Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 13, Issue, 10, pp.19068-19070, October, 2021

DOI: https://doi.org/10.24941/ijcr.42353.10.2021

ISSN: 0975-833X

RESEARCH ARTICLE

UPDATE ON THE EVOLUTION OF ZIRCONIA MATERIAL

*Sihem HAJJAJI, Sirine LIMEM, Hayet HAJJEMI and Abdellatif BOUGHZELA,

Department of Dentistry, Fixed Prosthesis Unit, Farhat Hached University Hospital, Tunisia

ARTICLE INFO

Article History:
Received 19th July, 2021
Received in revised form
17th August, 2021
Accepted 25th September, 2021
Published online 30th October, 2021

Key Words:

Zirconia, Aesthetics, Opacity, Density, Strength, Longevity.

***Corresponding author:**
Sihem HAJJAJI

ABSTRACT

The introducing of zirconia in dentistry has generated considerable interest, which has manifested itself in strong industrial, clinical and research activity. The technology contributes to the fabrication of novel "all-ceramic" zirconia-based restorations with improved physical properties and biocompatible for a wide range of promising clinical applications. Especially with the development of computer-aided design and assisted manufacturing systems, we now have a multitude of zirconia-based materials, each of which has a different microstructure and properties, making it possible to diversify their indications. This is how zirconia has amply deserved its place in prosthetic and implant restorations.

Citation: Sihem HAJJAJI, Sirine LIMEM, Hayet HAJJEMI and Abdellatif BOUGHZELA. *"*Update on the evolution of zirconia material*", 2021. International Journal of Current Research, 13, (10), 19068-19070.*

INTRODUCTION

Metal-free dentistry has long been the dream of every practitioner. However, the in herent brittleness, low flexural strength, as well as the low fracture resistance of ceramics have been the main obstacles hindering the indications of these materials. To overcome these shortcomings, researchers and manufacturers have developed advanced formulas to increase the strength of ceramics. Zirconia is one of the materials that has under gone particularly rapid and significant development, particularly with the democratization of computer-aided design and manufacturing (CAD / CAM). This article aims to take stock of the changes that zirconia has experienced in its composition and structural properties, as well as the methods of its manufacture for successful clinical application in dentistry.

ZIRCONIA PROPERTIES : The bending test measures the breaking strength of the material. For partially stabilized zirconia, it would be 800 to 1200 MPa. It is about twice that of alumina oxide-based ceramics on the market today, and five times that of standard glass-ceramics. The breaking strength varies according to the type of zirconia: in fact the lowest values correspond to so-called "translucent" monolithic zirconia containing a cubic phase. Depending on the percentage there of, the resistance will be between 550 Mpa and 800 Mpa. For reinforcing or monolithic Y-TZP zirconias which are more opaque, the strength will be between 800 Mpa and 1200 Mpa. The location of a restoration, and therefore the applied bite force (Fig. 1) is critical in determining the required level of strength of the material. To avoid fracture, the occlusal thickness must be adjusted to compensate for the strength of the selected zirconia material. The tenacity is a measure of the resistance to propagation in a material. The tenacity of a zirconia is between 7 and 15 Mpa, which is almost twice that of an aluminum oxide ceramic.Due to its tetragonal polycrystalline structure, when a crack develops, the material transforms into a monoclinic shape. This transformation is associated with a local increase of 4% in volume, which produces a blocking effect on the crack and stops its expansion.

MATERIALS EVOLUTION

Zirconia as an additive: It was commonly used to strengthen alumina before the advent of full Zirconia crowns. This was a process used by VITA, blocks of In-Ceram Zirconia® (Ab03 70% and Zr02 30%) were infiltrated with glass after machining (Fig. 2). The addition of zirconium oxide increases the flexural strength, but also the fracture toughness and fatigue resistance. This zirconia was used for the production of false dental abutments, small anterior bridges of three to four units, posterior three-unit bridges, and anatomical implant abutments.

