Values were

subjected to one-way ANOVA, and independent samples 't' test.

## RESULTS

In the present study a one-way ANOVA was used to find out the significance of bond strengths between different groups (types of teeth)( Table.1), different types of denture resins ( Table.2), and also among different types of grooves made in the ridge lap surface of each tooth. An independent samples t' test was applied for the comparison of bond strength between central incisor and lateral incisor (Table.3).

## DISCUSSION

A number of studies were conducted to evaluate the effect of mechanical modification on tooth denture base bond, with few studies giving contradictory results like study conducted by cardash in 1896[19] concluded that grooves would not help in increasing the bond strength while again in 1990[16] he concluded that vertical grooves enhanced bond strength. Hugget et al[7] disregarded that grooves would increase the bond strength. Hence the present study was conducted to determine whether retention grooves of various shapes cut into the ridge lap surface of acrylic resin teeth would enhance the bond strength between heat-cured denture base resin and acrylic resin teeth.

The results of the study indicated that central incisor bonded to the denture base resin have greater bond strength compared to lateral incisor. This finding correlates with the findings of Cardash[16] which concludes that the bond between denture teeth and denture base is improved when teeth have large ridge laps, when vertical retention grooves are placed, and when high impact resins are used. In their study they concluded that canine teeth has better bond strength compared to central and lateral incisors.[16]In our study central incisors have greater bond strength to denture base resins compared to lateral incisors since the ridge lap surface area of central incisors is greater than lateral incisors.

This finding is also in favor with the results of the study done by BhupinderKaur et al which concludes that lateral incisors exhibited the least bond strength and canines exhibited the highest.[24]

The result of our study are also based on t test applied which showed that central incisor showed higher bond strength values compared to lateral incisors in all the three groups. Statistically significant bond strength values were obtained in Group A and Group B when Trevalon was used as denture base material, and in Group C significant values were obtained when Trevalon and Lucitone 199 was used. Hence Trevalon showed statistically significant difference in bond strength values between central and lateral incisors in all the three groups and Lucitone 199 showed significance in values between central and lateral incisors when vertical grooves were cut into the ridge lap surfaces i.e. in Group C. Though Ivoclar did not show statistically significant values comparing central and lateral incisors, over all, our study showed that the load required to separate central incisors from the denture base resin is greater when compared to the load required to separate lateral incisors from the denture base resin.

The present study showed that mechanical preparation of teeth with horizontal and vertical grooves increased the bond strength between the teeth and denture base. These results were consistent with a number of studies in literature like study done by Cardash et al(1990)[16],Barpal et al(1998)[14],Vallittu(1995)[17]Luthra et al(2011)[21],Bhupinder Kaur (2013)[24] where they concluded that the use of mechanical retention is a primary means of securing the bond between acrylic resin teeth and heat cured denture base probably because the grooves increased the surface area of ridge lap.Vallittu determined that 2 retention grooves were more effective than a diatoric,and he attributed the better bond strength to greater surface area and better penetration of the acrylic resin to the created irregularities.[17] Furthermore, in our study the central incisor teeth with vertical grooves(Group C) with a mean bond strength value of (27.32 kg/cm$^2$)showed a significant superior bond strength compared to teeth with horizontal grooves cut on their ridge lap surfaces(Group B) with a mean value of (23.21 kg/cm$^2$)than with teeth without grooves (Group A)with a mean value of(20.63 kg/cm$^2$). For lateral incisors the mean bond strength values for Groups A, B, C being 17.75,21.65,25.66 kg/cm$^2$respectively.This result is also consistent with the findings of Cardash et al (1990).[16]This was

claimed because the vertical groove was closer to the point of force application thus providing a short lever arm which required a greater force to separate the tooth from the denture base. Horizontal grooves have higher bond strength when compared to teeth with no surface modifications. It correlates with the study of Luthra et al(2011) which concluded that the horizontal grooves made in the ridge lap area of acrylic resin teeth provided statistically superior bond strength (at 1% probability level) than that provided by acrylic resin teeth without grooves.[21] One way ANOVA was applied to compare the bond strength among the 3 groups in our study and the result showed that all the three denture base materials showed statistically significant difference in bond strength values between the groups, with the Group C(vertical grooves cut onto the ridge lap surface)showing highest bond strength values compared to Group B(horizontal grooves cut onto the ridge lap surfaces) followed by the control Group A. Denture tooth modifications resulted in varied bonding results with different denture base materials used. Since all the denture base materials used are of good impact strength, there is no statistically significant difference in values among the denture base materials. Interestingly, in Group A, Trevalon showed highest mean bond strength values of 20.63kg/cm$^2$ compared to Lucitone199 (19.65kg/cm$^2$) and SR triplex hot (20.50 kg/cm$^2$). Though it is difficult to quote the exact reason,one reason could be the neck of Ivoclar teeth is specially made for good bonding and Trevalon having less impact strength (absence of fibres) when compared to Lucitone 199 and SR triplex hot has less crosslinking agent. Presence of less crosslinking agents increases the bond strength.Hence the bond strength between Trevalon and Ivoclar teeth could be higher when compared to the high impact Lucitone199 and SR triplex hot when no modifications are done on the ridge lap surface. The chemical interaction of the acrylic resin and the ridge lap portion of the denture tooth influences bond strength. Bond strength decreases when high cross linking agents are present.[6,14,40] Yet another reason for low bond strength values of Lucitone 199 compared to Trevalon could be because the dough of lucitone 199 is quite dry, and only poor MMA is available for soaking. Hence bond could be increased further if monomer could be used for surface conditioning of teeth.[40] In our study, mechanical modifications of ridge lap surfaces of denture teeth used resulted in varied bond strength values between Lucitone199 and Ivoclar denture base materials.Lucitone 199 when bonded with the lateral incisors produced higher values compared to bond strength of lateral incisors with Ivoclar denture base materials though the values are statistically insignificant.But when bond strength of central incisors was compared after the ridge lap modifications that is in Group B and Group C, between Ivoclar and Lucitone199 ,bond strength values of Ivoclar denture base material to Ivoclar teeth was greater. This is in accordance with the results of Donna Barpal et al which concluded that denture tooth modifications resulted in a greater range of bond strength values with Ivocap than with Lucitone resin[14]. On the whole all the 3 denture base materials gave sufficient bond strength values with an edge to Trevalon in control group,Lucitone 199 when bonded with lateral incisors in Group B and C and Ivoclar denture base materials when bonded with central incisors in Groups B and C.

