# Effect Of Aging On Colour Stability Of Monolithic Multilayered Zirconia Crowns - An In Vitro Study

**[1]Dr. T.Anjan Kumar, [2]Dr. Doddy Lokanathan Balaji, [3]Dr. Ch. Revanth, [4]Dr.Vikranth Ravipati, [5]Dr. D. Pravalika, [6]Dr. Surabhi Halder**

*[1]Reader, [6]Senior Lecturer, Department of Prosthodontics, Priyadarshini Dental College and Hospital Thiruvallur, India*
*[2]Senior Lecturer, Department of Prosthodontics, Priyadarshini Dental College and Hospital Thiruvallur, India*
*[3]BDS, MDS, FICOI, Senior Lecturer, Department of Prosthodontics, Priyadarshini Dental College and Hospital, Thiruvallur*
*[4]MDS Prosthodontics, Orofacial Pain Resident At Eastman Institute Of Oral Health, USA*
*[5]Senior Resident, ACSR Government Medical College SPSR, Nellore, India*

**Corresponding Author:** Dr. Doddy Lokanathan Balaji,
lokanathan.balaji@gmail.com

## ABSTRACT

**Aim:** Toexamine the effect of aging on color stability of monolithic multilayered zirconia crowns.

**Objective:** The study's goal was to assess and contrast the color stability of veneered zirconia crowns and monolithic multi-layered zirconia crowns before and after thermocycling age.

**Methodology:** Twenty samples were created for each group: Group 1 is monolithic multi-layered zirconia and veneered zirconia is in Group 2. On a typodont tooth (Nissin), a full jacket crown preparation was made in respect to 6. All of the specimens were put through 6000 thermal cycles of immersion for 20 seconds at temperatures of (50°C, 37°C, 55°C, and 37°C) after the pre-test shade evaluation.

**Result:** The results of the study revealed significant changes in shade for both Group-1 (monolithic multi-layered zirconia) and Group-2 (veneered zirconia) after undergoing thermocyclic aging. Specifically, in Group-1, there was a noticeable shift towards lighter values and reduced chroma in all three regions, with an additional hue change observed in the incisal region

**Conclusion:** Conclusion, thermocyclic aging affected zirconia crown shades differently. After aging, Group-1 (monolithic multi-layered zirconia) was lighter while Group-2 was darker. These findings emphasize the relevance of zirconia crown color stability when choosing dental restorations. Further research, possibly employing the Degudent Shadepilot, is required to improve our comprehension of the color stability of zirconia crowns in order to improve clinical outcomes.

**Keywords:** Monolithic multi-layered zirconia, Veneered zirconia, Color, Translucency, Thermocycling

**DOI: 10.31838/ecb/2023.12.Si9.278**

## INTRODUCTION

To create dental restorations that closely mimic the color and translucency of genuine teeth is the primary objective of prosthetic dentistry. Ceramic materials are favoured over conventional metal repairs because to their superior mechanical and cosmetic qualities. Their strength and aesthetics are the main factors that substantially influence the ultimate choice of dental restorations. Zirconia stands out among the more recent materials accessible for its remarkable mechanical qualities, making it the go-to material for situations needing strong resistance to loading pressures. Zirconia now offers a wider range of dental uses because to the widespread adoption of CAD/CAM technology. Partially stabilized zirconia is a multi-phase material that possesses the best mechanical characteristics of zirconia [1]. The crystal structure of zirconia is polymorphic, and it can exist in three different forms depending on the temperature: a stable cubic structure at the highest temperatures (between the melting point of 2680°C and 2370°C), a stable tetragonal form at intermediate temperatures (2370-1170°C), and a stable monoclinic form at lower temperatures [2]. Because veneering porcelain, which is frequently used to cover high-strength zirconia, is prone to shatter, monolithic zirconia crowns are now preferred due to their great strength [3]. Dental restorations' aesthetics strongly rely on optical properties including light transmittance and reflectance [4], and the area of aesthetic dentistry works to imitate the beauty of teeth in their natural state [5]. Zirconia is suitable for esthetic applications because it may be colored to produce a good color match [4]. Monolithic zirconia's opaque appearance and lack of translucency may detract from front dentition aesthetics. Hydrothermal aging causes this fault by absorbing water from frequent heat swings in a moist environment. Tensile pressures between the material's tetragonal and monoclinic phases start a transition. Low-temperature degradation (LTD) aging generates surface microcracks, roughening, and color changes. As a result of aging, water permeates into the material, speeding up degradation and increasing repair failure. Prosthodontists and other dental practitioners must consider these variables when choosing dental restoration materials to give patients the greatest results [6]. Dental restorations' long-term clinical success depends on color stability and mechanical qualities. Dental restorations can change chemically and physically due to oral stresses [7]. Color stability must be maintained for restorations to last and look good. Thermal aging affects dental zirconia ceramics [8]. Thus, zirconia ceramics' tolerance to heat stress-induced aging is critical [9]. Aging causes microcracks, hardness loss, surface roughness, and flexural strength. Over time, these modifications may cause the zirconia ceramics to significantly deteriorate. The color stability of two different kinds of zirconia crowns—monolithic multi-layered zirconia and veneered zirconia crowns—has been evaluated and directly compared in in vitro tests. These experiments' purpose is to comprehend how these dental fillings function under simulated aging circumstances, especially through thermocycling.

