Ceramics, resins or hybrids in the posterior region?

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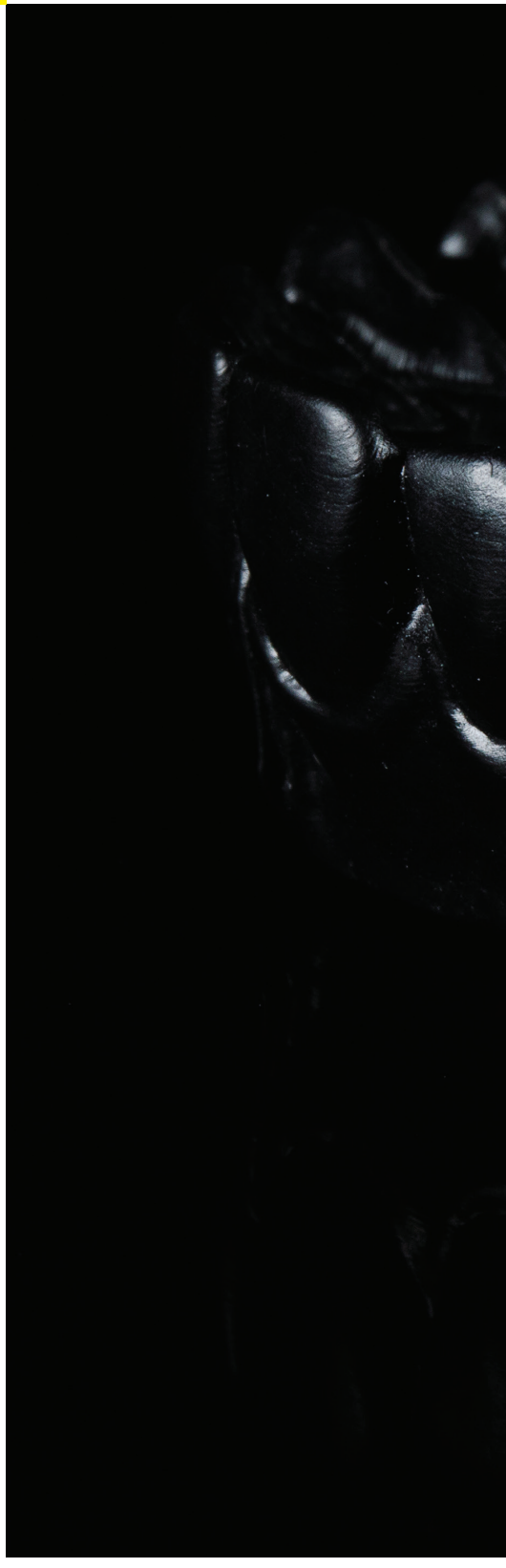

Previously, at a time when there were fewer options for indirect restorations, metal (especially gold) stood out as the main indirect restorative material in the posterior region, with excellent longevity. However, with the high demand for esthetic restorations, even in the posterior region, the technological development of materials such as ceramics and resins has accelerated. Different in their chemical structure, and with different manufacturing methods, these materials have different physical characteristics and mechanical properties, but are similar in optical quality for reproduction of the dental element, especially in the posterior regions of the mouth. So the question of which indirect material to use in the posterior region is recurrent among dentists. Ceramic or resin? This choice became even more doubtful with the emergence of hybrid materials (mixture of ceramic and resin), with this theme becoming more and more in evidence. In this HighLights session, recent studies on the materials will be covered, and the results of comparative clinical studies will be shown.

The **first article** is a systematic review with meta-analysis, which analyzes the survival of onlays restorations in the posterior region. The article was published in **Int J Environ Res Public Health**, in the year 2020.

