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RESEARCH ARTICLE

LAMINATE PORCELAIN VENEERS: TYPES, PREPARATION TECHNIQUES AND UPDATED STRATEGIES (REVIEW ARTICLE)

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ABSTRACT

Background: Several studies focused on the types of laminate porcelain veneers. This literature also highlighted on the technique of preparation and new strategies related to this subject. **Objectives:** the purpose of this review is to highlight on the technique of preparation and new strategies related to laminate porcelain veneers. **Methodology:** data was collected through the related articles published in the last ten years in Pub Med indexed journals. **Conclusion:** The knowledge and skills of the dentists are critical determinants of the attainment of desired treatment outcomes

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INTRODUCTION

Currently, there has been a growing demand for preventive treatment by patients in dental offices. Such patients are aware of the importance of preventive care and proper oral hygiene. In addition, the interest in aesthetics that can be approached by minimally invasive treatments, as a result of technological, technical, and material advances, is becoming widely known by the population. Ceramic veneers are among the minimally invasive aesthetic treatment options used to improve the tooth shape and color, as well as replacing composite resin restorations.Ceramic veneers, when well-planned and indicated, provide excellent end result to treatments due to the material property, biocompatibility with the periodontal tissues, and the possibility of being handled in low thicknesses, without harming the resistance or the aesthetics of the material. Thus, procedures are accomplished with minimal wear of the dental tissue, maintaining the color stability [1]. The use of the mock-up technique and bonding procedures are very important to achieve excellent results when working with feldspathic ceramic veneers for the restoration of anterior teeth [2].

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The clinical success of feldspathic laminate veneers depends on the appropriate indication and the adequate application of the available materials and techniques, according to the need and the goal of the aesthetic and functional treatment [3–5].The use of a mock-up prevents excessive or incorrect tooth preparation, as it indicates the exact location and amount of reduction, necessary to obtain the desired tooth color and shape, as well as the confection of the feldspathic ceramic veneers [6].

Type of ceramic material, thickness of restoration and cement layer: Tabletop or ultrathin occlusal veneers are a contemporary restorative approach indicated for teeth with occlusal wear. They consist of an important therapeutic modality to recover the occlusal vertical dimension of patients with great occlusal wear related to a parafunctional habit (Fons-Font, 2006) or physiological processes such as erosions (7). The main advantage of occlusal veneers is the recovery of the masticatory function with maximum preservation of dental structure (8) being a conservative option to traditional onlays (Gresnigt, 2011) and complete coverage crowns (9).Other advantages are the possibility to predict the final result with temporary restorations (Jankar, 2014) and the easiness of cementation. Although direct composite resins restorations are commonly made (10), the use of indirect ceramic materials may provide greater predictability to the treatment in recovering the occlusal vertical dimension during a prolonged time (11). However, multiple factors interfere in restoration dynamics such as the final appearance of the dental preparation, restoration geometry and thickness, as well as the mechanical performance of the ceramic material associated with the adhesive technique.With the advances in CAD/CAM (computer aided design/Computer aided manufacturing) materials and resin cements (12), the loss of dental structure can be minimized using conservative preparations for occlusal veneers (13). Several studies have evaluated fracture (12) and fatigue resistance (14) of restorations made in ceramics or composite resin (15) of different thicknesses.(11) The authors observed that thickness is not as influential as the material under a compressive load, thus allowing tabletop veneers to resist loads higher than masticatory ones. Until now (13), no clinical trial or case report has evaluated the most common type of failure of occlusal veneers. However, according to laboratorial fatigue tests, cracks in the restoration and debonding are the most common failure types (16). Therefore, it is important to understand how stress from masticatory forces is distributed in occlusal veneers. Computational simulations from modeling the structures to be evaluated (17) allows the visualization of stress concentration regions. As assessed in in vitro studies, defects in stress regions are the origin of fractures.