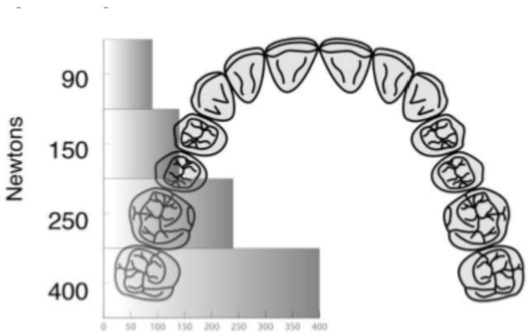

Fig. 1. Occlusal force applied depending on the location

Fig. 2. In-Ceram® Classic zirconia block for inLab® (Company VITA)

This material is becoming scarce; it can be obtained by the slip technique, which is no longer widely used today, or in the form of a block to be machined by CAD / CAM. These blocks have a porous pre-sintered crystal structure, which is infiltrated by a glass and sintered after machining.

Fig. 3. Restoration made from undyed block

Conventional Zirconia: Conventional zirconia has a high refractive index of light and also has an extremely high number of interfaces through which light will pass. This creates the opaque character of the material. Two different types of zirconia blocks are distributed by manufacturers: dyed or not industrially dyed. Restorations made from stained blocks already have a similar shade to teeth after milling, restorations made from undyed blocks have a hard white monochrome color, which can be an aesthetic drawback in many cases (Fig.3). To overcome this drawback, these restorations can be manually and individually stained with coloring oxides after the machining process and then sintered. For dyeing, the framework is immersed in a suitable colored liquid (Fig. 4).

Stratifiedzirconia : Due to the compromised aesthetics of first generation zirconium oxide, the framework of the prosthesis is covered with an appropriate glass ceramic (Fig. 5).

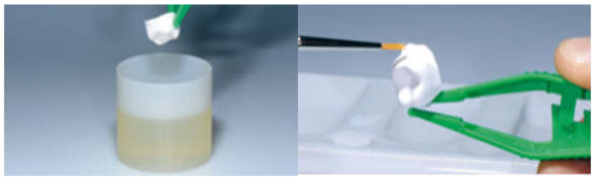

Fig. 4. Zirconia coloring

Fig.5 Bridge of 3 elements in layered zirconia

Fig. 6: fracture of the veneering ceramic at the pontic

The two ceramics do not have the same ductility: the layering ceramic has significantly lower strengths than zirconia, it fractures faster. In this context, the fracture is limited to the layering ceramic (Fig. 6).

Fig.7. Monochrome (right) vs multilayer (left)

Indeed, all the studies have shown that a fracture is never observed at the interface between the framework and the cosmetic, but always inside the cosmetic. The design of the zirconia framework has a decisive influence on the overall stability of restorations. Zirconia structures should be designed to increase the fracture threshold and minimize chipping.

Monolithic zirconia: To avoid the risk of chipping, the zirconia can now undergo a monolithic treatment. Thus, the long and complicated manual laminating process can be avoided. In order to be able to use the material monolithically, certain conditions must be met. In addition to continuing to have good long-term stability, it is essential that the material becomes more translucent and therefore more aesthetic. Zirconia blocks are available in monochrome or multi-layered blocks (Fig. 7).

The difference is that monochrome blocks are always one color while multi-layered blocks are pre-laminated and therefore contain different shades. Individual characterization of the zirconia blocks yields esthetic results that approximate common layering techniques, but there is no long-term follow-up data on color stability. The aim of the manufacturers is currently to find a compromise between the tetragonal phases, ensuring good stability and the physical properties of the zirconia, and the cubic phase, which will increase the translucency of the zirconia, and therefore itsaesthetic rendering. For Tetragonal zirconia, the grains have irregular boundaries that prevent light transmission (anisotropic), while cubic zirconia is isotropic, that is, the properties of the material are the same in all directions, which improves light transmission. It should be noted that the presence of cubic phase in so-called highly translucent monolithic zirconia has two main advantages:

- A significant increase in translucency
- A total absence of hydrothermal degradation

However, the lower sensitivity to transformation for cubic zirconia and a coarser microstructure cause a reduction in mechanical properties, which can represent a limitation in their application, in particular under conditions where high stresses will be applied. Therefore, handling and preparation of the crown should be done with care, avoiding thin walls and sharp edges as much as possible.