CLINICAL BEHAVIOR OF CERAMIC, HYBRID AND COMPOSITE ONLAYS. A SYSTEMATIC REVIEW AND META-ANALYSIS

Naia Bustamante-Hernández, Jose María Montiel-Company, Carlos Bellot-Arcís, José Félix Mañes-Ferrer, María Fernanda Solá-Ruíz, Rubén Agustín-Panadero, Lucía Fernández-Estevan

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Abstract:

A systematic review and meta-analysis was performed to analyze the survival of onlay restorations in the posterior region, their clinical behavior according to the material used (ceramic reinforced with lithium disilicate, conventional feldspathic ceramic or reinforced with leucite; hybrid materials and composite), possible complications, and the factors influencing restoration success. The systematic review was based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement, without publication date or language restrictions. An electronic search was made in the PubMed, Scopus, Embase, and Cochrane databases. After discarding duplicate publications and studies that failed to meet the inclusion criteria, the articles were selected based on the population, intervention, comparison, outcome (PICO) question. The following variables were considered in the qualitative and quantitative analyses: restoration survival rate (determined by several clinical parameters), the influence of the material used upon the clinical behavior of the restorations, and the complications recorded over follow-up. A total of 29 articles were selected for the qualitative analysis and 27 for the quantitative analysis. The estimated restoration survival rate was 94.2%. The predictors of survival were the duration of follow-up (beta = -0.001; p = 0.001) and the onlay material used (beta = -0.064; p = 0.028). Composite onlays were associated with a lower survival rate over time. Onlays are a good, conservative, and predictable option for restoring dental defects in the posterior region, with a survival rate of over 90%. The survival rate decreases over time and with the use of composite as onlay material.

Comments

This systematic review and meta-analysis evaluated clinical studies comparing different restorative materials for making onlay restorations, with many studies evaluating a single material, and other few studies comparing two or more materials. The studies that were part of this review were mostly clinical follow-up studies, in which at least one restorative material was used, and some studies showed comparisons between materials. Some of the materials used were: feldspathic ceramics, ceramics reinforced by leucite or disilicate, composites and hybrid

materials (nanoceramics). Many studies covered in this review showed that the clinical performance (survival over time) of the materials were similar. On average, the overall survival of the various materials was 94.2%. Slight differences between ceramics and composites were reported, as in the studies by Goujat et al. (94.9% and 91.1%) and Zimmer et al. (8.7% and 84.7%). These differences can be explained because the composites degrade more over time, causing wear and pigmentation of the restorations. Depending on the evaluation method used in the studies, these factors may mean that the studies were unsuccessful. On the other hand, taking into account the failure due to fractures, it is observed that it occurred more with ceramics. This is explained by the more friable nature of these materials. In relation to hybrid materials, it was observed a lower pigmentation and wear compared to composites, and a lower fracture rate than ceramics. An important fact of this study is about the complication rate with the different restorations according to USPHS. Approximately 99.5% of the restorations had Alpha and Beta scores (excellent and good performance), and only 0.1% Charlie and Delta scores (poor and poor). The authors conclude that it is not yet possible to say what is the best material to be used in the posterior region. However, hybrid and ceramic materials showed superiority over composites.

The **second article** is a systematic review of randomized clinical trials comparing the effectiveness of resin or ceramic inlays or onlays. The article was published in **Dental Materials**, in 2013.

CLINICAL EFFICACY OF COMPOSITE VERSUS CERAMIC INLAYS AND ONLAYS: A SYSTEMATIC REVIEW

Hélène Fron Chabouis, Violaine Smail Faugeron, Jean-Pierre Attal

Dent Mater. 2013 Dec;29(12):1209-18.

doi: 10.1016/j.dental.2013.09.009.

Abstract:

Objective: Large tooth substance losses are frequent in posterior teeth because of primary caries or aging restorations. Inlays and onlays are often the minimal invasive solution in such cases, but the efficacy of the composite and ceramic materials used is unknown. We performed a systematic review of randomized controlled trials comparing the efficacy of composite and ceramic inlays or onlays.

Data sources: MEDLINE, Embase and the Cochrane Central Register of Controlled Trials were searched without any restriction on date or language, as were references of eligible studies and ClinicalTrials.gov.