## CONCLUSION

Within the limitations of this in vitro study the following conclusions were drawn:

1. The mean bond strength of heat cure denture base to central incisor teeth was greater when compared to the mean bond strength of denture base to lateral incisor teeth whether no retention grooves were made or when horizontal or vertical retention grooves were made.

2. The teeth with vertical grooves showed significantly superior bond strength than the teeth with horizontal grooves on their ridge lap surface which was further superior to teeth without any grooves on its ridge lap surface.

3. Trevalon heat cure denture base material showed the highest bond strength values to both central and lateral incisors in control group. Lucitone 199 high impact denture base material showed high bond strength values than SR Triplex hot and Trevalon heat cure denture base materials when bonded to lateral incisors with horizontal and vertical grooves made on their ridge lap surface.SR Triplex hot heat cure denture base material showed high bond strength values when bonded to central incisors with grooves made on their ridge lap surface.

However ,there was no statistically significant difference in the mean bond strengths between the three denture base materials.

## Clinical significance

Clinical significance: Restoration of partially or completely edentulous arches with partial or complete dentures is common in the elderly group of population. Debonding of acrylic teeth from denture base remains a major problem, which may be frustrating to the patients as well as the dentist. So, selection of more compatible combinations of acrylic teeth and denture base resins may reduce the number of prosthesis fractures and repairs.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

## REFERENCES

1. S.B.Patil,Naveen. Bonding acrylic teeth to acrylic resin denture bases: A review. Gerodontol 2006; 23:131-139.
2. Yutaka Takahashi. Bond Strength of Denture Teeth to Denture Base Resins. Int J Prosthodont 2000; 13:59–65.
3. Huggett R, John G, Jagger RG, Bates JF. Strength of the acrylic denture base tooth bond. Br. Dent. J. 1982; 153: 187-191.
4. Deboro Barros Barbosa,Douglas Roberto Monteiro et al.Effect of monomer treatment and polymerization methods on the bond strength of resin teeth to denture base materials.Gerodontol 2009;26:225-231.
5. Schoonover IC, Fischer TE, Serio AF, Sweeney WT. Bonding of plastic teeth to heat cured denture base resins. J Am Dent Assoc 1952; 44: 285-287.
6. Morrow RM, Matvias FM, Windeler AS, Fuchs RJ. Bonding of plastic teeth to two heat curing denture base resins. J Prosthet Dent 1978; 39: 565-568.
7. CatterlinRK,Plummer KD,Gulley ME. Effect of tin foil substitute contamination on adhesion of resin denture tooth to its denture base.JProsthet Dent 1993;69:57-59.
8. Spratley MH. An investigation of adhesion of acrylic resin teeth to dentures. J.ProsthetDent. 1987; 58: 389-392.
9. GuilhermeSaavedra .Bond strength of acrylic teeth to denture base resin after various surface conditioning methods before and after thermocycling.Int J Prosthodont 2007;20:199-121.
10. Barpal D, Curtis DA, Finzen F, Perry J, Gansky. Failure load of acrylic resin denture teeth bonded to high impact acrylic resins. J Prosthet Dent 1998; 80:666-671.
11. J.L Cunningham.An investigation of the variables which may affect the bond between plastic teeth and denture base resin. J Dent 1999;27:129-135.
12. Harold S. Cardash. Effect of retention grooves on tooth-denture base bond. J.ProsthetDent. 1990;64:492-496.
13. Vallittu PK, Ruyter IE. The swelling phenomenon of acrylic resin polymer teeth at the interface with denture base polymers. J Prosthet Dent 1997; 78: 194–199.
14. Gabriel R. Zuckerman. A reliable method for securing anterior denture teeth in denture bases. J Prosthet Dent 2003;89:603-7
15. Cardash HS, Liberman Reticular, Helft M. The effect of retention grooves acrylic resin teeth on tooth denture base bond. J Prosthet Dent 1986; 55: 526-528.
16. BhupinderKauretal.Influence of retention grooves in acrylic resin teeth on tooth – denture base bond strength.IJDS 2013; 5(2):32-35.
17. Luthra RP, Renu Gupta, DivyVashisht, Naveen Sharma, Ranjan Gupta. Effect of horizontal grooves on tooth denture base. JIDS 2011 ;2(3):17-19.
18. Reinhold Lang etal.Bond of acrylic teeth to different denture baase resins after various surface conditioning methods.Clin Oral Invest 2012;16:319-323.