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The Effect of Different Veneering Techniques and Aging on Color Parameters of Y-TZP Zirconia Ceramics

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Abstract

Aim of the study: This study aims to evaluate the effect of different veneering techniques; Layering, Pressing, Double Veneering and CAD-On, and Hydrothermal aging on the color and translucency parameters of Y-TZP zirconia ceramics.

Methodology: 40 zirconia discs were milled and sintered. Zirliner was then applied to the discs and fired. The discs were then divided into 4 equal groups (n=10) according to the veneering technique used: a) Layering, b) Pressing, c) Double veneering technique and d) CAD-on veneering technique. Color parameters of the core veneered specimens were then measured. The data was expressed in terms of the three coordinate values L*, a* and b*. The color of a standard shade tab was also measured as the control group. The Translucency parameter (TP) values were evaluated by measuring the mean color difference of the specimens on black and white backgrounds. Hydrothermal aging was then performed on the discs and the color parameters and translucency were measured and ΔE was compared before and after aging.

Results: ΔE mean values showed statistically significant difference between groups, where pressing technique showed statistically significantly highest mean ΔE values followed by layering technique and double veneering, while CAD-on showed the statistically significant lowest mean ΔE values. Moreover, regardless of veneering technique, there was a statistically significant decrease in mean (TP) values after aging resulting in more opaque specimens.

Conclusion: Different veneering techniques and aging exhibited changes in the color and translucency parameters of Y-TZP zirconia ceramics. After hydrothermal aging, the mean color differences (ΔE) of different veneering techniques were below the perceptible range (ΔE). The translucency of different veneering techniques was negatively influenced by hydrothermal aging.

Keywords: Zirconia, Veneering techniques, Color

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Introduction

Conventional metal ceramic restorations are considered the standard for providing acceptable esthetics, high strength, and long-term success.[1] However the increased aesthetic requirements and demands of patients and dental professionals have resulted in the development of a large variety of metal free ceramic systems.[2, 3]

All ceramic restorations when compared to metal ceramic restorations have the advantage of having excellent ability to obtain optimal esthetic outcomes. However, because of their low mechanical stability, all ceramic systems (feldspathic-reinforced, glass-reinforced, and glass ceramics) have only been demonstrated to be suitable for single crowns. All ceramic fixed partial dentures showed high fracture rates in both anterior and posterior areas.[4, 5] High strength ceramics were thus introduced in reconstructive dentistry and showed superior mechanical properties in comparison with conventional ceramics.

The introduction of zirconia-based ceramics has generated considerable interest in the dental community. Its unique qualities, strength, transformation toughening, white color, chemical and structural stability made zirconia the core material of choice among high strength dental ceramics.[6,7] Computer aided design/computer aided manufacture (CAD/CAM) technology have been used to fabricate infrastructures of all ceramic restorations. Blocks can be milled according to the frameworks designed by CAD software. Then, after fully sintering at the second high temperature, outstanding mechanical properties, such as high flexural strength and fracture toughness are achieved, so that zirconia all ceramic restorations process superior fracture resistance to withstand occlusal force.[8] However, zirconia is an opaque ceramic material exhibiting a white color, and is, therefore only suitable as a framework material, and must be veneered for optimal esthetic outcomes.[9]

In concern of color, numerous veneering techniques for zirconia frameworks have been introduced to mask the opacity of zirconia to achieve excellent optical properties. Such techniques include, traditional layering technique, where the core is veneered by condensing and sintering veneering porcelain producing a bi-layer system. However, such a system required manual mixing and addition of the slurry and thus liable to multiple operators and structural defects affecting the appearance of the final restoration.[10] In addition, fully anatomical techniques utilizes heat-pressing flouroapatite glass-ceramic ingots has been introduced which has the advantage of pressing under controlled temperature and pressure and thus completed under more controlled parameters. However, heat-pressing is monochromatic which affected the final appearance of the restorations. A combination of pressing and layering was subsequently introduced by partially heat-pressing and subsequently layering can be applied on zirconia frameworks to combine both strength and optimal esthetics. Each technique was said to be able to improve the esthetic properties of Y-TZP based restorations.[11]

Lately, a new technique has been introduced, which utilizes a CAD/CAM milled veneering ceramic which is then fused onto the zirconia coping. It has been reported that this technique combines the strength and aesthetics as well as precision in fabrication and reduced chair time[12].Moreover, with zirconia based restorations, the materials directly exposed to the oral environment are mainly veneering ceramics. This tends to subject these materials to factors such as temperature changes, pH fluctuations, wear and mechanical load which affects the durability of these ceramics and thus the optical qualities. [12,13,14]

Due to the different factors that affect the final esthetic outcome, this study aims to evaluate the effect of different zirconia veneering techniques as well as their susceptibility to aging on color and translucency parameters of zirconia based ceramics.