Stress patterns in porcelain laminate veneers: Porcelain laminate veneers (PLVs) have continuously gained popularity among dental practitioners for the conservative restoration of unesthetic anterior teeth (18). Introduced by Pincus in the late 1930s, PLV restorations have become predictable in dental practices because of advancements in porcelain and composite resin technology (19). PLVs have been used to cover staining and/or discoloration, for diastema closure, and for accidental loss of an incisal edge in the anterior teeth with minimum tooth preparation and improved esthetics (20). The clinical survival rates of PLVs have improved, and many observational studies with a follow-up period of 18 months to 15 years report success rates varying between 56% and 96% in the literature (21-24). Several factors may affect the long-term endurance of PLVs such as the thickness of the porcelain, geometry of the preparation, functional and parafunctional activities, tooth morphology, and adhesive system (25). On the other hand, the failures of ceramic veneers are mostly related to debonding and fractures. Fractures alone account for up to 67% of recorded ceramic veneer failures during the clinical observation period of up to 15 years (26). Stress induced by masticatory and parafunctional forces influences the distortion and fracture potential of PVLs (27).

Cautious treatment planning as well as accurate tooth preparation design is vital for esthetics and optimum function. While appropriate space must be left for the restoration to possess decent homogeneous thickness for optical properties and strength, the conservation of the tooth structure should also be considered (28). In a traditional treatment, a chamfer finish line is generally placed close to or at the gingival margin, and the enamel is decreased by 0.3–0.5 mm, which enables maintenance in strong enamel bonding and the achievement of appropriate porcelain thickness (29). Four widely accepted preparation guidelines are justified for PLVs: (30) feathered incisal edge preparation, which is widened up to the incisal margin but does not have a precise finish line; incisal overlap preparation, in which a palatal extension is performed; incisal bevel preparation, which is performed by making a 0.5–1 mm bevel at the buccal surface and incisal edge level; and window preparation, which does not include an incisal edge and is narrowed to the labial surface, are frequently preferred preparation designs (31).The variations in an actual clinical situation generally affect the kind of veneer design, the essential factors generally considered requisite for enhanced esthetics (a highly translucent incisal edge), the actual situation of the incisal edge, the restoration's extension type, and the stress distribution anticipated at the veneer tooth interface. In cases of more severe defects such as fractured incisal angles, discolorations, facial or proximal caries, or previously made restorations that need to be replaced, another preparation design should be followed. In such situations, a deeper preparation, including a palatal and proximal extension, is required to enhance esthetics and function (22). At present, a consensus has not been reached regarding the design type to be applied for PLVs. Some variables in biomedical devices cannot be measured and monitored through in vivo models, as it would be ethically controversial to conduct them on live subjects. Therefore, virtual simulation approaches and models, such as finite element analysis (FEA), have been used and become an essential means of evaluation in biomedical materials (https://doi.org/10.1016/j.jpor.2014.01.001).

The method includes a numerical procedure that can be utilized to consider the effects of material properties, loading, geometry, and process variables on the distribution of stress in dental restorations, taking into account Poisson's ratio and the modulus of elasticity (29).A precise three-dimensional (3D) geometry is one of the key compounds for obtaining successful finite element data for more complicated features such as teeth and craniofacial structures (15). Computer-based systems can calculate much more complex issues, and the prognostication of the outcomes is thereby enhanced by the ability to refine the mesh (27). Many researchers have used FEA to investigate stress distributions in dental restorations (28-30). The restoration of unesthetic anterior teeth has always been a challenge to a dentist. With the increased demand and patient awareness, the use of ceramic laminate veneers to restore unesthetic teeth has increased. However, the longevity of ceramic veneer has always been questioned because of the multiple stresses they are subjected to (32).The various factors which could affect the long-term prognosis of ceramic veneers include careful case selection, tooth surface, preparation design, ceramic thickness, laboratory veneer fabrication, material used for cementation, and functional and parafunctional activities.Among all the factors affecting the success rate, preparation design is one of the most controversial aspects. There are four preparation designs for veneers. Window and feather edge design does not involve incisal edge whereas butt joint and incisal overlap design involve the incisal edge.The occlusal load is another important factor influencing the long-term success of ceramic veneers. Hence, the direction of load application during testing has a significant effect on the result.In the past, various studies have been performed to evaluate the fracture resistance of ceramic veneer with different preparations designs, but none has correlated them with functional movements (33).

