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Mechanical and optical properties of feldspathic ceramics and lithium disilicate: literature review

Beatriz Amaral Rios Tomaz de Almeida,[1] Kamilly Fagundes de Oliveira,[1] Ricardo Armini Caldas[2]

[1]Department of Dentistry, São Pedro Integrated Colleges – FAESA, Vitória, ES, Brazil.

[2]Department of Dentistry, Federal University of Santa Catarina, Florianópolis, SC, Brazil.

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Abstract

Objective: this literature review presents the existing data on the esthetic capacity and fracture resistance of feldspathic and lithium disilicate ceramics made for CAD/CAM. **Material and Methods:** original articles on feldspathic ceramics and lithium disilicate were collected in journals in the PubMed and ScienceDirect databases from 2015 to 2020 using the search terms "lithium disilicate AND esthetic AND CAD/CAM," "lithium disilicate AND fatigue AND CAD/CAM," "lithium disilicate AND fracture AND CAD/CAM," "feldspathic AND esthetic AND CAD/CAM," "feldspathic AND fatigue AND CAD/CAM," "feldspathic AND fracture AND CAD/CAM." Relevant articles published previously to 2015 were also selected by the authors. Longitudinal studies, literature reviews, clinical cases and in vitro studies were included. **Results:** in total, 209 articles were selected and 16 included for comparison. Data presented good esthetic capability for both materials, disilicate presented higher fracture strength. **Conclusion:** the study concluded that feldspathic ceramics and lithium disilicate for CAD/CAM have satisfactory optical capacity for esthetics restorations when multi-color blocks are used. Lithium disilicate should be chosen in situations of greater masticatory effort or thinness of the prosthetic piece.

Keywords: Dental esthetics; Dental veneers; Tensile strength; Dental prosthesis

Introduction

The ability of restorative materials to mimic dental tissues is an essential knowledge for dentists due to the growing search for esthetics and minimally invasive procedures.[1] Usually, patients seek esthetics restorative procedures because of dissatisfaction with smile harmony, shape, size or teeth color.[1–3] Among the minimally invasive treatments that require tooth preparation, ceramic indirect veneers show better esthetics results and clinical longevity when compared to composite resin veneers. [4,5]

Feldspathic ceramics and lithium disilicate are two of the most indirect materials used. Feldspathic ceramics became a good option because of their excellent esthetics, biocompatibility with adjacent tissue, color stability and high degree of translucency.[1,2,4,5] On the other hand, lithium disilicate ceramics, besides the esthetics and functional characteristics, bring benefits such as greater fracture resistance when compared to feldspathic ceramics, favoring their clinical longevity.[6,7] As for esthetics properties, both have a wide color variety, ability to mimic translucency and dental fluorescence, color stability and brightness maintenance.[5]

Ceramic restorations can be made by stratified and monolithic techniques. The first has greater laboratory complexity, as it shows several layers of colors and ceramic burns, thus acquiring greater esthetics potential due to the various colors in its layers, making its optical properties coming from both surface and depth.[8] Monolithic restorations have greater technical ease, becoming a promising alternative, since they can also be made with CAD/CAM technology, which makes it possible to digitally scan the patient's mouth (removing the conventional molding step), digitally planning restorations and milling them in a matter of minutes. Despite the technical ease, they are considered less esthetics than the stratified, because of their body's single coloration and subsequently made-up surface layer.[8]

Cementation should also be considered, since it is a step towards the final success of the restoration.[5] Photoactivated resinous cement agents have esthetics potential because of their range of opacity levels and color variety, they also increase the mechanical strength of ceramic fragments after cementing,[9–11] enabling the manufacture of slender ceramic laminates, with minimal to no enamel wear.[11–13] Additionally, cements fill the irregularities of the piece's inner surface, sealing it and preventing the development and propagation of cracks,[5,14] providing greater longevity to the treatment.[3]

The use of CAD/CAM equipment for the manufacture of dental restorations has become highly accurate and efficient.[15,16] Also, the use of digital systems for manufacturing restorations allows the dentist to control the desired contours and shapes. Initially, the ceramic blocks for milling had uniform coloring, which made it difficult for satisfactory esthetics in anterior regions. Currently, several manufacturers have ceramic blocks in an array of colors and translucency, allowing for greater esthetics of the milled restoration.[17]

Based on the points raised and the vast literature on indirect ceramic restorative materials, this study aims to review literature on feldspathic ceramics and lithium disilicate when used to make restorations with CAD/CAM, addressing the esthetics and physical features of the restorative materials of choice in the final success of the treatment.