Materials:

In this study, the following materials were used:

1. Copran Zr-i zirconia blanks: Y_2O_3 stabilized tetragonal partially sintered, dry milled white Zirconia blanks.

2) Veneering Ceramics:

a) IPS emax Ceram: IPS emax ceram is a veneering ceramic mainly consisting of glass ceramic and a nanoscale flouroapatite crystals, without addition of feldspar or leucite. Dentin/A2 shade is used to veneer the Corpran Zr-i specimens.

b) IPS e.max ZirPress: Flouroapatite, a highly esthetic lithium disilicate glass ceramic ingot for an efficient press-on technique on zirconium oxide frameworks. HT A2 IPS emax Zirpress ingots are used in this study to be pressed on the zirconia specimens.

c) IPS emax CAD: IPS emax CAD is a lithium disilicate glass-ceramic block used for the CAD/CAM technology. A2 HT block is used for the CAD-on.

Methods:

In this study, samples were constructed using CAD/CAM Y-TZP zirconia blanks in the form of disc specimens to act as frameworks. After sintering of the discs, four different veneering techniques were used to veneer the zirconia discs. The color parameters and translucency were then measured using a spectrophotometer and the four veneering techniques were compared. Hydrothermal aging was then performed on the four groups. The color parameters and translucency of the discs were then measured and compared using spectrophotometer.

Sample Grouping:

40 Y-TZP discs of 10mm diameter x 0.5 mm thick were prepared using a four axis MHO compact (Centroid, PA, USA) CNC machine that milled a Copran Zirconia blank. The disc specimens were divided into four groups according to the veneering technique (n=10).

Group I; Traditional Layering, **Group II**; Pressing, **Group III**; Double Veneering and **Group IV**; CAD-on Veneering.

The color and translucency were then measured and recorded using spectrophotometer. The discs were then subjected to hydrothermal aging in an autoclave for 5 hours representing 15-20 years intraorall[15,16] The color and translucency were then re-measured, and the color parameters and translucency were then compared before and after aging.

Aging:

For each group, the color and translucency was first measured and recorded using spectrophotometer. The discs were then subjected to hydrothermal aging in an autoclave for 5 hours representing 15-20 years intraorally. [15,16] The color and translucency were then re-measured, and the color parameters and translucency were then compared before and after aging.

Sample Preparation:

a) Construction of Zirconia discs:

A four axis MHO compact (Centroid, PA, USA) CNC machine was used for milling cylinders from a Copran-Zr Y-TZP blank into cylinders then sliced into round discs of 10mm diameters and 0.75mm thickness.

The milled discs were fully submerged in the coloring liquid of shade A2 for 20 minutes as recommended by the manufacturer and left on a glass slab.

i)Sintering

The discs were placed inside the Ceramill therm furnace (Amann Girbach AG, Koblach, Austria) at 1150°C for 12 hours recommended by the manufacturer.

b) Veneering of Zirconia:

Zirliner: E.max zirliner 1(Ivoclar Vivadent AG) was mixed with e.max zirliner buildup liquid to a creamy consistency. This mix was then applied with a glass instrument to all zirconia cores (n=40) and vibrated till the color is greenish and even. The specimens were then fired in Programmat EP 3010 (Ivoclar Vivadent AG) according to manufacturer's instructions as follow:

(a) 2 minutes predrying at temperature 403 °C .

(b) Heating time was at 60 °C per minute till the final temperature of 960 °C.

(c) Holding time as 1 minute with vacuum at maximum temperature.

i.Veneering by Layering Technique: For Groups I and II, a specially designed circular copper mold was fabricated with dimensions of 25 mm diameter and 5 mm thickness to standardize the thickness of the veneering ceramic. A hole was drilled in the center of the mold with dimensions of 10 mm diameter and 8.8 mm thickness leaving 1.2 mm between the end of the Teflon plunger and the end of the mold where the zirconia core and subsequent veneer will occupy. A2 dentin e.max Ceram is a (Ivoclar Vivadent AG) powder was mixed with special ceram buildup liquid to form a slurry mix. The zirconia core was placed inside the copper mold, and the porcelain mix was then applied and compacted over the core using a brush. Condensation was then carried out using tissue paper to remove excess liquid.

