Research Protocol

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Dentistry Section

Evaluation of Colour Stability of the Dentures by Two Different Methods (Intrinsic and Extrinsic) of Characterisation using Mobile Phone Colourimeter Application: A Research Protocol

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ABSTRACT

Introduction: The aesthetics of a dental prosthesis should blend with the surrounding soft tissues, particularly in the anterior region of the dentition. Advances in laboratory technology and dental materials have enabled us to produce aesthetically pleasing, customised dentures that closely resemble each patient's intraoral features.

Need for the study: Conventional denture fabrication lacks the natural appearance of healthy gingiva. When denture bases are fabricated with Polymethyl Methacrylate (PMMA) resin, aesthetics are restricted. Consequently, attempts have been made to fabricate cosmetic dentures tili using various intrinsic techniques (colour-matching resins) and more contemporary extrinsic techniques (gingival shade composite resin).

Aim: The aim of this study is to use a colourimeter software application on a mobile phone to compare the colour stability of denture characterisation using two distinct methods (intrinsic and extrinsic).

Materials and Methods: This experimental study will be conducted in the Department of Prosthodontics and Crown and Bridge at Sharad Pawar Dental College and Hospital, Sawangi (M), Wardha, Maharashtra, India, from July 2024 to January 2026. The study will involve two groups using two different characterisation methods: extrinsic (using gingival shade composite resin) and intrinsic (using colour blending resins). Colour stability will be assessed using a mobile phone colourimeter application based on Hue, Saturation, and Value (HSV), following pre- and post-staining with three solutions: tea, coffee, and turmeric solution. The normality of continuous outcome variables will be assessed initially at the 5% level of significance ($p \leq 0.05$) employing the Kolmogorov–Smirnov test. Significant differences between groups at the 5% level ($p \leq 0.05$) will be determined using an independent t-test.

Keywords: Aesthetics, Cosmetic dentures, Denture stains, Gingival shade

INTRODUCTION

The aim of prosthodontic therapy is to restore both function and appearance. The ageing population has led to an increased frequency of prosthetic therapy among the elderly and heightened aesthetic demands. For a long time, biological and mechanical limitations hindered our ability to meet the unrealistic aesthetic expectations of certain patients. However, recent revolutionary breakthroughs in dental materials and advances in laboratory technology have enabled us to create customised, aesthetically pleasing dentures that closely mimic the intraoral structures of individual patients.

The aesthetics of a dental prosthesis should complement the surrounding soft tissues, particularly in the anterior region of the dentition. Polymethyl Methacrylate (PMMA) resin is an effective denture base material [1]. Because conventional denture fabrication lacks the natural appearance of healthy gingiva, its aesthetics are restricted. As a result, several methods have been attempted to fabricate cosmetic dentures [1]. Pound was the first to use stained methyl methacrylate monomers in denture base resin to enhance the resin's inherent aesthetics [2]. By applying this technique in conjunction with adjusting the design to mimic the gingival shape, Pound produced an incredibly realistic denture base. Powers employed extrinsic staining, but it did not achieve the same organic look as Pound's [2]. Coe-Lor acrylics were developed as a result of Sawyer and Gerhard's work (COE Laboratories, Inc., Chicago, IL). For those with darker gingival tissues, there are three different pigmented resin hues available [3].

Both Quinlivan and Zimmerman provide techniques for characterising denture base resin using Pound's methodology; nevertheless, the process appears to be time-consuming and expensive [4,5]. Using these characterisation approaches with an interim full denture may not be cost-effective due to their complexity. Since temporary dentures are typically conceived of as a kind of plastic bandage that bridges the gap between a dentate and edentulous condition, there is no need for a specially made denture foundation because the prosthesis will only be worn temporarily [6]. A method for applying tints using a transparent Visible-light-curing (VLC) gel was presented by Berté JJ and Hansen CA [7]. It would be simple to modify their method for this patient's presentation. Haeberle CB and Khan Z blended stock hues of visible-light polymerised materials to alter the hue of the temporary prosthesis. Gingiva-Shade Composite Resins (GSCR) have been developed more recently to restore the appearance of the gingiva in prostheses that are detachable, tooth-supported, and implant-supported [8].

