DEMYSTIFYING THE USE OF LITHIUM DISILICATE AND CUBIC PHASE STABILIZED ZIRCONIA IN MONOLITHIC RESTORATIONS: A LITERATURE REVIEW

DESMISTIFICANDO O USO DO DISSILICATO DE LÍTIO E DE ZIRCÔNIAS ESTABILIZADAS NA FASE CÚBICA EM RESTAURAÇÕES MONOLÍTICAS: UMA REVISÃO DE LITERATURA

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ABSTRACT

The development and popularization of operative techniques associated with dental materials have enabled the transformation of oral health conditions into aesthetic rehabilitations. The aim of this study was to review the literature on the use of lithium disilicate and cubic phase stabilized zirconia in monolithic restorations. The databases used were Lilacs, Pubmed/Medline, Scielo, and ScienceDirect, crossing the following English descriptors: “Zirconium”, “Yttrium”, “CAD-CAM”, “Ceramics”, “Dental Porcelain” and “Material Resistance”. Monolithic indirect restorative techniques with dental ceramics coupled with the use of CAD/CAM technology have several short and long-term advantages. Lithium disilicate and high translucency zirconias stabilized in the cubic phase are current materials and of constant evolution in dental research due to their mechanical behavior, biological, optical, and aesthetic aspects, ensuring their use as materials of excellence in aesthetic-functional rehabilitations.

Keywords: Dental aesthetics; Ceramics; Zirconium; CAD-CAM.

RESUMO

O desenvolvimento e a popularização de técnicas operatórias associadas aos materiais odontológicos propiciaram a transformação das condições de saúde bucal em reabilitações estéticas. O objetivo deste estudo foi revisar a literatura acerca da utilização do dissilicato de lítio e de zircônias estabilizadas na fase cúbica em restaurações monolíticas. As bases de dados utilizadas foram Lilacs, Pubmed/Medline, Scielo e ScienceDirect, cruzando os seguintes descritores em língua inglesa: *“Zirconium”*, *“Yttrium*”, *“CAD-CAM*”, *“Ceramics”*, *“Dental Porcelain”* e *“Material Resistance”*. As técnicas restauradoras indiretas monolíticas com as cerâmicas odontológicas atreladas ao uso da tecnologia CAD/CAM possuem diversas vantagens a curto e a longo prazo. O dissilicato de lítio e as zircônias de alta translucidez estabilizadas na fase cúbica são materiais atuais e de constante evolução na pesquisa odontológica devido ao seu comportamento mecânico, biológico, aspectos ópticos e estéticos, garantindo seu uso como materiais de excelência nas reabilitações estético-funcionais.

Palavras-chave: Estética dentária; Cerâmica; Zircônio; CAD-CAM.

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How to cite this article: Silva AO, Ramalho IS. Demystifying the use of lithium disilicate and cubic phase stabilized zirconia in monolithic restorations: a literature review. Nav Dent J. 2023; 50(1): 27-33.

Received: 04/01/2023
Accepted: 05/05/2023

INTRODUCTION

Monolithic restorations have been considered the gold standard in esthetic-functional dental rehabilitations because of their optical characteristics, their excellent biocompatibility and mechanical properties, and the ease of their fabrication method by computer-aided design/computer-aided manufacturing (CAD/CAM) (1, 2). Lithium disilicate ceramics were introduced to the dental community by Ivoclar Vivadent (3). It is a glass matrix ceramic containing lithium disilicate crystals, which results in higher mechanical strength compared to feldspathic ceramics and in better esthetics than highly crystalline ceramics, resulting in the evolution of dental glass-ceramics for its mechanical and esthetic behavior and manufacturing technology (4).

Currently, lithium disilicate has the CAD/CAM-favored manufacturing method, which has adequate clinical performance as a restorative material in monolithic restorations (5). Moreover, its optical properties and translucency are superior to restorations made of different types of zirconia (6).

