OPTICAL AND MECHANICAL PROPERTIES OF MONOLITHIC ZIRCONIA Y-TZP: SYSTEMATIC REVIEW

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1.INTRODUCTION

More than a decade ago, Monolithic Zirconia Y-TZP (Yttria stabilized zirconia) was introduced in dentistry as a framework material for its superior mechanical properties, but for aesthetic reasons (its opaque white color and insufficient translucency) it needs to be covered with a glass ceramic or feldespathic ceramic to achieve a natural appearance and acceptable aesthetics (layered zirconia). However, some clinical problems arise due to coating layers are prone to fracture and it has been associated with delamination and spalling.[1,2,3] After 2013, second, third and fourth generations of Y-TZP were created from the original 3Y-TZP Zirconia. Modifications were mainly implemented on the Yttria percentage, porosity, grain size, temperature and duration of thermal pressing and sintering process and its thickness that modifies the translucency of the zirconia and mechanical properties such as flexural strength and fracture toughness.[4,5] CAD-CAM technologies and its techniques has expanded the availability of monolithic zirconia to clinicians and implemented to its daily practice. [6,7]

2.PROPOSITION

This study reviewed and evaluated existing research and publications about the influences that modifications have on Monolithic Y-TZP Zirconia to improve the optical properties that it confers, without reducing its mechanical properties.

3.METHODS

SEARCH STRATEGY

The search strategy was based on patient, intervention, comparison, and outcome (PICO)[8]. A structured PICO question was developed, where (P) stood for Yttria partially stabilized polycrystalline tetragonal zirconia Y-TZP, (I): evaluation of the optical and mechanical properties of zirconia Y-TZP, (C): glass ceramics and resin matrix ceramics (layered zirconia), (O): optical and mechanical properties of the zirconia Y-ZTP.

An electronic search was carried out in the databases: Pubmed, Cochrane, Scielo, LILACS, EBSCO, BMC, Trip Database, and Epistemonikos, from January, 2005 to July, 2021, using the key terms and their combinations: "Ytrria stabilized tetragonal zirconia, Yttria stabilized zirconia AND optical phenomena, Yttria stabilized tetragonal zirconia AND optical phenomena NOT dental implants, and lastly the combination of Yttria stabilized tetragonal zirconia AND optical phenomena And mechanical Phenomena".

INCLUSION AND EXCLUSION CRITERIA

The search was carried in the database of the last 16 years which contain articles only in English, full-text available electronically and articles containing information of the optical and mechanical properties of monolithic zirconia Y-TZP. The exclusion criteria were publications before 2005, does not include zirconia Y-TZP, not containing optical and mechanical properties of Y-TZP, and not monolithic zirconia.