Material and Methods

To carry out the study, original articles on feldspathic ceramics and lithium disilicate were collected in journals in the PubMed and ScienceDirect database, from 2015 to 2020 using the search terms "lithium disilicate AND esthetic AND CAD/CAM," "lithium disilicate AND fatigue AND CAD/CAM," "lithium disilicate and fracture AND CAD/CAM," "feldspathic AND esthetic AND CAD/CAM," "feldspathic AND fatigue AND CAD/CAM," "feldspathic and fracture AND CAD/CAM." Relevant articles published previously to 2015 were also selected by the authors. Longitudinal studies, literature review, clinical cases and in vitro research were also included.

Figure 1 shows the process of survey and selection of articles. The inclusion and exclusion criteria were reading the title, reading the abstract and then analyzing the full text. Articles that did not fit analyses on esthetics and resistance of feldspathic ceramics and lithium disilicate for CAD/CAM were excluded.

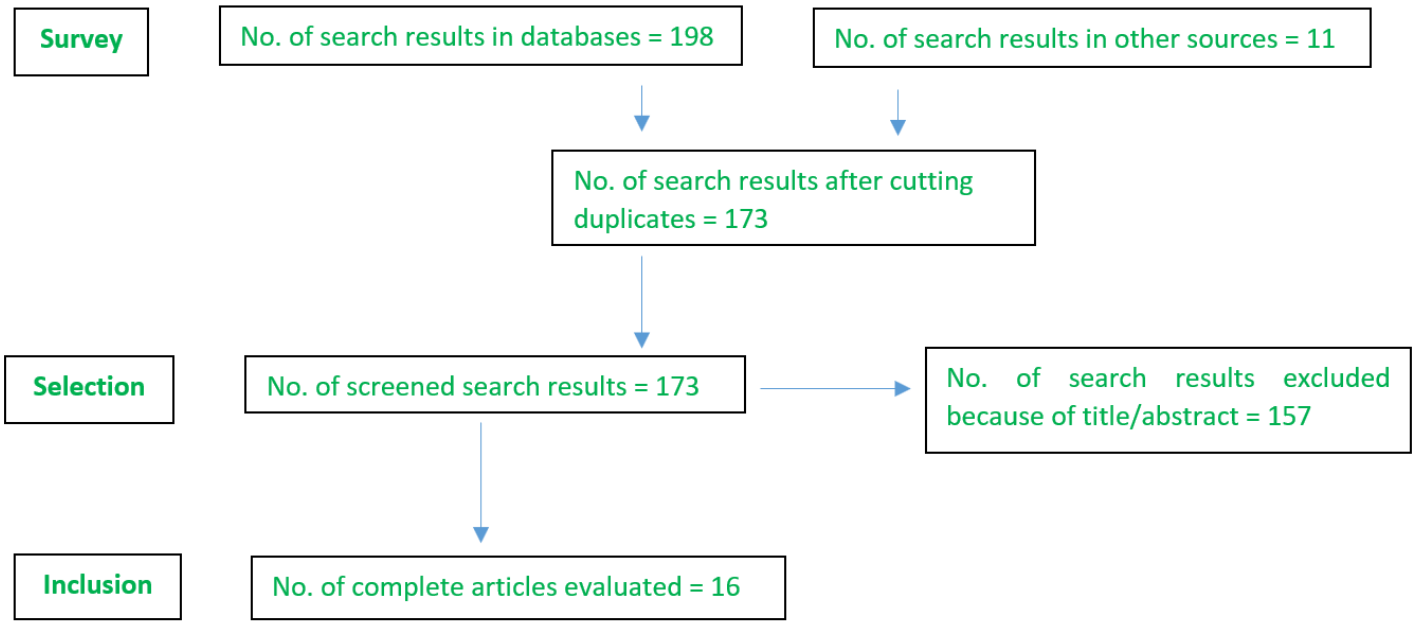

Figure 1. Flowchart of survey and selection of articles for review.

