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Original Article

Evaluation of Color Stability and Shear Bond Strength of Gingival Colored Composite Resin to Heat Cure Denture Base Resin using Compression Moulded Technique and Injection Moulded Technique

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Abstract

Statement of Problem: Acrylic resins are the materials of choice for Complete Denture fabrication but, the color of acrylic resin often fails to give a desired esthetic outcome.

Purpose: To triumph over this, gingival color composite resins were used for dentures which provide the gain of improving the esthetics. This study was done to comparatively evaluate and determine the color stability and shear bond strength of gingival colored composite resin when applied over heat cure denture base resin, fabricated by Injection molding technique and compression molding technique.

Materials and Methods: For color stability and shear bond strength testing, 40 acrylic blocks (n = 40) were fabricated. Twenty were compression molded and other 20 were injection molded. Out of 20 of each molding technique, 10 each were tested for color stability and shear bond strength. For color stability testing, a spectrophotometer was used. For shear bond strength testing, universal testing machine was used. The data obtained were statistically analyzed by independent sample $t$test.

Results: No statistical significance was observed in the color stability. However, when injection molded denture base resin was layered with gingival composite resin, the bond strength significantly was higher than when compared with compression molded denture base resin.

Conclusion: The bond strength of injection molded denture base layered with gingival colored composite resin was high and clinically acceptable. This adds to the clinical relevance for acceptability of this technique for the fabrication of dentures with superior esthetics.

Clinical Implication: This technique helps in the fabrication of dentures with superior esthetics and gives more characterization to the denture and a realistic appearance.

Key words: Compression molded denture base resin, Crealign, Gingival composite resin, Injection molded denture base resin

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INTRODUCTION

Esthetics has become increasingly important in dentistry and is related to a natural and harmonious appearance. A smile can enhance the personality of a person and can command social acceptance easily.[1] The dentist must visualize aesthetics in relation to the patient and then

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translate that visualization into a suitable aesthetic result. For a healthy gingiva, esthetics is also an important key factor. It's challenging to settle on acceptable, restorative treatment for teeth with gingival recession within the esthetic zone.[2] The esthetics of a dental prosthesis should blend seamlessly with the soft tissues that surround the dentition, especially within the anterior smile zone. Zalkind and Hochman introduced the usage of pink composite resin as a man-made gingival tissue for the management of a cervical defect.[3] The composites are more resistant to wear and are color stable. Fabrication of complete dentures not only replaces the missing teeth but also restores the esthetics and phonetics. Complete denture characterization is necessary to bring a life-like appearance to the dentures.[4] Every denture should be characterized consistent with a private patient, instead of doing a pearl-like arrangement of teeth with a twinkling acrylic denture base which reveals it to be false. Our aim was to fabricate dentures with anatomic characterization that were present before the loss of teeth. A natural-looking prosthesis is often achieved by applying artistic principles with reference to the key elements of the face. Every patient being unique requires more detailed and customized approach for proper esthetics, by incorporating the patient's characteristics in the denture, a natural-looking prosthesis can be fabricated. Inspite of all ongoing efforts to maximize esthetics with acrylic resins, there seems to be a shortfall. In completely edentulous patient gingival colored porcelain can also be used to enhance the esthetics and improve the look of the patient.[5] A new material gingival colored composite now can be used. Although studies have been published comparing the flexural strength of acrylic resin denture base materials; there are fewer studies comparing the bond strengths of homogenous denture base materials with denture base layered with gingival colored composite. The range and frequency of the use of the gingival-colored composites are expected to increase with time. The understanding and evaluation of the color stability and bond strength of these materials to the denture base resin is important to decide the relevance of the gingiva colored composite. The addition of gingiva shade composite resin to enhance the esthetics of denture base resin can be used if a thin layer of 1.5 mm is applied to the fabricated denture acrylic resin.

The purpose why the present study was chosen was to evaluate the influence of the fabrication process of the denture base resin on the shear bond strength and color stability of the removable prosthesis.