Study selection: Eligible studies were randomized trials comparing the clinical efficacy of composite to ceramic inlays or onlays in adults with any clinical outcome for at least 6 months. From 172 records identified, we examined reports of 2 randomized controlled trials involving 138 inlays (no onlays evaluated) in 80 patients and exhibiting a high-risk of bias. Outcomes were clinical scores and major failures. The 3-year overall failure risk ratio was 2 [0.38-10.55] in favor of ceramic inlays although not statistically significant. The reported clinical scores (United States Public Health Services and Californian Dental Association) showed considerable heterogeneity between trials and could not be combined.

Conclusions: We have very limited evidence that ceramics perform better than composite material for inlays in the short term. However, this result may not be valid in the long term, and other trials are needed. Trials should follow Fédération dentaire internationale recommendations and enhance their methodology. Trials comparing composite and ceramic onlays are needed.

Comments

In this systematic review, 172 potential scientific papers were found to carry out the review. However, after a more detailed inspection, fitting well-defined criteria, only 2 10-year longitudinal follow-up articles were included and used. This highlights the difficulty of finding research on the subject that can be compared with each other, and thus draw solid conclusions on the subject. In the studies included in this review, among the USPHS and FDI criteria, including evaluation of color

change, anatomical shape, marginal adaptation, and surface polishing, ceramic restorations were statistically superior only in relation to the lower risk of color change . For the other factors, although ceramics were slightly better than composites, there was no statistical difference. Regarding the susceptibility to fracture at 3 and 5 years of follow-up, the studies showed greater susceptibility of composites, although not statistically significant. However, after 10 years of follow-up, the greatest risk of fracture occurred for ceramics, although not statistically significant. The authors emphasize that the present review has many limitations due to the few studies used, but they suggest a subtle better performance of ceramics. They also emphasize that the new hybrid materials must be tested, since the difference between the composition of “resins” and ceramics will be reduced.

The **third article** compared the 1-year clinical performance of onlay restorations in lithium disilicate and CAD/CAM composite resin. The article was published in **Odontology**, in the year 2021.

ONE YEAR CLINICAL PERFORMANCE OF LITHIUM DISILICATE VERSUS RESIN COMPOSITE CAD/CAM ONLAYS

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Odontology. 2021 Jan;109(1):259-270.

doi: 10.1007/s10266-020-00539-3.

Abstract:

Objective: To compare the 1-year clinical performance of lithium disilicate and resin composite CAD/CAM onlay restorations. Twenty patients that required two restorations in posterior teeth, with at least one cusp to be covered, received two onlays. One was made with IPS e.max CAD (Ivoclar-Vivadent) and the other with Lava Ultimate (3M Oral Care). Two blind observers evaluated the restorations at baseline and 1 year after the onlays were cemented, according to FDI criteria. At each recall, digital photographs, bite-wing radiographs and impressions of the restorations were taken for SEM evaluation of the interface. Results were analyzed by Mann-Whitney U and Wilcoxon tests ($p < 0.05$). At baseline and in the 1-year recall, both CAD/CAM materials exhibited excellent results in most criteria with similar esthetic, functional and biological properties ($p > 0.05$). However, deterioration in surface lustre ($p = 0.020$) and color match/translucency ($p = 0.039$) were detected for IPS e.max CAD onlays after 1-year. Under SEM evaluation, there were no statistically differences in micromorphological criteria at baseline nor after a year between IPS e.max CAD and Lava Ultimate onlays. Conclusion: After 1 year of clinical service IPS e.max CAD and Lava Ultimate onlays showed a similar clinical performance that needs to be confirmed in long-term evaluations.

Comments

In this prospective 1-year follow-up study, the behavior of onlays in IPS.emax CAD and Lava Ultimate was evaluated in 40 patients. An interesting aspect of this study was the use of newly developed hybrid polymeric materials such as Lava Ultimate. Among the advantages of these materials in relation to composites, the greatest wear resistance, less pigmentation, and greater strength are highlighted, thus reducing some of the disadvantages of indirect composites. At 1 year of follow-up, there were no significant differences between the two materials. However, it should be taken into account that 1 year of clinical follow-up is a long period to observe clinical differences.

