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Biocompatibilty of Zirconia- Knowledge and Awareness among Dental Students

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Abstract:- With growing interest into zirconia as a biomaterial in dentistry, a lot of research has been invested in it and its behaviour as a dental material. Zirconia has a variety of clinical applications because of its favourable mechanical, chemical and optical properties and excellent biocompatibility. Hence, in this study, we conducted a survey on the awareness of zirconia biocompatibility among dental interns.

Aim-To assess the knowledge and awareness on zirconia biocompatibility and to highlight the need to learn more about zirconia and its clinical implication among dental interns.

Materials and method-A cross-sectional questionnaire study was conducted with 18 questions, divided into four forms to know different understandings and perceptions about zirconia biocompatibility among dental interns. A total of 100 participants took part in the survey. With their consent for the study, they chose the answers based on their knowledge and understanding with their free will. The data collection was done by convenience sampling. The statistics were calculated using SPSS (Statistical Package for Social Sciences) software version 21.0.

Keywords:- *Component; Zirconia Biocompatibility; Zirconia; Dental Materials*

I. INTRODUCTION

Zirconia has been recently introduced in prosthetic dentistry for the fabrication of crowns, fixed partial dentures, implants1] Zr is a metal that was discovered by chemist Martin Klaproth in the year 1789.[2] as important oxide material, it shows brilliant properties such as minimum thermal conductivity, increased thermal expansion, ideal thermal stability, fine mechanical strength, fracture toughness with increased thermal shock resistance[7-9]. Hence, ZrO2 is used in a variety of range of applications as a catalysts/catalyst support[10-16], oxygen sensors[13,14], fuel cells[15,16], biological materials[17,18], automobile parts and thermal barrier coatings on metal components[20-22]. ZrO2 nanomaterials have also been employed in various applications, mainly for repair and replacement of diseased and damaged parts of human skeleton, teeth and joints due to their biocompatibility, osseointegration, and bio inertness.[23]Its characterized by high flexural strength and fracture toughness as a result of a physical property known as transformation toughening.[3]

II. MATERIALS AND METHOD

The study was a cross-sectional, questionnaire-based study conducted in a private dental institution in Chennai, India. The questionnaire contained mix of 15 close and open ended questions, split up into four forms, the first form regarding personal details, the second form evaluating the basic knowledge on biocompatibility regarding dental materials and in clinical practice, the third form to assess their choice of material for crowns, their knowledge on zirconia products and the fourth section was to assess the attitude towards their knowledge zirconia and how to update themselves. Interns of various departments were approached; the nature and purpose of the study was explained to them and verbal consent was obtained. A total of 100 were included in the study. The questionnaire was distributed, all the questions were explained. The respondents were requested to provide appropriate answers. Multiple responses were discouraged.

The data was analyzed using Statistical Package for Social Sciences, IBM Corporation, SPSS Inc., Chicago, IL, USA version 21.0 software package (SPSS). Chi-square test was performed. A $P < 0.05$ was considered statistically significant.

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III. RESULTS

- *Form 1*

The age of the participants ranged from (21 to 27 years) and the mean age was (22.780years)

The number of female participants were 63(63%) and male participants were 37(37%)

- *Form 2*

2% of the total participants in the survey consider biocompatibility to be free of tissue reactions, 3% consider it to be free of toxic reactions, 4% consider it to be free of inflammation. And a majority of 91% consider all of the mentioned options.

S.NO	QUESTIONS	FREQUENCY AND %	P VALUE
1	BIOCOMPATIBILITY OF DENTAL MATERIAL		
	FREE OF TISSUE REACTIONS	2	.000
	FREE OF TOXIC REACTIONS	3	
	FREE OF INFLAMMATION	4	
	ALL OF THE ABOVE	91	
2	WHAT MATERIAL OFFERS GOOD BIOCOMPATIBILITY		
	BASE METAL ALLOYS	7	.000
	ACRYLIC	6	
	PFM	20	
	ALL CERAMIC	25	

Table 1:- Form 2 for Assessing the General Knowledge on Biocompatibility

Regarding their knowledge on the material they considered to be the most biocompatible, 7% consider it to be base metal alloys, 6% consider it to be acrylic, 20% consider *it* to be PFM, 25% of them consider it to be All ceramics, 38% of the majority consider it to be all of the mentioned materials and only 4% of them consider none of the mentioned materials to be biocompatible.