MATERIALS AND METHODS

Forty acrylic blocks of dimensions 8 mm*4 mm were fabricated. Vernier caliper was used to measure the dimension of the blocks. Twenty acrylic blocks were fabricated by each molding technique (20 compression molding, 20 injection molding) which were randomly divided into two groups of 10 samples each to evaluate the color stability and bond strength respectively.

Fabrication of acrylic block by compression molding was carried out on gypsum models in gypsum compression forms, which were received after burning out of wax. A mix of type II gypsum plaster was placed in the base of the bottom half (lower half) of the flask, the metal block (8 mm*4 mm) was centered in the lower half and pushed downward into plaster until the bottom of the block touched the base of the flask and nearly leveled with the top edge of the flask. After the final setting of plaster had occurred, it was coated with a separating medium. The upper lid of flask was placed and a mix of type III dental stone was poured and allowed to set. The lid was placed on the flask and was tapped firmly to place. Excess stone extruded through the holes in the lid and around the edges.

The flask was placed in boiling water for 5 min, separated following which the wax was flushed out. The flask was then placed aside to drain the water and allowed to dry. A heat cure acrylic resin (SR TripleX, Dental Products Ltd., India)was proportionally mixed according to manufacturer instructions. After the consistency was at dough stage, Bench curing of the flask was done under pressure for 30–60 min. The flask and clamp were placed in a curing unit. The block was processed for 9 h in water held at a constant temperature of (60–70°C). Deflasking was done.

According to the manufacturer instructions, wax was duplicated, flasked, and invested for injection molded specimens. The flask was heated in a hot water at 65°C for 5 min and separated, and wax was flushed by hot and clean water. After that, it was allowed to chill to room temperature. The Ivoclar Vivadent Separating Fluid was used while the plaster surfaces were moist and allowed to dry. For about 5 min, premeasured capsules of resin and monomer (SR Ivocap High Impact; Ivoclar Vivadent AG) were united in a commercial mixer (Cap Vibrator; Ivoclar Vivadent AG).In a hydraulic press (corresponding to about 80 bar/1133 psi hydraulic pressure), 3 tons/6000 lbs., pressure was applied to the clamping frame with the flask. The substance of the mixed capsule was embedded into the flask, and the pressure injection apparatus (SR Ivocap System; Ivoclar Vivadent AG) was connected. The pressure apparatus was connected to a compressed air supply (6 bar/85 psi) to allow the plunger to descend and inject material into the mold. The assembly was then immersed and polymerized in boiling water for 35 min as per the manufacturer guidelines. The assembly was then removed out and quickly placed in cold water while

maintaining the pressure, for around 15–25 min, after which the specimens were deflasked.[6]

After fabrication of compression and injection molded acrylic blocks, the blocks were Sandblasted with aluminum particles (110 μm) and then Gingiva colored composite resin was layered using Crealign, Bredent for 2.5 mm thickness [Figures 1 and 2]. The material has a gel-like consistency and the homogeneity of the material allows for the adaption of elasticity and hardness of the composite to various substructure materials [Figure 3]. Composite matrix combination (i.e. Opalescent ceramic and crack-resistant) transforms the properties of a liquid ceramic to Crealign. Using this procedure, restorations perfectly matching natural teeth can be produced with shade stability and plaque resistance within the laboratory. Chairside veneering can be done. Crealign can be used crowns and bridges and also for the "additional veneer technique". The Crealign was layered on the block using the Incremental Horizontal Layering technique. Small brush was used to apply material.

