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Analysis of Phase Transformation of Zirconia Implants before and After Uv Photofunctionalization By X Ray Diffraction - An In Vitro Study

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ABSTRACT

Aim: To analyze phase transformation of zirconia implants before and after photofunctionalization by X - ray Diffraction (XRD). **Materials and methods:** Ten commercially available zirconia implants,further divided into five implants in study group and five implants in control group were taken. Study group was subjected to Ultraviolet (UV) radiation for 48 hours using shorter wavelength of 254nm. **Results:** The Data revealed that phase transformation occurred at 50 degree, peak intensity reached and reduced to half of the percentage at 60 degree. Statistically significant difference noticed in both the groups. **Conclusion**: There is a definite peak shift in the right side of around 50 to 60 degree which could be manufacturer induced stress but UVphotofunctionalization (UV treatment) has not induced any phase transformation in zirconia implants.

Keywords: Implants, Photofunctionalization, X-ray diffraction (XRD), Phase transformation.

INTRODUCTION

In 1980s, Yttria stabilized tetragonal zirconia polycrystals (Y-TZP) were introduced as biomaterials in order to overcome the limits of alumina in the field of orthopedics[1] .The application of (Y-TZP) in restorative dentistry are rapidly evolving for past few decades[2] · Major advantage of zirconia includes good esthetics, high resistance to corrosion and absence of allergic reaction makes zirconia to replace titanium for fabrication of dental implants [3]. Various surface modification techniques were used on zirconia based bioceramics such as polishing, sandblasting, acid etching, biofunctionalization, coating, laser treatment and ultraviolet radiation so as to achieve improved osseointegration[4]. A successful osseointegration determined by numerous surface properties such as topography and chemistry[15].

Every crystalline substance gives a pattern and the same substance always gives the same pattern, whereas each mixture of substances produces its pattern independently of the others. The X – ray diffraction pattern of a substances looks like a fingerprint of the substance because it is based on the scattering of X– rays by crystals. X ray diffraction phenomenon is defined as atomic planes of a crystal cause an incident beam of X – rays to interfere with one another as they leave the crystal. Variety of x–ray techniques are available such as X - ray diffraction, X – ray absorption and X – ray

fluorescence. X ray diffraction (XRD) relies on the dual wave/particle nature of X-rays to obtain information about the structure of crystalline materials. A primary use of the technique is the identification and characterization of compounds based on their diffraction pattern[6]. XRD can be used to measure the average spacings between layers or rows of atoms, it can determine the orientation of a single crystal or grain, can be used to find the crystalline structure of an unknown material, and it can also measure the size, shape and internal stress of small crystalline regions. The aim of the study is to analyze phase transformation of zirconia implants before and after photofunctionalization by X - ray Diffraction (XRD).

MATERIALS AND METHODS

This is an in-vitro study and the rationale of using XRD in study is to identify the crystalline property of the surface. XRD can be used not only for qualitative identification, but also for quantitative estimation of various crystalline phases.Ten commercially available machined one piece zirconia implants (white sky implant system – bredent company). They are further divided into five implants (test group) and five implants (control group) were taken. The implants were received in their original sterile packaging and was opened at the start of the investigation (Fig 1& 2). They were carefully handled in order to prevent contamination during procedure and further manipulation. Study group was subjected to Ultraviolet (UV) radiation for 48 hours (Fig 2) with following parameters – UV activation device with 15W bactericidal lamp; intensity 2mW/cm^{2}and shorter wavelength of 254nm (Fig 3).In order to identify the crystalline property of zirconia implants, X-ray diffractometer (XRD) equipped with a Cu-Kα type x-ray source (D 8 Advance X-ray diffractometer, Bruker AXS, Karlsruhe, Germany) was used in Central Electrochemical Research Institute (CECRI), karaikudi (Fig 4 & 5). XRD spectra were collected on the samples at a 2θ range between 15° and 70° at a step size of 0.01° and a scan exposure of 4s per step. The accelerating voltage was 4kV and the beam current 40 mA. The monoclinic phase was calculated using the Garvie-Nicholson method (Garvie and Nicholson,1972). The identification and correction of peaks (monoclinic/tetragonal/cubic) was based on the ICSD database (www.icsdweb.fiz-karlsruhe.de).

Fig 1

Fig 2

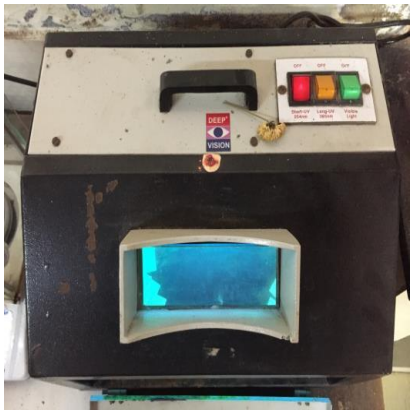

Fig 3

Fig 1 – Implants with original sterile packaging; Fig 2 – Commercially available single piece zirconia implant; Fig 3 – UV chamber used for photofunctionalization.