- *Form 3*

It is revealed that the material of choice for crowns for 6% of the participants is noble alloys, 5% preferred base metal alloys, 3% preferred acrylic, a majority of 47% of them preferred ceramics and the remainders 39% selected PFM It was seen that 90% of the participants were aware of zirconia as a material for crowns and only a 10% were not aware of its availability.

When assessed about their knowledge on types of zirconia products, 17% knew about crowns and bridges, a 2% of the participants knew about the bio ceramics, 13% of them knew about implants and a majority of 68% of them had knowledge on all of the mentioned products.

When questioned about zirconia's use in their practice, it appeared that 18% use it always, 60% of the use it sometimes and 22% of them denied its use.

Out of the zirconia products mentioned, 69% of participants used crowns and bridges in their practice, 1% used orthodontic brackets, a 6% of them used implants and 24% of them used all products.

Assessing the knowledge of zirconia biocompatibility and other properties, 57% of the participants believed that zirconia offers better biocompatibility and aesthetics and only 10% differed to believe, and the rest 33% were uncertain.

64% of the participants were aware that zr has lesser colonization of bacteria, 7% weren't aware and the rest 29% were not sure.

65% of the participants knew that zr implants offer better osteointegration and bone preservation, and the rest 35% did not.

It was revealed that 45% of them opted for zr products because of superior aesthetics, 19% because of high strength and the remaining 36% for excellent biocompatibility.

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S.NO	QUESTIONS	FREQUENCY AND %	P-VALUE
5	MATERIAL OF CHOICE FOR CROWNS		
	NOBLE ALLOYS	6	.000
	BASE METAL ALLOYS	5	
	ACRYLIC	3	
	CERAMIC	47	
	PFM	39	
6	ARE YOU AWARE OF ZIRCONIA AS A MATERIAL FOR CROWNS		
	YES	90	.000
	NO	10	
7	KNOWN ZIRCONIA PRODUCTS		
	CROWNS AND BRIDGES	17	.000
	ORTHODONTIC BRACKETS	0	
	DENTAL POSTS	0	
	BIO CERAMICS	2	
	IMPLANTS	13	
	ALL	68	
8	ZIRCONIA USE IN YOUR PRACTICE		
	YES, ALWAYS	18	.000
	YES, SOMETIMES	60	
	NO	22	
9	ZIRCONIA PRODUCTS BEING USED IN YOUR PRACTICE		
	CROWNS AND BRIDGES	69	.000
	ORTHODONTIC BRACKETS	1	
	DENTAL POSTS	0	
	BIO CERAMICS	0	
	IMPLANTS	6	
	ALL	24	
10	MATERIAL OF CHOICE IN CASE OF ALLERGY TO BASE METALS		
	TITANIUM	66	.000
	ZIRCONIA	33	
	OTHERS	1	
11	REASON FOR NOT CHOOSING ZIRCONIA		
	EXPENSIVE	78	.000
	LACK OF AWARENESS	22	

Table 2:- Form 3 for Assessing the Awareness and Use on Zirconia Products.

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S.NO	QUESTIONS	FREQUENCY AND %	P VALUE
12	ZR OFFERS BETTER BIOCOMPATIBILTY AND ESTHETICS		
	YES	57	.000
	NO	10	
	MAYBE	33	
13	ZR HAS LESSER COLONIZATION OF BACTERIA		
	YES	64	.000
	NO	7	
	MAYBE, NOT SURE	29	
14	ZR IMPLANTS OFFER BETTER OSTEOINTEGRATION AND BONE PRESERVATION		
	YES	65	
	NO	35	.003
15	WHAT PROPERTY OF ZR MAKES YOU OPT FOR IT		
	SUPERIOR ESTHETICS	45	
	HIGH STRENGTH	19	.005
	EXCELLENT BIOCOMPATIBILITY	36	
16	WHAT PROPERTY MAKES ZR BETTER THAN TI		
	BETTER ESTHETICS	50	.000
	EXCELLENT BIOCOMPATIBILTY	11	
	BOTH	39	

Table 3:- Form 3 Continuation- Assessing the Knowledge on Zirconia Biocompatibility

It was also seen that 50% of the participants believed that better aesthetics offered by Zr makes it better in comparison to Ti counterparts, 11% believed it to be the excellent biocompatibility that made the difference whereas 39% of them believed that both better aesthetics and biocompatibility offered by Zr set it apart from Ti.

