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ORIGINAL RESEARCH

Effect of Chemical Disinfectant on the Transverse Strength of Heat-polymerized Acrylic Resins Subjected to Mechanical and Chemical Polishing: An *in vitro* Study

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ABSTRACT

Aims: To evaluate the effect of chemical disinfectant on the transverse strength of heat-polymerized acrylic resins subjected to mechanical and chemical polishing.

Materials and methods: A total of 256 rectangular specimens (65 × 10 × 3 mm) 128 per resin (Lucitone-199 and Acralyn-H) were fabricated. One side of each specimen was not polished and the other was either mechanically (n = 96) or chemically (n = 96) polished and immersed for 10, 30 and 60 minutes in 2% alkaline glutaraldehyde. Mechanically polished (n = 32) and chemically polished (n = 32) control specimens were immersed only in distilled water. The transverse strength (N/mm^2) was tested for failure in a universal testing machine, at a crosshead speed of 5 mm/min. Data were statistically analyzed using 2-way ANOVA and Student t-test.

Results: chemical polishing resulted in significantly lower transverse strength values than mechanical polishing. Lucitone-199 resin demonstrated the highest overall transverse strength for the materials tested. Heat-polymerized acrylic resins either mechanically or chemically polished, did not demonstrate significant changes in transverse strength during immersion in the disinfecting solution tested, regardless of time of immersion.

Conclusion: Lucitone-199 resin demonstrated the highest overall transverse strength for the materials tested and significantly stronger than Acralyn-H with either type of polishing following immersion in 2% alkaline glutaraldehyde.

Clinical significance: There is a concern that immersion in chemical solutions often used for cleansing and disinfection of prostheses may undermine the strength and structure of denture base resins. In this study it was observed that, the transverse strength of samples of Lucitone-199 was higher than that of the samples of Acralyn-H. The chances of fracture of the denture made of Lucitone-199 are less than that of dentures made of Acralyn-H. The chemically polished dentures may be more prone to fracture than mechanically polished dentures.

Keywords: Heat-polymerized acrylic resins, Chemical disinfection, Mechanical polishing, Chemical polishing.

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INTRODUCTION

The introduction of acrylic resin as a denture base material in 1937 by Dr Walter Wright, revolutionized the discipline of dental prosthetics to a great extent. The acrylic resin has maintained its superiority over the other denture base materials in meeting the requirements of an ideal denture base material. Poly resins are resilient plastics formed by joining multiple methyl methacrylate molecules. Pure poly (methyl methacrylate) is a colorless, transparent solid. Resins have been used not only for denture base, but also for artificial teeth, veneers, crowns, temporary bridges, splints, orthodontic appliances, mouth protectors as well as for repair, relining and rebasing of dentures with excellent results.

Risk of exposure to harmful microorganisms in dental practice is multitude. To eliminate cross-contamination, all prostheses and dental appliances should be properly disinfected in both the dental office and laboratory before being delivered.

Commonly used chemical agents for disinfection of prostheses are chlorine, iodophors and aldehyde compounds. Several studies have emphasized the fact that, while disinfecting there can be decrease in transverse strength, hardness and degradation of surface appearance of the resins.

Polishing may be done either by the conventional mechanical procedures including the use of abrasive pastes with rotating felt cones and rag wheels or by chemical

procedures consisting of immersion in a monomer-based polishing fluid. Chemical polishing produces a coating on the resin that imparts smooth shiny surface to the prosthesis.

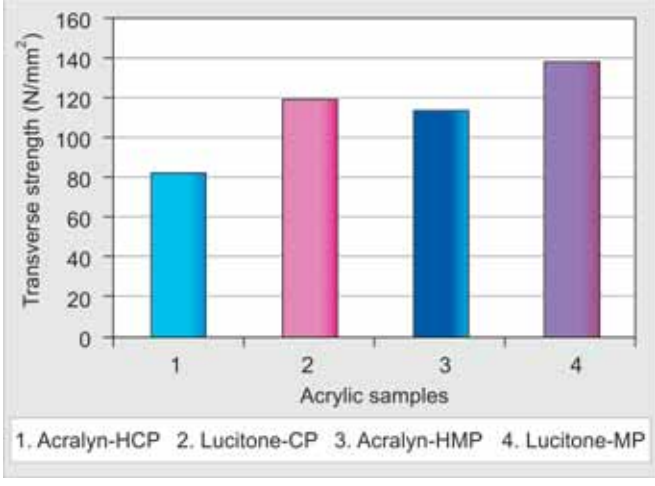
Considering the facts of polymerization, disinfection and polishing, the present study is taken up to evaluate the effects of chemical disinfectant on the transverse strength of heat-polymerized acrylic resins subjected to mechanical and chemical polishing.