Results

The clinical success of indirect restorations depends on the choice of the most appropriate ceramic material for each case. In this study we consider two types of ceramic materials for indirect restorations, feldspathic ceramics and lithium disilicate manufactured through the CAD-CAM process.[18]

Initially, restorations in stratified ceramics were manufactured using only the powder/liquid technique, thus, the esthetics properties of such restorations depended on the ceramist's ability to build with the correct anatomy, color variation and translucency.[19] However, the use of CAD/CAM systems allows to work around the difficulty of making the desired anatomy by hand. To make the anatomy of the restoration in CAD/CAM, databases can be used to import shapes that best adapt to the case desired. Another option is the use of the patient's own homologous teeth to perform a digital copy.[20]

Feldspathic ceramics for CAD/CAM were first manufactured in 1985 using a ceramic block composed of fine-grained feldspathic ceramics.[21] The block was commercially fully sintered for machining. The clinical performance of inlays and onlays restorations were evaluated in a prospective 10-year study, in which a 90.4% success rate was observed.[22] However, another study showed a fracture rate of up to 36% after 2 years.[23]

Seeking to improve the mechanical properties of feldspathic ceramics, Vita™ Mark II (Vita Zahnfabrik, Bad Sackingen, Germany) was launched in 1991, exhibiting bending strength of approximately 100 MPa and 160 MPa after glaze.[17,24] These feldspathic ceramic blocks are made by pressing a mixture of plasticized ceramic above its vitreous transition temperature to obtain the shape desired. The blocks are then dried for subsequent sintering.[25] Clinical studies using pressed feldspathic ceramic blocks showed survival rates of 94.7%, 90.6% and 85.7% after 5, 8 and 10 years, respectively. Esthetically, feldspathic materials for CAD/CAM presented themselves as a monochrome block, but available in various tones of the Vita scale. Due to esthetics needs, blocks containing multiple layers of colors were developed, offering a color gradient and translucency to mimic variance between cervical and incisal tooth.[23]

Feldspathic ceramics are composed of mineral feldspar tectosilicate ($KAlSi_3O_8$), quartz (SiO_2) or kaolin

($Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O$). These feldspathic ceramic compounds have excellent esthetics properties and have been recommended for use in the manufacture of laminates, inlays, onlays, anterior and subsequent unit crowns.[17] Several studies advocate the use of feldspathic porcelains for laminated veneers, showing success rates of 90% in cases older than 10 years. The results show that feldspathic porcelain veneers also have a low rate of adhesive failures when it comes to dental substrate in enamel,[26] with good performance and durability.[27] However, feldspathic ceramics do not present high enough mechanical strength to be used in parts of high masticatory exertion, although when used in a premolar region, the fracture resistance found was similar to natural teeth.[28] Also, when used for molar restoration, a survival rate of 94.6% was observed after 55 months.[16]

An esthetics alternative with better mechanical properties are lithium disilicate ceramics (Li_2SiO_5), having bending resistance between 350 MPa and 450 Mpa, considerably superior to feldspathic ceramics.[29] Lithium disilicate ceramics for CAD/CAM were introduced in the market in 2006 by Ivoclar with the IPS™ e.max CAD block (Ivoclar-Vivadent), available in various tones of A – D and Bleach (Vita scale), as well as 3 degrees of translucency, also being able to meet the esthetics demands required by feldspathic ceramics.[23]

Because of its high resistance, lithium disilicate ceramics blocks are offered in the pre-sintered version and exhibit bending resistance of 130±30 MPa. In this state, the block can be easily milled, and then be sintered in a ceramic oven at 850°C in vacuum for 20-25 min. After sintering, the block reaches the final properties of color, translucency and mechanical strength (bending strength of 360 Mpa).[29] In vitro studies show that CAD crowns in lithium disilicate are significantly more resistant to mechanical fatigue and have greater fracture resistance than feldspathic.[30] Lithium disilicate-based ceramics can be used in various cases, including the manufacture of pure ceramic crowns, inlays, onlays, veneers and fixed partial prostheses of three elements, anterior and posterior. A microstructure with crystal intertwining, used to stagnate the spread of cracks through the body of the material, guarantees this system additional mechanical strength.[31] Case reports have shown a low rate of fractures, with survival rates between 97.4% and 100% after two years.[16]

Besides the materials' strength, other factors are associated with feldspathic ceramics or lithium disilicate treatments' longevity. Factors related to the preparation of dental elements, previous treatment of dental surfaces, ceramics and adherence to the substrate directly influence the restoration's success. Resinous cement show great variation in the bond strength to enamel and dentin values depending on their adhesive system.[32] Furthermore, the fracture mechanisms of restorative materials can be affected by the substrate modulus of elasticity, with ultrafine restorations being more resistant when supported by materials of high elastic modulus.[33]

Conventional adhesive cements have higher means of bond strength for both substrates when compared to other conventional resinous cement. Self-adhesive resinous cement have significantly lower dentin bond strength compared to conventional cements. Thus, while performing ceramic restorations, one should consider not only the restorative material but also the cementing agent.[34] Therefore, dental technician and clinician must be thorough in the manufacturing, handling, cementing and restoration process.[35]

Feldspathic ceramics allow veneers with thickness of less than 0.5 mm, reaching 0.3 mm, with or without preparation of the tooth structure, being made in these cases in lithium disilicate because of higher resistance to fracture.[19,36] Both materials have a high degree of translucency, provide an optimal mimicking capacity of dental tissues and can be used in veneers, respecting the shape and chromatic variations so that restorations have a natural appearance.[37]

Conclusion

This study, through literature review and analysis, concludes that indirect restorations made of feldspathic ceramics and lithium disilicate for CAD/CAM show satisfactory optical capacity for esthetics restorations when multicolored blocks are used. Furthermore, lithium disilicate should be chosen in situations of greater masticatory effort or thinness of the prosthetic piece.