REVIEW OF LITERATURE

Colour stability is a critical factor in the long-term aesthetics of denture prostheses, influencing patient satisfaction and clinical success. Various denture characterisation techniques, such as intrinsic and extrinsic methods, are employed to enhance aesthetic realism, each with differing susceptibilities to discolouration over time. The advent of mobile-phone-based colourimeter applications offers a novel, accessible, and cost-effective approach to objectively assess denture colour changes. Singh SV and Aggarwal

P conducted a study to determine how different brands of denture-base acrylic resin, widely used in India, changed colour when exposed to solutions including tea, coffee, and turmeric, and used a spectrophotometer to measure the colour of specimens from each brand. The highest colour variation was observed in Ashvin, followed by Travelon-HI, DPI, and Lucitone-199. Conversely, Ashvin, DPI, Travelon-HI, and Lucitone-199 showed the greatest colour diversity in tea and coffee [9].

The colour stability of four types of resins—heat-polymerised, urethane dimethacrylate auto-polymerising, and Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) PMMA blocks—stored in various storage media (distilled water, coffee, coke, and red wine) after 5,000 cycles of thermal cycling was assessed by Dayan C et al., [10]. The colour stability of CAD-CAM denture base resins was shown to be superior to that of all other types of denture base resins [10]. To assess the colour stability of three different denture base materials after staining with beverages and cleaning using commercially available denture cleaners, Banu F et al., conducted a study and observed that thermoplastic resin exhibited less staining when submerged in coffee and cola compared to traditional and high-impact PMMA denture base materials [11].

In another study, Mulcare DC and Coward TJ concluded that a mobile-phone colourimeter application could serve as a useful tool for objectively matching the colours of silicone maxillofacial prostheses [12]. Similarly, Nimonkar SV et al., investigated how the colour of maxillofacial silicone changed after curing using a mobile-phone colourimeter software application, noting a significant shift in the silicone's colour value [13].

Despite these advances, there is limited research regarding the colour stability of denture characterisation using different methods: extrinsic (using gingival shade composite resin) and intrinsic (using colour-blending resins). A comparative evaluation of these methods is needed to aid in selecting the best approach while maintaining aesthetics. Therefore, the present study aims to evaluate the colour stability of dentures characterised by these two different methods (intrinsic and extrinsic) using a mobile-phone colourimeter application.

Primary objectives:

- To evaluate colour stability based on hue, saturation, and value in the extrinsic denture characterisation method using a mobile-phone colourimeter (Group A).
- To evaluate colour stability based on hue, saturation, and value in the intrinsic denture characterisation method using a mobile-phone colourimeter (Group B).

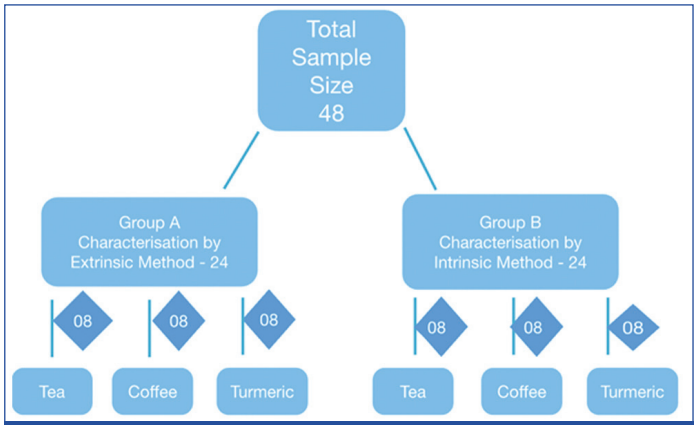
Secondary objectives: To compare the colour stability results of the intrinsic and extrinsic characterisation groups using a mobile-phone colourimeter.

Null hypothesis: There will be no significant difference in the colour stability of dentures fabricated using intrinsic characterisation and those fabricated using extrinsic characterisation, as evaluated by a mobile-phone colourimeter application.

Alternate hypothesis: There will be a significant difference in the colour stability of dentures fabricated using intrinsic characterisation compared with those fabricated using extrinsic characterisation, as evaluated by a mobile phone colourimeter application.

