

## INTRODUCTION

The color stability of an acrylic denture base is crucial for long-term success, as discoloration during routine use can lead to patient dissatisfaction and the need for denture replacement. Different beverages and food colorants are the main factors contributing to color change. Various denture base materials are available and have different mechanical and chemical properties, which result in varying levels of stainability

## PURPOSE

To present a narrative review of the available literature on the color stability of CAD-CAM denture base materials.

## METHODS

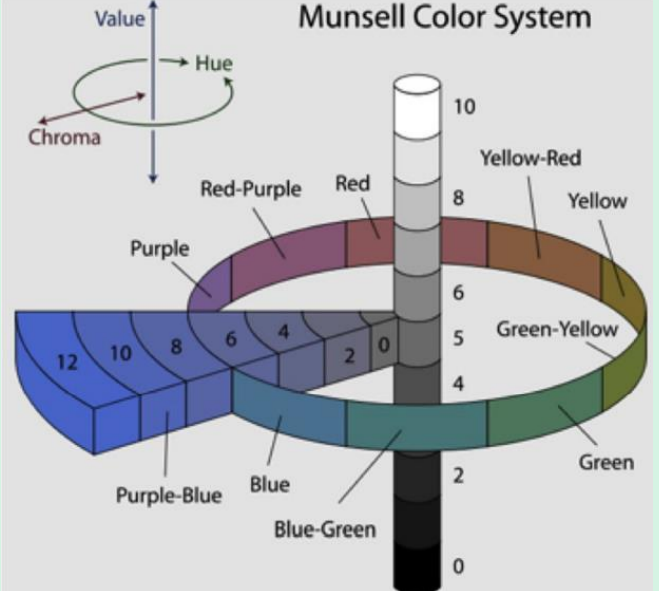
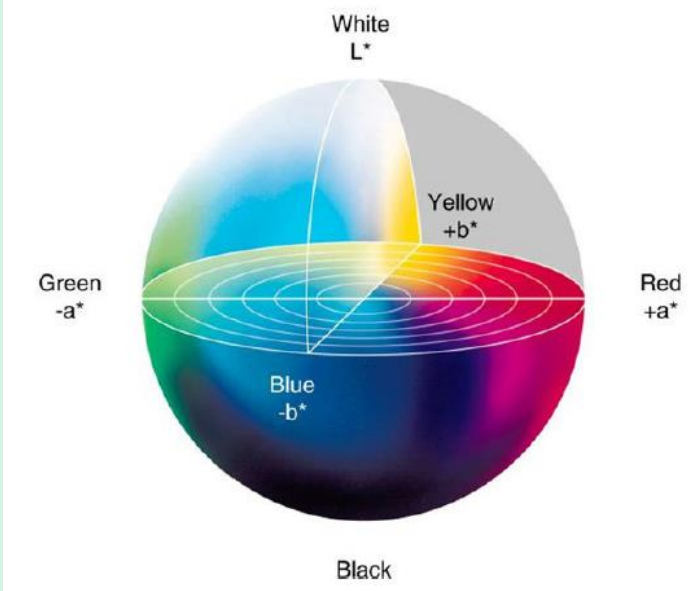
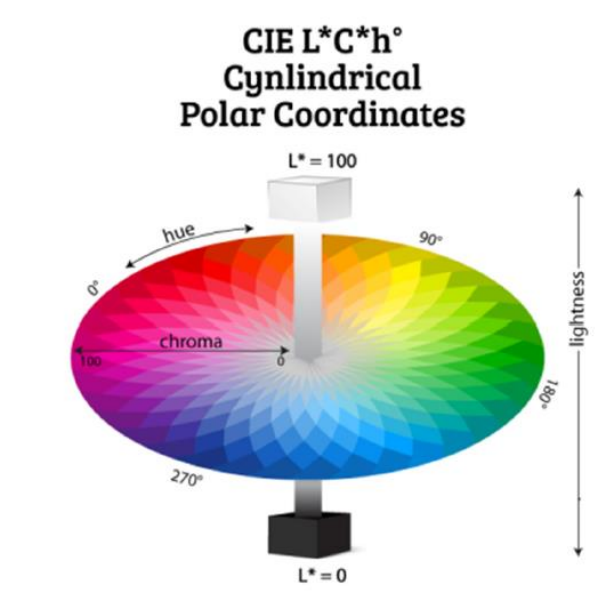
PubMed/MEDLINE and Google Scholar were selected as the search engines. An electronic search from January 2013 to September 2024 was conducted using the English language with keywords including color stability, stainability, stain resistance, polymethyl methacrylate (PMMA), ceramic reinforced polyetheretherketone (PEEK), CAD-CAM, 3D-printed resin, additive-manufactured resin, milled PMMA, and subtractive-manufactured PMMA.

The inclusion criteria for selection were CAD-CAM denture base materials for removable dentures, systematic reviews, clinical studies, in vitro studies, and articles that reported using different beverages to determine color stability. The exclusion criteria included articles that:

- case reports
- used denture cleansers to determine color stability
- focused solely on conventional removable dentures for color stability determination and
- reported color stability on denture teeth

A total of 48 articles were selected from the electronic databases. After excluding articles that did not meet the inclusion criteria and applying the exclusion criteria, 9 articles, including two systematic reviews and seven in vitro studies, were identified that focused on the color stability of CAD/CAM acrylic resins for denture bases.

