Medico Research Chronicles
ISSN NO. 2394-3971
DOI No. 10.26838/MEDRECH.2024.11.5.725
Contents available at www.medrech.com

Comparative Evaluation of Transmittance Between Zirconium Di-Oxide Crown and Human Natural Tooth Crown: An In-Vitro Study

Mohammad Abid[1], Abu Hena Helal Uddin Ahmed[2], Utpalendu Biswas [3], Md Shahidul Hasan[4], Rozina Akter[5], Rajib Kumar Banik[6]

1. Assistant Professor, Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
2. Assistant Professor, Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
3. Assistant Professor, Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
4. Assistant Professor, Department of Conservative Dentistry and Endodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
5. PhD Fellow, Department of Conservative Dentistry and Endodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.
6. Associate Professor, Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.

ARTICLE INFO

Article History
Received: August 2024
Accepted: October 2024
Key Words:
Transmittance, Translucency, Zirconium dioxide crown, Human tooth crown

ABSTRACT

ORIGINAL RESEARCH ARTICLE

Background: The transmittance/translucency of a dental crown is a crucial property that affects the color of a dental crown. The characteristics of the crown material and background contrast affect the transmittance of the value of the crown material.
Objective: This study was aimed to evaluate and compare the transmittance between zirconium dioxide crown and natural human tooth crown.
Methods: An in-vitro study was conducted at Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University. A total of 20 specimens/crowns prepared with zirconium di-oxide and 20 specimens/crowns of natural human tooth crown. A total of 40 crowns/specimens were included for testing transmittance/ translucency individually. The thickness of outer layer of these specimens was uniform in accordance with the American Dental Association (ADA) specifications. The zirconia crown preparation on model was done. The outer layer of both group of crown specimens was 2 mm in thickness. Fourier-transform infrared spectroscopy (FTIR) test was used to evaluate the transmittance/ translucency value of samples. This test was carried out using the FTIR test at Chemical Engineering Department of Bangladesh University of Engineering and Technology. A FTIR test was used to measure the contrast ratio, which is indicative of

transmittance level. The transmittance of the specimens was recorded with the help check list. The transmittance values were analyzed by One Sample T Test to determine the mean value with its standard deviation for each group. To compare between two groups, P≤0.05 was considered.

Results: The mean transmittance value (409.4±.7) cm-1 wavelength of natural tooth crown is less than zirconium di-oxide crown (467.2±.8) cm-1 wave length when intact form of sample was tested and it was significant (P 0.001). In addition, the mean of transmittance value (560.6±) cm-1 wavelength of natural tooth crown was lower than zirconium di-oxide crown (596.18) cm-1 wavelength when grinded form of sample was tested and it was also significant (P 0.001).

Conclusion: To conclude, the zirconia crown in both intact and grinded form showed more transmittance/ translucency when compared with the natural human tooth crown or enamel. So, it is expected that this study will help the dental professional to choose the zirconia as crown material to fulfill the patient's satisfaction.

Corresponding author
Dr. M. Abid*

2024, www.medrech.com

INTRODUCTION

The amount of light that passes through the ceramic depends on its transmittance/ translucency, which is an optical property that exerts important influence on the aesthetics of the restoration or dental crown.[1,2,3] It is defined as the property of a material of which most of the transmitted light undergoes scattering, reflecting and transmitting through it.[4,5,6] The greater the amount of light through the object, the greater the translucency. Translucency is material-and thickness-dependent and vary according to the measuring techniques.[7,8]

Because zirconia crowns have been widely used in anterior areas, their esthetic characteristics including translucency have been investigated using various methods.[8,9] Zirconia crowns became more translucent as they became thinner, although the effect was weaker than that of glass ceramic.[10] Zirconia crowns were less translucent than glass ceramic ones with the same thickness because the dense oxide ceramic structure of zirconia allowed more absorption and reflection rather than transmission of light. The relative translucency measuring method have been used to compare the relative translucency of various crowns materials by the contrast ratio or translucency parameter that is measured on a black and white background.[11]

On the other hand, there have been some recent studies on the shade masking ability of highly translucent of restorative materials.[12] Three methods are used to evaluate the translucency of materials used in dentistry, and these methods can be classified as direct transmission, total transmission, and spectral reflection.[13,14] TM is described as the difference between the reflected colors of a material of equal thickness on the background in two different colors, black and white, and this study the TM value was evaluated by determining the spectral reflections.[15,16] Generally, spectrophotometers have been preferred for instrumental transmittance/ translucency determination.[17] The translucency of dental restorative materials can be evaluated by three conventional methods: direct transmission (when light moves through without an alteration in direction or quality), total transmission (combination of direct and diffused transmission), and spectral reflectance (reflection of incident light from an interface such as porosity).[18,19]

As, there are scarce of studies regard the comparison of transmittance/ translucency of most useful crown materials.[20] So, the aim of this study was to assess and compare the translucency between natural human tooth and zirconium di-oxide crown both intact crown form and grounded form materials.