Figure 1: Copper mold with Teflon piston

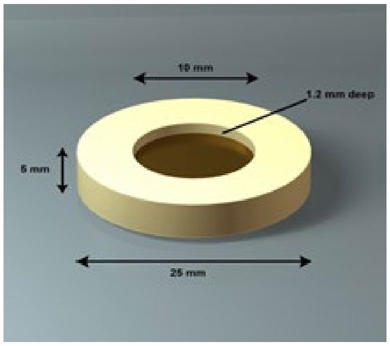

Figure 2: Schematic diagram of the Copper mold with Teflon piston

After complete buildup of porcelain, the plunger was pushed from the underside of the mold and the built up core was carefully removed and fired in the EP 3010 porcelain furnace (Ivoclar Vivadent AG).

First dentin firing cycle was carried out according to manufacturer's instructions as follow: (d) 4 minutes of pre-drying time at 400 °C.

(e) Heating time was 7 minutes at a rate of 50°C per minute to reach the firing temperature of 750 °C with holding time of 1 minute.

After sintering, porcelain was applied again to compensate for the firing shrinkage of porcelain and a second dentin firing cycle was performed in the same manner.

Glazing was then performed by covering the specimens with IPS e.max Ceram Glaze (Ivoclar Vivadent AG) and fired according to manufacturer's instructions as follow:

(a) 6 minutes of pre-drying time at 400 °C.

(b) Heating time was 5.5 minutes at a rate of 60 °C per minute to reach the firing temperature of 725 °C with holding time of 1 minute.

ii.Veneering of Zirconia using Pressing technique :

For Group II, the zirconia cores are placed in the copper mold, and wax was built over the zirconia cores till the end of the mold (0.6 mm thickness). The wax/zirconia was then sprued and attached to the crucible-former and invested using 200g of IPS PressVest Speed (Ivoclar Vivadent AG) using 32 ml of pressvest liquid and 22ml of distilled water. Mixing was performed in 2 minutes and after pouring, the investment was left to set for 40 minutes undisturbed.

The set investment ring was then placed in a burnout furnace (Ney, Dentsply, USA) that was preheated where the ring was held inside the furnace for 1 hour. IPS e.max ZirPress ingots(Ivoclar Vivadent AG) (A2 HT) were placed inside the heated ring followed by the placement of an alumina plunger (alox plunger) and the ring was placed in its position inside the pre heated porcelain furnace Programat EP3010 (Ivoclar Vivadent AG).

The pressing procedure was carried out according to manufacturer's instructions as follow: (a) The starting temperature was 400 °C and (b) The heating rate was 60 °C per minute till the final temperature of 910 °C. This temperature was held for 15 minutes, followed by pressing for 5 minutes at 5 bar pressure. After completion of the pressing procedure, the investment ring is left to cool on the bench. A diamond disc was then used to cut off the investment ring at the plunger attachment, then the rest of the investment is removed in a sandblasting unit Basic Classic Sandblaster(Renfert GmbH, Hilzingen, Germany) using 50 um glass beads at 2 bar pressure.

The reaction layer usually forms on the emax surface was removed by placing the specimens in an acidic cleaning Invex liquid (Ivoclar Vivadent AG) for 20 minutes followed by placing in an ultrasonic cleaner for 10 minutes. The specimens were then ground and polished using sand paper and glazed as previously described according to manufacturer's instructions.

iii.Veneering of Zirconia using Double Veneering technique: For group III, another specially designed circular copper mold was fabricated with dimensions of 20 mm diameter and 10 mm thickness. A hole was drilled in the center of the mold with dimensions of 10 mm diameter and 9.1 mm thickness leaving 0.9 mm between the end of the Teflon piston and the end of the mold where the zirconia core and subsequent veneer will occupy. The wax was built on zirconia cores till flushing with the end of the mold (0.4 mm wax) and then sprued and attached to the crucible former and invested and pressed as mentioned previously in group II. The pressed specimen was then divested, finished and then placed back in the copper mold used for the layering technique, thus leaving 0.3 mm between the end of the pressed specimen and the end of the mold, where e.max ceram slurry was built up and fired according to manufacturer's instructions as mentioned earlier for the layering technique (Group I). After firing, the specimens were then ground and polished, then glazed according to manufacturer's instructions.

iv. Zirconia Veneering using CAD-on technique: For group IV, 10 e.max CAD discs were fabricated with dimensions of 10 mm diameter and 0.6 mm thickness. This was achieved by milling around e.max CAD block to round it using Bench Lathe BV20BL(Shanghai Shenji International Co., Ltd. Shanghai, China)followed by slicing the block into 0.7mm discs using Isomet 4000 under water coolant.

