International Journal Dental and Medical Sciences Research
Volume 3, Issue 5, Sep-Oct 2021 pp 01-07 www.ijdmsrjournal.com ISSN: 2582-6018

Effects of Artificial Aging Procedure on Translucency of Translucent Zirconia.

[1]Ahmed H. Mohammed , B.D.S. and [2]Ibtihal H. Hasan , B.D.S. ,M.Sc.
[1]B.D.S. ,M.Sc. student, College of Dentistry, University of Mosul, Ninavah, Iraq
[2]Department of Prosthetic Dentistry, College of Dentistry, University of Mosul, Ninavah, Iraq

Submitted: 15-08-2021 Revised: 29-08-2021 Accepted: 31-08-2021

ABSTRACT
Objective: The aim of the study is to compare the effect of artificial aging procedure on two types of dental zirconia for translucency parameter with two different thickness before and after aging procedure.
Materials and Methods: A total of (40) samples were used in this study; each group contained 10 samples; two groups contained samples with a thickness of 1 mm, and two groups contained samples with a thickness of 1.5 mm; two groups contained samples from ZirCAD MT Multi, while the other two groups contained samples from DD Cube X2 ML. After applying artificial aging by autoclave for five hours at 134°C,0.2 bar to each group's samples, the test was conducted by using paired t-test where significant p-value of ($p \leq 0.01$).
Results: The statistical results of translucency parameter of the two materials the ZirCad MT Multi (4Y-TZP&5Y-TZP) and the DD Cubic X^2 ML (5Y-TZP) compare the results before and after aging and the results show that there is no significant difference appear after aging in the two materials.
Conclusions: Increase the thickness of the material result in decrease in translucency parameter also result in increased risk for low temperature degradation.
Keywords: zirconia, translucency, artificial aging

I. INTRODUCTION

The use of all-ceramic restorations has increased in recent years,[1] Dental all-ceramic restorations have been used as an alternative to metal ceramic restorations due to their excellent esthetics, chemical stability and biocompatibility.[2]

Translucent zirconia materials have been developed for such monolithic restorations. [3] Some investigators have expressed concern about the aging or LTD of translucent zirconia's associated with the spontaneous transformation of the metastable tetragonal phase to the monoclinic phase in the oral environment. [4] Transparent materials transmit light with little absorption and reflection; translucent materials transmit just a portion of the light; and opaque materials communicate no light at all. Nonmetallic materials may be transparent (single-crystal) or opaque inherently (polycrystalline). In general, electron transitions between the valence and conduction bands and electronic polarization both influence the light transmission properties of non-metallic materials.[5] Both intrinsic (materials) and extrinsic (features and surroundings) factors influence the color and look of monolithic zirconia dental restorations [6]. Extrinsic factors related to materials and processes, such as the cement layer thickness and low-temperature deterioration, may influence the optical properties, Microstructural characteristics intrinsic to the material, such as grain boundaries and pores, scatter some light, resulting in translucency or even opacity.[7]

Translucency is also affected by the kind and quantity of dopants and stabilizers.[8] Greater yttria concentration results in increased grain size and a larger cubic phase that is optically isotropic and does not exhibit birefringence, unlike the other crystallographic phases.[9] Additionally, cubic granules do not change at room temperature, which may help increase resistance to LTD.

Another drawback of zirconia is low-temperature degradation or aging which can affect surface topography and the flexural strength. As the aging time was increased, the flexural strength decreased [10] with concomitant surface roughness increase.[12] The presence of cubic zirconia [11] and grain size bigger than 0.1mm [14] will make the zirconia microstructure more sensitive to aging. It has been proposed that steam sterilization at 134°C for 5h simulates 15–20 years at 37°C. [13]

Microstructural variation, raising yttria content, decreasing or removing the alumina dopant, optimizing the sintering conditions, minimizing residual porosity, and producing a nanometric microstructure are all strategies for enhancing the optical performance of YTZP.[15] Recently, new extremely transparent zirconia ceramics have been developed, claiming to offer better optical characteristics. However, little information on their characteristics is known.[16]

The aim of the study was to compare the effect of artificial aging procedure on two types of translucent zirconia. The null hypotheses planned for the present study was that increase thickness does not affect translucency and artificial aging of the translucent zirconia.

II. MATERIALS AND MEHODS

The materials were used in this study (Table 1).

