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

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ABSTRACT

Introduction: Goals in dentistry was obtaining high esthetics through dental restorations that mimic the color and translucency of natural teeth. When ceramic restorations are placed adjacent to natural teeth, they should match not only the shape and texture but also the reproduction of the optical characteristics of natural teeth.

Aims and objectives: The purpose of the study was to evaluate and compare the color stability of monolithic multi-layered zirconia and veneered zirconia crowns before and after thermocycling aging.

Materials and methods: 40 specimens, were fabricated for each group. Group 1 - Monolithic Multi-layered Zirconia and Group 2 - Veneered Zirconia. A Full jacket crown preparation was done on a typodont tooth (Nissin) in relation to 21. After pre-test shade evaluation, all the specimens were subjected to 5000 thermal cycles immersing for 15 seconds in each tank with temperature of (5^0C,37^0C,55^0C,37^0C).

Results: Results showed that post thermocyclic aging the shade of Group-1 (monolithic multi-layered zirconia) changed to lighter in value and chroma in all the three regions and hue change incisally. Group-2 (veneered zirconia) changed to darker value and chroma in incisal regions.

Conclusion: The shade of group-1 (monolithic multi-layered zirconia) changed lighter post thermocyclic aging whereas the shade of group-2 (veneered zirconia) appeared to be darker post thermocyclic aging. Further studies may be required to evaluate the effect of color stability of zirconia crowns with the Vita Easyshade 0.4.

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INTRODUCTION

One of the main goals in prosthetic dentistry is obtaining high esthetics through dental restorations that mimic the color and translucency of natural teeth. Ceramic materials are popular in prosthodontics and they are often chosen over traditional metal restorations because of their excellent esthetics and acceptable mechanical properties. When ceramic restorations are placed adjacent to natural teeth, they should match not only the shape and texture but also the reproduction of the optical characteristics of natural teeth.Even though, monolithic zirconia ceramics can provide excellent mechanical properties without the risk of chipping of veneering porcelain, the literature suggested that they have low translucency and are susceptible to hydrothermal aging[1].It is observed that monolithic zirconia in anterior dentition compromises estheticsby giving a rather opaque appearance and an unpredictable and as yet unexplored color stability during clinical function.

The monolithic zirconia restorations in their clinical life are subjected to repeated thermal changes in a wet environment. This exposure could result in the absorption of water radicals which can yield tensile stresses between tetragonal and monoclinic phases and the energy difference between the 2 phases further activates the transformation, resulting in surface microcracks, roughening and potentially contribute to color changes. This phenomenon of transformation refers to aging or low temperature degradation (LTD)[2]. It could result in the penetration of water inside the material, accelerate the degradation phenomenon and increases the failure probability.

In the past, many researchers contributed to the understanding of the optical behavior of dental zirconia. Various parameters were evaluated such as the number of firing cycles, glaze application, type and shade of the infrastructure, thickness of the veneering ceramic and the degree of opalescence or translucency of zirconia.veneering of zirconia may result in high clinical chipping rates of more than 30%, which requires a more invasive tooth preparation, and the manufacturing process is more complex[3]. They suggested to avoid veneering completely and advised to use zirconia in monolithic form. This form needs no extra laboratory effort as the bulk of the restorations are milled in the clinical settings. However, their ability to achieve optimal esthetics is still challenged.

Furthermore, to achieve esthetics comparable with those of veneering porcelain, researchers have proposed two approaches to color monolithic zirconia i.e., adding metallic pigments to the initial zirconia powder before or after pressing the milling blocks or the immersion of the zirconia restorations in coloring liquids containing chloride solutions of rare earth elements to produce cores of various shades[4].It is important to understand the alteration in the physical and chemical structures of the restorative materials mainly due to the effect of oral environmental factors. The dynamic nature of the oral environment with constant changes in pH, stress and temperature may significantly influence the colour stability of esthetic restorative materials[5]. With laboratory tests, such as thermocycling it is possible to have foresight about the long-term clinical behaviour of dental restorative materials. Thermocycling is one of the most commonly used artificial aging methods in dentistry, an effective method to mimic the natural aging process of dental restorations and imitate oral conditions in laboratory environment[6].