E.max CAD crystall/connect (Ivoclar Vivadent AG) fusing glass was then using to attach the zirconia discs to the e.max CAD veneering discs.The crystall/connect fusing glass is thixotropic in nature and thus ivomix vibrator (Ivoclar Vivadent AG) was used to vibrate the material to allow flow. As it vibrated, it was then applied on the zirconia core and the veneering disc was then brought into contact with the zirconia. The 2 components were then fired together in porcelain furnace EP3010 following manufacturer's instructions.

c) Evaluation of Color and Translucency: Color parameters of the core-veneered specimens were measured using Agilent Cary 5000 spectrophotometer (Agilent Technologies, USA). The wavelength scan in these measurements was carried out from 380nm to 780 nm.

The color of the specimens was measured against a black background. The color of a standard A2 shade tab by ivoclar vivadent was also measured as the control group to which the four other groups will be compared to. The data was then expressed in terms of the three coordinate values L*, a* and b*, which were established by the Commission International de I'Eclairage (CIE) (17) to quantify the appearance of the specimens. Three measurements were recorded to determine the color coordinates for each disc and then converted to CIE lab values. The color difference in the form of ΔE *ab is measured by comparison of the specimens with a standard L*, a* and b* values using the following equation73,100: ΔE = [(ΔL*) 2 + (Δa*) 2 + (Δb*) 2] 1/2 The Translucency parameter (TP) values were evaluated by measuring the color difference of the specimens on black and white backgrounds using the following equation(18): TP = [(Lb * -Lw *) 2 + (ab * - aw *) 2 + (bb * - bw *) 2] 2 Where b represents color parameter over a black background while w represents color parameter over a white background.[18,19,20]

Aging: Following completion of color and translucency measurements, the specimens of the 4 groups were subjected to hydrothermal aging. This was done by placing the discs in the stainless steel tray in a steam autoclave(CARLO DE GIORGI S.R.L, Milano (Italy). A 20 minutes cycle was selected and parameters were adjusted to 134 oC at 2 bar pressure. This cycle was repeated 15 times to have the specimens autoclaved for a total of 5 hours. After the aging process, the color parameters and translucency of the specimens of the 4 groups were re measured and the results before and after aging were compared.

Statistical Analysis

Data were presented as mean, median, standard deviation (SD), minimum, maximum and 95% Confidence Interval (95% CI) for the mean values. One-way ANOVA test was used to compare between (ΔE) of the four veneering techniques and a standard A2 shade tab. Repeated measures Analysis of Variance (ANOVA) was used to study the effect of veneering technique, aging and their interactions on mean (TP) value.

Results:

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Color parameters data showed parametric distribution.

Pair-wise comparisons revealed that Pressing technique showed the statistically significantly highest mean ΔL values resulting in lighter specimens. This was followed by Layering technique and Double veneering technique, while CAD-on showed the statistically significantly lowest mean ΔL values.

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ΔE

revealed that there was a statistically significant difference between the veneering techniques (P-value <0.001). Pair-wise comparisons revealed that the Pressing technique showed statistically significantly highest mean ΔE values followed by Layering technique and Double veneering, while CAD-on showed the statistically significantly lowest mean ΔE values. As shown in table 1

Veneering technique	Mean	SD	Median	Minimum	Maximum	95% CI		P-value
						Lower bound	Upper bound	
Layering	18.57^{B}	0.78	18.82	17.22	19.49	18.01	19.13	<0.001*
Double Veneering	16.41^{C}	0.60	16.56	15.45	17.26	15.98	16.84	
Pressing	19.39^{A}	0.67	19.60	18.15	20.48	18.91	19.87	
CAD-on	15.52^{D}	0.66	15.51	14.63	17.06	15.05	16.00	

Table 1: Descriptive statistics, results of one-way ANOVA and Tukey's tests for comparison between ΔE values of the different veneering techniques (Color difference from standard A2 shade)