Various techniques will be presented to assess dental materials' color stability. The available studies will be summarized in a table.

| Color System                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Munsell system                                                                                                                                                                                                                            | CIELAB Color System                                                                                                                                                                                                                                                                                                                                          | CIEHLC Color System                                                                                                                                                                                       |
| Three dimensional characteristic of colors (hue, saturation and brightness)<br><br>Used in the visual determination of color<br><br><br>Munsell system | This system expresses color as 3 values, L*, a* and b*<br>L* = lightness (0 = black to 100 = white)<br>a* = chromaticity of the red-green<br>b* = chromaticity of the yellow-blue<br>Used for color determination in instrumental method<br><br><br>Cartesian coordinates | Uses the cylindrical coordinates<br>C* = chroma<br>h° = hue lightness<br>L* = lightness<br><br><br>CIEHLC Color System |

| The different methods for color stability determination |                                                                                       |                                                                                                                        |                                                                                                                         |                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                         | Visual Methods                                                                        | Instrumental Methods                                                                                                   |                                                                                                                         |                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                               |
|                                                         |                                                                                       | Colorimeters                                                                                                           | Spectrophotometers                                                                                                      | Delta E (ΔE)                                                                                                                                                             | Delta E 2000                                                                                                                                                                                                                                                                                                  |
|                                                         | Determine the optical changes in the oral tissues by comparing it to the chosen color | Calculated based on the spectrum of diffuse reflection or light transmission                                           | Measure the amount of light energy reflected from an object at intervals of 1 to 2.5 mm for the entire visible spectrum | Defined as the difference between two colors in an L*a*b* color space.<br>$\Delta E_{Lab}^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$                      | - Latest color difference formula<br>- Improved from Delta E<br>$\Delta E_{2000} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2} + R_T \left(\frac{\Delta C'}{k_C S_C}\right) \left(\frac{\Delta H'}{k_H S_H}\right)$ |
| Advantages                                              | Several different shade guides available for color determination of the denture bases | Stable measurements on transparent and translucent objects                                                             | most accurate                                                                                                           | - Used extensively in the dental research community<br>- There are a study reported perceptibility threshold was 2.6 ΔE unit and acceptability threshold was 5.5 ΔE unit | - More sophisticated and computationally involved<br>- Enhance the performance for blue and grey colors                                                                                                                                                                                                       |
| Disadvantages                                           | Subjective                                                                            | - Not reliable when measuring complex and multilayer translucent structures<br>- less accurate than spectrophotometers | Slower than colorimeters                                                                                                | -This formula rates saturated regions too highly as opposed to other colors                                                                                              | - More studies focusing on the perceptibility and acceptability of Delta E 2000 are needed                                                                                                                                                                                                                    |

| Denture Base Materials |                                                                                                                                                       |                                                                                                                                             |                                                                         |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Denture Base Materials | Advantages                                                                                                                                            | Disadvantages                                                                                                                               | Color Stability                                                         |
| Conventional           | “Gold-standard” for the fabrication of complete denture. Good mechanical properties, aesthetic appeal, tissue compatibility, and repairability        | Polymerization shrinkage, water absorption, and the release of internal stress                                                              | Less color change than 3D printed group                                 |
| Milled PMMA            | Reduced fabrication time and few clinical appointments<br>Low technique sensitivity as opposed to conventional dentures                               | Expensive, waste materials and milling burs wearing                                                                                         | Less color change than 3D printed group                                 |
| 3D-printed             | Improved mechanical and physical properties<br>Preservation of the digital record of the final denture<br>Increase patient and clinician satisfaction | Increased water sorption after thermal cycling causes a significant reduction of the flexural strength, and an increase surface degradation | Maximum color change                                                    |
| PEEK                   | An aesthetically pleasing alternative to metallic frameworks and stronger alternative to PMMA dentures                                                | Pearl-white opaque color, the veneering of frameworks with a composite resin is needed                                                      | Insufficient scientific evidence concerning the color stability of PEEK |

## RESULTS

Additively manufactured denture bases demonstrated the maximum color change compared to conventional and subtractively manufactured ones. However, the color stability of denture base material manufactured with subtractive technique is equal or superior to conventionally fabricated ones. Scientific evidence regarding the color stability of PEEK denture bases is insufficient, and further studies are needed.

Within the limitations of this study, two databases were selected, and the narrative review included two systematic reviews and seven in vitro studies. The conclusions of this study should be approached with caution, considering the number of studies and the level of evidence. Future studies focusing on the color stability of CAD-CAM denture base materials are recommended.

## CONCLUSIONS

Dental resins may undergo color changes over time due to intrinsic and extrinsic factors. Extrinsic factors are considered the most frequent causes of color changes. Although assessing one brand of materials doesn't apply to all, denture base materials manufactured through subtractive and conventional techniques are superior to ones manufactured through additive techniques.

## REFERENCES