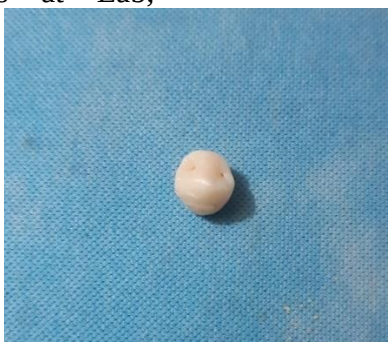
METHODS

An in-vitro study was conducted at Department of Prosthodontics, Bangabandhu Sheikh Mujib University for duration of 12 months. The transmittance/ translucency was measured and compared between two groups; zirconium di-oxide crown and natural human tooth crown (n=40) (20 for each group). Fourier-transform infrared spectroscopy (FTIR) technique was used to obtain an infrared spectrum of absorption or emission of the samples. An FTIR spectrometer simultaneously collects high-resolution spectral data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time.

RESULTS:

The term Fourier-transform infrared spectroscopy originates from the fact that a Fourier transform (a mathematical process) is required to convert the raw data into the actual spectrum which was considered as transmittance of natural and zirconia crown both intact and grounded form. Purposive sampling technique was used based on inclusion/ exclusion criteria to select the study sample. Investigation site was at Lab, Department of Chemical Engineering, BUET. The samples of each Zirconium Di-oxide crown were prepared, according to universal American Dental Association direction. The tooth preparation on model was done. Then the impression of model was taken for making the crown. Then model was sent to Lab to make the Zirconium Di-oxide. To evaluate the translucency of Zirconium Di-oxide crown, a crown sample of dimension 2.0 mm thickness was prepared by lab. This test was carried out using the FTIR Spectrophotometer. FTIR was used to measure the translucency parameter (TP) of the samples using CIELAB color coordinates at baseline. The transmittance of the specimens was recorded with the help of check list. A total of 20 specimens/crowns of natural human tooth crown prepared and 20 specimens/crowns were customized with Zirconium Di-oxide. A total of 40 crowns/specimens were taken for testing transmittance separately. The thickness of these specimens was uniformed in accordance with the American Dental Association (ADA) specifications. It is needed to make crown with standard thickness for the transmittance tests. During the zirconium di-oxide crown making procedure, it is needed to make sure that no air bubbles were formed. According to ADA specifications, samples were prepared at room temperature of 23 ± 2°C, with a relative air humidity of 50 ± 10%. Data were collected with the help of a pretested semi-structured check list.