The **fourth article** compared the fatigue strength of modern dental ceramic materials versus composite resin. The article was published in **Dental Materials**, in 2014.

MECHANICAL FATIGUE DEGRADATION OF CERAMICS VERSUS RESIN COMPOSITES FOR DENTAL RESTORATIONS

Renan Belli, Eva Geinzer, Anna Muschweck, Anselm Petschelt, Ulrich Lohbauer

Dent Mater. 2014 Apr;30(4):424-32.

doi: 10.1016/j.dental.2014.01.003.

Abstract:

Objetives: For posterior partial restorations an overlap of indication exists where either ceramic or resin-based composite materials can be successfully applied. The aim of this study was to compare the fatigue resistance of modern dental ceramic materials versus dental resin composites in order to address such conflicts. **Methods:** Bar specimens of five ceramic materials and resin composites were produced according to ISO 4049 and stored for 14 days in distilled water at 37°C. The following ceramic materials were selected for testing: a high-strength zirconium dioxide (e.max ZirCAD, Ivoclar), a machinable lithium disilicate (e.max CAD, Ivoclar), a pressable lithium disilicate ceramic (e-max Press, Ivoclar), a fluorapatite-based glass-ceramic (e.max Ceram, Ivoclar), and a machinable color-graded feldspathic porcelain (Trilux Forte, Vita). The composite materials selected were: an indirect machinable composite

(Lava Ultimate, 3M ESPE) and four direct composites with varying filler nature (Clearfil Majesty Posterior, Kuraray; GrandioSO, Voco; Tetric EvoCeram, Ivoclar-Vivadent; and CeramX Duo, Dentsply). Fifteen specimens were tested in water for initial strength (σin) in 4-point bending. Using the same test set-up, the residual flexural fatigue strength (σff) was determined using the staircase approach after 10(4) cycles at 0.5 Hz (n=25). Weibull parameters σ0 and m were calculated for the σin specimens, whereas the σff and strength loss in percentage were obtained from the fatigue experiment. **Results:** The zirconium oxide ceramic showed the highest σin and σff (768 and 440 MPa, respectively). Although both lithium disilicate ceramics were similar in the static test, the pressable version showed a significantly higher fatigue resistance after cyclic loading. Both the fluorapatite-based and the feldspathic porcelain showed equivalent initial and cyclic fatigue properties. From the composites, the highest filled direct material Clearfil Majesty Posterior showed superior fatigue performance. From all materials, e.max Press and Clearfil Majesty Posterior showed the lowest strength loss (29.6% and 32%, respectively), whereas the other materials lost between 41% and 62% of their flexural strength after cyclic loading. **Conclusions:** Dental ceramics and resin composite materials show equivalent fatigue strength degradation at loads around 0.5σin values. Apart from the zirconium oxide and the lithium disilicate ceramics, resin composites generally showed better σff after 10,000 cycles than the fluorapatite glass-ceramic and the feldspathic porcelain. Resin composite restorations may be used as an equivalent alternative to glass-rich-ceramic inlays regarding mechanical performance.

Comments

This in vitro study evaluated the fatigue resistance of various ceramic and resin-based materials (direct and indirect) used for making restorations in posterior teeth.

High-strength ceramics (e.max ZirCAD, e.max CAD, e.max press) had the highest initial flexural strength, and after the fatigue cycle, e.max ZirCAD and e.max press had the highest strength residual flexural fatigue. Among resin-based materials, it was observed that resins that contain a large amount of filler particles have less degradation of their strength.

The authors point out that from a mechanical point of view, materials with high fatigue resistance such as e.max ZirCAD, e.max press should be indicated in areas of high masticatory force. In addition, indirect resins are preferable to vitreous ceramics, and the location of the restoration should be restricted to places of low masticatory strength. Among all materials tested, the e.max press showed the least fatigue degradation, thus suggesting that clinically it would present the lowest tendency to fracture and the best survival.