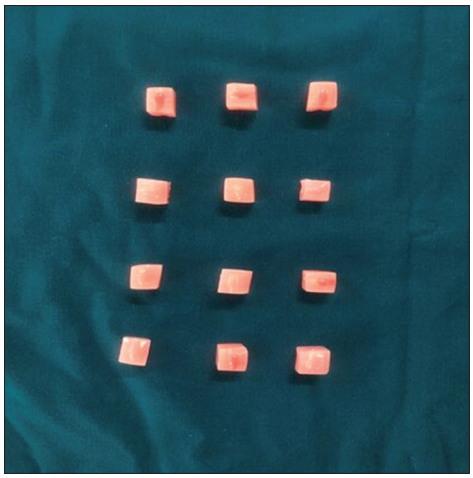


Figure 1: Compression molded denture base resin layered with gingiva colored composite resin

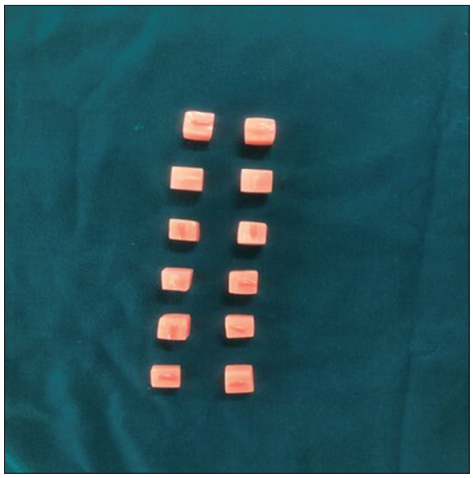


Figure 2: Injection molded denture base resin layered with gingiva colored composite resin

Pre-curing for 2–3 s was done with the Bre.Lux hand lamp with a suitable light source [Figure 4]. The thickness was measured using the Caliper and was standardized, and thus it was polymerized for 180 s in the Bre. Lux Power Unit Curing device and the final polymerization was done for 360 s. The dispersion layer was removed using surface cleaner and a toothbrush.

Specimens were stored in distilled water at 37°C for 24 h and thermocycled between 5°C and 55°C for 1000 cycles, with a dwell time of 30 s [Figures 5 and 6]. After thermocycling, they were stored in 37°C distilled water for an additional 15 h before subjecting to color stability and shear load testing. All color stability samples were tested under Spectrophotometer [Figure 7]. VITA Easyshade was adjusted by setting a probe tip on the calibration port aperture before measuring every specimen. The targets were measured by holding the probe tip at 90 degrees on the surface of the teeth. The CIE color space represents a uniform color space, with equal distances corresponding to equal perceived color differences.

Figure 3: Gingival colored composite resin (Crealign)

Figure 4: The Bre.Lux curing unit

Figure 5: Thermocycling: Samples kept in cold chamber

Figure 6: Thermocycling: Samples kept in hot chamber

Figure 7: Equipment used for color stability

Figure 8: Equipment used for testing of shear bond strength (Universal Testing Machine)

The three axes in this three-dimensional color space were L*, a*, and b*. The L* value was a metric for item lightness that was measured on a scale with a perfect black having a L* value of 100. The a* value represented the proportion of redness (positive a*) or greenness (negative a*) in the image. The b* number represented a percentage of yellowness (positive b*) or blueness (negative b*) in the image. For natural colors, the a* and b* coordinates were close to zero but grew in magnitude for more saturated or strong hues. The CIE Laboratory approach had the advantage of expressing color contrasts in units that could be linked to visual perception and clinical relevance. The measurement was accepted when two consecutive, indistinguishable readings were produced for each region, as per the manufacturer's instructions. The data for continuous variables were presented as mean ± standard deviation (SD).

All the samples of the shear bond strength were measured on computerized, software-based Universal Testing Machine (Acme Engineers, India, Model: UNITEST 10) with a crosshead speed of 5 mm/min at a 50 mm distance. Each specimen was positioned on the lower part of the machine [Figure 8]. The jigs had a diameter of 10 mm and the span length was 50 mm. The upper part of the testing machine had a steel pointer which was placed in between of the specimen. Shear forced values required to separate the block (N) were recorded by machine's software. The data on continuous variables were shown as mean ± SD.

Statistical Analysis

The inter-group statistical significance of difference was tested using independent sample *t*-test. The data on continuous variables were shown as mean ± SD. The inter-group statistical significance of difference was tested using independent sample *t*-test. The underlying normality assumption of study variables was tested before subjecting the study variables to *t*-test. All results were displayed in tabular and graphical configuration to envision the factually significant difference precisely.