*: Significant at P ≤ 0.05, Different superscripts in the same column are statistically significantly different

There was a statistically significant difference between the veneering techniques after aging (P-value <0.001). Pair-wise comparisons revealed that Pressing technique showed the statistically significantly highest mean ΔE values followed by Layering technique and Double Veneering techniques respectively, while CAD-on showed statistically significantly lowest mean ΔE values, as shown in table 2

Aging	Veneering technique	Mean	SD	Median	Minimum	Maximum	95% CI	
							Lower bound	Upper bound
Before aging	Layering	10.55	0.90	10.81	8.87	11.44	9.91	11.20
	Double Veneering	9.13	0.73	9.15	8.07	10.07	8.61	9.65
	Pressing	11.81	0.73	11.82	10.61	12.74	11.29	12.33
	CAD-on	8.73	0.64	8.47	8.01	9.75	8.27	919
After aging	Layering	10.30	0.89	10.55	8.67	11.16	9.66	10.93
	Double Veneering	8.95	0.78	9.01	7.84	9.93	8.40	9.51
	Pressing	11.59	0.66	11.67	10.44	12.35	11.11	12.06
	CAD-on	8.45	0.67	8.24	7.70	9.64	7.97	8.93

Table 2: Descriptive statistics for (TP) values of the different veneering techniques before and after aging

Regardless of aging, Pressing showed the statistically significantly highest mean (TP) value resulting in more translucent specimens followed by Layering technique. There was no statistically significant difference between Double Veneering and CAD-on techniques; both showed the statistically significantly lowest mean.

Whether before or after aging, Pressing technique showed the statistically significantly highest mean (TP) values resulting in more translucent specimens followed by Layering technique. There was no statistically significant difference between Double Veneering and CAD-on techniques; both showed the statistically significantly lowest mean (TP) values, as shown in table 3.

Aging	Veneering technique	Mean	SD	Median	Minimum	Maximum	95% CI	
							Lower bound	Upper bound
Before aging	Layering	10.55	0.90	10.81	8.87	11.44	9.91	11.20
	Double Veneering	9.13	0.73	9.15	8.07	10.07	8.61	9.65
	Pressing	11.81	0.73	11.82	10.61	12.74	11.29	12.33
	CAD-on	8.73	0.64	8.47	8.01	9.75	8.27	919
After aging	Layering	10.30	0.89	10.55	8.67	11.16	9.66	10.93
	Double Veneering	8.95	0.78	9.01	7.84	9.93	8.40	9.51
	Pressing	11.59	0.66	11.67	10.44	12.35	11.11	12.06
	CAD-on	8.45	0.67	8.24	7.70	9.64	7.97	8.93

Table 3: Descriptive statistics for (TP) values of the different veneering techniques before and after aging

Discussion

The null hypothesis of the present study was rejected as different veneering techniques and hydrothermal aging had a statistically significant effect on the color and translucency parameters of Y-TZP zirconia ceramics.

In the present study, the ΔL, Δa, Δb and the color difference ΔE values which represents a difference between L*, a* and b* of two colors were evaluated by comparing each veneering technique to a standard A2 shade tab. Moreover, the same parameters of each group were evaluated by comparing before and after aging. When ΔE<1, the color match can be judged. When ΔE is between 1and 2, judgment can still be frequent among observers. When ΔE value is greater than 2, all observers can detect color difference[21]. It was stated that the acceptable value of color difference is considered to be 3.7 ΔE80,[22]

In addition, in 1998, Douglas and brewer stated that 50% acceptability tolerance of for a group of 20 prosthodontists was ranging between 1.7 and 2.7 for restorations with variable yellowness and between 0.5 and 1.5 for restorations with variable redness. Moreover, they found that 50% of dentists can predict a color difference when the value of ΔE is 2.6 units, and remake of a restoration is indicated when the ΔE value is 5.5 units81.

In the present study, the mean color difference ΔE when compared to an A2 shade tab, values of all groups were noticeably above the perceptible range.