Table 1: The two translucent zirconia with the same color A2.

Material	Group A	Group B	Manufacture	Origin	Dimension	Patch
ZirCad MT Multi [a]	1mm	1.5mm	ivoclar vivadent	Swissland	98.5x16 mm	686878
DDCubX^2 [b]	1mm	1.5mm	dental Direkt	Germany	95.5x14 mm	G852001

[a] The new translucent dental zirconia involved increasing the content of Y2O3, resulting in two crystalline materials: 4Y-TZP (4 mol% Y2O3) and 5Y-PSZ (5 mol% Y2O3). Due to the increased Y2O3 content, cubic phase occurs alongside metastable tetragonal phase. The quantity of the cubic phase increases from around 25% in 4Y-TZP the main phase (more than 50%) which is why 5Y-TZP is sometimes referred to as partially stabilized zirconia (5Y-PSZ).

[b] is based on 5 mol% yttria oxide, which leads to a stabilization of approx. 53% cubic and 47% tetragonal crystals. The DD cubeX² ML give 49% translucency at 1450[c] sintering

Experimental design

A total sample of 40 standardized translucent zirconium, divided into four groups of 10, were used for translucency test. The four groups were divided according to different thicknesses of the translucent zirconium, 1 mm and 1.5 mm thickness from ZirCad MT Multi and same number of samples form DD cube X^2 (Table 1).

Design and production of translucent zirconium

Prepare 40 specimens of dimensions as specified in table1for both types of Translucent zirconium. Samples design in the CAD/CAM, apply the design on the zirconia disc to fabricate the sample by using carbide bur inside the machine cut the samples to exact design in the software. The samples that finished from the CAD/CAM machine, we cut the rods that support and hold the sample by carbide bur to obtain the sample, Fire the specimens in sintering furnace (ZIRKONOFEN 600/V2) accordance with the manufacturer's instructions modified as needed due to specimen dimensions. The program 1 in the device for 8 h (first 3 h heating up to 1500^{0}C then 2 h hold up at 1500^{0}C then cooling down for 3 h). After finished the samples from the sintering, The samples then finishing by use Dia zircon polish (Dia tessen) to get polish surface. Check all samples for the dimensions by digital caliber.

Translucency samples

- 1 mm thickness: 10 mm (±0.02 mm) length x 10 mm (±0.02 mm) width x 1 mm (±0.02 mm) thickness.
- 1.5 mm thickness: 10 mm (±0.02 mm) length x 10 mm (±0.02 mm) width x 1.5 mm (±0.02 mm) thickness.

Aging of samples

All samples underwent artificial aging at same time according to ISO 13356-2015. Each sample put inside the glass test tube and put all the tube in the stainless-steel rack. For aging we used autoclave unit (model B, type Tenda, Wesson, China) following ISO 13356 – 2015 recommendations, then test tube rack with sample put inside the autoclave unit under a pressure of 2.1 bars with a temperature of 134^{0}C for 5h this time give us from 15 to 20 year at patient mouth.[17]

Translucency test

For this test we used the colorimeter (3nh D65- china) for determine the translucency parameter (TP), The optical properties of the test specimens two type of zirconia placed on white or black backings [18], All specimens were measured at four predetermined sites, using 45°/0° geometry with CIE illuminant D65 and 2° observer function (ISO 28642-2016) against the white and black background. The translucency parameter (TP) was calculated by placing the Lw, aw, bw and Lb, ab, bb values (as obtained by the colorimeter) of the specimens placed on the white (w) and black (b) background into the following formula [19]:

TP=([Lb−Lw]2+[ab−aw]2+[bb−bw]2)1/2. [19]

A higher TP value means higher translucency. A TP of 100 describes the color difference between

International Journal Dental and Medical Sciences Research
Volume 3, Issue 5, Sep-Oct 2021 pp 01-07 www.ijdmsrjournal.com ISSN: 2582-6018

black and white for a fully transparent material. In contrast, a TP of 0 characterizes a totally opaque material without any color difference against a white and black background. [20]

Statistical analysis

The data obtain where statistically analyzed by spss program by using paired t – test where significant p-value of ($p \leq 0.01$)

III. RESULTS

Results for translucency parameter (TP) test:

The Shapiro-Wilk test of normality was done for translucency data to determine the statistical tests need to analyze the results. The results of the normality test showed that the data was parametric and normally distributed.

