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Effect of Corrosion On Some Properties of Dental Ceramics

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ABSTRACT

Objective: The purpose of this study was to investigate Effect Of Corrosion On Some Properties Of Dental Ceramics.
Materials and Method: Twenty four samples were constructed and divided into 3 groups according to ceramic materials used (8 samples for each) group 1(E max), group 2(High Translucent Zirconia (DD BioZx2)) and group 3 (Opaque Zirconia. (DD BioZ)). Then each group was subdivided into three subgroups (3 samples each) according to sequence of tests performed. Then 4 samples from each subgroup were subjected to acetic acid as a corrosive agent. Those samples were first weighted, after that subjected to corrosion test, then weighted again to determine weight loss of each sample. Then samples were tested for color stability using the VITA Easy shade before and after corrosion. shade guides for samples were used (A3). Disinfection methods included immersion for 10 minutes in 1 of the tested disinfectant solutions (5.25% sodium hypochlorite, 2% alkaline gluteraldehyde or 1.7% trialkyl ammonium propionate). The specimens were cleaned after disinfection; the cleaning methods included ultrasonic cleaning in distilled water for 5 minutes and for 10 minutes, steam cleaning for 30 seconds, and under tap water for 30 seconds (n=5). The L*a*b value were recorded and ΔE were calculated. Two-way Repeated Measure ANOVA was used to compare the mean differences over time.
Result: All the samples used showed a perceivable change in color (ΔE>1).
Conclusion: All ceramic samples after corrosion show significant change in color (P<.001). with the highest color change was observed in E max group(ΔE=2.803) and the least change was observed in Opaque zircon group(ΔE=1.063). Frequent and periodic checkups for changes in the color (ΔE) of shade guides are indicated.

Keywords: corrosion, color, Delta E.

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INTRODUCTION

Matching restorations to natural teeth has been a challenge to both clinicians and dental laboratory technicians. The appearance of a tooth or dental restoration is a multifactorial effect of illumination, observer, anatomic form, surface texture, color, and also translucency. [1] The color effect of natural teeth is a complex phenomenon of multilayer diffused reflection and scattering of incident light through layer of enamel and dentin. Anatomic contours and surface texture affect the initial diffuse reflectance of light, whereas translucency affects the within and between layers of reflection and scattering.[2] Besides reproducing anatomic contour and surface texture, dental restorations should also reproduce similar optical effects as natural tooth structure to achieve a good color match. Mismatch in any one or more of the parameters can result in unsatisfactory shade matching. Corrosion was generally associated with metals, ceramic materials also undergo unintentional degradation in contact with environment. Today the impact of corrosion on society and the related deterioration of materials lead to the increased complexity and diversity of material system including ceramics, which are not susceptible to electrochemical degradation due to its poor conductor property but due to the simple dissolution of the material. [(3)] New monolithic CAD-CAM restorative materials are designed to improve mechanical properties of restorations. Lithium disilicate ceramic restoration is one of monolithic ceramic systems that have gained popularity for anterior and posterior single crowns and partial coverage restorations.[(4)]
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. (5)
Recently, a zirconia-reinforced lithium silicate ceramic has been introduced which aims to combine the positive material characteristics of both lithium disilicate ceramic and zirconia. This new glass ceramic is enriched with zirconia (≈10% by weight). The inclusion of zirconia particles in the lithium silicate glass matrix has been reported to reinforce the ceramic structure by providing crack interruption.[(6)] Color, shape, and surface texture are very important in esthetics for characterizing and personalizing a smile. Among this, the color stability is one of the most important characteristics of esthetic restorative materials. Maintenance of color throughout the functional lifetime of restorations is important for the durability of treatment.[(7)] Shade guides are recommended to be used clinically to achieve matching restorations to the natural teeth. Also, since the early 1970s, several electronic devices for color assessment have been used for various purposes in dentistry. Spectrophotometers, colorimeters, spectroradiometers, and digital cameras have been used for color determination. The basic principles of these mechanisms have been described elsewhere. In general, the output of the color measurements can be classified and specified in several ways. The most common systems for describing color are Munsell's System and the International Commission on Illumination (CIE) L*a*b* color system. In the latter system, L*represents the darkness–lightness coordinate, a* the chromaticity between green (−) and red (+), and b* the chromaticity between yellow (+) and blue (−).The CIE L*a*b* color system is commonly used in perceptual