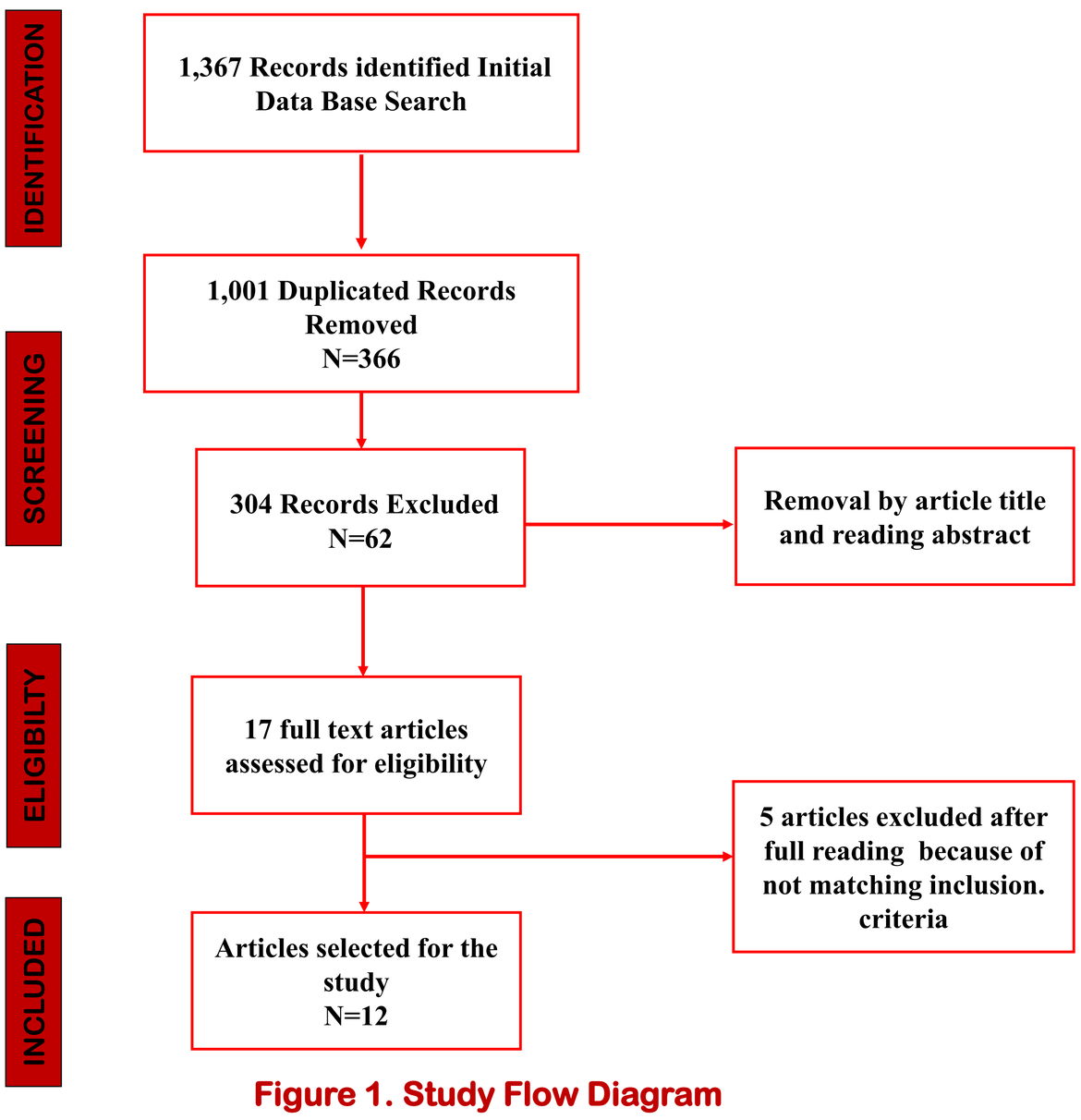

Figure 1. Study Flow Diagram

4.RESULTS & DISCUSSION

From the total of 1367 articles, 1001 were eliminated for having duplicate titles, resulting in 366 articles, of these 304 were eliminated for not including information associated with the research question in their title, later 62 articles were subject to revision of the introduction, eliminating a total of 45, for not having information according to the topic, 17 articles were used for full reading and analysis between authors. 12 articles were selected for the analysis of this systematic review, according to the inclusion criteria.

Y-TZP zirconia "transformation hardening" mechanism is responsible for its excellent mechanical properties; which is when the zirconium oxide grains transform from their tetragonal (2370C) to monoclinic form (1170C) accompanied by a volumetric expansion of the grain by approximately 4%, thus restricting cracks that may occur when subjected to; and with a flexural strength of 900 to 1200 Mpa and fracture resistance of more than 2000N.[9,10,11]

To achieve better optical properties, translucency parameters increases by adding Yttria mols (3 - 6%) which prevents polymorphic transformation during heating and cooling. The cubic (2680C) phase in highly translucent zirconia (5Y) carries two advantages: increase in translucency and 2) the total absence of hydrothermal degradation, despite this, the lack of hardening of the phase of cubic zirconia and its coarse microstructure generates a severe decrease in the mechanical properties.[12,13]

In addition, increasing the sintering temperature leads to greater translucency by increasing the grain, providing a more compact crystal structure but if this temperature is above 1600C, there is a decrease in flexural strength.