First-generation yttria-stabilized zirconia (Y-TZP) has been increasingly used in oral rehabilitation as a component of the framework, anterior and posterior, single and multiple restorations, presenting superior mechanical properties and biocompatibility when compared to other dental ceramics, besides high strength, fracture toughness and excellent mechanical properties as its main characteristics (7,8,9,10,11). The high opacity of Y-TZP is a negative factor especially when used in esthetic restorations though (12,13).

The second generation of Y-TZP presents higher translucency, due to more refined processing, which occurs by reducing the concentration of alumina oxide grains (Al_2O_3) and by increasing the sintering temperature, which aims to eliminate material porosity (11,14). This same second-generation zirconia presents medium translucency, with a better indication for the production of monolithic crowns in the posterior region (14). Despite the improvement in the optical properties of second-generation zirconia, they are not yet comparable to glass ceramics in terms of esthetics, which encourages the introduction of third-generation zirconia in the search for translucency and tooth mimicry (11,15).

The third generation had the important change of increasing the percentage of yttrium oxide stabilizer (> 3 mol%). This change resulted in a partially or fully stabilized material, in which up to 53% of the cubic phase could be observed in the ceramic crystalline microstructure, in addition to the tetragonal phase, present in previous generations such as Y-TZP (11).

In order to promote improvements in the optical properties of third-generation zirconia, partially stabilized cubic phase zirconia (Y-PSZ) and fully stabilized cubic phase zirconia (Y-FSZ) were developed, which have in their composition a higher amount of yttrium oxide when compared to Y-TZP (4 to 6 mol% for Y-PSZ and 8 mol% for Y-FSZ) (13,16). The addition of yttrium oxide to zirconia promotes an increase in the crystalline content of the cubic phase and allows for increased translucency because, unlike the tetragonal phase, the cubic phase has an isotropic refractive index (13,14,17).

The aim of this study is to present the characteristics of lithium disilicate, Y-PSZ, and Y-FSZ, such as structural aspects, phase transformation, mechanical and optical properties, abrasion and wear, and clinical performance, in order to demystify their use and support their correct indication in monolithic dental restorations.

LITERATURE REVIEW

Data Collection

A non-systematic electronic search was performed in the Lilacs, Pubmed/Medline, Scielo, and ScienceDirect databases using the following English descriptors: “Zirconium”, “Yttrium”, “CAD-CAM”, “Ceramics”, “Dental Porcelain”, and “Material Resistance”. Research articles, literature reviews, randomized clinical trials, and case reports pertinent to the subject, published from 2007 to 2020, were included. Exclusion criteria included articles with disparities in the proposed theme, abstracts, and letters to the editor. A total of 1613 articles were found, forty of which met the selection criteria for inclusion in this study.

Structural Properties and phase transformation

Injection-molded lithium disilicate ceramics have one glassy phase and two crystalline phases in their matrix. The glassy matrix involves both crystalline phases for structural shaping (3). These properties are present in the material after its complete sintering cycle (18). Its microstructure is characterized by a lithium disilicate crystalline phase (70%) surrounded by a silica glass phase and a second lithium orthophosphate crystalline phase. The crystals are elongated (5 μm in length and 0.8μm in diameter) and interconnected, which prevents the propagation of cracks (18,19).

The commercialized lithium disilicate blocks for CAD/CAM undergo a two-stage sintering process. In the pre-sintered phase, the crystals of metasilicate, lithium disilicate, and orthophosphate have a size of 0.2 to 1.0 μm and a flexural strength of about 130 to 150 MPa, which allows milling and, when tested, facilitates occlusal adjustment. Additionally, in the final sintering, the prosthetic piece must be baked at 850ºC (4,18,20).

The third-generation zirconia characterized by Y-PSZ and Y-FSZ are considered more translucent than other zirconias and are indicated for the fabrication of monolithic crowns in the anterior region, providing better aesthetic results (17). This translucency is mainly related to the isotropic refractive index and the absence of light scattering by birefringence at the cubic grain boundaries, unlike what occurs in Y-TZP (15). In this generation, the optical and aesthetic properties, characterized by translucency and light transmittance, have been improved, although the mechanical properties are expected to be somewhat compromised by the elimination of the mechanism of transformation from tetragonal phase to monoclinic phase (11,21). In addition, it is worth noting that improved resistance to low-temperature degradation of Y-PSZ and Y-FSZ is suggested (14).