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Fig 4

Fig 5

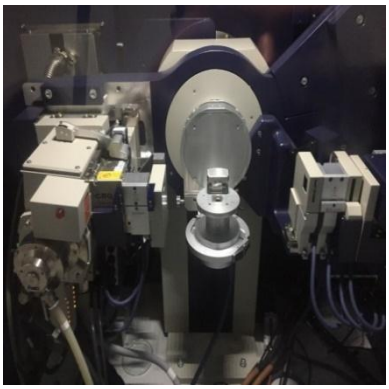
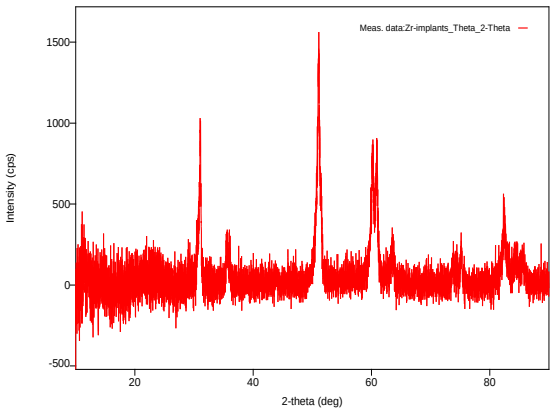


Fig 6

Fig 4- provision in the UV chamber for choosing shorter wavelength; Fig 5 – X ray diffractometer; Fig 6 – zirconia implants on the X ray diffractometer.

RESULTS

The quantitative and qualitative statistical analysis has been done to analyze the phase transformation of zirconia implants and UV treated zirconia before and after photofunctionalization by X - ray Diffraction (XRD). The Data (Fig 7,8) revealed that phase transformation occurred at 50 degree , peak intensity reached and reduced to half of the percentage at 60 degree. Statistically significant difference noticed in both the groups.(Fig 7,8,9,10).



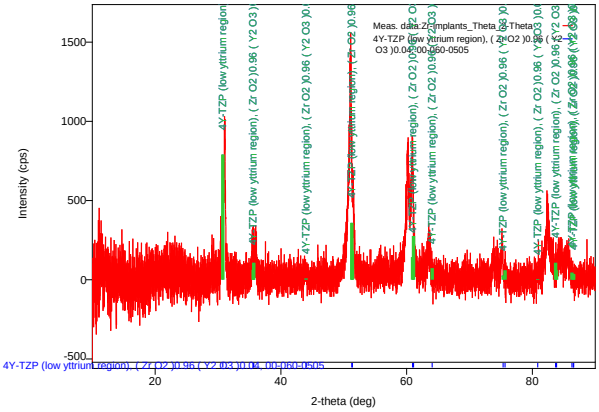
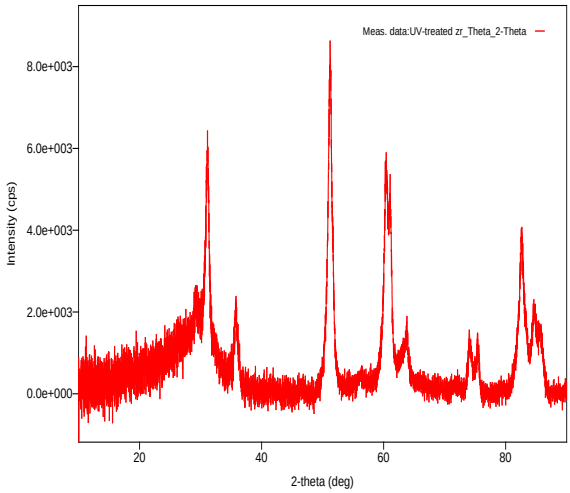


Fig 7 – Measurement profile of Zr implants; Fig 8–Comparision of peaks of Zr implants with ICSD data base



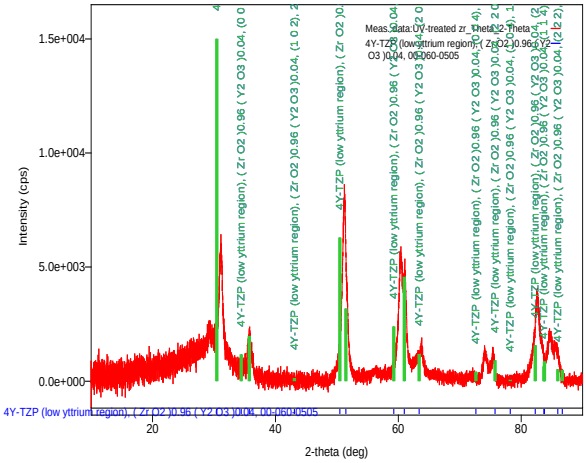


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Fig 9– Measurement profile of UV treated Zr implants; Fig 10 – Comparision of peaks of UV treated Zr implants with ICSD data base

