ZIRCONIA: A CREDITABLE RESTORATIVE MATERIAL – A REVIEW

[1] Haragopal S [1] Assistant Professor
[2] Sreeramulu B [2] Assistant Professor
[3] Shalini K [3] Assistant Professor
[4] Sudha Madhuri D [4] Associate Professor
[5] Kiran G [5] Assistant Professor

[1,2,3,] Department of Prosthodontics, [5]Department of Oral pathology, Government Dental college and Hospital, Hyderabad. Andhra Pradesh
[4]Department of Prosthodontics. Government Dental college and Hospital, Vijayawada, Andhra Pradesh

ABSTRACT: Advanced ceramic materials such as Zirconia have great potential as substitutes for traditional materials in many biomedical applications. Since the end of 1990's, the form of partially stabilized zirconia has been promoted as suitable for dental use due to its excellent strength and superior fracture resistance as a result of its inherent transformation toughening. The purpose of this review is to know the evolution of zirconia as a biomaterial, to explore the materials physical, chemical, biological and optical properties of the material.

KEYWORDS: Zirconia, Advanced ceramics, Crowns, Bridge, Posts, Implant abutments.

INTRODUCTION

Ceramic materials that are developed specially for medical and dental use are termed as Bioceramics. Over the last decade, zirconia has propelled a rapid development of metal free dentistry that may provide high biocompatibility, enhanced esthetics and improved material strength [1]

History

Zirconium minerals were discovered decades ago, but were referred to as Jargon, Jacinth and Hyacinth. The term zirconium comes from Arabic word: Zargon (golden in colour) which was derived from two Persian words : Zar (gold) and Gun (colour).The metal dioxide zirconia was discovered by the German chemist Martin Heinrich Klaproth in 1789 and was first isolated by Swedish chemist Jons Jakob Berzelius in 1824.[1]

Properties

Zirconia is a polycrystalline ceramic without glass component. It is a transition metal element with atomic number 40, weight of 91.22, lustrous and exceptionally corrosion resistant. Pure zirconium exists in crystalline form as white and ductile metal and in amorphous form as a blue black powder. It has density of 6.49 gm / cm, a melting point of 1855^{o}C or 3371^{o}F and a boiling point of 4409^{o}C or 7968^{o}F. Among elements in earth's crust it is 18th in abundance. However it does not occur in nature in a pure state, but only in conjunction with silicate oxides (Zro_2xSio_2) or as free oxide (Zro_2) [2,3,4]

Zirconia is available in three forms, they are[1] (**Fig.1**)

a) Monoclinic at room temperature (27^{o}C)
b) Tetragonal at 1170^{o}C
c) Cubic at 2370^{o}C

Types of Zirconia

Three types of zirconia are

a) Fully sintered or Hot Isostatically Presintered (HIP) type - manufactured using hot isostatic pressing with high temperature and pressure to increase density. Ex: Zirkon, Everest-ZH.
b) Partially sintered (Non-HIP) type – manufactured using dried Zirconia powder that is isostatically pressed and incompletely sintered. E: Lava, Cercon.[(3)]
c) Non Sintered or Green State.

Three types of Zirconia containing ceramic systems currently used in dentistry are

a) Yttrium stabilized Tetragonal Zirconia Polycrystalline (Y-TZP) which exhibits high biocompatibility and improved fracture toughness.[3, 5, 6]
b) Magnesium Partially Stabilized Zirconia (Mg-PSZ)
c) Zirconia Toughened Alumina (ZTA) [7,8]

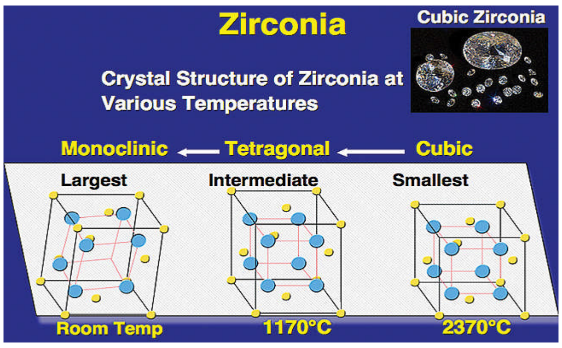

Fig.1Structure of zirconia

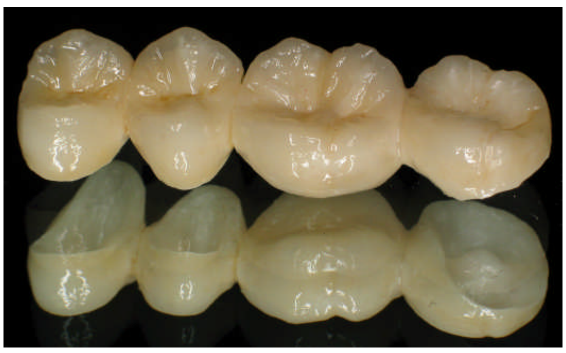

Fig.2 Zirconia Bridge

Fig.3 Zirconia posts

Fig.4 Implant abutments

Zirconia- Machining Techniques

Commonly used machining techniques are

a) Soft machining of presintered blocks: where a die or a wax pattern is scanned. An enlarged restoration is designed by computer software (CAD) and a presintered ceramic blank is milled by computer aided machining (CAM) and the restoration is then sintered at high temperature.

b) Hard machining of 3Y-TZP and MG-PSZ – presintered Y-TZP blocks are processed by hot isostatic pressing at 1400-1500^{o}C and machined using milling systems.[9]

Indications

- It is used as a component in some abrasives such as grinding wheels and sandpaper.
- Used for orthodontic brackets.[10,11,12]
- To fabricate crowns, bridges (**Fig.2**), posts[13 -17] (**Fig.3**) and implant abutments[1] (**Fig.4**).