Many studies in the past have contributed to the understanding of the optical behavior of dental zirconia. However, the color stability of the monolithic multi-layered zirconia and veneered zirconia are not clear. Thus, the present study aimed to evaluate and compare the colour stability of monolithic multi-layered zirconia and veneered zirconia crowns before and after thermocyclic aging.

The purpose of the study is to evaluate and compare the colour stability of monolithic multi-layered zirconia and veneered zirconia crowns before and after thermocycling aging. The hypothesis of current study is that there is no significant change after thermocyclic aging in group 1 and group 2.

AIMS AND OBJECTIVES

The aim of the present study was to evaluate and compare the colour stability of monolithic multi-layered zirconia and veneered zirconia crowns before and after thermocyclic aging. Objectives of the study were to evaluate the colour stability of the core material before and after thermocyclic aging on monolithic multi-layered zirconia and to evaluate the colour stability of the core material before and after thermocyclic aging on veneered zirconia crowns.

MATERIALS AND METHODS

The present in-vitro study aimed to evaluate and compare the color stability of monolithic multi-layered zirconia and veneered zirconia crowns before and after thermocycling aging. A Full jacket crown preparation was done on a typodont tooth (Nissin) in relation to 11 (Figure 1). A total of 40 specimens were fabricated for this study. All the specimens were randomly divided into two groups. Group 1 - Monolithic Multi-layered Zirconia and Group 2 - Veneered Zirconia with twenty specimens in each group (n=20).The prepared model was sprayed with TeleScan CAD/CAM scan spray (Figure 2) which was available in white color. It was intended to be used during CAD/CAM scanning to avoid the mirror effect on scanned objects and to improve the scan quality. The fine dry powder film was easily removed with a brush. After spraying the prepared model was inserted into Dentsply Sarona inEosX5 lab scanner (Figure 3). The model was scanned with a robotic arm with unique 5-axis scanning technology that had accuracy and the highest depth of field with clear software interface. With this scan, data were collected as an STL file for group 1 and group 2. An STL file of the prepared model was obtained. An STL file of the prepared model was transferred to a computer-aided design. The software deguDent Cercon art CAD/CAM was used to design the full anatomic crowns for group 1 (n=20) samples. The thickness of the crown in cervical region was 0.8mm, middle region was 1.2mm and incisal region was 1.3mm to mimic natural tooth (Figure 4). An STL file of the prepared model was transferred to a computer-aided design. The software deguDent Cercon art CAD/CAM was used to design the facing cut-back of crowns for group 2 (n=20) samples. The thickness for cut-back crown in cervical region, middle region and incisal region was 0.3mm which was designed for conventional layering. Milling of samples of group-1 (n=20) crowns of Monolithic Multi-layered Zirconia was done on Cercon XT ML using partially sintered blank. This blank was milled in SIRONA inLab MC X5. After the milling procedure, the specimens were subjected to regular sintering temperature cycle at 1450°C with a holding time of 120 mins in SIRONA inFire HTC speed. After the sintering of samples glazing was done on monolithic multi-layered zirconia (group -1) with E-max Ceram Glaze Stain Liquid. Milling of samples of group-2 (n=20) copings of Veneered Zirconia was done on Cercon HT using partially sintered blank. The copings were milled in SIRONA in Lab MC X5. After the milling procedure, the specimens were subjected to regular sintering temperature cycle at 1450°C with a holding time of 120 mins in SIRONA inFire HTC speed. After the sintering of samples, conventional layering was done on veneered zirconia (group -2) with IPS E-max Ceram A4 shade. The layering of copings in group-2 (n=20) i.e., veneered zirconia was done by E-max Ceram multilayer Layering material (Figure 10). Thickness of the facings of copings was 0.3mm labially. Ceramic was layered on labial surface of the coping in a precise order to simulate dental structures. The layering process began with opacifying layer and opaque dentine continued with dentin and was finished with enamel and translucent layers. Each new layer was less opaque than the underlying layer. Indexes were made for every layer of copings. First index was made with silicone impression material after having applied deep dentine body on to the coping which was of a thickness of 0.3mm at the cervical surface. After this second index were made with silicone impression material after having applied dentin body on to the coping which was of thickness of 0.2mm at the cervical, middle and incisal regions. Third index was made with silicone impression material after having applied enamel body on to the coping which was of a thickness of 0.2mm at the cervical, middle and incisal. Forth index was made with silicone impression material after having applied glazing material on to the coping which was of a thickness of 0.1mm at all the surfaces of the coping. With this procedure we achieved indexes of layering to maintain the thickness of the layering material.