MATERIALS AND METHODS

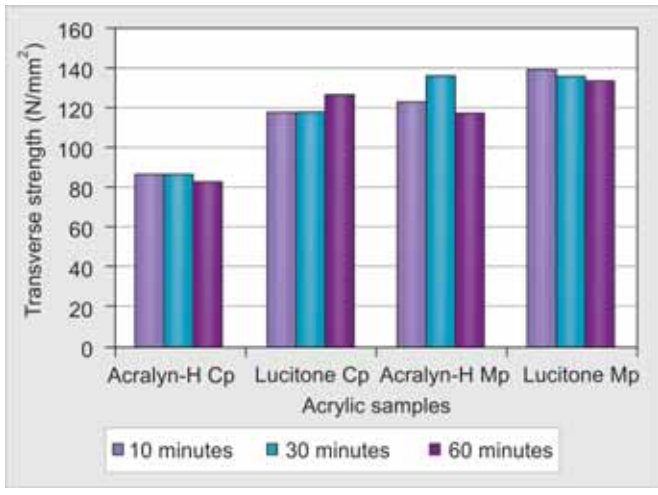
A total of 256 specimens were fabricated, 128 from each brand of resins (Acralyn-H and Lucitone-199) using stainless dies of 65 × 10 × 3 mm. In the experimental group (n = 192) 48 specimens from each resin were mechanically polished and 48 were chemically polished. In the control group (n = 64) mechanically polished (n = 32) and chemically polished (n = 32) specimens were immersed only in distilled water. Specimens were then treated according to the following protocol:

One side of the acrylic resin rectangle was hand-polished with coarse sand paper using water as a coolant and the other side was sequentially polished with coarse, medium and fine sand paper. The purpose of this approach was to simulate both sides of a complete denture.

The mechanically polished specimens were polished using a lathe (Unident, India) with a rag wheel and polishing pastes (pumice and water). Specimens submitted to chemical polishing were processed in an oven by soaking in a methyl methacrylate-based solution (Asian Acrylates Mumbai) heated to approximately 70 to 80°C for 10 seconds and then placed on a glass plate to dry. All specimens were stored in distilled water at room temperature for 7 days, after which they were disinfected and transverse strength testing, was done. Transverse strength of controlled (Graph 1) and experimental specimens (Graph 2) of the specimens were determined using a 3-point bending testing device in a universal testing machine (Model no. TUE-C-400). Transverse strength was computed using the following equation $S = 3PI/2bd^2$



Graph 1: Comparison of mean transverse strength values of control groups



Graph 2: Comparison of mean transverse strength values of experimental groups

Where S = transverse strength (N/mm^2), P = load at fracture (N), I = distance between the supporting wedges (mm), b = width of the specimen (mm), d = thickness of the specimen (mm).

The obtained data was tabulated and statistically analyzed. The pertinent data has been presented in the tabulated form in the section of results.

RESULTS

The Student t-test revealed significant difference ($p < 0.01$) between types of polishing, with mechanical polishing (133.69 N/mm^2 ± 18.05) yielding higher transverse strength means than the chemical polishing (106.66 N/mm^2 ± 28.18) (Table 1).

Two-way analysis of variance for mechanically and chemically polished specimens did not identify significant differences among immersion times (Tables 2 and 3).

The Student t-test identified no significant difference between the chemically polished Lucitone-199 and Acralyn-H resin control group values and the group immersed in 2% alkaline glutaraldehyde (Table 4).

The Student t-test identified a significant difference ($p < 0.05$) between the mechanically polished Lucitone-199 resin control group values and the group immersed in 2% alkaline glutaraldehyde (Table 5).

DISCUSSION

The present study was carried out to evaluate the effect of chemical disinfectant on the transverse strength of heat-

Table 1: Mean transverse strength of acrylic resin specimens subjected to chemical and mechanical polishing (N/mm^2)

Heat polymerized acrylic resins	*Polishing*	
	Mechanical	*Chemical*
Lucitone-199	146.46 (± 9.18)	126.59** (± 18.62)
Acralyn-H	120.93 (± 12.21)	86.73** (± 11.52)

**Correlation is significant at the p < 0.01 level

Table 2: Mean transverse strength and standard deviation for the mechanically polished specimens subjected to different immersion times (N/mm^2)

Immersion period (min)	*Heat polymerized acrylic resins*	
	Lucitone-199	*Acralyn-H*
10	137.93 (± 8.80)	123.66 (± 14.64)
30	136.79 (± 7.08)	136.87 (± 36.47)
60	133.34 (± 15.76)	117.61 (18.07)

Table 3: Mean transverse strength and standard deviation for the chemically polished specimens subjected to different immersion times (N/mm^2)