In terms of material thickness, a decrease in zirconia thickness from 1.5 to 0.8 mm significantly increased translucency and although CAD-CAM monolithic ceramics can mask a normal dentin background, they cannot mask severely discolored dentin at thicknesses of 0.8mm to 1mm.[9,14,15,16]

In Niwut et. al, in vitro search, it stated that increasing the thermal tempering rate of Y-TZP resulted in a larger grain size which increases translucency, while slow thermal tempering rate resulted in improved flexural strength.[17,18]

Between the three types of Y-TZP, Y-TZP of high translucency (5Y-TZP) seems like the best candidate for monolithic dental restorations.[19]

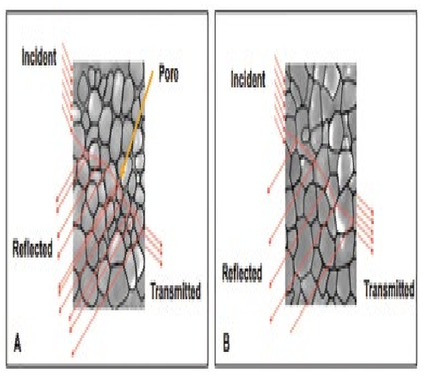

Figure 2. Possible explanation of behavior in light reflection scatterring, and transmission in relation with microstructure for partially sintered Y-TZP monolithic zirconia upon slow (A) and fast thermal tempering processes (B).[17]

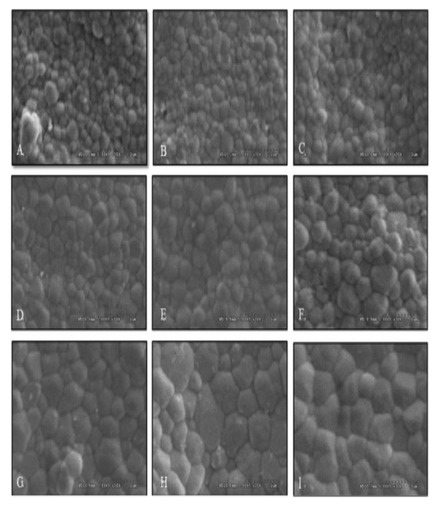

Figure 3. SEM photomicrographs indicated gran size and grain distribution of monolithic zirconia, sintered at decreasing- (A,B,C), regular- (D,E,F), and increasing- (G,H,I) sintering temperature, with shortening- (A,D,G), regular- (B,E,H), and prolonged- (C,F,I) sintered-holding time at X30K magnification..[20]

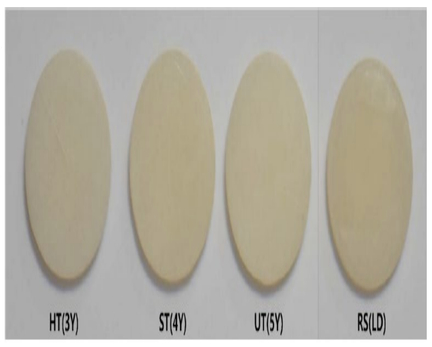

Figure 4. Tested ceramic specimens. Katana HT (3 Y-TZP), Katana STML (4Y-TZP), Katana UTML(5Y-TZP); compared to Rosetta SM (lithium disilicate).[16]

5.CONCLUSION

Based on the findings of this systematic review on the optical and mechanical properties of Y-YZP monolithic zirconia, it was detected that most of the studies are experimental and in vitro, however, very few show the long-term behavior of the material. Therefore, the following conclusions are drawn: most authors agree that zirconia has good optical and mechanical properties and while its optical properties increase, mechanical resistance decrease proportionally. However, these findings must be interpreted with caution given the limitations of the study, in the same way to carry out an analysis on hydrothermal degradation at low temperatures to which it may be exposed.

6.REFERENCES

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