## AIM

The primary aim of this study was to investigate how the color stability of two distinct types of zirconia crowns, namely monolithic multi-layered zirconia and veneered zirconia crowns, would be affected by thermocycling aging. By subjecting both types of crowns to simulated temperature fluctuations, the study aimed to discern any potential variations in color stability before and after the aging process.

## METHOD

20 crowns in total were created, and they were split into two groups based on two distinct types of materials, taking into account the sample size from earlier studies: Group 1 consists of monolithic, multilayered zirconia, while Group 2 consists of veneered zirconia (n=10). To make the specimens, a typodont tooth model (Nissin) representing tooth number 6 underwent a Full jacket crown preparation. To guarantee uniformity in hue among the specimens, a pre-test shade evaluation was carried out before the experimental phase started. This phase was very important since perfect shade matching is necessary for dental restorations to look as good as possible. As seen in Table 1, the participants were divided into two major groups. Multi-layered Zirconia was included in Group 1, which was further broken down into the subgroups Multi-layered Zirconia Control and Multi-layered Zirconia Thermocycled. Similar to Group 1, Group 2 included Veneered Zirconia, which was further separated into the

Veneered Zirconia Control and Veneered Zirconia Thermocycled subgroups. The effects of prolonged oral exposure were then mimicked by aging the samples from both groups using a thermocycling technique. The thermocycling encompassed 6000 cycles in which the specimens were alternately submerged in two water baths at different temperatures. The following described the thermal cycling conditions: 20 seconds in a water bath that is heated to 50 °C, then 20 seconds at 37 °C, 20 seconds at 55 °C, and lastly 20 seconds at 37 °C. These quick and frequent temperature variations mimicked the strains put on dental restorations in the oral environment during routine activities like eating and drinking. A digital spectrophotometer was used in this investigation to assure accurate and trustworthy shade matching for both natural teeth and Zirconia restorations (VITA Easyshade Compact). The color stability of the crowns was also assessed before and after the thermocycling process using the spectrophotometer. Utilizing LED technology, the instrument used a 400–700 nm wavelength range and was unaffected by the surroundings. The SPSS program was used to examine the data that was collected. It was discovered that the data for color stability (E) were not normally distributed after carrying out normality tests such as the Kolmogorov-Smirnov test, Levene test, and Shapiro-Wilk test. In order to compare the values between the various groups, non-parametric tests, especially the Wilcoxon-Mann-Whitney U-tests, were used. P value = 0.05 was chosen as the significance threshold, allowing for strong statistical analysis and insightful comparisons between the variables under study.