The ***fifth article*** investigates the behavior of 6 different restorative materials regarding the wear of these materials through an electromechanical test. The article was published in the ***Journal of Advanced Prosthodontics***, in 2019.

IN VITRO WEAR BEHAVIOR BETWEEN ENAMEL CUSP AND THREE AESTHETIC RESTORATIVE MATERIALS: ZIRCONIA, PORCELAIN, AND COMPOSITE RESIN

Yong-Seok Jang, Thuy-Duong Thi Nguyen, Young-Han Ko, Dae-Woo Lee, Byeong Ju Baik, Min-Ho Lee, Tae-Sung Bae.

J Adv Prosthodont. 2019 Feb;11(1):7-15.

doi: 10.4047/jap.2019.11.1.7

Abstract:

Objective: The aim of this study was to identify the effects of three aesthetic restorative materials on the wear between tooth and restoration by a pin-on-disk manner. **Materials and methods:** Six aesthetic restorative materials were used to prepare disk specimens for wear test, which were Lava Zirconia as zirconia group, Vintage MP and Cerabien ZR as veneering porcelain group, Gradia Direct microhybrid composite containing prepolymerized fillers, Filtek Z250 microhybrid composite containing zirconia glass and colloidal silica particles, and Filtek Z350 nanocomposite as composite resin group. Vertical loss of the worn cusp, change of the surface roughness of the restoration materials, and the surface topography were investigated after wear test under 9.8-N contact load. **Results:** The porcelain groups (Vintage MP and Cerabien ZR) caused the largest vertical loss of teeth when compared with those of the composite resin and zirconia groups, and Filtek Z250 microhybrid composite results in the second-largest vertical loss of teeth. The surface of Filtek Z350 nanocomposite was deeply worn out, but visible wear on the surface of the zirconia and Gradia Direct microhybrid composite was not observed. When the zirconia surface was roughened by sand-blasting, vertical loss of teeth considerably increased when compared with that in the case of fine polished zirconia. **Conclusion:** It was identified that microhybrid composite resin containing a prepolymerized filler and zirconia with reduced surface roughness by polishing were the most desirable restorative materials among the tested materials to prevent the two-body wear between aesthetic restorative material and tooth.

Comments

In this study, a two-body wear test was performed, with a premolar enamel cusp maintaining an occlusal relationship with one type of zirconia ceramic, two types of porcelain, and three types of composite resin, using an electromechanical test.

The highest wear on human enamel was observed when veneer porcelains were used, and the Filtek Z250 micro-hybrid composite containing zirconia glass and colloidal silica particles caused the second highest vertical loss of tooth wear.

Second, the greatest wear was observed on the surface of Filtek Z350 nanocomposite, and there was no visible wear on the surface of zirconia and Gradia Direct (micro-hybrid composite) after the wear test.

Greater vertical loss of the premolar cusp was observed increasing the roughness of the zirconia surface. Considering these results, it is recommended to perform esthetic or rehabilitative restorations using a micro-hybrid composite resin containing a pre-polymerized filler or to reduce the surface roughness of the zirconia surface by means of micro-coating, in order to avoid the reduction of the vertical dimension occlusal and damage to both the esthetic restoration and the tooth surface, minimizing antagonistic wear.

The wear of the tooth and restorative materials could lead to a reduction in occlusal dimension, malocclusion and poor esthetic results. Of course, wear is an important factor that must be considered when choosing materials during a restorative procedure. The most suitable materials for this type of restoration must have wear resistance characteristics similar to those of enamel. Thus, the results of this study suggest that this should be done with well-polished zirconia or micro-hybrid composite resin, as they are effective in preventing wear on the opposing tooth and restoration. However, the results of this research were laboratory conditions, requiring clinical studies to prove the evidence.

The **sixth article** is a review that investigates the structure and some properties of resin-infiltrated ceramic systems. The article was published in **Dental Materials**, in 2016.