CAD/CAM Porcelain Laminate Veneers: During the last few decades, the demand for the computer-aided design and manufacturing systems in dentistry has dramatically increased because of the rapid developments in computer technology and science (https://www.hindawi.com/journals/ crid/2019/ 6731905/#B1). The idea of CAD/CAM was emerged with the aim of creating excellent restorations with the least possible error by the computer, as opposed to the conventional manufacturing techniques by free hand, which is prone to numerous subjective failures (35https://www.hindawi.com/ journals/ crid/2019/6731905/#B2). CAD/CAM systems can be categorized as either chairside or laboratory systems (35). Chairside CAD/CAM systems allow the clinicians in private offices to independently design and also machine dental ceramic restorations within a few hours during a single visit (36https://www.hindawi.com/journals/crid/2019/6731905/#B1). Inlay, onlay, porcelain laminate veneer, crown, and bridge can be produced with today's CAD/CAM systems.

The clinical technique for porcelain laminate veneers includes bonding very thin restorations to tooth adhesively in order to correct an unesthetic appearance of the anterior teeth (37https://www.hindawi.com/journals/crid/2019/6731905/#B5). The main reason why PLVs are so demanded restorations is that they are very minimally invasive restorations and very good esthetic results can be achieved with them (38https://www.hindawi.com/journals/crid/2019/6731905/#B6). With the improvements in CAD/CAM systems, such thin restorations with a thickness of 0.3 - 0.7 mm could be created almost perfectly with the help of computer design (39). Excellent esthetic results can be provided by these restorations especially with the use of digital workflow in recent years (Ozturk, 2014). Several medium-to-long-term clinical studies have evaluated the clinical performance of PLVs produced by conventional techniques. The success of conventional PLVs in these clinical trials ranges from 100% to 67% [Jankar, 2014; Magne, 2012]. However, to the authors' knowledge, only limited clinical data about the porcelain laminate veneers (PLVs) produced by CEREC CAD/CAM chairside systems have been reported and no long-term clinical results have existed. Therefore, the aim of this case report is to explain the clinical procedures for fabricating PLVs with CAD/CAM in a single session using digital workflow with a facilitating step and to report a year of clinical results.

Digital Workflow for Virtually Designing and Milling Ceramic Lithium Disilicate Veneers: Ceramic materials have been used to mimic the appearance of natural teeth in dental restorationsfor years now. Several materials and fabrication methods are available on the market (40). The intention of ceramics has been to closely imitate the optical properties of natural teeth while maintaining acceptable biomechanical and biocompatibility characteristics. Lithium disilicate glass ceramic using a pressed technique and its applications in clinical dentistry were introduced in 1998 by Brodkin and others (41). It is composed of 65% lithium disilicate in the form of crystalline structures, which results in relatively strong ceramic with high flexural strength of about 400 MPa, a fracture toughness of 3.3 MPa $m^{0.5}$, and a good translucency. Lithium disilicate glass ceramic can be etched and bonded to both enamel and dentin (42). A solution of 10% hydrofluoric acid is used to microetch the bonding surface to increase the bond strength (43). Different clinical applications are suggested for lithium disilicate ceramics including veneers, anterior and posterior single crowns, and anterior fixed dental prostheses (44).By definition, porcelain laminate veneers are thin bonded ceramic restorations that restore the facial and part of the proximal surfaces of teeth requiring esthetic restoration (45). Introduction of the acid-etch technique by Buonocore in 1955 and porcelain etching in 1983 resulted in long-lasting veneers after adhesive bonding (46). According to the published literature, the veneer material with the most clinical data is feldspathic porcelain. However, new research on ceramics, including hot pressed, is becoming available in the literature. Lithium disilicate glass ceramic has been used for veneers, but there are limited clinical data regarding its outcome (47). Porcelain laminate veneer preparations have the advantage of being more conservative than full-coverage crowns and can address some of the limitations of metal-ceramic full-coverage restorations, such as superior optics and color control, supragingival margins, and bonding with improved tissue response (48).Digital technology is emerging quickly and has introduced many new aspects to contemporary dental practice. Digital impressions have become an alternative to conventional polyvinyl siloxane (PVS) impression techniques and materials. Clinical evaluation of intraoral digital impressions has shown very promising results. It has been claimed that all ceramic crowns fabricated using chairside scanners have superior marginal fit and improved proximal contact points compared with those fabricated using conventional impressions (49).The demand for treating unaesthetic anterior teeth continues to grow. Available options to restore their aesthetics include conservative treatments, such as bleaching and direct composite laminate veneers (50), and reliable but aggressive treatments, such as full crown restorations (51). However, crown preparations are associated with some problems, including the extensive removal of the sound tooth structure and irreversible effects on the dental pulp (50). Calamia (1984) (52) first described the treatment of porcelain with hydrofluoric acid and silane to create an adhesive interface, which serves as the basis for porcelain laminate veneers (53,54). These tooth-colored materials can improve the aesthetic outcome of anterior restorations (55). Improvements in adhesive systems and the development of new-generation porcelain technology have supported the growing demand for treating unaesthetic teeth with porcelain laminate veneers (56).

