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Research Article

Comparison of Flexural Strength and Colour Stability of Dentures Characterised Using Conventional Auto-Polymerising Resin Stains and New Light-Cured Composite Staining Material: An *In Vitro* Study

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ABSTRACT

Introduction: Complete dentures are a common treatment option for edentulous patients. They provide masticatory functions as well as aesthetics synchronising with the surrounding oral soft tissue.

Aim: To examine and compare the flexural strength and colour stability of heat-activated acrylic resin incorporated with auto-polymerising acrylic stains and light-cured gingival shade composite resin

Materials and Methods: Forty heat-activated acrylic resin bar-shaped samples (64×40×3 mm) were fabricated. The samples were segregated into two groups: Group 1 - Heat cure acrylic resin incorporated with auto polymerising resin stains (n = 20); Group 2 - Heat cure acrylic resin incorporated with gingival shade composite stains (n = 20). The samples were subjected to 5000 cycles of thermal cycling for 30 seconds from 5 °C to 55 °C. Colour stability was evaluated using a spectrophotometer for 10 specimens in each group. Flexural strength was done using a 3-point bend test measured using an Instron universal testing machine. One-way ANOVA was used to statistically analyse the results.

Results: On descriptive statistical analysis, flexural strength and colour stability of the heat-activated acrylic resin with auto-polymerising acrylic resin stains ($\Delta E = 0.87$; Mean ± SD = 59.7 ± 0.53) were significantly higher than the heat-polymerised gingival shade composite resin ($\Delta E = 1.28$; Mean ± SD = 36.1 ± 0.44).

Conclusion: The flexural strength and the colour stability of the heat-activated acrylic resin are both reduced by the addition of gingival shade composite resin.

Keywords: Colour Stability, Flexural Strength, Auto-Polymerising Stains, Gingival Shade Composite Stains

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Introduction

The state of edentulousness without natural teeth is called edentulism.[1] Complete dentures are one of the commonly used treatment options for the oral rehabilitation of edentulous patients. The colour and contour of the soft tissue are vital to dental aesthetics as they increase the social acceptability and confidence of the patient.[2] Apart from providing masticatory functions, complete dentures should provide aesthetics synchronising with the surrounding oral soft tissue. Denture gingival aesthetics can be improved by including extrinsic stains, intrinsic self-cure stains and gingival-shade composite resins.[3] Depending on the type of materials used for gingival characterisation, it is important to study the effect of these materials on the properties of denture base resins.[4] Many clinical studies have established that denture base polymers tend to discolour in the oral environment. Advantages of conventional heat cure resins include easy manipulation and workability, adequate aesthetic and relatively lower cost.[5] Adequate literature is available regarding the flexural strength and colour stability of heat-activated acrylic denture base materials, whereas the same with auto-polymerising stains and light-cured gingival composite resin is insufficient. Hence this study was designed with the aim of comparing the flexural strength and colour stability of heat-activated acrylic resin incorporated with auto-polymerising acrylic stains and light-cured gingival composite resin.

Materials and Methods

This experimental study was conducted in a laboratory set up at SRM Institute of Science and Technology, Kattankulathur campus in October 2019.

Heat polymerised denture base (DPI Heat cure) with auto-polymerising acrylic stains (Denture art, Dreve Dentamid Gmbh, Germany) and gingival composite resin (Gradia gum shades; GC America) are the two different staining materials which were evaluated (Figure 1). Twenty specimens per group were fabricated and analysed.