Figure 1: Typodont

Figure 2: TeleScan CAD/CAM spray

Figure 3: inEosX5 lab scanner.

Figure 4: STL file of Full jacket crown of monolithic multi-layered zirconia irt 11

DISCUSSION

Zirconia based ceramic dental restorations are fabricated using CAD/CAM. These materials have gained popularity for their metal-free, natural-looking appearance as suggested by Li RW et al (2014)[7], Luthardt RG et al (2004)[8]. Computer aided design / computer aided machining (CAD/CAM) technology is the ideal method for manufacturing zirconia crowns. CAD-CAM techniques were developed to help automate the production process, to optimize the quality of restorations and to use new biocompatible and esthetic materials[Batson ER et al (2014)[9], Hamza TA et al (2013)[10]].The traditional methods of ceramic fabrication were time consuming, technique sensitive and unpredictable due to the many variables and CAD/CAM may be a good alternative for both the dentists and laboratories as suggested by Miyazaki T et al (2013)[11], Christensen RP and Ploeger BJ (2010)[12], Liu RP and Essig ME

(2008)[13], Takaba M et al (2013)[14]. Zirconia has received considerable clinical and research interest from modern dental practices as a means of delivering all-ceramic restorations. Up to now the CAD/CAM system with zirconia has the highest fracture strength in all-ceramic materials and consistently enabled the most esthetic, lifelike reproduction of natural dentition as suggested by Hamza TA and Sherif RM (2019)[15]. Zirconia has been widely accepted by both dentists and patients. The CAD/CAM system with zirconia is indicated for crowns and bridges in natural teeth or implants and telescope dentures as suggested by "Bindl A et al (2006)[16], Bindl A and Mörmann WH (2004)[17]".

Ceramics are highly popular materials in prosthodontics due to their advantages and excellent aesthetics properties. They have high mechanical strength and toughness and hence can be used as crown restorations in the anterior as well as posterior regions as stated by Holden JE et al (2009)[18], Sieber C (1992)[19]. The properties that favour their use in dentistry are biocompatibility, low thermal conductivity, resistance to corrosion and high tenacity, due to its totally crystalline microstructure. However, being opaque, they have to be covered with a more translucent feldspathic ceramic to improve esthetics. High-translucency zirconia has recently gained popularity owing to its esthetic features and high strength in accordance with Rekow et al (2011)[20], Windisch S et al (1999)[21], Bindl A and Mörmann WH (1997)[22].

Most recently, high strength milled alumina and zirconia have been developed for use as a core material in posterior ceramic crowns. Owing to superior mechanical properties, zirconia has been used for single to multiunit and complete arch frameworks, implant abutments and complex implant superstructures for fixed and removable prostheses as stated by Conrad HJ et al (2007)[23], Krejci et al (1999)[24], Christel P et al (1989)[25]. Although zirconia has superior mechanical properties, its opaque white colour and insufficient translucency require glassy porcelain veneering on the framework to achieve a natural appearance and acceptable esthetics. However, cracking or chipping of the porcelain veneer has been reported to be a major complication of these restorations as reported by Larsson C et al (2006)[26], Sailer et al (2007)[27].

Anatomic contour monolithic zirconia restorations have become popular in recent years because of their high flexural strength, conservative tooth preparation, minimal wear on opposing teeth, reduced clinical and laboratory time of fabrication and absence of veneering porcelain as stated by Malkondu O et al (2016)[28]. The monolithic multi-layered zirconia is made up of Zirconium oxide, Yttrium oxide 9%, Hafnium oxide < 3%, Aluminium oxide, Silicon oxide and other oxides < 2%. These monolithic zirconia restorations can be produced in the laboratory with computer-assisted manufacturing (CAD/CAM) systems in a short time without adding any porcelain as suggested by Koseoglu M et al (2019)[29], Christensen GJ (2014)[30], Griffin JD (2013)[31], Sripetchdanond and J,Leevailoj C (2014)[32], Zhang Y and Sailer I (2013)[33], Flinn BD et al (2017)[34].