These results were in relevance with Lee et al, who conducted a study in 2007 to evaluate the color difference between seven A2 core veneered all ceramic restorations; In ceram spinell, In ceram alumina, ADENS Zi ceram, Digident Digizon, Vita 2000 YZ, Vitablock mark II and IPS Empress 2 to an A2 shade tab and concluded that the difference was in the range of 8.5 to 13.1 ΔE units. This discrepancy in color reproduction might have been caused by the difference in translucency of all-ceramic core and veneer ceramics and shade guide tabs, background, and layering scheme. Therefore, based on this study, it was impossible to determine which of the all ceramic materials would reproduce the color of the corresponding shade tab[23] . Between different groups of veneering techniques, all differences in ΔE were in the acceptable range below 3.7 units except when comparing the pressing technique and CAD-on technique which was just above the acceptable range (3.87). These results were in accordance with a study in 2014 by Jae-Hong K et al, to evaluate the color reproducibility of two different veneering techniques; conventional and digital veneering techniques, and concluded that the color difference between the two veneering techniques of the same shade was in the acceptable range[24] .

However, these results were not in accordance to a study conducted in 1989 by Rosnsteil et al who measured the color parameters of five different ceramic systems; Cerestore, Dicor, Hi-Ceram, Renaissance, and Vitadur-N and found that there is a difference between different ceramic systems of the same shade[25]. There is a difference in pigment content between pressed ingots and layered dentin despite them being of the same shade A2, suggesting the difference in color parameters of different veneering techniques.

The effect of aging on the color of Y-TZP veneered restorations:

When comparing between different groups of veneering techniques after aging, the Pressing technique showed the highest ΔE (2.96) value followed by the layering technique (2.56), double veneering (2.30) and the lowest values were presented by the CAD-on veneering technique (1.92), which indicates that the Pressing veneering technique was the most to be affected by aging. This is explained by several studies[26,27] , which reported that that color changes in porcelain materials can occur due to their metal oxide content, which can break down to cause such color changes. Thus, as specified by the manufacturer the addition of different amounts of metal oxides can cause variable color changes between different ceramics. However, the ΔE values in the present study, ranged from 1.92 to 2.96 ΔE units which indicates that the difference after aging is below the acceptable limit of color difference which is 3.7 ΔE units80,[22] .

The results of the present study were in agreement with a study conducted by Angela MV et al, who evaluated the influence of aging times 1- 4 hours in an autoclave at 1340C and 2 bar pressure, on the color stability of dental zirconia, and concluded that discrete color changes can occur in dental zirconia when subjected to aging, however still maintains its colorimetric properties being below the perceptible range.[28]

Moreover, Multiple studies[29,30] , evaluated the effect of accelerated aging on the color stability of all ceramic restorations and their results were in accordance with the present study results. It was concluded that although there is a statistical difference between specimens when compared after aging, the effect was within the acceptable range and did not produce a perceptible change.

The effect of veneering techniques and aging on the translucency of Y-TZP veneered restorations:

The translucency of dental ceramics is important to reach to final optimal esthetics. Translucency of all ceramic restorations could be affected by many factors such as, thickness of the restoration, crystal volume and particle size, and number of firing cycles[31,32,33] . Moreover, different veneering techniques have shown to have an effect on the color and translucency of final restorations.[34]

As a densely sintered material, Y-TZP core is barely affected by veneering techniques regarding translucency following its sintering. Thus, the variable translucency parameters were related the technique of veneering.[31]

In this study, the translucency of different veneering techniques was measured and the results stated that the pressing technique showed the statistically highest TP value(11.8),resulting in more translucent specimens followed by layering technique(10.55) . The double veneering technique(9.13) and CAD-on veneering technique(8.73) showed the lowest mean TP values with no statistical significance between them.

Xiao PL et al, studied the effect of different veneering techniques on color and translucency of Y-TZP restorations. The results was in accordance to the present study results, which claimed that the pressing technique was the most translucent, followed by layering technique, while double veneering technique was least translucent among different veneering techniques.[11] This is suggested to be due to the homogenous structure of heat-pressed ingot with a uniform crystal distribution as well as minimum porosity. On the other hand, different manipulative procedures such as powder/liquid ratio, condensation methods, firing temperatures and number of cycles resulted in a less homogenous structure and increased porosity which thereby leads to more interfaces and more reflection of light and less translucency. In addition, themultiple interfaces in the double veneering and CAD-on techniques suggests a more reflection of the incident light and thus more interfaces which results in least translucency among the aforementioned veneering techniques [11] .