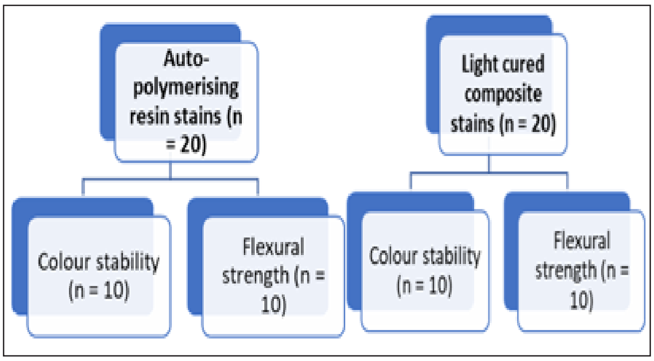

Figure 1.Fabricated Specimens

Forty acrylic resin bar-shaped samples were designed according to ISO 1567 and ISO 20795-1:2013. Group I sample of the heat-activated acrylic resin bar with specifications of 64×40×3 mm was fabricated along with the incorporation of auto-polymerising resin stains in it using compression moulding technique. Wax sheets were cut according to dimensions and were flasked with type II dental plaster. Once set, dewaxing was done. Heat-activated acrylic resin was packed in the flask and processing was done. After the processing, the resin bar was trimmed to a thickness of 1.5 mm and auto-polymerising acrylic stains (Casdon red) were packed into the silicone mould to maintain the standardised thickness of 3 mm (Figure 2).

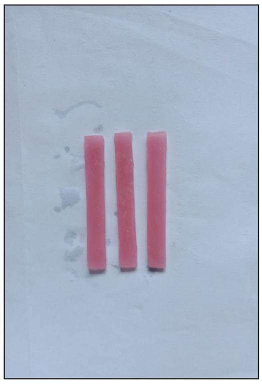

Figure 2.Heat Cure Acrylic Resin Incorporated with Auto-Polymerising Acrylic Stains

Group II samples of heat-cured acrylic resin bar were fabricated using the same technique with dimensions of 64×40×3 mm and reduced using tungsten carbide bur to a thickness of 1.5 mm. Primer was coated on the roughened surface of the heat cure acrylic sample and photo-polymerised for 60 seconds. Gingival shade composite resin was added to a thickness of 1.5 mm onto the heat-activated denture base samples using the 3mm silicone template. The samples were photo-polymerised for 3 minutes and then polished (Figure 3).

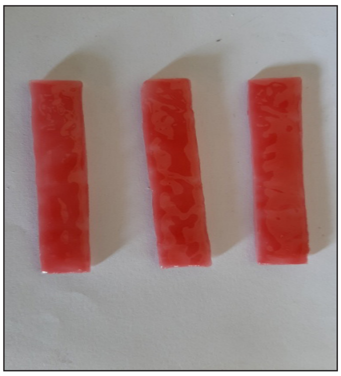

Figure 3.Heat Cure Acrylic Resin Incorporated with Light-Cured Gingival Composite Resin

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Spectrophotometer analysis of group 1 and 2 samples was done to estimate the initial base colour for comparative analysis (T1- Before thermo-cycling). The spectrophotometer follows the CIE (International Commission on Illumination) standards using the L*a*b* system. It indicates the L* (Lightness), a*(green-red component), and b*(blue-yellow component).

The samples were subjected to 5000 cycles of thermal cycling for 30 seconds from 5 °C to 55 °C. Following air blow drying of the samples, colour measurement records were obtained (T2 - following thermal cycling). A spectrophotometer was used to do the colour analysis at the centre of each sample's polished surface. The following formula can be used to calculate the size of the differences in the colour: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)2]^{1/2}$. Using the National Bureau of Standards (NBS) units, the formula to quantify the colour variance was derived. NBS units = $\Delta E \times 0.92$ is used to correlate the variations in colour of the stained specimens (Table 1).

Table 1.The National Bureau of Standards (NBS) Units of Colour Variance

Marks of Colour Difference	NBS Units
Minimal	0.0–0.5
Visible	0.5–1.5
Small	1.5–3.0
Appreciate	3.0–6.0
High	6.0–12.0
Significantly	> 12.0

The samples from both groups underwent a 3-point loading test for the purpose of evaluating flexural strength using a piece of universal testing equipment. Each specimen received force in the middle. Each specimen was held with the stained surface facing down and the acrylic resin of the denture facing the bespoke fixture. Using the formula S = 3FL/2BD2, the calculation of the provided sample's flexural strength was done by giving the maximum load, where F indicates the applied load (maximum) before it fractured, L indicates the distance between the supports, B indicates the width at the centre of the sample, and D indicates the thickness of the sample. ANOVA, or evaluation of variance, was used to evaluate the data. A significance value of $p = 0.05$ was used for statistical analyses.