INTERPENETRATING NETWORK CERAMIC-RESIN COMPOSITE DENTAL RESTORATIVE MATERIALS

M V Swain, A Coldea, A Bilkhair, P C Guess

Dent Mater. 2016 Jan;32(1):34-42.

doi: 10.1016/j.dental.2015.09.009.

Abstract:

Objectives: This paper investigates the structure and some properties of resin infiltrated ceramic network structure materials suitable for CAD/CAM dental restorative applications. **Methods:** Initially the basis of interpenetrating network materials is defined along with placing them into a materials science perspective. This involves identifying potential advantages of such structures beyond that of the individual materials or simple mixing of the components. **Results:** Observations from a number of recently published papers on this class of materials are summarized. These include the strength, fracture toughness, hardness and damage tolerance, namely to pointed and blunt (spherical) indentation as well as to burr adjustment. In addition a summary of recent results of crowns subjected to simulated clinical conditions using a chewing simulator are presented. These results are rationalized on the basis of existing theoretical considerations. **Significance:** The currently available ceramic-resin IPN material for clinical application is softer, exhibits comparable strength and fracture toughness but with substantial R-curve behavior, has lower E modulus and is more damage tolerant than existing glass-ceramic materials. Chewing simulation observations with crowns of this material indicate that it appears to be more resistant to sliding/impact induced cracking although its overall contact induced breakage load is modest.

Comments:

This work focused on the properties of resin/ceramic hybrid systems available for CAD/CAM used in dental restorations and compared them to a variety of existing pure ceramic materials. It was pointed out that these materials have lower hardness and modulus of elasticity, but higher fracture resistance compared to many other existing porcelains and vitreous ceramics currently used for the same purpose. The results indicate that the hybrid materials have a higher tenacity that gives greater tolerance to damage induced by contact and slip. This combination of low hardness and modulus of elasticity, together with higher toughness, allows for lower edge failures, as well as greater ability to handle the load distribution due to occlusal contact fatigue. Additional work is needed to better appreciate the failure criteria as well as fatigue damage and wear response.

The **seventh article** evaluates the mechanical properties of 4 blocks for the CAD/CAM system. The article was published in the **Journal Prosthetic Dentisry**, in 2018.

MECHANICAL PROPERTIES AND INTERNAL FIT OF 4 CAD-CAM BLOCK MATERIALS

Alexis Goujat, Hazem Abouelleil, Pierre Colon, Christophe Jeannin, Nelly Pradelle, Dominique Seux, Brigitte Grosgogeat

J Prosthet Dent. 2018 Mar;119(3):384-389.

doi: 10.1016/j.prosdent.2017.03.001.

Abstract:

Statement of problem: Recent polymer-based computer-assisted design and computer-assisted manufacturing (CAD-CAM) materials have been commercialized for inlay restorations, a polymer-infiltrated ceramic-network (PICN) and composite resin nanoceramics. Little independent evidence regarding their mechanical properties exists. Internal adaptation is an important factor for the clinical success and longevity of a restoration, and data concerning this parameter for inlays made with these blocks are scarce. **Purpose:** The purpose of this in vitro study was to evaluate and compare the mechanical properties (flexural strength, flexural modulus, Vickers hardness, fracture toughness) and the internal adaptation of these recent polymer-based blocks with a lithium disilicate glass-ceramic block. **Material and methods:** The materials tested in this study were a PICN material (Vita Enamic), 2 composite resin nanoceramics (Lava Ultimate; 3M ESPE and Cerasmart; GCDental Products), and a lithium disilicate glass-ceramic (IPS e.max CAD). Mechanical properties were evaluated according to ISO norm DIS 6872:2013. Bar-shaped specimens (18×3×3 mm) were prepared and submitted to a 3-point bend test using a universal testing machine at a cross-head speed of 0.5 mm/min. In addition, identical cavities were prepared in 60 human mandibular extracted molars (n=15) and optically scanned to receive mesioocclusodistal inlays milled with the 4 materials tested in a CEREC Inlab milling machine. The replica technique and a stereomicroscope (×20) were used to measure the internal fit of the inlays at 9 preselected locations. All data were statistically analyzed using 1-way ANOVA and the post hoc Tukey multiple comparison or Games-Howell test (α=.05). **Results:** The mean flexural strength of the tested blocks ranged from 148.7 ±9.5 MPa (Vita Enamic) to 216.5 ±28.3 MPa (Cerasmart). The mean flexural modulus ranged from 23.3 ±6.4 GPa (Vita Enamic) to 52.8 ±10.5 GPa (IPS e.max CAD). The mean Vickers hardness ranged from 0.66 ±0.02 GPa (Cerasmart) to 5.98 ±0.69 GPa (IPS e.max CAD). The mean fracture toughness ranged from 1.2 ±0.17 $MPa.m^{1/2}$ (Cerasmart) to 1.8 ±0.29 $MPa.m^{1/2}$ (IPS e.max CAD). The values for internal discrepancy ranged from 119 ±55 μm to 234 ±51 μm. The mean internal discrepancy was significantly higher for Lava Ultimate (P<.05) than IPS e.max CAD and Cerasmart but not for Vita Enamic. The factor "material" was statistically significant in relation to the mechanical properties evaluated in this study (P<.05). The Pearson correlation was negative between the flexural strength results and the internal discrepancy of the materials tested (R2=0.941; P<.05). **Conclusions:** The mechanical properties of the CAD-CAM block materials tested were

within the acceptable range for fabrication of single restorations according to the ISO standard for ceramics (ISO 6872:2008). IPS e.max CAD and Cerasmart were observed to have superior flexural strength and better internal fit.

Comments

The findings of this study showed that internal mismatches can occur more frequently for Lava Ultimate systems and, to a lesser extent, with Vita Enamic. The fact that the other nanoceramic resin material does not show the same trend could be attributed to differences in the structural composition of the two materials. Other variables such as the configuration of the virtual space in the software, the intrinsic properties of the CAD-CAM system, the choice of rotary instrument on the mill and its speed can also influence the results. Perhaps a virtual three-dimensional analysis would be recommended to effectively assess the fit of the pieces. Regarding flexural strength, the Cerasmart and IPS e.max CAD systems were significantly higher than that of Lava Ultimate or Vita Enamic. The flexural modulus and Vickers hardness of IPS e.max CAD were significantly higher than that of Cerasmart, Lava Ultimate or Vita Enamic. The fracture toughness of IPS e.max CAD and Lava Ultimate was significantly higher than that of Vita Enamic or Cerasmart. The results showed that the mechanical properties seem to depend more on the structural composition of the material than on its chemical composition.

FINAL CONSIDERATIONS

The recovery of posterior teeth is a challenge due to the incidence of high chewing loads on the tooth element. Ideally, the use of a biomimetic material in relation to enamel and dentin is desired. After this review, on resin, ceramics and hybrid materials, it became evident that the use of traditional indirect composites has a great cost-benefit for the patient, however, due to the intrinsic characteristic of these materials, they suffer greater pigmentation and wear over time.

Even today, lithium disilicate-based ceramics represent the most reliable material for use in posterior teeth. This is due not only to the excellent adhesion and good mechanical properties of these ceramics attested in numerous in vitro studies, but also due to the excellent clinical performance in longitudinal studies.

Newly introduced in the market, the hybrid materials (ceramic/resin) have stood out with promising in vitro results, similarly to lithium disilicate ceramics. The characteristics of these materials seem to be more similar to the characteristics of dental structures, as they present high fracture toughness and lower elastic modulus, thus offering greater balance and occlusal resilience. However, there is still not enough clinical evidence to say that these materials are comparable to lithium disilicate reinforced ceramics in the long term. If long-term clinical performance is similar to laboratory performance, these materials may be a promising alternative for restoring posterior teeth. Let's wait!

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