The increase in the cubic phase of Y-FSZ reduces its mechanical properties. In addition, the total stabilization in the cubic phase does not allow the transformation from the tetragonal to the monoclinic phase (22). These modifications aim to reduce light scattering and thus improve the translucency of the material (14).

In terms of adhesion, the absence of any glass matrix in zirconia is a silica free and therefore detrimental as it cannot be etched with conventional acid etching techniques, unlike glass ceramics such as lithium disilicate (1,13,23).

Mechanical Properties

The crystalline structure of lithium disilicate influences its mechanical properties and the material undergoes 2% shrinkage after complete sintering. It can undergo mechanical changes in different sintering cycles contrary to what is indicated by the manufacturer (4). After sintering, it has a biaxial flexural strength of 407±45 Mpa (20), a modulus of elasticity of ±95GPa, which is similar to that of dental enamel 91GPa, and a fracture toughness of ±3 MPa m½. These values are 10% higher than those of injected lithium disilicate, ensuring better mechanical performance (24).

Lithium disilicate, when fabricated for monolithic restorations, is also able to withstand fracture loads better (2665.4±759.2N) when compared as a cover material (1431.1±404.3N) (5). The technique of fabricating monolithic lithium disilicate restorations with CAD/CAM reduces the possibility of porosities in the restoration that can negatively affect its fracture toughness and flexural strength (24).

Due to the greater occlusal overload in the posterior region, lithium disilicate milled crowns have a higher fracture rate in the molar region when compared to the premolar region. These risks are greater in patients with bruxism, for example (20). The same material, when used for the fabrication of posterior indirect restorations, requires minimum thicknesses of 1.5 to 2 mm in the occlusal thickness for good mechanical performance (6). This material is not indicated for the fabrication of three-unit fixed partial dentures because it does not support the minimum loads (500 MPa) of fatigue strength and 3.5 MPa of fracture toughness (25).

Moreover, minimum thicknesses of the material on the enamel surface provide a lower risk of micro fractures when compared to larger thicknesses on the dentin tissue substrate due to the different values in the modulus of elasticity, demonstrating its good performance in minimally invasive indirect restorations (23).

Obermeier *et al.* demonstrated that the use of screw-retained lithium disilicate monolithic crowns on dental implants leads to a lower risk of implant-related damage compared to monolithic crowns made of Y-TZP and Y-TZP with lithium disilicate coating (26).

Y-FSZ has a partial reduction or absence of tetragonal grains that may limit its application in situations of high mechanical stress, suggesting that further investigations are necessary for a better characterization of the clinical performance of this type of zirconia since the high translucency makes this material promising to act in esthetic areas (27). The higher translucency of Y-FSZ, when compared to Y-TZP and Y-PSZ, is a result of the increased yttria oxide concentration, which stabilizes higher content in the cubic phase. These cubic grains have an isotropic orientation, having less interference with light transmission. In addition, they are larger than tetragonal grains, which reduces the grain boundary, which are sources of light deviation (22).

Currently, lithium disilicate ceramics are the most used material for monolithic crowns in the anterior region (28). However, this material is friable and susceptible to fatigue failure after mechanical loading (17). Y-PSZ, when compared to lithium disilicate ceramics, despite being less translucent, presents higher values of flexural strength and fracture toughness (29).

There is also a consensus that Y-FSZ has lower flexural strength than Y-PSZ due to the higher concentration of yttrium oxide and, consequently, a higher amount of crystalline content in the cubic phase (16,17,30).

Optical properties

The presence of the crystalline structure of lithium disilicate influences the microstructural properties of the material and is directly related to its optical properties (24). The colors of the material are determined by dye ions, usually, vanadium being the major composition of the dyes that are incorporated into the matrix. Moreover, lithium disilicate presents colors and translucency that differ by the size of the crystals and the amount of staining ions, bringing great advantage in the use in aesthetic regions, such as in anterior teeth, where the material can provide mimicry, besides its better translucency when compared to Y-TZP (4,31).