Translucency (TP) results of ZirCad MT Multi

Descriptive statistics of Translucency (TP) of ZirCad MT Multi - group A (1mm thickness) and group B (1.5 mm thickness) for the samples before and after aging.

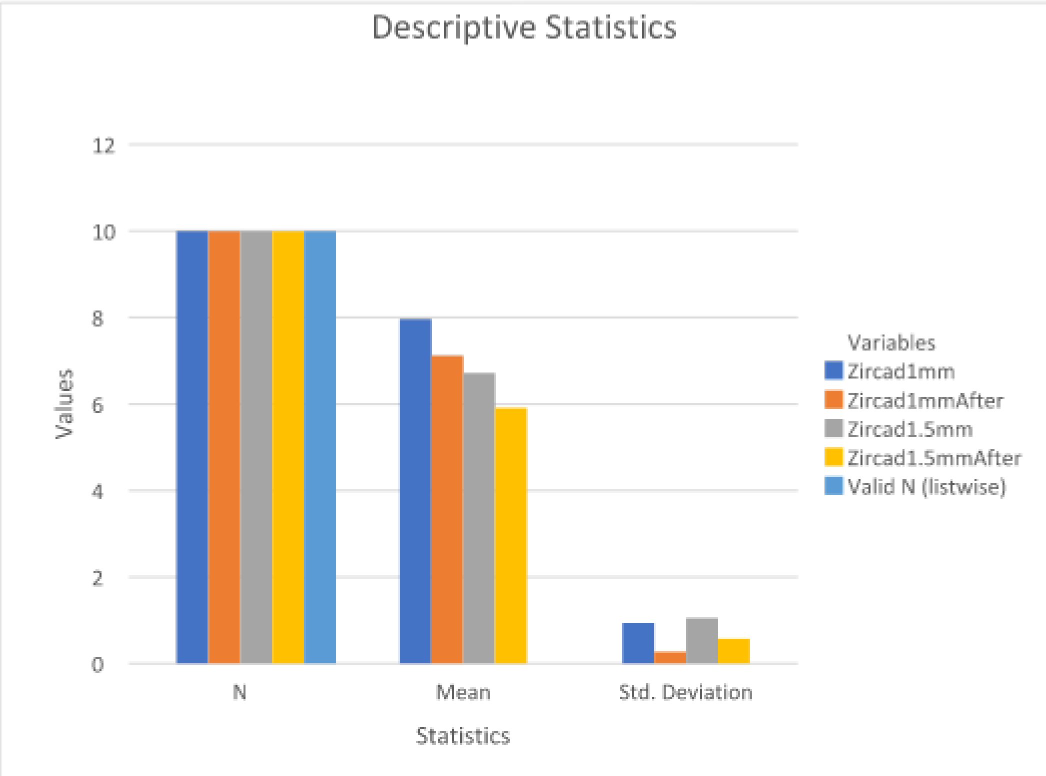

Figure 1: Bar chart show the mean value and stander deviation value of all ZirCad MT Multi before and after aging.

Paired t-test was used statically to test the translucency parameter (TP) data between the ZirCad MT Multi material before and after aging of the samples and show a significant difference ($P \leq 0.01$), as shown in (Table 2).

Z groups	Mean difference	Stander diffusion	Std.EROR Mean	t	df	Sig (2-tail)
Group A (ZirCad 1mm before - ZirCad 1mm After aging)	.84450	.88306	.27925	3.024	9	.014*
Group B	.79789	.92403	.29220	2.731	9	.023*

International Journal Dental and Medical Sciences Research
Volume 3, Issue 5, Sep-Oct 2021 pp 01-07 www.ijdmsrjournal.com ISSN: 2582-6018

(ZirCad 1.5 mm before - ZirCad 1.5 mm After aging)						

*Significant difference

Table 2: Paired t -test of translucency parameter (TP) comparison between ZirCad MT Multi before and after aging

Paired t-test used was used to compare the mean and stander deviation between the materials in each group before and after aging and the result show that there is significant difference ($P \leq 0.01$) in group A between the ZirCad MT Multi 1 mm thickness before and after aging, also a significant difference ($P \leq 0.01$) showed in group B between the ZirCad MT Multi 1.5 mm thickness before and after aging.