## RESULT

The results of the study revealed significant changes in shade for both Group-1 (monolithic multi-layered zirconia) and Group-2 (veneered zirconia) after undergoing thermocyclic aging. Specifically, in Group-1, there was a noticeable shift towards lighter values and reduced chroma in all three regions, with an additional hue change observed in the incisal region. The mean $\Delta E$ (color change) for Group-1 was found to be 14.69 (0.82), indicating a considerable alteration in color stability. On the other hand, in Group-2, a distinct darkening effect was observed in the incisal regions, with the mean $\Delta E$ measuring 6.18 (0.39). Statistical analysis using the Wilcoxon-Mann-Whitney U-test demonstrated that the changes in color for both groups were statistically significant ($p < 0.01$). These findings indicate that both types of zirconia crowns experienced notable alterations in color stability following thermocyclic aging. Table 2 provides evidence of this notable change in color stability for both types of crowns following the simulated aging process. Furthermore, the E values exhibited a significant difference between the control group and the thermocycled group for both zirconia and veneered crowns ($p < 0.001$). This finding indicates that the thermocycling aging process had a substantial impact on the color stability of the crowns compared to the non-aged control group.

**Table 1: Particulars of the multi-layered and veneered zirconia crowns employed in this research**

| **Groups** | **Prosthetic Crowns (n = 20)** | |
|---|---|---|
| | Multi-layered **(n = 10)** | Veneered **(n = 10)** |
| **Control** | Multi-layered Zirconia control (n=5) | Veneered Zirconia control (n=5) |
| **Thermocycled** | Multi-layered Zirconia thermocycled (n=5) | Veneered Zirconia thermocycled (n=5) |

**Table 2: The multi-layered and veneered crowns' color stability test results**

| Color Stability | Crown Types | | | | p Value |
|---|---|---|---|---|---|
| | Multi-layered | | Veneered | | |
| | Mean | Median | Mean | Median | |
| **Control** | 17.68 (0.67) | 17.82 (0.61) | 9.55 (0.52) | 9.51 (0.63) | <0.001 * |
| | | | | | |
| **Thermocycled** | 14.69 (0.82) | 14.58 (1.02) | 6.18 (0.39) | 6.23 (0.57) | <0.001 * |
| | | | | | |
| **Friedman Test (*p* value)** | <0.001 * | | <0.001 * | | |

## DISCUSSION

Dental restorations' color and translucency have a significant impact on how well they look aesthetically [10]. The findings of this study highlight the significance of taking into account how aging affects the color stability of zirconia crowns. While veneered zirconia showed a darkening effect in the incisal zones, monolithic multi-layered zirconia showed a shift towards lighter colors and lower chroma. These results emphasize the necessity for careful shade selection and aesthetic considerations when utilizing zirconia crowns, especially when long-term color stability is crucial for getting the best possible aesthetic results. As a result, in this study, emphasis was placed on assessing changes in the material's translucency and color. With reference to the work of Hamza et al. [11], measurements were taken using the CIE Lab system to evaluate color. Additionally, clinically perceivable color changes were designated as Veenered E units based on earlier research on the topic [12], whereas clinically acceptable color alterations were designated as multi-layered E units. In the field of aesthetic dental restorations, achieving the exact replication of color and translucency equivalent to real teeth stands as a fundamental goal. In order to produce aesthetically pleasing and natural outcomes, dental experts strive to smoothly integrate restorations with the patient's existing dentition. Numerous studies have looked into how the thickness of monolithic zirconia affects its optical characteristics. These investigations repeatedly demonstrate that monolithic zirconia's translucency reduces as its thickness grows [13]. Furthermore, it has been discovered that monolithic zirconia goods from various producers might have variable levels of translucency [14]. Similar to the findings in the literature [13], we observed in the current investigation that translucency significantly decreased as material thickness rose ($p < 0.001$). These findings support prior studies and highlight the impact of thickness on monolithic zirconia's translucency, highlighting the need of taking this into account when choosing and utilizing zirconia materials for dental restorations. It is crucial to remember that both surfaces of the specimens were influenced by the thermocycling technique in the study, which could have resulted in some limitations to the results. Another drawback was the lack of a comparison of surface roughness before and after thermocycling. It is known that variations in surface roughness may have an effect on the specimens' apparent color changes. Additionally, in clinical circumstances, elements like the color of the underlying tooth tissue and the type of resin cement employed might have an impact on the color and translucency of the restoration in addition to the restoration material itself. These extra factors in the clinical environment could affect how aesthetically pleasing the restorations turn out.