studies for dental color assessment because of its approximate visually uniform coverage of the color space. In this color space, color difference between two objects (L*1, a*1, b*1 and L*2, a*2, b*2) can be calculated. Among the color difference values expressed as ΔE, values greater than 1 unit were visually detectable by 50% of human observers in controlled conditions and the color differences between 2.0 and 3.7 were visually detectable under clinical conditions.

MATERIAL AND METHOD

Twenty four samples were constructed and divided into 3 groups according to ceramic materials used (8 samples for each) group 1(E max), group 2(High Translucent Zirconia (DD BioZx2)) and group 3 (Opaque Zirconia. (DD BioZ)) with selecting the most commonly used shade (A3) (Fig. l). They were subjected to spectrophotometeric test using the VITA Easyshade device (VITA Easyshade, Vident®, Brea, CA) before and after corrosion. The ΔE was obtained after comparing the standard Vita coordinates of the A3 shade stored in the Easy shade. For each specimen three measurements were taken at the center by placing the tip of easy shade at 90 degree to the surface of the sample directly (perpendicular to the sample's surface) to ensure standardized measurement conditions for all samples and their average was recorded. After each specimen was measured the Easy shade was recalibrated. The color difference (ΔE) values were evaluated by calculating the difference in color measurements of the specimens before and after artificial accelerated aging by using the following formula ΔE (L*a*b*) = [(L*1 - L*2)2 + (a*1 - a*2)2 + (b*1 - b*2)2]1/2, where numbers "1" and "2" refer to the color coordinates before and after artificial accelerated aging, respectively.

Figure (1) Prepared samples

The L* coordinate is a measure of lightness-darkness of the specimen; therefore, the greater the L*, the lighter the specimen. The a* coordinate is a measure of chroma along the red-green axis. A positive a* relates to the amount of redness, and a negative a* relates to the amount of green of the specimen. The b* coordinate is a measure of chroma along the yellow-blue axis, where a positive b* relates to the amount of yellowness, and a negative b* relates to the amount of blue of the specimen. Among several electronic devices for color assessment, the Easy shade was found to be accurate and precise.[8] However, color difference between human-eye and computerized color matching is perceivable under clinical settings as delta E values are greater than 3.[9] statistical analyses of data were conducted with Two-way ANOVA to compare the mean differences over time.

RESULTS

Corresponding means and standard deviations of ΔE and the change in lightness, and darkness of the samples before and after corrosion were measured and presented as shown in figure(5). ΔL was measured first and calculate the mean difference between different groups and within the same group and the same procedures were don also for Δa and Δb as presented in tables 1,2and 3 . There was a significant difference in all color parameters that were measured between different groups and within the same groups before and after corrosion (P<.001)but clinically no significant color change in samples before and after aging which is considered as clinically acceptable[10]. The highest ΔE finally was produced at the E max group(ΔE=2.803) which means that lithium disilicate show less color stability after corrosion.

Table 1: Comparison of ΔL Color between Groups Before and After Corrosion

		Zircon HT (n=3)	E Max (n=3)	Opaque Zr (n=3)	P-value*
Before	Mean SD	83.97 ± 0.9	82.70 ± 0.1	98.00 ± 0.1	< 0.001
	Median (IQR)	84.4 (1)	82.7 (0.9)	98 (0)	
P-value*		= 0.020	< 0.001	< 0.001	
After	Mean SD	83.57 ± 0.2	85.23 ± 0.3	96.97 ± 0.1	< 0.001
	Median (IQR)	83.7 (0.5)	85.1 (0.8)	97 (0)	
P-value*		< 0.001	< 0.001	< 0.001	
P-value**		= 0.373	= 0.008	= 0.007	P=0.043***