Translucency parameter (TP) results for DD Cubic X^2 ML

Descriptive statistics of translucency parameter (TP) of DD Cubic X^2 ML - group A (1mm thickness) and group B (1.5 mm thickness) for the samples before and after aging.

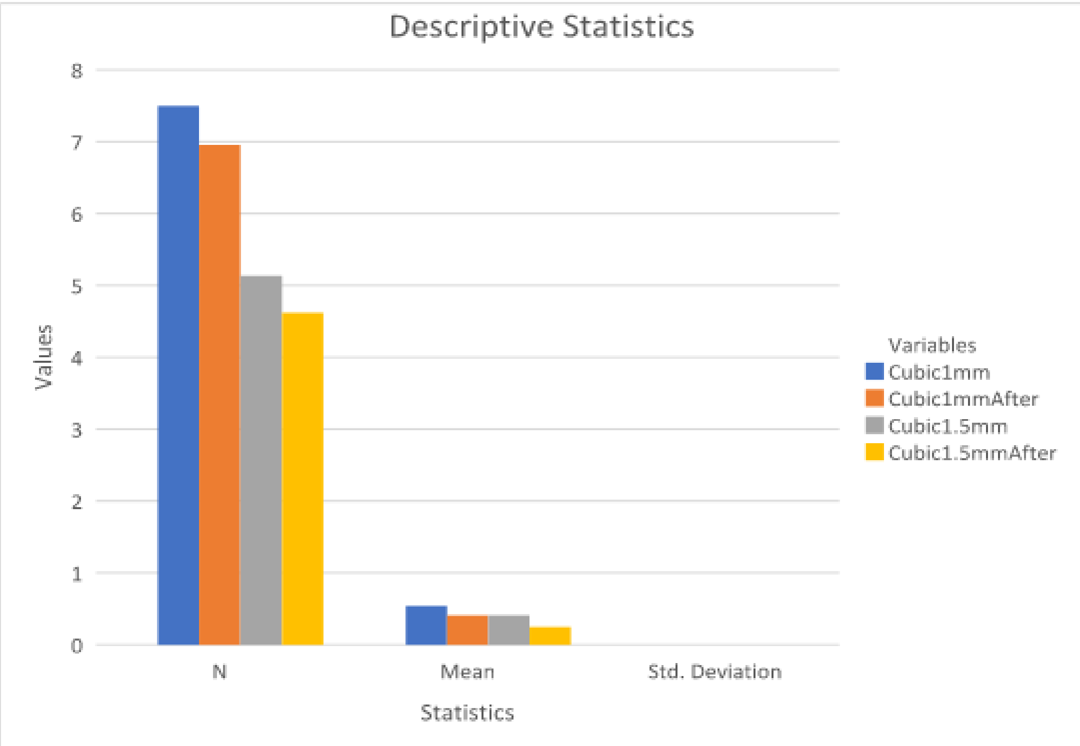

Figure 2: Bar chart show the mean value and stander deviation value of all Cubic X^2 ML before and after aging.

Paired t-test was used statically to test the translucency parameter (TP) data between the DD Cubic X^2 ML material before and after aging of the sample and the result show that there is a significant difference ($P \leq 0.01$), as shown in (Table 3).

Z groups	Mean difference	Stander diffusion	Std. EROR Mean	t	df	Sig (2-tail)
Group A (Cubic 1mm – Cubic	.54144	.55252	.17472	3.099	9	.013*

1mm After aging)						
Group B (Cubic 1.5 mm – Cubic 1.5 mm After aging)	.51157	.43268	.14423	3.547	8	.008*

*Significant difference

Table 3: paired t -test of translucency parameter (TP) comparison between DD Cubic X^2 ML before & after aging.

Paired t-test used was used to compare the mean and stander deviation between the material in each group before and after aging and the result show that there is significant difference ($P \leq 0.01$) in group A between the DD Cubic X^2 ML 1 mm thickness before and after aging, also a significant difference ($P \leq 0.01$) showed in group B between the Cubic X^2 ML 1.5 mm thickness before and after aging.

IV. DISCUSSION

The statistical results of TP of the two materials the ZirCad MT Multi (4Y-TZP&5Y-TZP) and the Cubic X^2 ML (5Y-TZP) compare the results before and after aging and the showed results show a significant difference appear after aging in the two materials. The mean of the ZirCad MT Multi in the two thickness have shown decreasing after aging and statistically significant and the mean of Cube X^2 ML has shown decreasing and statistically significant ($p<0.01$).

