REVIEWARTICLE

Hybrid Ceramics in Dentistry: A Literature Review

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ABSTRACT

The scientific and technological development of dental materials grows exponentially, every year new materials are placed on the market with the aim of giving dentists new clinical alternatives for the treatment of their patients. This added to that all new materials are focused on the application of new technologies such as cad-cam systems. Hybrid ceramics seek to combine the optical and mechanical properties of ceramics and composite resins, two of the most used materials in restorative dentistry. This review article aims to ensure that clinical dentists know and can choose the best treatment option for their clinical cases**.**

Key words: Ceramics blocs, dental ceramics, hybrid ceramics, resin blocs

INTRODUCTION

The continuous development of new materials for computer-aided design/computer-aided manufacturing (CAD/CAM) systems has allowed to increase the variety of alternatives for the clinician to rehabilitate their patients. As is known, CAD/CAM technology has permitted to reduce the number of clinical sessions and fabrication time of dental restorations, as well as allowing the use of new materials with better mechanical and optical properties. The first CAD/CAM restoration was fabricated in 1985 with the CEREC 1 unit and was made with a prefabricated ceramic block. Since then, the technique has evolved, being more economic, quick, and precise.[1] Ceramics and composites are some of the materials available for definitive machined restorations. Ceramics have excellent mechanical and optical properties, as well as biocompatibility; however, they are fragile, rigid, and hard to repair. On the other hand, composites are easy to manipulate and repair, more flexible, and less abrasive on the antagonist tooth, but their poor wear resistance and difficulty to obtain good polish put them in a disadvantage compared to ceramics.[2] Conventional ceramics produce highly esthetic restorations; however, some studies have identified a higher incidence of failure of these materials, possibly caused by their rigidness and abrasive effect on the antagonist tooth.[3] Machinable composite blocks suffer high material wear levels, loss of superficial gloss, and color instability, as well as low resistance to fracture.[3] Some authors suggest associating the elastic modulus of composites, being similar to that of dentine, with feldspathic ceramic, being similar to enamel, adding esthetic properties while searching for the ideal restorative material.[4] To fulfill this objective, materials that intend to simulate mechanical and optical properties of a natural tooth have been developed, hybrid ceramics. This mixed structure would reduce fragility and superficial hardness of the material, allowing for an easier milling in a shorter time and promising better clinical results.[5] As a part of these new hybrid materials, we can find Vita Enamic (VE) (Vita Zahnfabrik), a polymer-infiltrated ceramic-network; Lava Ultimate (LU) (3M ESPE), a resin nanoceramic; and Cerasmart (GC Dental Products), a hybrid ceramic with nanofiller particles.[1]

Up to date, there is a lack of scientific evidence regarding hybrid ceramics. In fact, to this moment, there are no randomized cohort clinical studies that evaluate the clinical performance, properties, or indications of these materials. It is for this reason that the present review has the objective of organizing the available evidence in relation to these new materials and tries to comprehend their optical and mechanical properties to orientate material selection for the clinician. In this review, 18 *in vitro* studies were included, comparing three types of hybrid ceramics (VE, LU, and Cerasmart) against conventional materials, in relation to their optical and mechanical properties.

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MATERIALS AND METHODS

Three databases were searched: PUBMED, EBSCO, and CHOCRANE. The keywords used were resin infiltrated ceramic, resin ceramic, CAD-CAM - resin nanoceramic, fluorapatite nanoceramic, ceramic infiltrated with resin, polymer-infiltrated ceramic, CAD-CAM composite, polymer-infiltrated ceramic-network, and nanoceramics. As inclusion criteria, at least one of the three previously mentioned hybrid materials had to be in the study (LU, VE, and Cerasmart) referring to their mechanical and/or optical properties.

Article	Author	Year	Journal
Color stainability of CAD/CAM and nanocomposite resin materials	Acar *et al.*	2016	The Journal of prosthetic dentistry
Color stainability of indirect CAD-CAM processed composites versus conventionally laboratory processed composites after immersion in staining solutions	Arocha *et al.*	2014	Journal of dentistry
Translucency of esthetic dental restorative CAD/CAM materials and composite resins with respect to thickness and surface roughness	Awad *et al.*	2015	The Journal of prosthetic dentistry
Shade correspondence, color, and translucency differences between human dentine and a CAD/CAM hybrid ceramic system	Pop-Ciutrila *et al.*	2016	Journal of esthetic and restorative dentistry
Comparative characterization of a novel CAD-CAM polymer-infiltrated-ceramic-network	Albero *et al.*	2015	Journal of clinical and experimental dentistry
Mechanical properties of resin-ceramic CAD/CAM restorative materials	Awada *et al.*	2014	The Journal of prosthetic dentistry
Fatigue resistance of ultrathin CAD/CAM complete crowns with a simplified cementation process	Magne *et al.*	2015	The Journal of prosthetic dentistry
Fracture strength of CAD/CAM composite and composite-ceramic occlusal veneers	Johnson *et al.*	2014	Journal of prosthodontic research
Characterization of a polymer-infiltrated ceramic-network material	Bonaa *et al.*	2014	Dental materials
The fracture resistance of a CAD/CAM RNC and a CAD ceramic at different thicknesses	Chena *et al.*	2014	Dental materials
Survival of resin infiltrated ceramics under the influence of fatigue	Moustafa *et al.*	2015	Dental materials
Polymer-infiltrated ceramic-network structures for resistance to fatigue fracture and wear	Zhawia *et al.*	2016	Dental materials
Evaluation of mechanical and optical behavior of current esthetic dental restorative CAD/CAM composites	Stawarczyk *et al.*	2016	Journal of the mechanical behavior of biomedical materials
Edge chipping resistance and flexural strength of polymer-infiltrated ceramic-network and resin nanoceramic restorative materials	Argyrou *et al.*	2016	The Journal of prosthetic dentistry
Fracture resistance and microleakage of endocrowns utilizing three CAD/CAM blocks	El-Damanhoury *et al.*	2015	Operative dentistry
Mechanical properties of polymer-infiltrated-ceramic-network materials	Coldea *et al.*	2013	Dental materials