Veneered zirconia is a type of ceramic material known as zirconia oxide. They are used to make full or partial crown restorations. It is designed to give teeth a natural appearance as stated by Holden JE et al (2009)[35]. The esthetic result of ceramic materials depends mostly on the type of color application, the glazing and polishing technique and the time and method of sintering. These procedures may affect the grain size and the pore distribution of the material. As with all dental restorations, monolithic zirconia restorations are submitted to repeated thermal changes in a wet environment during their clinical life [Piconi C and maccauro G (1999)[36], Christel P et al (1989)[37]]. These conditions may alter their structure through a transformation phenomenon from the metastable tetragonal phase to the stable phase at room temperature and to monoclinic phase and to potentially contribute to color changes or the deterioration of mechanical properties.

CONCLUSION

Within the limitations of this invitro study, the following conclusions were drawn: The shade of group-1 (monolithic multi-layered zirconia) changed lighter post thermocyclic aging whereas the shade of group-2 (veneered zirconia) appeared to be darker post thermocyclic aging. Further studies may be required to evaluate the effect of color stability of zirconia crowns with the Vita Easyshade.

REFERENCES

1. Munoz EM, Longhini D, Antonio SG, Adabo GL. The effects of mechanical and hydrothermal aging on microstructure and biaxial flexural strength of an anterior and a posterior monolithic zirconia. J Dent. 2017;63:94-102.
2. Mitov G, Anastassova-Yoshida Y, Nothdurft FP, Von See C, Pospiech P. Influence of the preparation design and artificial aging on the fracture resistance of monolithic zirconia crowns. J. Adv Prosthodont. 2016;8(1):30-36.
3. Herpel C, Rammelsberg P, Rues S, Zenthöfer A, Seceleanu I, Corcodel N. Color stability of individually stained monolithic zirconia following occlusal adjustment. J Esthet Restor Dent. 2021;33(2):387-393.
4. Kontonasaki E, Giasimakopoulos P, Rigos AE. Strength and aging resistance of monolithic zirconia: an update to current knowledge. Jpn Dent Sci Rev. 2020;56(1):1-23.
5. Rossomando KJ, Wendt SL Jr. Thermocycling and dwell times in microleakage evaluation for bonded restorations. Dent Mater. 1995;11(1):47-51
6. Kingery WD. Factors affecting thermal stress resistance of ceramic materials. Journal of the American Ceramic society. 1955;38(1):3-15.
7. Li RW, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: state of the art. J Prosthodont Res. 2014; 58(4):208-216.
8. Luthardta RG, Holzhutera MS, Rudolpha H, Heroldb V, Walter MH. CAD/CAM-machining effects on Y-TZP zirconia. Dent Mater. 2004; 20 (1): 655–662.
9. Batson ER, Cooper LF, Duqum I, Mendonça G. Clinical outcomes of three different crown systems with CAD/CAM technology. J Prosthet Dent. 2014; 112(4):770-777.
10. Hamza TA, Ezzat HA, El-Hossary MM, Katamish HA, Shokry TE, Rosenstiel SF. Accuracy of ceramic restorations made with two CAD/CAM systems. The J Prosthet Dent. 2013; 109(2): 83-87.
11. Miyazaki T, Nakamura T, Matsumura H, Ban S, Kobayashi T. Current status of zirconia restoration. J Prosthodont Res. 2013; 57: 236–261
12. Christensen RP, Ploeger BJ. A Clinical Comparison of Zirconia, Metal and Alumina Fixed-Prosthesis Frameworks Veneered With Layered or Pressed Ceramic: A three-year report. The J Am Dent Assoc. 2010; 141 (11): 1317-1329.
13. Liu PR, Essig ME. Panorama of dental CAD/CAM restorative systems. Compend Contin Educ Dent. 2008;29(8):482- 488
14. Takaba M, Tanaka S, Ishiura Y, Baba K. Implant-Supported Fixed Dental Prostheses With CAD/CAM-Fabricated Porcelain Crown And Zirconia-Based Framework.J Prosthodont. 2013; 22 (5): 225-231.
15. Hamza TA, Sherif RM. Fracture Resistance of Monolithic Glass-Ceramics Versus Bilayered Zirconia-Based Restorations. J Prosthodont. 2019; 28(1):259-264..
16. Bindl A, Lüthy H, Mörmann WH. Strength and fracture pattern of monolithic CAD/CAM-generated posterior crowns. Dent Mater. 2006; 22(1): 29-36.
17. Bindl A, Mörmann WH Survival rate of mono-ceramic and ceramic-core CAD/CAM-generated anterior crowns over 2–5 years. Eur J Oral sci. 2004. 112 (2): 197-201.
18. Holden JE, Goldstein GR, Hittelman EL, Clark EA. Comparison of the marginal fit of pressable ceramic to metal ceramic restorations. J Prosthodont 2009; 18:645-648.
19. Sieber C. Illumination in anterior teeth. Quintessenee Dent Tech 1992:81-88