Milled lithium disilicate also allows the application of liquids for extrinsic staining and glazing after sintering, with great aesthetic gains as the optical properties of the material, are improved (4,5). Adhesive cementation and the color availability of the adhesive cements available in the dental market provide less interference in the color and translucency of the material (2).

Third-generation zirconia is considered more translucent than other zirconias and is indicated for the fabrication of monolithic crowns in the anterior region, providing better aesthetic results (17). This translucency is mainly related to the isotropic refractive index and the absence of light scattering by birefringence at the cubic grain boundaries, unlike what occurs in Y-TZP (14). The optical and aesthetic properties characterized by translucency and light transmittance have been improved, although the mechanical properties are expected to be somewhat compromised by the elimination of the transformation mechanism from the tetragonal to the monoclinic phase (11).

Y-PSZ and Y-FSZ are good alternatives to overcome the opacity of first and second-generation monolithic zirconia crowns, given the greater translucency and coloring possibilities of the material that can be associated, improving the optical and esthetic properties (32). This partial and total stabilization of Y-PSZ and Y-FSZ with cubic grains, which are isotropic, can improve the light transmission through the restoration, bringing great esthetic advantages (33). This factor also contributes to the cementation of Y-FSZ restorations due to the amount of light able to pass through the material, increasing the degree of conversion of resin cements during photoactivation (27).

Abrasion and wear

Lithium disilicate has a better performance against enamel abrasion, bringing less wear on the antagonist when compared to Y-ZTP and feldspathic ceramics (34). However, the material promotes higher values of abrasiveness to the enamel surface compared to composite infiltrated ceramics and nanoceramic resin also available for making and milling in CAD/CAM, due to the higher hardness of lithium disilicate (35,36). Lithium disilicate has a similar abrasiveness to dental enamel, so the glazing of the material has a greater indication of esthetic surfaces and smooth slopes that will not be influenced by masticatory wear over the clinical time (5).

It is important to be accurate throughout the fabrication of indirect restorations with this material, since intraoral adjustments with diamond-tipped instruments can lead to the formation of surface irregularities responsible for the initiation of micro cracks and fractures, making it necessary to polish the material after occlusal adjustments to minimize damage to the structure of the restorations (5,33).

Some authors have reported that polishing and glazing reduce the flexural strength of Y-PSZ, while the staining procedure increases the flexural strength of Y-FSZ, directly influencing the abrasive process against its antagonist (17,20,30,37).

Hatanaka *et al.* established that different protocols for adjusting monolithic Y-FSZ restorations such as the application of glaze and polishing rubbers do not increase the flexural strength of the material; even when subjected to the aging process in an autoclave at 134ºC and 200KPa for twenty hours (33).

Clinical Performance

Lithium disilicate restorations show good clinical performance in oral rehabilitations followed up to eleven years, as well as a 25-year longevity as veneers and ceramic laminates (20,38).

Brand *et al.* evaluated the longevity of restorations with single crowns made of IPS e.MAX lithium disilicate over a period of four years and demonstrated great success. They concluded that there is a higher survival rate in endodontically treated teeth and that adhesive cementation, as a sensitive technique, may negatively influence this rate (2).

Yang *et al.* demonstrated a 96.6% survival rate of 6855 different indirect lithium disilicate restorations in a five-year clinical follow-up. They also observed a lower survival rate in veneer restorations (90.6%) and concluded that the most frequent failures are related to delamination, cracks, and fractures and that the failures occur mainly one year after cementation (24).

Beier and Dumfahrt observed a survival rate of lithium disilicate restorations of 93.5% in ten years and 78.5% in twenty years of follow-up. The failures were mainly attributed to bruxism and caries infiltration (39).

Lithium disilicate should be avoided in three-unit fixed partial dentures in the posterior region since there is a higher fracture rate due to the compression forces developed by chewing, which are accentuated in patients with bruxism (20,25). Stabilizing plates associated with indirect lithium disilicate restorations in patients with bruxism is an indication that ensures treatment predictability and longevity (39).