Article	Author	Year	Journal
In vitro strength degradation of dental ceramics and novel polymer-infiltrated ceramic-network material by sharp indentation	Coldea *et al.*	2013	Mechanical behavior of biomedical materials
Mechanical fatigue degradation of ceramics versus composites for dental restorations	Belli *et al.*	2014	Dental materials

RNC: Resin nanoceramic, CAD/CAM: Computer-aided design/computer-aided manufacturing

RESULTS

Being relatively new materials, little evidence exists with respect to their clinical use and only *in vitro* studies were found. The following table summarizes the articles included in this review.

DISCUSSION

Regarding optical properties of hybrid materials, Awad *et al*. evaluated the degree of translucency of different restorative materials (different types of glass-ceramics, hybrid materials, and composites) and if this varied according to thickness of the material, also evaluating whether the translucency changed when measured on polished or rough surfaces. In this study, LU presented high values of translucency versus VE, even though Enamic has a better equivalence in tone and opacity for anterior and posterior teeth.[6] Stawarczyk *et al*. obtained high values of translucency for Cerasmart and LU. On the contrary, VE showed the lowest levels.[7] In a study conducted by Ozlem, it was established that VE and Lava Ultimate are susceptible to discoloration, in this case caused by the consumption of coffee. The color change of VE was perceptible, however, clinically acceptable, but the discoloration of LU was clinically unacceptable. This phenomenon occurs because LU contains bisphenol A-glycidyl methacrylate (Bis-GMA) and its ethoxylated state, Bis-EMA. Gajewski *et al*. demonstrated that Bis-GMA causes water absorption, which could be responsible for the higher discoloration of the material.[1] Arocha *et al*. concluded that glass-ceramics presented less color change compared to Cerasmart and LU.[8] In addition, LU and Paradigm MZ100 composite blocks demonstrated higher discoloration when exposed to red wine, tea, and coffee, compared to composites processed conventionally in the laboratory (SR Adoro and Premise Indirect). This could be due to an insufficient polymerization of CAD/CAM resins.[8] He L and Swain described the mechanical properties of these materials and found that they were very similar to those found in natural dentin and enamel, being the main objective during past years to develop new restorative materials. Coldea Andrea found a lower amount of ceramic in VE, meaning lower elastic modulus and hardness, accompanied by a higher fracture and flexural resistance. The hardness of dentin varies between 0.6 and 0.9 GPa and between 3 and 5.3 GPa in enamel. VE (1.70 ± 0.12 GPa) has a hardness value substantially lower than the rest of ceramics, but similar to LU (1.15 ± 0.13 Gpa), this aspect is very important considering that it could provoke less wear on antagonist teeth.[9] Due to the need of creating well adjusted, continuous and smooth margins during milling, it could be thought that hybrid materials, being more flexible and less hard, could lead to deficient marginal integrity of the restoration. In a study by Awada *et al.*, Cerasmart, VE, and LU showed smoother and more defined margins than those obtained in ceramics such as IPS Empress CAD and Vitablocs Mark II, being capable of producing acceptable margins from more conservative preparations.[3] In the same study, Cerasmart and LU obtained high levels of flexural strength and resistance under flexural forces, and a lower flexural modulus compared to the other materials studied. The polymer-based materials (Cerasmart, LU, VE, and Paradigm MZ 100) showed a better margin integrity compared to conventional ceramics.[3]