A



B

C

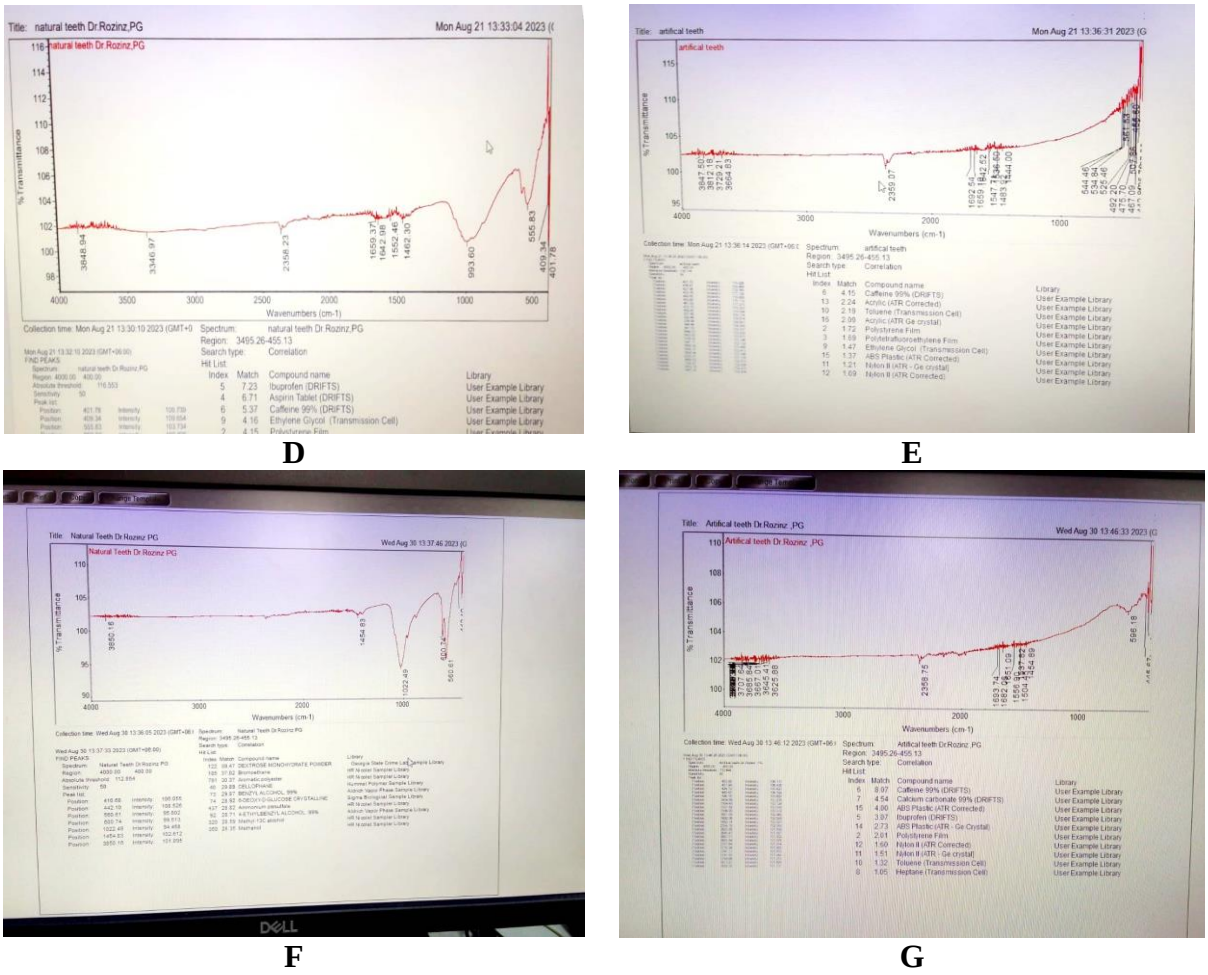


Figure 1 Fourier-transform infrared spectroscope (A), Natural human tooth crown (B), Customized Zirconium Di-oxide crown (C), Transmittance value of natural tooth crown (intact form) is 409.4±.7 cm^{-1} wave length (D), Transmittance value of zirconium di-oxide crown (intact form) is 467.2±.8 cm^{-1} wave length (E). Transmittance value of natural tooth crown (grinded form) is 560.6±1 cm^{-1} wave length (F) Transmittance value of zirconium di-oxide crown (grinded form) is 596.18±.9 cm^{-1} wavelength.

Statistical analysis: The transmittance values were analyzed by t-test to determine the mean value with its standard deviation. To compare the transmittance in between zirconium di-oxide crown and natural tooth crown when p-value < 0.05 was considered as statistically significant. To present the results, tables were also used.

Table 1: Mean value of transmittance/ translucency value (wavelength cm^{-1}) of zirconium di-oxide crown compared to natural tooth crown in intact form (n=40).

One-Sample Statistics					
	N	**Mean**	**Std. Deviation**	**Std. Error Mean**	**P-value**
Zirconia crown	20	467.29	.87050	.19465	0.001
Natural crown	20	409.40	.72647	.16244	

The transmittance/ translucency value (wavelength cm^{-1}) of natural tooth crown is lower than zirconium di-oxide crown in intact form. It was significant different (*P* 0.001) **(Table 1).**

Table 2: Mean value and standard deviation of transmittance of zirconium di-oxide and natural tooth crown (n=40).

One-Sample Statistics					
	N	**Mean**	**Std. Deviation**	**Std. Error Mean**	**P-value**
Zirconia crown	20	560.6	1.03	.19465	0.001
Natural crown	20	596.18	.91	.16244	
Natural crown	20	409.40	.72647	.16244	

The transmittance/ translucency value (wavelength cm^{-1}) of natural tooth crown is also lower than zirconium di-oxide crown in grinded form. It was also significant different (*P* 0.001) **(Table 2)**.