- *Form 4*

This form revealed that 54% of the participants agreed they had adequate knowledge on Zr, rest 46% disagreed, admitted to not having adequate knowledge. When asked about ways to stay updated with knowledge relating to the clinical applications of Zr, 52% of the participants preferred articles and literature, 18% preferred lectures and the rest 30% of them preferred conventions and conferences.

S.NO	QUESTION	FREQUENCY AND %	P VALUE
17	DO YOU HAVE ADEQUATE KNOWLEDGE ON ZR AS A DENTAL MATERIAL		
	YES	54	
	NO	46	.424
18	PREFERRED MODES OF UPDATING ON CLINICAL APPLICATIONS OF ZR		
	ARTICLES AND LITERATURE	52	.000
	LECTURES	18	
	CONVENTIONS AND CONFERENCES	30	

Table 4:- Assessing the Attitude towards Information on Zirconia Biocompatibility

IV. DISCUSSION

With various clinical applications of zirconia products due to its superior aesthetic and mechanical properties, it gained lot of recognition and popularity. It's being used in various forms such as abutment crowns, single crowns, implants abutments, implant screws, intramucosal inserts, and very recently being employed as a scaffold in procedures of bone grafting.[23]

It's also a material that possess high fracture resistance and improved fracture toughness. Addition of zirconia nanofillers to acrylic resin improved mechanical properties of PMMA.[24]

Garvie et al implanted magnesia partially stabilized zirconia in paraspinal muscles of rabbits, that were then examined at various time intervals (1 week, 1 month, 3 months and 6 months) and no significant adverse soft tissue response was evident. Proving that zirconia is highly biocompatible.

Our study revealed to us that a majority of the respondents believed that they had sufficient knowledge on zirconia but not enough to know its complex biocompatible and mechanical properties.

The need for further research and studies in this material is needed. And addition of the facts and literature into the curriculum for dental students is the need of the hour as the next generation of practitioners need to have sufficient clinical and material knowledge on zirconia.

V. CONCLUSION

The study reveals about the knowledge and awareness of zirconia products and its biocompatibility, their attitude towards staying updated with the latest trends and information relating to the material and its clinical implications among the dental interns. Interns were specifically selected as our target sample because they are the fresh graduates, who would next step into the world of clinical dental practice in the future and be held responsible for the type of treatment being offered.

Though a large number of respondents believed that they had sufficient knowledge, they failed to understand the material on the molecular level. Their false perception of their sufficient knowledge on zirconia can be readily changed by their attitude towards learning more. They show affirmative and eager attitude towards staying updated with information regarding zirconia. Majority of them preferred articles and literature from a trusted source to keep up with the newer studies. Some of them also showed interest in conferences and lectures that hold a platform for exposure to information.

REFERENCES

[1]. ***Denry I***, *Kelly JR. State of the art of zirconia for dental applications. Dent Mater 2008;* ***24****: 299-307 [PMID: 17659331 DOI: 10.1016/j.dental.2007.05.007]*

[2]. ***Serkan Saridag,*** *Onjen Tak, Gamze Alniacik, Basic properties and types of zirconia: An overview, World J Stomatol 2013 August 20; 2(3): 40-47*

[3]. ***Piconi C***, *Maccauro G. Zirconia as a ceramic biomaterial. Biomaterials 1999;* ***20****: 1-25 [PMID: 9916767 DOI: 10.1016/ S0142-9612(98)00010-6]*

[4]. ***Porstendörfer J***, *Reineking A, Willert HC. Radiation risk estimation based on activity measurements of zirconium oxide implants. J Biomed Mater Res 1996;* ***32****: 663-667 [PMID: 8953157]*

[5]. ***Chevalier, J., et al***. *2000 Extending the lifetime of ceramic orthopaedic implants, Advanced Materials. 12(21), 1619-1621*