When choosing a restorative material for posterior areas, it is important to consider its fracture resistance, even more when treating patients with parafunctional activity. Magne *et al*. evaluated the fatigue resistance and fracture pattern of different CAD/CAM materials (Vitablocs Mark II, LU, and IPS e-max CAD) in ultrafine crowns luted with self-adhesive cements and no significant differences between resistance to fatigue or catastrophic failures were observed.[10] When comparing the same quality of fracture resistance in occlusal veneers of different thicknesses between two polymeric materials, Paradigm MZ100 and the nanoceramic resin LU, a statistically significant difference was observed. The type of material affected the fracture resistance of occlusal veneers restorations, and those fabricated from LU fractured under significantly higher loads than the counterpart Paradigm MZ100.[11] In addition, in another study, the relationship between fracture resistance and thickness of IPS emax CAD and LU restorations was studied. A linear relationship was found for this parameter for pure ceramics but not for LU, which presented high resistance in all the thicknesses. This could be due to the ceramic particles in the resin matrix acting like "supporting bricks" that stop elastic deformation at the load zone. In addition, it was observed that sandblasting the surface created better adhesive values to dentin and improved fracture resistance results, meaning that when using LU, sandblasting is recommended previous to cementation.[12,13] In a 2015 study by El-Damanhoury, fracture resistance under compressive forces in molars that had received root canal treatments and restored with endocrowns made of lithium disilicate, nanoceramic resins (LU), and feldspathic porcelain was evaluated. LU showed better fracture resistance than the other materials, while those made from lithium disilicate presented the highest levels of catastrophic fractures.[14] Bonna *et al*., according to images captured by electronic microscopy, observed that the hybrid material VE is composed by 71% ceramic network, mainly leucite and zirconia in a lower amount, interconnected by a polymer-based network formed by poly methyl methacrylate, among others. In average, the samples showed the following mechanical properties values: Young modulus 37.95 Gpa, density 2.09 g/cm^3, and fracture toughness of 1.09 Mpa m1/2.[4] It is difficult to agree on a prognosis of hybrid ceramics based only on their *in vitro* and static behavior. Accordingly, Moustafa *et al*. analyzed the behavior of IPS emax CAD, IPS Empress CAD, IPS Zir CAD, LU, and VE under repetitive loading. Even though the initial fracture resistance of conventional ceramics was superior to LU and VE, these hybrid materials were less affected by dynamic fatigue in their residual strength.[15] In a similar case, wear resistance of VE against a ceramic antagonist under cyclic loads of 200 N at a 2 Hz frequency for 1.25 million cycles was observed to correspond to approximately 5 years in the oral cavity. None of the crowns in the study showed fractures. The only failure that was observed could be caused by high loads over 100 N, concluding that this material is well suited for full coverage restorations including patients with parafunctional activity. However, all the crowns were supported by dentin-like composite abutments, so caution is advised when using VE in the fabrication of bridges, for their behavior is unknown.[16] Stawarczyk *et al.* observed the wear resistance of different ceramics, CAD/CAM composites, and hybrid materials against natural teeth. VE, followed by IPS emax CAD, showed higher wear resistance than the other materials. In addition, IPS emax CAD and LU showed higher flexural strength, with the lowest values obtained by VE and IPS Empress CAD. However, VE obtained high values of flexural strength VE presented an elastic modulus of 30 GPa, similar to structural values of natural teeth.[7] Renos *et al*. studied the chipping resistance at the restoration margin and flexural strength in hybrid ceramics (LU and VE), comparing them with a feldspathic ceramic and a leucite-reinforced glass-ceramic. LU obtained the highest flexural and fracture resistance values. Finally, in this study, LU and VE presented better flexural strength than commonly used CAD/CAM ceramics.[2] The hybrid composition of LU and VE gives these materials a higher elastic modulus (12.8 GPa), similar to that of dentin (5.5–19.3 GPa). The elastic modulus affects the susceptibility to fracture of a cemented ceramic restoration because materials tend to bend under load and distribute tension in a uniform way, while rigid materials concentrate tension in critical areas that may cause catastrophic failures. The failure patterns reported in this study validate this explanation, asno LU specimens showed catastrophic failures, while 80% presented favorable failure patterns. On the other hand, 70% of the feldspathic ceramic specimens presented catastrophic failures.[5] In addition, the elastic modulus of VE in this study was 16.4–28.1 GPa which is very similar to that of human dentin (16–20.3 GPa) and adhesive cements (6.8–10.8 GPa), compared to ceramics (50–380 GPa).[5] Similar conclusions were obtained in a study by Coldea and Swaina.[17]

CONCLUSION

Within the lack of scientific evidence involving hybrid ceramics, in this literature review, we can point out that these new materials show adequate physical and optical properties *in vitro* studies, even superior to that of certain ceramic materials commonly used in clinical practice. We can conclude that the three hybrid ceramics mentioned in this study (LU, VE, and Cerasmart) possess low hardness levels, high levels of flexural strength, and high flexural resistance, apart from presenting acceptable marginal integrity of the restoration and acceptable optical properties for the posterior sector. They can be used as a restoration material for single full coverage restorations, even in patients with parafunctional activity. However, there are no studies that describe their behavior as plural fixed prosthesis. In particular, VE presents lower levels of resistance to flexural forces but higher flexural strength. Cerasmart and LU present better levels of translucency. LU presents less chromatic stability than its pairs. As a limitation of this revision, it is necessary to point out that all the studies included are *in vitro* studies, and clinical studies are necessary to evaluate performance in function online adaptive switching frequency hybrid ceramics.

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