*Mean differences between Group Comparison with Post-hoc pairwise comparisons
**Mean differences within Group Comparison
***Two-way Repeated Measure ANOVA was used to compare the mean differences over time

Table 2: Comparison of ΔA Color between Groups Before and After Corrosion

		Zircon HT (n=3)	E Max (n=3)	Opaque Zr (n=3)	P-value*
• Before	Mean SD	2.30 ± 0.06	1.8 ± 0.01	3.47 ± 0.06	< 0.001
	Median (IQR)	2.3 (0.01)	1.8 (0)	3.2 (0.01)	
P-value*		< 0.001	< 0.001	< 0.001	
• After	Mean SD	1.77 ± 0.06	1.7 ± 0.01	3.20 ± 0.07	< 0.001
	Median (IQR)	1.8 (0.05)	1.7 (0)	3.2 (0)	
P-value*		< 0.001	< 0.001	< 0.001	
P-value**		= 0.423	= 0.423	= 0.094	P=0.016***

*Mean differences between Group Comparison with Post-hoc pairwise comparisons
**Mean differences within Group Comparison
***Two-way Repeated Measure ANOVA was used to compare the mean differences over time

Table 3: Comparison of ΔB Color? between Groups Before and After Corrosion

		Zircon HT (n=3)	E Max (n=3)	Opaque Zr (n=3)	P-value*
• Before	Mean SD	39.20 ± 0.1	28.87 ± 0.08	7.20 ± 0.1	< 0.001
	Median (IQR)	39.2 (1)	28.9 (0.6)	7.2 (0)	
P-value*		< 0.001	< 0.001	< 0.001	
• After	Mean SD	40.87 ± 0.2	28.90 ± 0.5	7.57 ± 0.2	< 0.001
	Median (IQR)	40.8 (2)	28.7 (0..1)	7.6 (0.01)	
P-value*		< 0.001	< 0.001	< 0.001	
P-value**		= 0.003	= 0.902	= 0.111	P=0.001***

*Mean differences between Group Comparison with Post-hoc pairwise comparisons
**Mean differences within Group Comparison
***Two-way Repeated Measure ANOVA was used to compare the mean differences over time

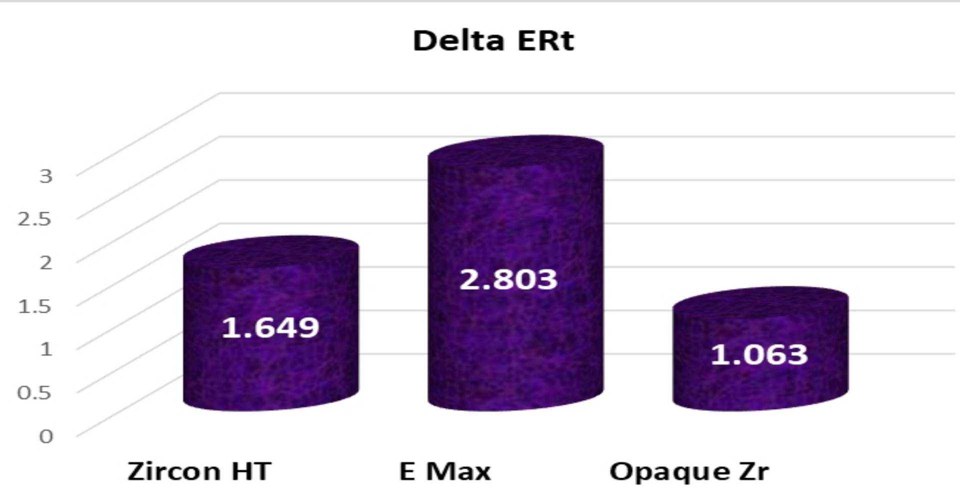

Fig. 2: Effect of Corrosion on the studied Materials(ΔE)