[6]. ***S Renoldelsen*** *and M Vivekananthan 2018 IOP Conf. Ser.: Mater. Sci. Eng.* ***402*** *012031*

[7]. ***Kelly, J. R.*** *& Denry, I. Stabilized zirconia as a structural ceramic: An overview. Dent. Mater.* ***24,*** *289–298 (2008).*

[8]. ***Gu, X.*** *Y., Li, X., Liu, Q., Chen, Y. X. & Li, Y. X. Effects of Calcium Acetate on the Hydrothermal Synthesis of Tetragonal-Phase ZrO2 (3Y) Nanocrystals. Rare Met. Mater. Eng.* ***38,*** *1044–1066 (2009).*

[9]. ***Liu***, *X. Y., Chu, P. K. & Ding, C. X. Surface Nano-functionalization of biomaterials. Mater. Sci. Eng. R* ***70,*** *275–302 (2010).*

[10]. ***Lee***, *H. S., Huy, C. N., Pham, T. T. & Shin, E. W. ZrO2-impregnated red mud as a novel catalyst for steam catalytic cracking of vacuum residue. Fuel* ***165,*** *462–467 (2016).*

[11]. ***Harju,*** *H., Lehtonen, J. & Lefferts, L. Steam reforming of n-butanol over Rh/ZrO2 catalyst: role of 1-butene and butyraldehyde. Appl. Catal. B* ***182,*** *33–46 (2016).*

[12]. ***Goscianska***, *J., Ziolek, M., Gibson, E. & Daturi, M. Meso–microporous zirconia modified with niobia as support for platinum— Acidic and basic properties. Catal. Today* ***152,*** *33–41 (2010).*

[13]. ***Ward***, *D. A. & Ko, E. I. Preparing Catalytic Materials by the Sol-Gel Method. Ind. Eng. Chem. Res.* ***34,*** *421–433 (1995).*

[14]. ***Li,*** *Y. W. et al. Effect of calcium salts on isosynthesis over ZrO2 catalysts. J. Mol. Catal. A: Chem.* ***175,*** *267–275 (2001).*

[15]. ***Viazzi,*** *C., Bonino, J. P. & Ansart, F. Synthesis by sol-gel route and characterization of Yttria Stabilized Zirconia coatings for thermal barrier applications. Surf. Coat. Technol.* ***201,*** *3889–3893 (2006).*

[16]. ***Mazzoni***, *A. D. & Conconi, M. S. Study of carbonitriding reactions of zirconia. Synthesis of Zr (C, N, O) phases and β-type Zirconium oxynitrides. Ceram. Int.* ***30,*** *23–29 (2004).*

[17]. ***Ravichandran,*** *K. S., An, K., Dutton, R. E. & Semiatin, S. L. Thermal conductivity of plasma-sprayed monolithic and multilayer coatings of alumina and yttria-stabilized zirconia. J. Am. Ceram. Soc.* ***82,*** *673–682 (1999).*

[18]. ***Korotcenkov***, *G., Han, S. D. & Stetter, J. R. Review of Electrochemical Hydrogen Sensors. Chem. Rev.* ***109,*** *1402–1433 (2009).*

[19]. ***Manicone,*** *P. F., Iommetti, P. R. & Raffaelli, L. An overview of zirconia ceramics: Basic properties and clinical applications. J. Dent.* ***35,*** *819–826 (2007).*

[20]. ***Subbarao***, *E. C. & Maiti, H. S. Oxygen sensors and pumps. Adv. Ceram.* ***24,*** *731–747 (1988).*

[21]. *Wang, Y. Q. & Sayre, Commercial thermal barrier coatings with a double-layer bond coat on turbine vane and the process repeatability. Surf. Coat. Technol. 203, 2186–2192 (2009)*

[22]. ***Thamaraiselvi***, *T. V. & Rajeswari, S. Biological evaluation of bioceramic materials. Trends Biomater. Artif. Organs* ***18,*** *9–17 (2004).*

[23]. ***Harianawala H,*** *Kheur M, Kheur S, Sethi T, Bal A, Burhanpurwala M, Sayed F.*