CONCLUSION

The zirconia used in dentistry is actually a grouping of a multitude of materials, each of which has adifferent microstructure and properties, making it possible to diversify their indications.Its undeniable mechanical resistance is linked to its ability, in the presence of defects such as cracks, to strengthen its structure. On the aesthetic level, many studies have been carried out to improve the aesthetics of monolithic zirconia, and mainly its translucency, in particular thanks to the zirconia stabilized in the cubic phase. These modifications allowed a compromise between esthetics and mechanical imperatives, bringing new zirconias on the market, with a translucency which approaches the natural tooth. Ultimately, we can say that zirconia is the material of the future.

REFERENCES

1.Chevalier J, Olagnon C, Fantozzi C, Subcritical crak propagation in 3YTZP Ceramics. Static and cyclic fatigue . J Am Ceram Soc. 1999 ; 11 : 3129-3138.

2. Garvic RC, Nicholson PS. P h a s e analysis in zirconia systems. J Am Ceram Soc. 1972 ; 55 : 3035

3.Rimondini L, Cerroni L, Carassi A, Torricelli P. Bacterial colonization of zirconia ceramic surfaces. Intern. J of Oral and Maxillof Implants (JOMI) Vol. 17 Num.6

4.Stevens R. Zirconia and zirconia ceramics, 5eme ed. USA New York : Magnesium Elektron, 1986, 51.

5. Sadoun M, Perelmuter S. Alumina zirconia machinable abutments for implant-supported single-tooth anterior crowns.The Implant Report PP&A, 1997 : 1047-1053.

6. Seghi R, Sorensen JA. Relative flexural strengh of six new ceramics materials. Int. J. Prosthondont, 1995 ; 8, 4 : 239-46.

7. Probster L, Diehl J. Slip casting alumina ceramic for crown and bridge restorations. Quintessence Int, 1992 ; 1 : 23-31.

8. Griffith. Phenomena of rupture and flow in solids. Trans. R.Soc, 1920 ; 163 : a 221.

9. Magne P, Belser U. Esthetic improvements and in vitro testing of In-Ceram Alumina and Spinell Ceramic. Int. J. of Prosthodont, 1997 ; 10, 5 : 459-466.

10. Stawarczyk B, Oczan M, Schmutz F, Trottmann A , Roos M , Hämmerlé CH. Two-body wear of monolithic, veneered and glazed zirconia, and their corresponding enamel antagonists. Acta Odontol Scand. 2013 Feb;71(1): 102-12.

11. Tinschert J, Schulze KA, Natt G, Latzke P, Heussen N, Spiekermann H. Clinical behavior of zirconia based fixed partial dentures. Int J Prosthodont. 2008 May-Jun; 21(3): 217-22.

12. Walton TR. An up to 15-year longitudinal study of 515 metal-ceramic FPDs: Part 1. Outcome. Int J Prosthodont. 2002 Sep-Oct; 15(5):439-45.

13. Sailer I, Pjetursson BE, Zwahlen M, Hämmerle CH. A systematic review of the survival and complication rates of all ceramic and metal ceramic reconstructions after an observation period of at least 3 years. Part II : fixed dental prostheses. Clin Oral Implants Res. 2007 Jun;18 Suppl 3:86-96.

14. Sailer I, Fehér A, Filser F, Gauckler LJ, Lüthy H, Hämmerle CH. Five years clinical results of zirconia frameworks for postérior fixed partial dentures. Int J Prosthodont. 2007 Jul-Aug;20(4): 383-8.

****