The translucency value that we get from our study it is confirmed by the study done by Fathy et al., (2015) which is stated that there is significant deference between the non-aged group and aged group of monolithic zirconia (Zirkonzahn Prettau anterior) where value was 16.4 and 13.35 respectively, aging protocol was autoclave 134^{0}C, 0.2 bar for 15h and sample thickness was 1mm. Similarly, Kim and Kim, (2019) his study also agree with our study who stated that there is significant difference in mean of TP after 5h aging when he uses katana monolithic zirconia as material to be tested for TP and specimens were put in an autoclave at 134 ^{0}C under 0.2 MPa for 0, 1, 3, 5 or 10h, the thickness of spacemen was 1.5 mm and the result showed significant decrease in value after aging he use at this study delta E00 values for calculated.[21] Walczak et al., (2019) his study takes different brand of zirconia (Cercon ht white, BruxZir Solid Zirconia, ZenostarT0 and Lava Plus) and applied artificial aging with storage in steam autoclave at 134 ^{0}C and 0.2 MPa pressure for 5 h, and after testing the TP test the result showed significant difference and the value showed decrease in value after aging and use at this study delta E00 values for calculated.[19]

Putra et al., (2017) his study show some difference from our study when he test different type of zirconia brand (BruxZir Anterior Solid Zirconia (BA), Lava Plus High Translucency (LPHT), Katana Zirconia Super Translucent (KST) and Katana Zirconia Ultra Translucent (KUT) and apply aging protocol Steam autoclave: 134^{0}C, 0.2 MPa for 0, 5, 50 and 100 h and material thickness was 1mm, and the result of translucency data showed statistically significant decreases over aging time for groups KUT and KST ($P<.01$) and showed statistically significant, increases for group LPHT as related to aging time ($P<0.05$). But no statistically significant differences were found in the translucency values during hydrothermal treatment time periods between groups KUT and KST ($P>0.05$) which this disagrees with our study, Putra et al in this study use spectrophotometer for testing at 550 nm.[22]

In this study we observed that there is decrease in the TP after aging for the both type of zirconia and statistically significant. With increasing aging time, the TP decreased and the zirconia became opaquer darker (lower L*). [23]

At the surface, a monolithic phase appears, which is followed by microcracking. The monoclinic phase itself may act as a weakness or defect in the ZrO_2 microstructure. Microcracking can act as a porosity or crack, increasing the scattering of incident light and thereby decreasing translucency. The presence of voids or porosities, as well as the thickness, crystallinity, and grain size of the material, can all affect light scattering and thus impair translucency. [24]

Increased changes in the microstructure of Y-TZP with age may be related to changes in the light reflection of monoclinic crystals and at the interfaces between monoclinic and tetragonal crystals.[25] The translucency parameter of zirconia was affected by lightness /darkness variation.[23]

The thickness of the restorations affects their translucency; as the thickness increases, the translucency decreases [26], Additionally, the aging effect of colored and pre-colored zirconia is different; the translucency of pre-colored dental monolithic zirconia ceramics was affected by aging.[21]

V. CONCLUSION

Increase the thickness of the material result in decrease in translucency parameter for the two materials, also result in increased risk for low temperature degradation, The 5 Y-TZP show better result for aging for optical properties (TP) than combination of 4&5 Y-TZP.

REFERENCES

[1]. Zarone F, Russo S and Sorrentino R. (2011). From porcelain-fused-to-metal to zirconia: clinical and experimental considerations. Dent Mater. Jan;27(1):83–96.

[2]. Kelly JR, Nishimura I, Campell SD. (1996) Ceramic in dentistry: historical roots and current perspectives. J Prosthet Dent.;75:18–32.

[3]. Casolco SR, Xu J and Garay JE. (2008). Transparent/translucent polycrystalline nanostructured yttria stabilized zirconia with varying colors. Scripta Materialia, 58:516-9.

[4]. Tong H, Tanaka CB, Kaizer MR and Zhang Y. (2016). Characterization of three commercial Y-TZP ceramics produced for their high-translucency, high-strength and high-surface area. Ceram Int, 42:1077-85.

[5]. William D and David G. (2007). Materials science and engineering: An introduction 8th edition. John Wiley & Sons, USA.