DISCUSSION

This study analyzed phase transformation of zirconia implants before and after UV photofunctionalization by x ray diffraction method and results revealed that presence of predominantly tetragonal zirconia peaks and there is negligible presence of monoclinic phase. Lattice parameter values have been changed. So, that there is a peak shift in the right side of around 50 to 60 degree and there is high chance for lattice parameter value change will happen due to heat or stress induced by manufacturer. The peak value (2θ) is the same for both Zr implants & UV treated Zr implants. In 4Y- TZP phase both the peaks are coinciding. Previous studies suggested that the UV-mediated change in the wettability behavior of oxides of Ti and Ti alloys could be attributed to the electrostatic properties of TiO_2 and its high photocatalytic activity[7-9].

Jérôme Chevalier in 2011 conducted study to analyze the impact of the transformation was evaluated in terms of structural integrity. Bending strength was not affected but the cohesion of the porous coating and its adhesion with the dense part deteriorated. The examination of the crystalline structure showed a general increase in the surface's monoclinic content upon UV treatment. While irrelevant in material Zr2, the increase in the monoclinic content was remarkable in material Zr1. Here, it is well known that the amount of monoclinic phase denotes the stability level of zirconia surface [10,11].

In this study ,they used commercially available zirconia implants instead of zirconia blocks or discs,because surface modification of zirconia is considered more difficult than titanium.The irreversible tetragonal-to-monoclinic transformation of zirconia, caused by low temperature degradation property or different surface treatments, whereas zirconia does not react to modifying agents like acids, and other surface treatments such as sandblasting may induce surface cracking[10,11].One of the main advantage in using shorter UV wavelength (254 nm) for this study and is that more penetrative. The advantage of using XRD is it is a novel & non-destructive method, which means that no additional transformation of the material takes place during the examination, when compared to other spectroscopic techniques for structural characterization.XRD possess the greatest accuracyof the measurements.The limitation of using XRD is the instrumental source of error such as specimen displacement, Instrument misalignment, error in zero 2θ positionand peak distortion due to $K\alpha_2$ and Kβ wavelengths.

CONCLUSION

There is a definite peak shift of around 50-60 degree which could be because of manufacturer induced stress but UV photofunctionalization (UV treatment) certainly has not induced any phase transformation in zirconia implants.

REFERENCE

1) ChevalierJ.What future for zirconia as a biomaterial? Biomaterials 2006; 27; 535-543
2) Denry I, Kelly Jr, State of the art of zirconia for dental applications, Dental Materials 2008; 24;299 -307
3) Andreiotclli M, Wenz HJ, Kohal RJ. Are ceramic implants a viable alternative to titanium implants? A systematic literature review. Clin Oral Implants Res 2009; 20; 32-47
4) Karthigeyan S, Ravindran AJ, Bhat RT, Nageshwarao MN, Murugesan SV, Angamuthu V. Surface modification techniques for zirconia based bioceramic; A review. J Pharm Bioall Sci 2019;11:S131-4
5) Anil S, Anand PS, Alghamdi H, Jansen JA. Dental Implant Surface Enhancement and Osseointegration. Implant Dent – A Rapidly Evol Pract 2011; pg83-108
6) Azároff LV, Kaplow R, Kato N, Weiss RJ, Wilson AJ, Young RA. X-ray Diffraction. New York: McGraw-Hill; 1974.
7) H. Aita, N. Hori, M. Takeuchi, T. Suzuki, M. Yamada, M. Anpo, *et al.*The effect of ultraviolet functionalization of titanium on integration with bone Biomaterials, 30 (2009), pp. 1015-1025

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8) Att W, Hori N, Iwasa F, Yamada M, Ueno T, Ogawa T. The effect of UV-photofunctionalization on the time-related bioactivity of titanium and chromium–cobalt alloys. Biomaterials. 2009 Sep 1;30(26):4268-76.

9) Iwasa F, Hori N, Ueno T, Minamikawa H, Yamada M, Ogawa T. Enhancement of osteoblast adhesion to UV-photofunctionalized titanium via an electrostatic mechanism. Biomaterials. 2010 Apr 1;31(10):2717-27.

10) Lughi V, Sergo V. Low temperature degradation-aging-of zirconia: A critical review of the relevant aspects in dentistry. Dental materials. 2010 Aug 1;26(8):807-20.

11) Chevalier J, Loh J, Gremillard L, Meille S, Adolfson E. Low-temperature degradation in zirconia with a porous surface. Acta Biomaterialia. 2011 Jul 1;7(7):2986-93.

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