Effect Of Joint Surface Treatment On The Flexural Strength Of Repaired Auto-Polymerized Acrylic Resin.

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Citation

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Abstract

Objective: Repair of acrylic part of removable orthodontic appliance involves, joining two parts of fractured appliance with acrylic. The study was designed to evaluate the effect of joint surface treatment on the flexural strength of repaired auto-polymerized acrylic resin. Materials and Methods: 100 rectangular specimens were fabricated of clear auto-polymerized acrylic resin. Specimens were divided into five groups (n=20) coded A to E. The Group A was intact specimens, used as a control. Other specimens were sectioned in the middle to simulate fracture. Group B had no joint surface treatment. In the remaining three groups, joint surface was treated with abrasive air blasting, methymethacrylate and acetone respectively. Specimens were repaired with pink auto-polymerized acrylic resin. The flexural strength of the specimens was measured using a three - point bending test. The data was statistically analyzed using student's t-test at p<.05. Results: Statistically significant differences were found between the control and all repair groups. Within Repair groups, there were statistically significant differences between untreated joint surface group and joint surface treated groups. There was no statistically significant difference among joint surface treated groups. Conclusion: Mechanical joint surface treatment by abrasive air blasting or application of methylmethacrylate or acetone resulted in a significant improvement in the flexural strength of repaired auto-polymerized acrylic resin. However none of the repair method used in this study could produce comparable flexural strength, as of intact auto-polymerized acrylic resin.

INTRODUCTION

Removable orthodontic appliances, if used in properly selected cases, still can be very useful devices and the treatment outcome can be satisfactory.[1] At present removable appliances are indicated primarily for Thumb deterrent, tipping teeth, block movements, overbite reduction, space maintenance and retention after comprehensive treatment.[2] For manufacturing the acrylic base of removable orthodontic appliances, poly-methylmethacrylate resin (PMMA) is the most commonly material used. Although there are thermo-polymerized and photo-polymerized acrylic resins, auto-polymerized acrylic resin remain the most popular material for use in orthodontics because of their low cost and ease of use.[3]

Fracture of acrylic base of removable appliances is a common clinical problem. Acrylic base plate and bite planes fracture more frequently than wire element.[4] Success of repairs relies on the phenomenon of adhesion at the repair site.[5] Good bond should exist between the repair material and broken surface to be joined. Chemical or mechanical treatment changes the morphology or surface chemistry of acrylic resin material to promote better adhesion.[6]

Various studies have investigated the repair of thermo-polymerized acrylic denture. However there is limited research investigating the repair of auto-polymerized acrylic base. Objective of the study was to evaluate the effect of joint surface treatment (mechanical treatment with abrasive air blasting, chemical treatment with methymethacrylate or acetone) on the flexural strength of repaired auto-polymerized acrylic resin, and to determine the nature of fracture of repaired specimens as adhesive, cohesive or mixed.

MATERIALS AND METHODS

A total of 100 rectangular specimens measuring 64 mm in length, 10 mm in breadth, and 3.3 mm in thickness were fabricated of clear auto-polymerized acrylic resin (Dental Product India, Mumbai, India) with the sprinkle on technique using a stainless steel mould as per ISO/FDI 1567 standards.[7] All specimens were polymerized at 40° C, for 20 minutes, pressure of 2.2 bars. The surface of the beam was finished with 600-grit silicon carbide abrasive paper to remove surface irregularities. The accuracy of the dimensions was verified with a digital vernier caliper, at three locations of each dimension to within 0.2 mm tolerance. To simulate fracture, 80 specimens were sectioned in the middle using a double sided diamond disk. The cut end of each specimen was ground to 45° bevel joint with 600 grit silicon carbide abrasive paper. Specimens were then ultrasonically cleaned with distilled water and dried with compressed air.

All samples were divided into five groups of 20 samples each: (A) Intact auto-polymerized acrylic resin specimens, used as a control, (B) specimens repaired without joint surface treatment, (C) specimens repaired after joint surfaces were treated by abrasive air blasting with 50µ aluminum oxide particles at a pressure of 0.5 MPa for 5 seconds using sandblaster (Danville Engineering Inc, Danville, California, USA), (D) Specimens repaired after joint surfaces were immersed with methylmethacrylate for 180 seconds, (E) Specimens repaired after joint surfaces were immersed with acetone for 30 seconds. The repair method with auto-polymerized resin was as follows: after the joint surface treatment, the specimens were ultrasonically cleaned with distilled water and dried with compressed air. The halves were placed back into the stainless steel mould. Specimens were repaired with pink auto-polymerized acrylic resin using sprinkle on technique. All specimens were polymerized at 40° C, for 20 minutes, pressure of 2.2 bars. Prior to mechanical testing, specimens were stored in water at 37 ° C for 7 days.

The transverse strength was measured using a three-point bending test in a universal testing machine with a 100 kg load cell and crosshead speed of 5 mm/min. The transverse strength was determined using the formula: $S = 3WL/ 2bd^2$. Where W is the fracture load, L is the distance between support (50mm), b is the width and d is the thickness of the specimens.

The fractured specimens were examined to determine whether the fracture was adhesive (interface), cohesive (only at repair material) or mixed (interface and at repair material). Layer of pink auto-polymerized resin on repair surfaces of specimen was inferred as cohesive failure.

The obtained data was tabulated and statistically analyzed using student's t-test at $p<0.05$.

RESULTS

The mean flexural strength values and SDs of the groups are presented in Table 1. The statistical comparisons are presented in Table 2. The type and frequency of failures are presented in Table 3.

Figure 1

Table 1. The mean flexural strength values in MPa.