[6]. Brodbelt RH, O'Brien WJ and Fan PL. (1980). Translucency of dental porcelains. J Dent Res ,59:70-5.

[7]. Wang SF, Zhang J, Luo DW, Gu F, Tang DN and Dong ZL. (2013). Transparent ceramics: processing, materials and applications. Prog Solid State Chem, 41:20-54.

[8]. Sen N, Sermet IB and Cinar S. (2018). Effect of coloring and sintering on the translucency and biaxial strength of monolithic zirconia. J Prosthet Dent ,119: e1-7.

[9]. Denry I and Kelly R. (2008). State of the art zirconia for dental applications. Dental Materials Journal , 24: 299-307.

[10]. Inokoshi M, Vanmeensel K, Zhang F, De Munck J, Eliades G and Minakuchi S. (2015). Aging resistance of surface-treated dental zirconia. Dent Mater, 31:182–94.

[11]. Inokoshi M, Zhang F, De Munck J, Minakuchi S, Naert I and Vleugels J. (2014). Influence of sintering conditions on low-temperature degradation of dental zirconia. Dent Mater 30:669–78.

[12]. Lucas TJ, Lawson NC, Janowski GM, Burgess JO. (2015). Effect of grain size on the monoclinic transformation, hardness, roughness, and modulus of aged partially stabilized zirconia. Dent Mater, 31(12):1487–92.

[13]. Chevalier J, Drouin JM, Cales B. (1997). Low temperature ageing behavior of zirconia hip joint heads. Bioceramics: Proceedings of the 10th Inter-national Symposium of Ceramics in Medicine, Pergamon UK, Cambridge, p. 135–8.

[14]. Zhang Y. (2014). Making yttria-stabilized tetragonal zirconia translucent. Dent Mater, 30:1195–203.

[15]. Klimke J, Trunec M and Krell A. (2011). Transparent tetragonal yttria-stabilized zirconia ceramics: influence of scattering caused by birefringence. J Am Ceram Soc, 94:1850-8.

[16]. Sen N and Isler S. (2020). Microstructural, physical, and optical characterization of high translucency zirconia ceramics, Volume 123, Issue 5: 761-768

[17]. Kou W, Garbrielsson K, Borhani A, Carlborg M and Molin Thorén M. (2019). The effects of artificial aging on high translucent zirconia. Biomater Investig Dent, 6(1):54-60.

[18]. Nazmiye S and Sabire I. (2020). Microstructural, physical, and optical characterization of high translucency zirconia ceramics. Journal of prosthetic dentistry, 123:5, 761-768.

[19]. Walczak, K.; Meißner, H.; Range, U.; Sakkas, A.; Boening, K.; Wieckiewicz, M. and Konstantinidis, I. (2019). Translucency of Zirconia Ceramics before and after Artificial Aging. J. Prosthodont, 28, e319–e324.

[20]. Johnston WM, Ma T and Kienle BH. (1995). Translucency parameter of colorants for maxillofacial prostheses. Int J Prosthodont, 8:79-86

[21]. Kim H.K. and Kim S.H. (2019). Eject of hydrothermal aging on the optical properties of precolored dental monolithic zirconia ceramics. J. Prosthet. Dent, 121, 676–682.

[22]. Putra, A.; Chung, K.H.; Flinn, B.D.; Kuykendall, T.; Zheng, C.; Harada, K. and Raigrodski, A.J. (2017). Eject of hydrothermal treatment on light transmission of translucent zirconias. J. Prosthet. Dent, 118, 422–429.

[23]. Al ghazzawi T. (2016). The effect of extended aging on the optical properties of different zirconia materials. Journal of Prosthodontic Research, 61(3)
[24]. Baldissara P, Llukacej A and Ciocca L. (2010). Translucency of zirconia copings made with different CAD/CAM systems. J Prosthet Dent, 104:6–12.
[25]. Fathy, S.M.; El-Fallal, A.A.; El-Negoly, S.A. El Bedawy and A.B. (2019) Translucency of monolithic and core zirconia after hydrothermal aging. Acta Biomater. Odontol. Scand., 1, 86–92.
[26]. Abdelbary O, Wahsh M, Sherif A and Salah T. (2016). Effect of accelerated aging on translucency of monolithic zirconia, Future Dental Journal, 2: 2:65-69,