Regardless of the veneering technique, hydrothermal aging resulted in a statistically significant decrease in the TP values resulting in more opaque specimens, which has significantly decreased in the four veneering techniques. This is related to the effect of hydrothermal aging on the microstructure of Y-TZP and the veneering ceramics. This has been explained in several studies[35,36] where it was stated that hydrothermal aging lead to phase transformation resulting in an increase in the monoclinic phase. The appearance of the monoclinic phase on the surface was accompanied by formation of microcracks and this phase itself acted as a flaw or defect on the surface of zirconia. These microcracks act like porosities which scatter the incident light away leading to decreased translucency.

Another study conducted by Turgut S et al, evaluated the the effect of aging on the transclucency of dental ceramics and concluded that artificical aging has caused a decrease in the translucency of all ceramic restorations. This is explained by the fact that aging leads to a change in the crystal form and size which thus affects the degree of transmittance of the incident light.[37]

The presence of an abutment under the restoration was stated to affect the final color of the all ceramic restoration.[38]Thus further studies should be made comparing different substructures such as natural abutments or different post and core systems and materials.

Finally, the luting agent used in cementing the restoration also has a direct effect on the final color parameters and translucency of the restoration.[39] The shade and thickness of the luting cement will also affect the color. Thereby, more studies should be made to investigate the interaction of ceramic materials and luting agents and their relation to the final color and translucency of the restoration.

Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

1. Different veneering techniques and aging exhibited changes in the color and translucency parameters of Y-TZP zirconia ceramics.
2. After hydrothermal aging, the mean color differences (ΔE) of different veneering techniques were below the perceptible range ($\Delta E<3.7$).
3. The translucency of different veneering techniques was negatively influenced by hydrothermal aging.

References:

1. **Kelly JR, Nishimura I, Campbell SD**. Ceramics in dentistry: Historical roots and current perspectives. J Prosthet Dent 1996;75:18-32.
2. **N.V. Raptis, K.X. Michalakis, H. Hirayama**, Optical behavior of current ceramic systems. Int J of Periodontics & Restorative Dent, 2006, 26: 31–4.
3. **H.J. Conrad, W.J. Seong, I.J. Pesun**. Current ceramic materials and systems with clinical recommendations: a systematic review. J Prosthet Dent, 2007;98 389–404.
4. **Sorensen JA, Kang SK, Torres TJ, Knode H**. InCeram fixed partial dentures; 3-year clinical trial results. J Calif Dent Assoc 1998;3:207-14.
5. **Pospiech P, Kistler ST, Frasch C, Rammelsberg P**, Clinical evaluation of Empress 2 bridges. First results after two years. J Dent Res 2000;79:334.
6. **I. Denry, J.R. Kelly**. State of the art of zirconia for dental applications. Dental Materials, 2008, 24. 299–307.
7. **J.R. Kelly, P. Benetti**. Ceramic materials in dentistry: historical evolution and current practice. Australian Dental Journal 2011;56: 84–96
8. **Raigrodski AJ, Chiche GJ, Potiket N, et al**: The efficacy of posterior three-unit zirconium-oxide-based ceramic fixed partial denture prostheses: a prospective clinical pilot study. J Prosthet Dent 2006;96:237-44.
9. **Filser F**. Direct Ceramic Machining of Ceramic Dental Restorations Zurich: Swiss federal institute of technology. 2001.
10. **Aboushelib MN, de Jager N, Kleverlaan CJ, et al**: Microtensile bond strength of different components of core veneered all-ceramic restorations. Dent Mater 2005;21:984-91
11. **Xiao PL, Lei Z**. Effect of veneering techniques on color and translucency of Y-TZP J Prosthet Dent. 2010; 465-70.
12. **Oh WS, Delong R, Anusavice KJ**. Factors affecting enamel and ceramic wear: a literature review J Prosthet Dent 2002; 87:451-9.
13. **Kukiattrakoon B, Hengtrekool C, Kedjarune-Leggat U**. Degradability of flouroapatite-leucite ceramics in natural acidic agents. J Dent mater 2010;38:875-81.
14. **Seghi RR, Denry IL, Rosenstiel SF**. Relative fracture toughness and hardness of new dental ceramics. J Prosthet Dent. 1995;74:145-50.
15. **Caroline C, Anelyse A, Renata M, Marco A, et al.** Effects of aging procedures on the topographic surface, structural stability, and mechanical strength of a ZrO2 based dental ceramic. Dent Mater 2014;30(12):396-404.
16. **Jing C, Hui-ming H, Zhong-yi W**. Color stability against accelerated aging of alumina- and leucite-based ceramic materials. Int Chin J Dent 2007;(7):49-52.