Groups	Mean	Standard Deviation
Intact	68.69	4.081
Untreated	29.53	9.084
Abrasive air blasting	51.45	5.247
Methylmethacrylate	49.18	6.346
Acetone	48.60	7.126

Figure 2

Table 2. The statistical comparisons of mean flexural strength using student's t-test

Groups	Intact	Untreated	Abrasive air blasting	Methylmethacrylate	Acetone
Intact	-	0.000*	0.000*	0.000*	0.000*
Untreated	-	-	0.000*	0.000*	0.000*
Abrasive air blasting	-	-	-	0.225	0.158
Methylmethacrylate	-	-	-	-	0.787
Acetone	-	-	-	-	-

* - Significant ($p<0.05$); 20 samples in each group.

Figure 3

Table 3. Type of failure.

Type of Failure	Untreated	Abrasive air blasting	Methylmethacrylate	Acetone
Adhesive	14	-	1	2
Cohesive	-	12	11	10
Mixed	3	8	8	9

The mean flexural strength for control group (Intact) was found to be highest. Within repair groups, joint surface treated with abrasive air blasting produced highest flexural strength, followed by methylmethacrylate joint surface treated group and acetone joint surface treated group. The untreated joint surface group recorded lowest mean flexural strength.

There were statistically significant differences between the intact and all repair groups. Within Repair groups, there were statistically significant differences between untreated joint surface group and joint surface treated groups. There was no statistically significant difference among joint surface treated groups.

The mode of failure in joint surface treatment samples is observed to be cohesive or mixed; whereas in the untreated group, adhesive type of fracture was noticed.

DISCUSSION

Fracture of acrylic base of removable appliances is a common clinical problem. Repair will require the appliance to be reseated onto the working model, after the model has been treated with a mould seal. The area adjacent to the break should be cut and roughened so that additional acrylic may be added before curing and finishing.[8] The choice of the most durable and strongest repair method is of clinical importance to eliminate further appliance fracture and aspiration or ingestion of its fragments.

It is generally accepted that repair strength can be improved by roughening of the joint surface. Such treatment is reported to be a standard method to enhance bonding and also to create increased surface area to enhance van der Waals forces of attraction.[9] Adhesion between the fractured surface and the repair material can be promoted by treating the repair surfaces such as roughening or wetting with some chemicals.[10]

The present study investigated the effect of joint surface treatment on the flexural strength of repaired auto-polymerized acrylic resin. Many studies have investigated the repair of thermo-polymerized acrylic denture. No study has examined the flexural properties of auto-polymerized acrylic resin base repaired with the same resin.

The mean flexural strength in all repair groups was significantly lower than intact group. It is obvious that one of the criteria for a successful repair i.e. restoration of the original strength, cannot always be achieved.

Mechanical joint surface treatment by abrasive air blasting significantly improved the flexural strength of repaired auto-polymerized acrylic resin when compared with untreated samples. This finding is in agreement with a study by Minami et al.[11] They reported a significant increase in bond strength between the sandblasted thermo-polymerized denture base resin and an auto-polymerized resin. Memarian et al. [12] reported abrasive air blasting produce scratches and depressions on the surface, results in improvement in the shear bond strength of base material.

Chemicals such as methylmethacrylate,[13, 14] chloroform,[14, 15] methylene chloride,[6, 16, 17] and acetone [6, 14, 15, 18, 19] have also used to increase strength of a repair material to the denture base. Chloroform and methylene chloride are toxic and potentially carcinogenic agent,[20] for this reason we investigated only methymethacrylate and acetone.

The present study revealed that the joint surface treatment with methylmethacrylate significantly improved the flexural strength of repaired auto-polymerized acrylic resin when compared with untreated samples. Penetration of monomer into acrylic base theoretically improves the bonding by their participation in polymerization and by dissolving the acrylic base.[21] Vallittu et al.[22] stated that 180 sec of wetting of poly-methylmethacrylate with methymethacrylate enhanced adhesion, compared with shorter duration of wetting. On the contrary, Shen et al.[9] reported that monomer is not a powerful solvent for poly-methylmethacrylate and would therefore not remove the debris efficiently. The base material used in their study was thermo-polymerized acrylic resin. In our study we used auto-polymerized acrylic base. The reactivity ratio of the thermo polymerized and auto-polymerized acrylic might be different.

Joint surface treatment with acetone significantly improved the flexural strength of repaired auto-polymerized acrylic resin when compared with untreated samples. Acetone could dissolve the polymer, thus promoting mechanical interlocking associated with monomer penetration and polymerization along the repair material.[23] There is no comprehensive evaluation of optimum timing for acetone application as a wetting agent and therefore, further research should be focused on most effective application instruction.

The mode of failure in joint surface treatment samples is observed to be cohesive or mixed, suggesting tight adhesion of the repair joint; whereas in the untreated group, adhesive type of fracture was noticed.

In the present study, the repair joint design was 45° bevel. According to the result of Ward et al. the strength of repairs made with round and 45° bevel joint contour were similar and significantly greater than those with a butt joint design.[24]

Finally, it must be noted that in vitro studies are limited in predicting the success of a material or technique in clinical use. The use of a simple rectangular shaped specimen rather than a complex orthodontic appliance, as well as the absence of longer periods of water storage or thermal cycling, are limitations of the present study.

CONCLUSION

Mechanical joint surface treatment by abrasive air blasting or application of methylmethacrylate or acetone resulted in a significant improvement in the flexural strength of repaired auto-polymerized acrylic resin. However none of the repair method used in this study could produce comparable flexural strength, as of intact auto-polymerized acrylic resin.

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