20. Rekow ED, Silva NR, Coelho PG, Zhang Y, Guess P, Thompson VP. Performance of dental ceramics: challenges for improvements. J Dent Res. 2011;90(8):937-952.
21. Windisch S, Mörmann WH, Bindl A. Full-ceramic CAD/CIM anterior crowns and copings. Int J Comput Dent. 1999;2(2):97-111.
22. Bindl A, Mörmann WH. Clinical evaluation of adhesively placed Cerec endo-crowns after 2 years – preliminary results. J Adhes Dent 1997;1(3):255-265.
23. Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review. J Prosthet Dent. 2007;98(5):389-404
24. Krejci I, Albert P, Lutz F. The Influence of Antagonist Standardization on Wear. J Dent Res 1999;78: 713.
25. Christel P, Meunier A, Heller M, Torre JP, Peille CN. Mechanical properties and short-term in vivo evaluation of yttrium-oxide-partially-stabilized zirconia. J Biomed Mater. 1989; 23(1):45–61.
26. Larsson C, Vult von Steyern P, Sunzel B, Nilner K. All-ceramic two- to five-unit implant-supported reconstructions. A randomized, prospective clinical trial. Swed Dent J. 2006; 30(2):45-53.
27. Sailer I, Pjetursson BE, Zwahlen M, Hämmerle CH. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part II: Fixed dental prostheses. Clin Oral Implants Res. 2007;18(3):86-96
28. Malkondu O, Tinastepe N, Kazazoglu E. Influence of type of cement on the color and translucency of monolithic zirconia. J Prosthet Dent. 2016 Dec;116(6):902-908.
29. Koseoglu M, Albayrak B, Gül P, Bayindir F. Effect of thermocycle aging on color stability of monolithic zirconia. Open J Stomatol. 2019;9(03):75.
30. Christensen GJ. Rapid Change in the Fabrication of Crowns and Fixed Prostheses. The J Am Dent Assoc. 2014; 145(1): 862-864.
31. Griffin JD. Combining monolithic zirconia crowns, digital impressioning, and regenerative cement for a predictable restorative alternative to PFM. Compend Contin Educ Dent. 2013; 34(3):212-222.
32. Sripetchdanond J, Leevailoj C. Wear of human enamel opposing monolithic zirconia, glass ceramic, and composite resin: an in vitro study. J Prosthet Dent. 2014;112(5):1141-1150.
33. Zhang Y, Sailer I, Lawn BR. Fatigue of dental ceramics. J Dent. 2013;41(12):1135-1147.
34. Flinn BD, Raigrodski AJ, Mancl LA, Toivola R, Kuykendall T. Influence of aging on flexural strength of translucent zirconia for monolithic restorations. J Prosthet Dent. 2017;117(2):303-309
35. Holden JE, Goldstein GR, Hittelman EL, Clark EA. Comparison of the marginal fit of pressable ceramic to metal ceramic restorations. J Prosthodont 2009; 18:645-648.
36. Piconi C, Maccauro G. Zirconia as a ceramic biomaterial. Biomaterials. 1999;20(1):1-25.
37. Christel P, Meunier A, Heller M, Torre JP, Peille CN. Mechanical properties and short-term in vivo evaluation of yttrium-oxide-partially-stabilized zirconia. J Biomed Mater. 1989; 23(1):45-61.