Immersion period (min)	*Heat polymerized acrylic resins*	
	Lucitone-199	*Acralyn-H*
10	117.72 (±9.88)	86.13 (±15.86)
30	118.39 (±14.38)	87.13 (± 12.38)
60	126.26 (± 14.06)	83.06 (±18.77)

Table 4: Mean transverse strength and standard deviation for mechanically polished control specimens and mechanically polished specimens immersed in disinfecting solution (N/mm^2)

Disinfectant	*Heat polymerized acrylic resins*	
	Lucitone-199	*Acralyn-H*
Control	146.46 (± 9.18)	120.93 (± 12.21)
2% alkaline glutaraldehyde	136.02** (± 11.13)	126.04 (± 25.75)

**Correlation is significant at the p < 0.05 level

Table 5: Mean transverse strength and standard deviation for chemically polished control specimens and chemically polished specimens immersed in disinfecting solution (N/mm^2)

Disinfectant	*Heat polymerized acrylic resins*	
	Lucitone-199	*Acralyn-H*
Control	126.59 (± 18.62)	86.73 (± 11.52)
2% alkaline glutaraldehyde	120.79 (± 13.25)	84.44 (± 15.64)

polymerized acrylic resins subjected to mechanical and chemical polishing. Heat-polymerized acrylic resin systems include powder and liquid components. The powder consists of prepolymerized spheres of poly (methyl methacrylate) and a small amount of benzoyl peroxide and is termed the initiator. The liquid is predominantly nonpolymerized methyl methacrylate with small amounts of hydroquinone which acts as an inhibitor.

Glycol dimethacrylate is used as crosslinking agent. If sufficient glycol dimethacrylate is included in the mixture, several interconnections may be found. A polymer formed in this manner yields a net like structure that provides increased resistance to deformation. As a rule, heat activated denture base resins are shaped via compression molding.[1]

In an attempt to achieve smooth exposed surfaces that contribute to oral hygiene and low plaque retention, prostheses must be finished and polished appropriately. Normally, polishing procedures for acrylic resin appliances are performed mechanically by using polishing wheel, felt cones and slurry of pumice and water. Mechanical polishing is a time consuming procedure and difficult to carry out.[2]

Chemical polishing of acrylic resin was first introduced by Gotusso (1969),[2] who suggested the immersion of acrylic resin devices in heated monomer (108°C) for 60 seconds. The advantages of the chemical polishing over the conventional mechanical polishing are its cleanliness, rapidity, easiness and the possibility of smooth intaglio surface.[2]

Glutaraldehyde has been founds to be safe for disinfecting and sterilizing denture base resins.[3] Glutaraldehyde in 2% solution can disinfect denture base resins within 10 minutes.[4] The specimens of each brand of resin, submitted to either polishing procedure, were immersed in the chemical disinfectant solutions for 10, 30 and 60 minutes. This schedule was based on the minimum of 10 minutes required to achieve disinfection after which the 20 and 30 minutes increments represented consecutive immersions.[3,5-7] Long-term exposure of denture base to glutaraldehyde does not significantly change the surface property or bulk of the material and hence the flexural strength.[3,14]

The first null hypothesis was rejected because of the differences found in the transverse strength of acrylic resin specimens submitted to mechanical or chemical polishing. The second null hypothesis was rejected because of the differences found in the transverse strength of mechanically polished acrylic resin specimens (Lucitone 199) immersed in 2% alkaline glutaraldehyde and controlled specimens. The third null hypothesis was accepted because there was no difference in the transverse strength of acrylic resins submitted to mechanical or chemical polishing after immersion in disinfecting solution for different immersion times.

Lower transverse strength values were reported for chemically polished specimens, whereas mechanically polished specimens demonstrated significantly higher transverse strengths, emphasizing the observation that chemical polishing may adversely affect resin strength and structure. Heat-cured resins release less residual monomer

after mechanical polishing as described by Braun et al[2] which was also observed by Bombonatti et al. The probable explanation for this is the higher degree of polymerization of heat-cured acrylic materials. Chemical polishing of the heat-cured resins generated higher levels of residual monomer than mechanical polishing.[3] After polymerization of the polishing fluid (methyl methacrylate) a pellicle is formed on the denture surface providing a glossy exterior. Although this pellicle reduces water absorption, the monomer that penetrates the resin matrix into the internal porosities is not polymerized but may result in increased levels of residual monomer, because the unpolymerized monomer may not be easily released due to the presence of a polymerized pellicle.[7,11]

Sadamori[8,13] indicated that the residual monomer content in heat-polymerized acrylic resins is very resistant to removal by immersion in water. The residual monomer may act as a plasticizer and when present in high levels may negatively interfere with the mechanical properties of the resin.