17. **CIE (Commission International de I'Eclairage)**. Colorimetry- technical report. 3rd ed. Vienna: Bureau Central de la CIE. CIE Publication No 15; 2004.
18. **Ahn SJ, Lee YK**. Difference in the tranclucency of all-ceramics by the illuminant. Dent Mater 2008;(24):1539-44.
19. **Baldissara P, Liukacej A, Ciocca L, Valandro FL, et al**. Translucency of zirconia coping made with different CAD/CAM systems. J Prosthet Dent 2010;(104):6-12.
20. **Perez MM, Ghinea R, Ugarte-Alvan LI, Pulgar R, et al**. Color and translucency in silorane-based resin composite compared to universal and nano filled composites. J Dent 2010;(38):110-6.
21. **Majdi AR, Ahmed MK, Omar AQ, Abdulmohsen AA, Rohit F, Elfaith E.** Subjective and objective methods of shade selection – A Comparative Study. Int J Healthcare Sciences.2017;480-4.
22. **Ban S, Sata H, Suehiro Y, Nakanishi H, et al**. Biaxial flexural strength and low temperature degradation of nanocomposite and Y-TZP as dental restoratives. J Biomed Mater Res B Appl Biomater 2008;87(2):492-8.
23. **Vichi A, Louca C, Corciolani G, Ferreri M**. Color related to ceramics and zirconia restorations: a review. Dent Mater 2011;(27):97-108.
24. **Jae-hong K, Ki-Baek K, Woong-Chul K, Hae-Young K**, Ji-Hwan K. Evaluation of the color reproducibility of all ceramic restorations fabricated by digital veneering method. J Adv Prosthodont 2014; 6(2): 71-8.
25. **Rosenstiel SF, Porter SS, Johnston WM**: Color measurements of all ceramic crown systems. J Oral Rehabil 1989;(16):491-501.
26. **Seghi RR, Hewlett ER, Kim J**: Visual and instrumental colorimetric assessments of small color differences on translucent dental ceramic. J Dent Res 1989;(68):1760-4.
27. **Shokry TE, Shen C, Elhosary MM, Elkhodary AM**. Effect of core and veneer thicknesses on the color parameters of two all-ceramic systems. J Prosthet Dent. 2006; 95(2):124-9.
28. **Angela MV, Francisco CP, Antonio BM**. Influence of accelerated aging on the color stability of dental zirconia. J Esthet Restor Dent 2016;(28)5:304-312.
29. **Fernanda PP, Luciana AC, Lucas FRG, Diogo RC**. Color stability of dental ceramics subjected to accelerated aging after repeated firings. J Prosthet Dent 2009;101(1): 13-8.
30. **Atay A, Oruc S, Ozen J, Sepahi C**. Effect of accelerated aging on the color stability of feldspathic porcelain treated with various surface treatments. Quintessence Int 2008;39(7):603-9.
31. **Dagg H, O'Connell B, Claffey N, Byrne D, et al**. The influence of some different factors on the accuracy of shade selection. J Oral Rehabil. 2004; (31): 900–4.
32. **Berger-Schunn A**. Practical color measurement: a primer for the beginner, a reminder for the expert. New York: Wiley; 1994.
33. **Aboushelib M, Dozic A, Liem J**. Influence of framework color and layering technique on the final color of zirconia veneered restorations. Quintessence Int. 2010; 41(5):84-9.
34. **Lee YK, Cha HS, Ahn JS**. Layered color of all ceramic core and veneer ceramics. J Prosthet Dent 2007;(97):279-86.
35. **Pires-de-Souza FC, Casemiro LA, Garcia LF, Cruvinel DR**. Color stability of dental ceramics submitted to artificial accelerated aging after repeated firings. J Prosthet Dent 2009;(101):13–8.
36. **Ertan AA, Sahin E**. Colour stability of low fusing porcelains: an in vitro study. J Oral Rehabil 2005;(32):358–61.
37. **Antonson SA, Anusavice KJ**: Contrast ratio of veneering and core ceramics as a function of thickness. Int J Prosthodont 2001;(14):316-20.
38. **Rochard VN**: Introduction to Dental Materials. St. Louis, Elsevier, 2002;(2):235-6
39. **Denry I, Kelly R. State of the art of zirconia for dental applications**. Dent Mater 2008;24:299–307.