## CONCLUSION

In conclusion, the present study demonstrated that thermocyclic aging had contrasting effects on the shade of zirconia crowns. Group-1 (monolithic multi-layered zirconia) exhibited a lighter shade, while Group-2 (veneered zirconia) appeared darker after the aging process. These findings highlight the importance of considering the color stability of zirconia crowns when selecting materials for dental restorations. Further investigations, possibly utilizing the Degudent Shadepilot, are warranted to deepen our understanding of zirconia crown color stability for enhanced clinical outcomes.

## REFERENCE

1. Christensen, G.J., 2014. Rapid change in the fabrication of crowns and fixed prostheses. The Journal of the American Dental Association, 145(8), pp.862-864.
2. Millar, B.J., 2017. An assessment of burs designed to cut zirconia. Open Journal of Stomatology, 7(5), pp.277-282.
3. Zhang, Y., 2014. Making yttria-stabilized tetragonal zirconia translucent. Dental materials, 30(10), pp.1195-1203.
4. Sripetchdanond, J. and Leevailoj, C., 2014. Wear of human enamel opposing monolithic zirconia, glass ceramic, and composite resin: an in vitro study. The Journal of prosthetic dentistry, 112(5), pp.1141-1150.
5. Acar, O., Yilmaz, B., Altintas, S.H., Chandrasekaran, I. and Johnston, W.M., 2016. Color stainability of CAD/CAM and nanocomposite resin materials. The Journal of prosthetic dentistry, 115(1), pp.71-75.
6. Saifullah, M., Reddy, K.M., Shastry, Y.M. and Aditya, S.V., 2023. Effect of aging on colour stability of monolithic multilayered zirconia crowns-an in-vitro study. Journal of Advanced Medical and Dental Sciences Research, 11(3), pp.1-8.
7. de Oliveira, A.L.B.M., Botta, A.C., Campos, J.Á.D.B. and Garcia, P.P.N.S., 2014. Effects of immersion media and repolishing on color stability and superficial morphology of nanofilled composite resin. Microscopy and Microanalysis, 20(4), pp.1234-1239.
8. Oh, S.H. and Kim, S.G., 2015. Effect of abutment shade, ceramic thickness, and coping type on the final shade of zirconia all-ceramic restorations: in vitro study of color masking ability. The journal of advanced prosthodontics, 7(5), pp.368-374.
9. Tuncel, I., Eroglu, E., Sari, T. and Usumez, A., 2013. The effect of coloring liquids on the translucency of zirconia framework. The journal of advanced prosthodontics, 5(4), pp.448-451.
10. Tuncdemir, A.R., Polat, S., Ozturk, C., Tuncdemir, M.T. and Gungor, A.Y., 2012. Color differences between maxillar and mandibular incisors. European Journal of General Dentistry, 1(03), pp.170-173.
11. Hamza, T.A., Alameldin, A.A., Elkouedi, A.Y. and Wee, A.G., 2017. Effect of artificial accelerated aging on surface roughness and color stability of different ceramic restorations. Stomatological Disease and Science, 1, pp.8-13.
12. Paravina, R.D., Ontiveros, J.C. and Powers, J.M., 2004. Accelerated aging effects on color and translucency of bleaching-shade composites. Journal of Esthetic and Restorative Dentistry, 16(2), pp.117-126.
13. Ilie, N. and Stawarczyk, B., 2015. Quantification of the amount of blue light passing through monolithic zirconia with respect to thickness and polymerization conditions. The Journal of prosthetic dentistry, 113(2), pp.114-121.
14. Sulaiman, T.A., Abdulmajeed, A.A., Donovan, T.E., Ritter, A.V., Vallittu, P.K., Närhi, T.O. and Lassila, L.V., 2015. Optical properties and light irradiance of monolithic zirconia at variable thicknesses. Dental Materials, 31(10), pp.1180-1187.