Contraindications

- Very short clinical crown that does not permit height of connector.
- In class II-Div 2 – due to deep bite where there exists insufficient space for labiolingual connector width.
- Mesial tilting of abutment with supra erupted teeth.
- As cantilever pontic.

Advantages

The various advantages zirconia posses are:-

- Ability to be cemented with any type of adhesive
- Preparation design similar to porcelain fused metals
- Enhanced visibility in radiographs[1]
- Decreased thermal conduction
- Tissue compatibility[3,18,19]
- Properties that prevent crack propagation
- Strong core and high flexural strength
- Ability to deliver metal free fixed partial dentures with pontic spans of 38mm.

Disadvantages

- Weak core-veneer interface. So ceramic chipping or cracking is possible.
- Aging can reduce mechanical features of Zirconia.[3,20]

CONCLUSION

The introduction of zirconia opens a new horizon in the application of metal free, full ceramic restorations without limitations. Zirconia based restorations are quiet versatile and can be used to fabricate crowns, bridges, posts and implant abutments in a variety of clinical situations if appropriate guidelines are followed.

References

1. Zirconia in Dentistry:Part 1.Discovering the nature of an upcoming bioceramic. Eur J Esthet Dent 2009; 4:130-151.
2. Cox JD, Wagmann DD, Medvedev VA, CODATA key values for thermodynamics, New York: Hemisphere publishing corp, 1989.
3. Piconic Maccaurog. Zirconia as ceramic biomaterial, Biomaterials 1999; 20:1-25. http://dx.doi.org/10.1016/S0142-9612(98)00010-6
4. Lindemann W. Dentalkeramiken-mineralogisch betrachet. ZMK 2005; 5: 280-285.
5. Christel P, Meunier A, Heller M, Torre JP, Pielle CN. Mechanical properties and short term invivo evaluation of yttrium-oxide-partially stabilized zirconia. J Biomed Mater Res 1989; 23: 45-61. http://dx.doi.org/10.1002/jbm.820230105
6. Theunnisen G, Bouma JS, Winnubst AJA, Burggraaf AJ. Mechanical properties of ultra fine grained zirconia ceramics. J Mater Sci 1992; 27 : 4429 – 1470. http://dx.doi.org/10.1007/BF00541576
7. The zirconia: A new dental material: an overview-prague medical report/vol 108 (2007) no:1, p.5-12.
8. Clinical and Laboratory considerations for use of CAD/CAM Y-TZP based restoration- Aesthetic Dent 2003;15 (6); 469-476.
9. Luthardt RG,Holzhutar MS: Rudolph H et al CAD/CAM – Machining effects on YTZP zirconia .Dent Mater 2004; 20: 655-662. http://dx.doi.org/10.1016/j.dental.2003.08.007
10. Keith O, Kusy RP, Whitley JQ. Zirconia brackets: an evaluation of morphology and coefficients of friction. Am J Orthod Dentofacial Orthop 1994;106: 605—614. http://dx.doi.org/10.1016/S0889-5406(94)70085-0
11. Kittipibul P, Godfrey K. In vitro shearing force testing of the Australian zirconia-based ceramic Begg bracket. Am J Orthod Dentofacial Orthop 1995;108: 308—315. http://dx.doi.org/10.1016/S0889-5406(95)70026-9
12. Tanne K, Matsubara S, Hotei Y, Sakuda M, Yoshida M. Frictional forces and surface topography of a new ceramic bracket. Am J Orthod Dentofacial Orthop 1994;106: 273—278. http://dx.doi.org/10.1016/S0889-5406(94)70047-8
13. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999; 27: 275—278. http://dx.doi.org/10.1016/S0300-5712(98)00066-9
14. Kern M, Wegner SM. Bonding to zirconia ceramic: adhesion methods and their durability. Dent Mater 1998;14: 64—71. http://dx.doi.org/10.1016/S0109-5641(98)00011-6
15. Meyenberg KH, Luthy H, Scharer P. Zirconia posts: a new allceramic concept for nonvital abutment teeth. J Esthet Dent 1995; 7: 73—80. http://dx.doi.org/10.1111/j.1708-8240.1995.tb00565.x
16. Hochman N, Zalkind M. New all-ceramic indirect post-and core system. J Prosthet Dent 1999; 81: 625—629. http://dx.doi.org/10.1016/S0022-3913(99)70220-9
17. Zalkind M, Hochman N. Direct core buildup using a preformed crown and prefabricated zirconium oxide post. J Prosthet Dent 1998;80: 730—732. http://dx.doi.org/10.1016/S0022-3913(98)70062-9
18. Covacci V, Bruzzese N, Maccauro G, Andreassi C, Ricci GA, Piconi C, et al. In vitro evaluation of the mutagenic and carcinogenic power of high purity zirconia ceramic. Biomaterials 1999; 20: 371-376. http://dx.doi.org/10.1016/S0142-9612(98)00182-3
19. Satoh Y, Niwa S. Tissue-Biomaterial Interface Characteristics of Zirconia Ceramics. Bioceramics 1990; 3:101:108.
20. Sato TS, Shimada M. Transformation of yttria-doped tetragonal Zro_2 polycrystals by annealing in water. J Amer Ceram Soc 1985; 68: 355-359. http://dx.doi.org/10.1111/j.1151-2916.1985.tb15239.x

Corresponding Author

Sreeramulu B
Asstant Professor,
Department of prosthodontics.
Govt.Dental College & Hospital,
Afzalgunj, Hyderabad. 500012. A.P.
Phone No:09052030499
drsreeramulub@gmail.com
.