In the whole study, the *P*-values under 0.05 were viewed as statistically significant. Using two-tailed alternatives, all the

hypothesis were formulated against every null hypothesis (hypothesis of no distinction). The data were measurably analyzed utilizing Statistical Package for Social Sciences (SPSS ver 21.0, IBM Corporation, USA) for MS Windows.

RESULTS

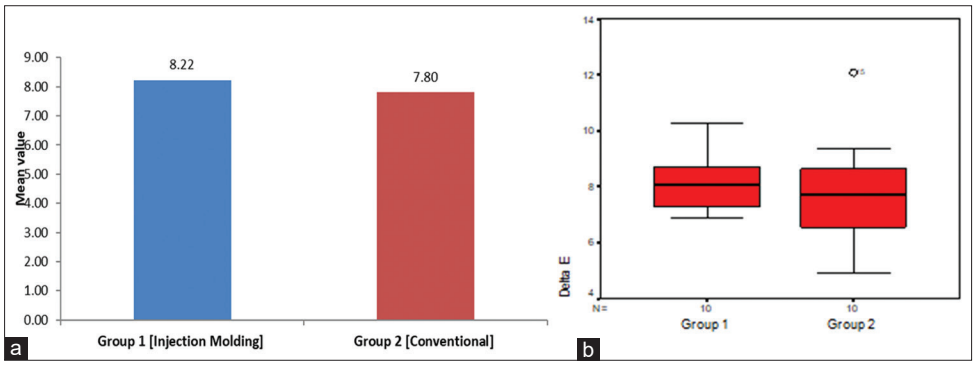
From the study conducted, the following results were observed:

1. The inter-group comparison of mean color stability (Delta E) between the groups was shown in [Graph 1] The inter-group comparison of mean shear bond strength between the groups was shown in [Graph 2]
2. The mean ± SD of color stability (delta E) in Group 1 (Injection Molding) and Group 2 (Conventional) was 8.22 ± 1.03 and 7.80 ± 2.09 respectively. The minimum-maximum range of color stability (delta E) in Group 1 and Group 2 was 6.92–10.24 and 4.94–12.07 respectively
3. The distribution of mean color stability (delta E) in Group 1 (Injection Molding) did not differ significantly compared to Group 2 (Conventional) ($P > 0.05$)
4. The mean ± SD of shear bond strength in Group 1 (Injection Molding) and Group 2 (Conventional) was 3.68 ± 1.81 MPa and 1.95 ± 0.58 MPa respectively. The minimum-maximum range of shear bond strength in Group 1 and Group 2 was 2.08–7.46 MPa and 1.05–2.82 MPa respectively
5. The distribution of mean shear bond strength was significantly higher in Group 1 (Injection Molding) compared to Group 2 (Conventional) ($P < 0.05$).