References

1. Tuzzolo Neto H, Nascimento WF, Erly L, Ribeiro RA, Barbosa JS, Zambrana JM, *et al*. Laminated Veneers with Stratified Feldspathic Ceramics. Case Rep Dent. 2018;2018:1–6.

2. Federizzi L, Gomes ÉA, Báratro SSP, Baratto-Filho F, Bacchi A, Spazzin AO. Use of feldspathic porcelain veneers to improve smile harmony: A 3-year follow-up report. Braz Dent J. 2016;27(6):767–74.

3. Zen BM, Caldas RA, Anacleto FN, dos Santos MBF. Reabilitação de dentes anteriores: a ciência aliada à arte. Prótese News. 2016;3(2):168–82.

4. Rotoli B, Lima D, Pini N, Aguiar F, Pereira G, Paulillo L. Porcelain Veneers as an Alternative for Esthetic Treatment: Clinical Report. Oper Dent. 2013;38(5):459–66.

5. Pini NP, Aguiar FHB, Leite Lima DAN, Lovadino JR, Suga Terada RS, Pascotto RC. Advances in dental veneers: Materials, applications, and techniques. Clin Cosmet Investig Dent. 2012;4:9–16.

6. Olivera AB, Marques MM. Esthetic Restorative Materials and Opposing Enamel Wear. Oper Dent. 2008;33(3):332–7.

7. Samra APB, Pereira SK, Delgado LC, Borges CP. Color stability evaluation of esthetics restorative materials. Braz Oral Res. 2008;22(3):205–10.

8. Silva LH da, Lima E de, Miranda RB de P, Favero SS, Lohbauer U, Cesar PF. Dental ceramics: a review of new materials and processing methods. Braz Oral Res. 2017;31(suppl 1):e58.