DISCUSSION

Among a diversity of ceramic materials, zirconia has been regarded as "Ceramic Steel." Its opacity has always been a limiting factor. It consistently established the expected translucency whenever the relative translucency of zirconia was compared to natural human tooth enamel or crown. Although Alamri et al. showed that zirconia-based restorations provided higher transmittance, this result is similar to our current study.[1,2] The Journal of Contemporary Dental Practice, Volume 21 Issue 1 in January 2020 revealed that zirconia-based crown is better esthetics than porcelain fused to metal restorations.[2,3,4]

Furthermore, they elaborated on the masking properties of these opaque materials. The previous studies were able to establish a significant difference in the relative translucency of the different core materials. These results are in accordance with a study done by several previous studies which determined the most transmittance/ translucent zirconia coping that can be used to improve esthetics. In our study, we were also able to demonstrate that zirconia is better than even natural tooth enamel transmittance/ translucency.[5,6,7]

According to Heffernan, the amount of absorbed, reflected, and transmitted light will differ with the crystals content in the matrix, the chemical nature of the crystals, and the particles size in comparison to the wavelength of the incident light.[8,9] The results of the present study are in accordance with Heffernan's results; since zirconia was determined more translucent in grinded form than intact form. Several factors can affect the translucency related to the specimen, the material itself, or the measurement process such as specimen thickness, crystal structure, surface texture, material's batch, etc. Effort was made to limit the variables that could change the TM measurement, which is considered as strength in this study.[10]

Also the small average deviations found in the groups confirmed consistency in specimen's production and control over variables.[11,12] The literature has revealed that thickness inversely affects the light transmission through dental ceramics.[12] For this reason, in this study, the measurement of the specimen's thickness was taken almost similar between two groups. The current study has evaluated the transmittance/ translucency of monolithic zirconia ceramic introduced for crown restorations enamel.[13] The results have shown that monolithic zirconia ceramic was brighter than the natural tooth.

CONCLUSION

To conclude, the zirconia made crown in both intact and grinded form has showed more transmittance/ translucency value when compared with the natural human tooth crown or enamel. So, it is expected that this study will help the dental professional to choose the zirconia as crown material to fulfill the patient's satisfaction.

REFERENCES

1. Abdulsamee N. and Elkhadem AH. Zirconomer and Zirconomer Improved (White Amalgams): Restorative Materials for the Future. Review. EC Dental Science. 2017;15(4):134-150.
2. Alamri MD, Labban N, Alhijji S, Alamri H, Iskandar M. and Platt JA. In Vitro Evaluation of Translucency and Color Stability of CAD/CAM Polymer-Infiltrated Ceramic Materials after Accelerated Aging. J Prosthodont. 2021;30(4):318-328.
3. Asharaf S, Karthigeyan AS, Mangala D. and Ranjana M. Zirconia: properties and application - a review. Pakistan Oral and Dental Journal. 2014;34(1):178-184.
4. Baghdasaryan T, Geernaert T. and Chah K. Anomalous transparency in photonic crystals and its application to point-by-point grating inscription in photonic crystal fibers. Sci Rep. 2018; 8:5470.
5. Kohal RJ. and Klaus G. A zirconia implant-crown system: a case report. International Journal of Periodontics and Restorative Dentistry. 2004;24(2):147-153.
6. Lee YK. Criteria for clinical translucency evaluation of direct esthetic restorative materials. Restorative dentistry &endodontics. 2016;41(3):159–166.
7. Lim HN, Yu B. and Lee YK. Spectro radiometric and spectrophotometric translucency of ceramic materials. J Prosthet Dent. 2010;104(4):239-246.
8. Li Q, Yu H. and Wang YN. Spectrophotometric evaluation of the optical influence of core build-up composites on all-ceramic materials. Dent Mater. 2009;25(2):158-65.
9. Prabhakar AR, Kalimireddy PL, Yavagal C. and Sugandhan S. Assessment of the clinical performance of zirconia infused glass ionomer cement: An in vivo study. Int J Oral Health Sci. 2015; 5:74-79.
10. Sehgal K. and Bida L. Zirconia: a promising alternative to metals in dentistry. Indian Journal of Dental Sciences. 2013; 52:145-148.
11. Schmeling, D.E., Andrada, M.A., Maia, H.P. and Araújo, E.M. 2012. Translucency of value resin composites used to replace enamel in stratified composite restoration techniques. J EsthetRestor Dent. 24(1), pp.53-58.
12. Tuncel İ, Turp I. and Üşümez A. Evaluation of translucency of monolithic zirconia and framework zirconia materials. J AdvProsthodont. 2016;8(3):181-186.
13. Wulandari. And Dyah. Spectrophotometry: Lab Report. Suranafee University of Technology. 2017.
14. Mourouzis P, Koulaouzidou EA, Palaghias G, Helvatjoglu-Antoniades M. Color match of resin composites to intact tooth structure. J Appl Biomater Funct Mater. 2015;13: e259–e265.
15. Johnston WM. Review of translucency determinations and applications to dental materials. J Esthet Restor Dent. 2014; 26:217-223.