DISCUSSION

Monolithic restorations have satisfactory optical properties, biocompatibility, and mechanical properties for clinical use (1). Their manufacture enables the use of the same ceramic material throughout the structure, reducing the likelihood of problems related to delamination, cracks, and fracture of the restoration (2,5,24). Lithium disilicate is a promising ceramic for clinical use in monolithic restorations such as veneers and ceramic laminates, anterior and posterior single crowns, and implant or denture-supported fixed partial dentures (2,26,38).

Lithium disilicate blocks for monolithic restorations have the advantage of processing facilitated by CAD/CAM, providing a reduction in the time to fabricate the restoration (18,20). Moreover, some crystals that are elongated and interconnected prevent the propagation of cracks and micro-cracks, contributing to success and ensuring longevity (18,19).

The respect for mechanical principles in the fabrication of monolithic restorations and the correct indication of use ensure the clinical success of the material. The sintering cycle, respecting the manufacturer's recommendation, contributes to its adequate mechanical performance (4); furthermore, the elasticity modulus of lithium disilicate after sintering corresponds to ±95GPa which is similar to dental enamel (91GPa) contributing to the good clinical performance against the adjacent dental tissues (24). The greatest meticulousness in the preparation and indication of the material falls on posterior indirect restorations with the need for minimal occlusal thicknesses, as well as the use with caution on posterior fixed partial dentures, given the greater occlusal overload on these teeth (6,25).

However, Y-PSZ has higher flexural strength and fracture toughness values compared to lithium disilicate ceramics and has good indications for making posterior monolithic crowns (29). Whereas Y-FSZ is better indicated for the anterior region because of its lower mechanical performance when compared to Y-PSZ and Y-TZP (40).

Currently, the great use of lithium disilicate in indirect restorations is mainly due to its optical properties and greater dental mimicry compared to other ceramic systems and its possibility of staining (4,24). It has the great advantage of use in esthetic regions, such as in anterior teeth, besides its better translucency when compared to Y-TZP, which has an indication for infrastructure due to its high opacity (31). The finishing of the material with glaze and liquids for extrinsic staining becomes essential steps for improving the optical properties of the material (4,5). Furthermore, Y-PSZ and Y-FSZ are also good alternatives to overcome the opacity of Y-TZP, due to their optical and aesthetic properties such as higher translucency and coloring possibilities of the material (32). Y-PSZ and Y-FSZ also allow a light transmittance through the restoration, bringing great esthetic advantages and ensuring indications for use in anterior monolithic restorations (6,31).

Lithium disilicate has similar abrasiveness to dental enamel compared to other ceramic systems (5,34). The Y-PSZ has low abrasiveness and the ability to wear antagonist teeth, with indications, especially for patients who present bruxism or other parafunctional habits (31). Protocols for material finishing and polishing processes are essential for the success of monolithic restorations, directly influencing the process of wear, crack formation, micro-cracks, and fractures of the material (5,6).

Lithium disilicate has better adhesion due to the presence of a glassy matrix and being acid-sensitive, showing high adhesion strength to the substrate, because of micromechanical and chemical bonding mechanisms, unlike zirconia that its adhesion is still controversial in the literature (13,23).

In vitro, studies are highly recommended to clarify the performance and longevity of restorations fabricated with Y-PSZ and Y-FSZ (40). As Y-PSZ and Y-FSZ are recent materials in the dental market, the scientific literature is scarce in clinical studies of these materials. Among the limitations of the present work, we can highlight the diversity of research methodologies of the articles, as well as the limitation of studies with zirconia stabilized in the cubic phase.

CONCLUSION

Lithium disilicate has proven clinical success and longevity and becomes a viable ceramic alternative for the fabrication of indirect restorations, while meticulously respecting the mechanical and biological principles and properties of the material. Cubic phase stabilized zirconia, despite its mechanical, optical, and biological properties proven by in vitro studies, are recent materials in the dental market and present themselves as viable alternatives in monolithic restorations when correctly indicated.

The authors declare that there is no conflict of interest.

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