9. Anusavice K. Philips-Materiais Dentários. 11th ed. Rio de Janeiro: Elsevier; 2005.

10. Karaagaclioglu L, Yilmaz B. Influence of Cement Shade and Water Storage

on the Final Color of Leucite-reinforced Ceramics. Oper Dent. 2008;33(4):386–91.
11. Kina S, Brugrera A. Inivisível: Restaurações estéticas cerâmicas. 3rd ed. Maringá: Dental Press; 2016.
12. Baratieri LN GJ. Laminados Cerâmicos. In: Soluções Clínicas: fundamentos e técnicas. 1st ed. Santa Catarina: Ponto;2008. P. 214–71.
13. Cardoso PC, Decurcio RA, Lopes LG, Souza JB, Restauradora D, Especialização C De, *et al*. Importância da Pasta de Prova (Try-In) na Cimentação de Facetas Cerâmicas – Relato de Caso Importance of Try-In Pastes in Cementing Ceramic Veneers - A Case Report. Rev Odontológica do Bras Cent. 2011;20(53):166–71.
14. Manso AP, Silva NRFA, Bonfante EA, Pegoraro TA, Dias RA, Carvalho RM. Cements and Adhesives for All-Ceramic Restorations. Dent Clin North Am. 201155(2):311–32.
15. Rosenblum MA, Schulman A. A review of all-ceramic restorations. J Am Dent Assoc. 1997;128(3):297–307.
16. Fasbinder DJ. Clinical performance of chairside CAD/CAM restorations. J Am Dent Assoc. 2006;137 Suppl:22S-31S.
17. Giordano R. Materials for chairside CAD/CAM-produced restorations. J Am Dent Assoc. 2006;137 Suppl:14S-21S.
18. Aurélio IL, Fraga S, Dorneles LS, Bottino MA, May LG. Extended glaze firing improves flexural strength of a glass ceramic. Dent Mater. 2015;31(12):e316–24.
19. Magne P, Belser UC. Novel porcelain laminate preparation approach driven by a diagnostic mock-up. J Esthet Restor Dent. 2004;16(1):7–16; discussion 17-8.
20. de Siqueira F, Cardenas A, Gruber YL, Kose C, Pupo YM, Gomes GM, *et al*. Using CAD/CAM-Modified Correlation Mode to Produce Laminate Veneers: A Six-Month Case Report. Oper Dent. 2017;42(5):E139–47.
21. Mörmann WH, Bindl A. All-ceramic, chair-side computer-aided design/computer-aided machining restorations. Dent Clin North Am. 2002;46(2):405–26.
22. Otto T, De Nisco S. Computer-aided direct ceramic restorations: a 10-year prospective clinical study of Cerec CAD/CAM inlays and onlays. Int J Prosthodont. 2002;15(2):122–8.
23. Li RWK, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: State of the art. J Prosthodont Res. 2014 Oct;58(4):208–16.
24. Bindl A, Lüthy H, Mörmann WH. Fracture load of CAD/CAM-generated slot-inlay FPDs. Int J Prosthodont. 2003;16(6):653–60.
25. Della Bona A. Bonding to ceramics: scientific evidence for clinical dentistry. São Paulo: Artes Médica; 2009.
26. Peumans M, De Munck J, Fieuws S, Lambrechts P, Vanherle G, Van Meerbeek B. A prospective ten-year clinical trial of porcelain veneers. J Adhes Dent. 2004;6(1):65–76.
27. Fradeani M, Redemagni M, Corrado M. Porcelain laminate veneers: 6- to 12-year clinical evaluation-a retrospective study. Int J Periodontics Restorative Dent. 2005;25(1):9–17.
28. Attia A, Kern M. Fracture strength of all-ceramic crowns luted using two bonding methods. J Prosthet Dent. 2004;91(3):247–52.
29. Basso GR, Moraes RR, Borba M, Griggs JA, Della Bona A. Flexural strength and reliability of monolithic and trilayer ceramic structures obtained by the CAD-on technique. Dent Mater. 2015;31(12):1453–9.
30. Asai T, Kazama R, Fukushima M, Okiji T. Effect of overglazed and polished surface finishes on the compressive fracture strength of machinable ceramic materials. Dent Mater J. 2010;29(6):661–7.
31. Fabianelli A, Goracci C, Bertelli E, Davidson CL, Ferrari M. A clinical trial of Empress II porcelain inlays luted to vital teeth with a dual-curing adhesive system and a self-curing resin cement. J Adhes Dent. 2006;8(6):427–31.
32. Haddad MF, Rocha EP, Assunção WG. Cementation of prosthetic restorations: From conventional cementation to dental bonding concept. J Craniofac Surg. 2011;22(3):952–8.
33. Chen SE, Park AC, Wang J, Knoernschild KL, Campbell S, Yang B. Fracture Resistance of Various Thickness e.max CAD Lithium Disilicate Crowns Cemented on Different Supporting Substrates: An In Vitro Study. J Prosthodont. 2019;28(9):997–1004.
34. Kumari RV, Poluri RK, Nagaraj H, Siddaruju K. Comparative Evaluation of Bond Strength of Dual-Cured Resin Cements: An In-Vitro Study. J Int oral Heal JIOH. 2015;7(Suppl 1):43–7.
35. Spazzin A, Guarda G, Oliveira-Ogliari A, Leal F, Correr-Sobrinho L, Moraes R. Strengthening of Porcelain Provided by Resin Cements and Flowable Composites. Oper Dent. 2016;41(2):179–88.
36. Heck K, Paterno H, Lederer A, Litzenburger F, Hickel R, Kunzelmann K-H. Fatigue resistance of ultrathin CAD/CAM ceramic and nanoceramic composite occlusal veneers. Dent Mater. 2019;35(10):1370–7.
37. Lien W, Roberts HW, Platt JA, Vandewalle KS, Hill TJ, Chu T-MG. Microstructural evolution and physical behavior of a lithium disilicate glass–ceramic. Dent Mater. 2015;31(8):928–40.

Mini Curriculum and Author's Contribution

1. Beatriz Amaral Rios Tomaz de Almeida – DDS. Contribution: data acquisition, data interpretation; wrote the manuscript. ORCID: 0000-0001-8893-2459
2. Kamilly Fagundes de Oliveira – DDS. Contribution: data acquisition, data interpretation; wrote the manuscript. ORCID: 0000-0002-7692-4977
3. Ricardo Armini Caldas – DDS; PhD. Contribution: technical procedures; effective scientific and intellectual participation for the study; critical review and final approval. ORCID: 0000-0002-5362-4744

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Corresponding author
Ricardo Armini Caldas
E-mail: ricardo.caldas@ufsc.br