DISCUSSION

This study investigated whether there is a significant changes in color occurred after corrosion by acetic acid or no significant difference will be found. In the present study, the different ceramic materials were kept in a 4% acetic acid solution at 80º C for a shorter period of time to permit the detection of early surface changes. Compared with the ISO standard for hydrolytic stability tests of ceramic materials [10], the time factor was increased from 16 to 18 h to compensate for the time taken to reach the recommended temperature level. Acetic acid was used because of its pH value (pH 2.4). That pH value is similar to pH values of some refreshing drinks, juices and to values found in the dental plaque [11]. Acetic acid is, also, the most frequently used acid for domestic purposes [12]. The present ISO 6872:1995(E) protocol used 4% acetic acid as the chemical agent to evaluate chemical solubility of the ceramic materials by refluxing the acid for 18 hours [10]. Duration of measurement and number of samples were also performed according to ISO standard[10]. Dental computer-assisted design and computer-assisted manufacturing (CAD-CAM technology is widely used, as reducing the number of clinical appointments and manufacturing time needed to product ceramic restorations Clinicians choose ceramic restoration because their chemical stability and biocompatibility are preferable to those of conventional metal-ceramic restorations [13,14,4]. With the expanding use of dental CAD-CAM systems ceramics with different compositions have been introduced. The increased patient awareness led to the need not only for esthetic materials that provide close reproduction of the tooth color but also for materials which maintain such color [15]. Since instrumental color measurement has the advantages of being objective and quantified, CIE lab system was used in the present study to detect minor color differences [15,16] . ΔE is the numerical distance between the L*a*b* coordinates of two colors, and it represents the color change values whereas the clinical acceptability level was set to 3.7 ΔE units [17,18]. The device's reproducibility in the present study was evaluated from 5 specimens of each group by calculating the ΔE value after 2 color measurements of the same surface at different time intervals (2 hours).

The results of the present study agreed with **Salem K S et al** [19] where samples showed clinically no significant color change in samples before and after thermodynamic aging and also in accordance with Researchers [20,10,21] which recorded significant change in color coordinates of IPS e.max CAD due to aging ,yet they still lie within the clinically acceptable range. They related this to the material itself not to the selected shade. They also recorded that glazing of ceramic samples had a significant effect on maintenance of colour stability and restoration protection from stains[20, 22]. Also our results agreed with **Palla E S et al** [23] almost all groups, independently of the aging process, presented with ΔE values below 2, suggesting acceptable color stability, also our results agreed with **Hamza et al** [24] which 3 ceramic groups showed clinically acceptable color stability after 300 h of artificial accelerated aging, whereas the clinical acceptability level was set to 3.7 ΔE units, as determined by many studies.[24,17,18]

Results of this study are contrast with **Rosenstiel S F et al** [25] observed that the unglazed specimens presented the highest color change after immersion in beverage solution ΔE=4.99 and this was explained as minor occlusal adjustment and/or crown re contouring is required after cementation. These adjustments can remove the surface glaze, leaving a roughened surface capable of absorbing more colorants and having inferior ability to reflect the light[23]. Also our results are contrast with **Kurt M et al** [26] which stated that monolithic zirconia was susceptible to higher discoloration from coffee, with Δ E values were 5.602 and those results based on monolithic zirconia, without an overlaying ceramic veneer, is directly exposed to the water and body fluids. The water exposure at 37C leads to low-temperature degradation (LTD) by phase transformation from a tetragonal to a monoclinic structure. Phase transformation to monoclinic led to a 4% increase in volume; consequently results in structural disintegration, surface roughness and the development of micro-cracks[26,27].

CONCLUSIONS

Within the limitations of the study, the following conclusions were drawn:

-all the tested samples have a statistical significant difference in color stability after corrosion over time examination but still clinically not predictable as ΔE was below 3.7 which considered clinical accepted.

-Lithium disilicate shows the highest color change after corrosion.

-Opaque zircon shows the least color change after corrosion.

-Frequent and periodic checkup for changes in the color (ΔE) of the ceramic restorations used in the oral cavity over long periods are indicated especially lithium disilicate restorations.

-Ceramic restorations with ΔE more than 3.0 should be evaluated for replacement.

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