MATERIALS AND METHODS

The present experimental study will be conducted in the Department of Prosthodontics and Crown and Bridge at Sharad Pawar Dental College and Hospital, Sawangi (M), Wardha, Maharashtra, India, from July 2024 to January 2026. Ethical clearance has been granted by the Institutional Ethics Committee (Re-regd. No ECR/440/Inst/MH/2013/RR-2019) under reference number DMIMSU(DU)/IEC/2024/237, prior to the commencement of the study. The present study will involve two distinct sample groups employing two different characterisation methods: extrinsic (using gingival shade composite resin) and intrinsic (using colour blending resins) [Table/Fig-1].



[Table/Fig-1]: Flowchart of the study design

Group A (Extrinsic characterisation): Plaster moulds will be fabricated using the lost-wax technique. PMMA and monomer will be mixed in a 24 g powder to 12 mL liquid ratio and packed into the mould. The samples will undergo overnight bench curing, followed by a curing cycle at 74°C for nine hours. This process will continue until 24 samples are obtained. Each sample will receive one coat of surface bonding agent, followed by the application of a 1 mm thick layer of Light Pink (LP) gingival shade composite. The composite layer will be light-cured using a visible blue light spectrum (440-470 nm), after which a 1 mm thick layer of Dark Pink (DP) gingival shade composite will be applied and cured again. The samples will then be finished and polished using sandpaper and pumice [11,14].

Group B (Intrinsic characterisation): Plaster moulds will also be fabricated using the lost-wax technique. PMMA and monomer will be mixed in a 24 g powder to 12 mL liquid ratio and packed into the mould. Acrylic resin will be packed laterally up to 0.5 cm, and a solution containing one drop of brownish-violet stain mixed with one drop of monomer will be applied. This process will be repeated once more. Another 0.5 cm layer of acrylic resin will then be packed laterally, and one drop of reddish stain mixed with one drop of monomer will be applied as a single coat. The remaining space will then be filled with acrylic resin. After overnight bench curing, the samples will be subjected to a curing cycle at 74°C for nine hours. Finishing will be completed using sandpaper and pumice. This process will continue until 24 samples are obtained [11,15].

Colourimetric analysis and staining procedure: The Red, Green, and Blue (RGB) Colourimeter software (White Marten UG, Stuttgart, Germany) will be installed on a smartphone (iPhone 11, iOS 15, Apple Inc.) and stabilised using a tripod to analyse and record the HSV scores pre-testing. A total of 48 samples will undergo 5,000 thermocycles, with each cycle consisting of a 30-second dwell period and a 20-second transfer time, fluctuating between 5°C and 55°C. The staining agents used in the present study will be coffee, black tea, and turmeric solution, prepared by mixing 400 mL of boiling distilled water with 8 g of colourant. After 10 minutes of cooling, the mixture will be filtered using gauze. Each sample type (A and B) will be divided into three separate containers, each containing one of the three staining solutions, resulting in six containers in total. To ensure uniformity and minimise temperature variations, all procedures will be performed by the same operator at room temperature. The specimens will undergo two 15-minute storage periods per day, with the solution medium changed daily for up to 60 days. Following treatment, the specimens will be thoroughly cleaned in distilled water before storage [10].

Outcomes: The RGB Colourimeter software (White Marten UG, Stuttgart, Germany) installed on the smartphone (iPhone 11, iOS

15, Apple Inc.) will be used to record the HSV scores on days 15, 30, 45, and 60, both pre- and post-intervention.

STATISTICAL ANALYSIS

Statistical analysis will be conducted using R software. All data will be summarised with baseline characteristics, where categorical variables are presented as frequency and percentage, and continuous data as mean and standard deviation. For parametric data, key statistics—including mean, standard deviation, and 95% Confidence Interval (CI)—will be reported. The Kolmogorov–Smirnov test ($p \leq 0.05$) will assess normality; non normal data will be analysed using non parametric tests. The t-test will determine significant differences ($p \leq 0.05$) for comparing the intrinsic and extrinsic characterisation groups. For non parametric data, the Mann-Whitney test will assess significance using mean, median, and quartiles. Categorical variables will be summarised by frequency and percentage, with Chi-square analysis used for efficacy assessment. A p-value of less than 0.05 will be considered significant.

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