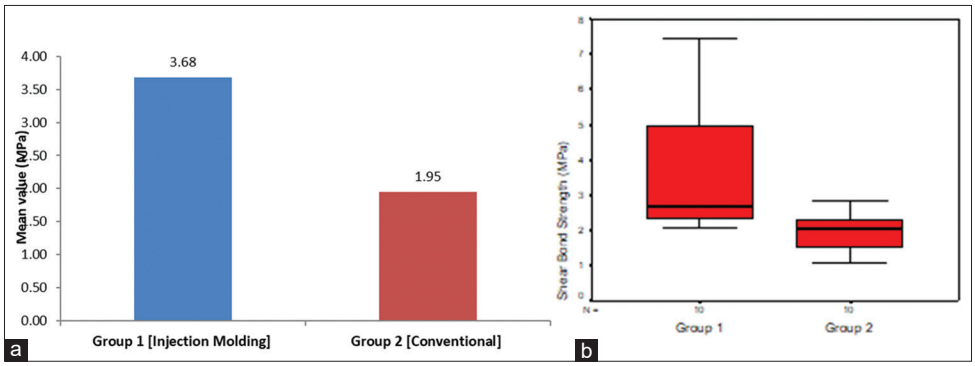
DISCUSSION

The objective of the present study was to evaluate and compare the Color Stability and Bond Strength of Gingival Colored Composite Resin to Denture Base Resin processed by two Different Techniques: Compression Moulding Technique (SR Triplex Hot by Ivoclar Vivadent), and Injection Moulding Technique SR Ivocap system-BPS-Ivoclar Vivadent. Polymethyl methacrylate is a successful denture base material for removable dentures. However, because it does not portray the natural appearance of the gingiva, traditional acrylic denture base resin has restricted aesthetics. Therefore, efforts have been made to modify or veneer these resins to enhance their appearance either with gingival color porcelain or gingival colored composite resin. But these materials have had limitations in their color stability and their bond strength to resins.

Color stability is the capacity of any dental material to have the option to hold its unique color. The resin matrix, depth of polymerization, filler particle measures, and coloring agents all affect the color stability of a resin composite. The oral cavity has a dynamic environment.



Graph 1: (a and b) Bar-graph and Box-Whisker Plot showing inter-group distribution of mean color stability (Delta E)



Graph 2: (a and b) Bar-graph and Box-Whisker Plot showing inter-group distribution of mean shear bond strength

With the persistent presence of microflora, salivation, and successive admission of colored food (chromatogens), the color stability of material may get bargained aesthetically.

Da Silva *et al.* compared the Easyshade spectrophotometer to three other optical shade guidance systems in 2008. The crowns were made using a spectrophotometer in their study, which resulted in a substantially better color match and a reduced percentage of rejection owing to shade mismatching. There are a number of other studies that support instrumental procedures above visual ones. Hence, Easyshade Spectrophotometer was used for the color stability.[7] Crea.lign consists of nano particles and no ground glass filler. It consists of 50% opalescent ceramic filler and a high-strength oligomer matrix. The absence of strong glass fillers improves plaque and abrasion resistance and keeps the material from being embrittled.

Even after the thermocycling of gingival colored composite resin (Crealign), there was no change in the color of the specimen when bonded with two differently processed denture base resins. This indicates that the properties of the material are highly unaffected by and useful as an esthetic material for characterization of the denture.

Injection molding, which was first used in 1942, has the property through which it reduces the resin flash and compensates for shrinkage by pushing additional resin into the flask during the polymerization process. According to recent studies, full dentures made with an injection method have a much smaller incisal pinhole than dentures made with the compression moulding approach. Injection molding allows directional control of the polymerization process through the flask design.[8] A constant flow of new material from the sprue compensates for the polymerization shrinkage. This method permitted the utilization of new thermoplastic resins as a choice to the heat-cured PMMA, without the requirement for synthetic added substances or catalysts that might be unfavorably susceptible for patients. The chemical properties may cause some porosity and can increase the contact surface area; therefore, greater forces are needed for fracture. This could have increased the bond strength between the gingival-colored composite resin and injection molded denture base resin.

In this *in-vitro* study, the bond strength of gingival colored composite resin to injection molded denture base resin showed maximum shear bond strength when compared with compression molded denture base resin while the color stability did not differ significantly.

The results of this study could be used to fulfill the following clinically relevant objectives:

1. Help the clinician decide which fabrication procedure of the denture base resin would provide better bond strength to gingival colored composite resin
2. Help the clinician get an idea about the errors that can be minimized using different techniques for the fabrication of denture base resin
3. Help the clinician get an idea about the gingival color composite resin and its color stability with the denture base resin.

CONCLUSION

Within the limits of this *in-vitro* study, the following conclusions were drawn:

1. When layered with gingival colored composite resin, compression molded denture base resin showed higher color changes after thermocycling as compared to the injection molded denture base resin
2. Injection Molding technique and Compression Molding technique layered with Gingival Colored Composite Resin did not show statistical difference, in the Color Stability test
3. Injection Molding technique of fabrication showed significantly higher bond strength as compared to the Compression Molding technique with gingival composite resin.

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