Lucitone-199 exhibited higher transverse strength compared to Acralyn-H when the specimens were subjected to mechanical polishing. The differences in chain formation and composition, primarily due to different plasticizers may explain the different transverse strength values recorded for the material. The higher transverse strength of Lucitone-199 may be related to its higher molecular weight values. The remarkable strength of Lucitone-199 is the result of incorporating rubber molecules into the acrylic infrastructure, effectively creating an internal shock absorber.[12] The fine powder ensures a dense compact mix, avoiding porosity.

For the specimens subjected to chemical polishing, Lucitone-199 yielded higher transverse strength values while Acralyn-H yielded much lower values. A possible explanation is that Acralyn-H may retain more amount of unreacted monomer after chemical polishing, because as previously stated, these unreacted monomers act as plasticizers decreasing the mechanical properties of the resins.

According to Vallitu,[9] the reduction of residual monomer released from the polished test specimens may be caused by the diminished diffusion surface rather than by reduction of the monomer content inside the test specimens. On the other hand for the chemically polished specimens, the superficial pellicle formed after polishing may prevent water sorption.

Considering the immersion periods tested no significant differences were observed among the transverse strength means recorded. These outcomes are in agreement with Shen et al[3,16] who reported that a period of immersion upto 12 hours did not affect the transverse strength of the specimens and resulted in complete disinfection of all dentures. Polyzois et al[10] also concluded that the transverse strength was not affected by the periods of immersion in the chemical solutions.

Many speculate that immersion of chemically polished resin specimens in the disinfectants for different periods may have led to dissolution of the superficial layer thereby allowing the disinfectants to diffuse into the matrix.[15] The chemical agent used in this study is aqueous based solution it may be assumed that it had plasticizing effect on the resin matrix, thus decreasing resin strength.

CONCLUSION

Lucitone-199 resin demonstrated the highest overall transverse strength for the materials tested and significantly stronger than Acralyn-H with either type of polishing following immersion in 2% alkaline glutaraldehyde.

REFERENCES

1. Anusavice. Philips' science of dental materials (11th ed).
2. Braun KO, Mello JAN, Rached RN, et al. Surface texture and some properties of acrylic resins submitted to chemical polishing. J Oral Rehabil 2003;30:91-98.
3. Chiayi Shen, et al. The effect of glutaraldehyde base disinfection on denture base resins. J Prosthetic Dentistry1989;61:583-89.
4. Meng TR, Latta MA. Physical properties of four acrylic denture base resins. J Contemp Dent Pract 2005;6:93-100.
5. Tehmina Asad, et al. The effect of disinfection procedures on flexural properties of denture base acrylic resins. J Prosthetic Dentistry 1992;68:191-95.
6. Vonica B Chau, Timothy R Saunders, Meade Pimsler, et al. In-depth disinfection of acrylic resin. J Prosthetic Dentistry 1995;74:309-13.
7. Iara Augusta Orsi, Vanessa Gomes Andrade. Effect of chemical disinfectants on the transverse strength of heat-polymerized acrylic resins submitted to mechanical and chemical polishing. J Prosthetic Dent 2004;92:382-88.
8. Shinsuke Sadamori, et al. The usage period of dentures and their residual monomer contents. J Prosthetic Dentistry 1992;68:374-76.
9. Pekka K Vallittu. The effect of surface treatment of denture acrylic resin on the residual monomer content and its release into water. Acta Odontol Scand 1996;54:188-92.
10. Gregory L, et al. The effect of glutaraldehyde and microwave disinfection on some properties of acrylic denture resin. Int J Prosthodont 1995;8:150-54.
11. Park SE, Chao M, Raj PA. Mechanical properties of surface-charged poly (methyl metacrylate) as denture resins. J Dent 2009;37:66-70.
12. Machado C, et al. Comparative study of the transverse strength of three denture base materials. J Dent 2007;35:930-33.
13. Durkan R, et al. In vitro comparison of autoclave polymerization on the transverse strength of denture base resins. Dental Material Journal 2008;27(4):640-42.
14. Ayman EE, et al. effect of chemical disinfectants and repair materials on the transverse strength of repaired heat-polymerized resin. Journal of Prosthodontics 2006;15(5):300-05.

15. Nonglax thunyakitpisal, et al. The effect of chemical surface treatments on the flexural strength of repaired acrylic denture base resin. Journal of Prosthodontics 2011;20(3):195-99.
16. Karen TA, et al. Effectiveness of two disinfectant solution and microwave irradiation in disinfecting complete dentures contaminated with methicillin-resistant staphylococcus aureus. J Am Dent Assoc 2012;143(3):270-77.

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