Results

Colour Stability

When the mean colour change values were compared between the two groups, a significant difference was found statistically ($p > 0.05$) according to the one-way ANOVA test. Descriptive statistical analysis according to NBS units revealed that Group I have a less pronounced shift in colour stability than Group II (Table 2).

Table 2.Comparison of Colour Stability Between Group I and Group II

Colour Measurement	Group I (n = 10)	Group II (n = 10)
Before ageing		
L	48	43.29
a	12.43	10.48
b	-0.82	-3.5
After ageing		
L	47.6	42.98
a	11.92	10.76
b	-1.4	-2.29
ΔE	0.87	1.28

L: Lightness, a: Green-red component, b: Blue-yellow component, ΔE: Colour change

Flexural Strength

One-way ANOVA showed that mean values for flexural strength in Group I and Group II were statistically different from one another. Group I specimens (59.7 ± 0.53 MPa) had higher flexural strength than the Group II specimens (36.1 ± 0.44 MPa) (Table 3).

Table 3.Comparison of Flexural Strength Between Groups I and II

Flexural Strength	Group I (n = 10)	Group II (n = 10)
Mean ± SD	59.7 ± 0.53	36.1 ± 0.44

Discussion

Numerous research revealed that defined dentures boost patients' self-assurance and contentment. This resulted in the development of numerous denture characterisation approaches.[6–8] Colour instability caused by acrylic resin's susceptibility to sorption due to the process of multiple colours' adsorption and absorption is one of the most common issues that complicate aesthetics.[9] Fabricating the characterised denture requires a lot of meticulous planning and incorporation of shades into the denture. It is time-consuming, and the cost of fabrication escalates enormously. The effort for characterisation of a denture would be worthwhile only if characterisation doesn't affect the flexural strength and longevity of applied stains in the denture. In previous studies, there has been a comparison of colour stability between different types of acrylic resins, but literature is lacking when comparing the auto-polymerising stains and gingival composite stains that are used for the characterisation of a denture in clinical practice.

Complete dentures after placement into the patient's mouth are exposed to a variety of oral cavity conditions, including temperature changes, the pH of saliva and its components, and contact with a variety of consumables. As an outcome, the denture base resins' physical and optical properties can change because of various contaminants being absorbed into them.[10] Translucency and colour of the acrylic resins are expected to deteriorate over a period. According to the study's findings, Group I auto-polymerising stains are more colour-stable when compared with the Group II composite resin stains.

The flexural strength of the material is an important property of the acrylic resin which helps in preventing catastrophic collapse under a transverse load. The results of this investigation demonstrated that adding gingival shade composite considerably lowered overall flexural strength; this may have been caused by a reduction in the thickness of acrylic resin.

Recent materials, such as CAD-CAM acrylic resins, have higher levels of polymerisation along with high condensation rates, lower remaining monomer content, and less porosity, preventing the reduction in flexural strength.[11] Ayman observed that heat-activated polymethylmethacrylate had a lesser flexural modulus than CAD-CAM-made denture base resin.[12]

The limitation of the study is that there was a lack of thermocycling before the loading test, which prevented a more effective stimulation of the intraoral condition. Different types of acrylic resins can be considered and more recent materials like pre-polymerised CAD-CAM acrylic resins can be included in the study for better comparison.

Conclusion

Within the constraints of the current *in vitro* study, it was observed that compared to gingival shade composite resins, auto-polymerising acrylic resins showed a higher degree of colour stability and the flexural strength of the heat-polymerised acrylic resin is reduced by the addition of gingival shade composite resin.

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Conflict of Interest: None

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