Studies have shown a 7% failure rate of porcelain laminate veneers, but failure had no direct impact on the clinical success in terms of longevity or durability) (57). These restorations are highly esthetic, biocompatible, and resistant to staining and wear (58).Porcelain laminate veneer preparation can be a stressful for dentists with insufficient clinical skills or experience. Lack of good procedural knowledge frequently results in failed restorations. Several longitudinal clinical studies have been performed on the performance of porcelain laminate veneers placed by general practitioners or specialists, revealing acceptable results regardless of the type of failure and/or veneer design (59). An evaluation of the clinical performance of veneers placed by undergraduate students in Ireland also revealed satisfactory restorations (60). However, no studies have been performed in Saudi Arabia regarding the performance of porcelain laminate veneers placed by dentists at any level. Case unavailability, the need for time-consuming continuous and close supervision by clinical instructors, and procedural difficulty for students may explain the lack of such reports.

Conclusion

The knowledge and skills of the dentists are critical determinants of the attainment of desired treatment outcomes

REFERENCES

1. Fons-Font A., Solá-Ruíz M. F., Granell-Ruíz M., Labaig-Rueda C., Martínez-González A. 2006. Choice of ceramic for use in treatments with porcelain laminate veneers. Medicina Oral, Patología Oral y Cirugía Bucal.;11(3):E297–E302. [PubMed] [Google Scholar]
2. Vanlıoğlu B. A., Kulak-Özkan Y. Minimally invasive veneers: current state of the art. Clinical, Cosmetic and Investigational Dentistry. 2014;6:101–107. doi: 10.2147/CCIDE.S53209. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
3. Coachman C., Gurel G., Calamita M., Morimoto S., Paolucci B., Sesma N. The influence of tooth color on preparation design for laminate veneers from a minimally invasive perspective: case report. The International Journal of Periodontics & Restorative Dentistry. 2014;34(4):453–459. doi: 10.11607/prd.1900. [PubMed] [CrossRef] [Google Scholar]
4. Gresnigt M., Ozcan M. Esthetic rehabilitation of anterior teeth with porcelain laminates and sectional veneers. Journal of the Canadian Dental Association. 2011;77, article b143 [PubMed] [Google Scholar]
5. Shillingburg H. T., Hobo S., Whitsett L. D., Jacobi R., Brackett S. E. Fundamentos Prótese Fixa. 4th. Quintessence Editora; 2007. [Google Scholar]
6. Jankar A. S., Kale Y., Kangane S., Ambekar A., Sinha M., Chaware S. Comparative evaluation of fracture resistance of ceramic veneer with three different incisal design preparations - an in-vitro study. Journal of International Oral Health. 2014;6(1):48–54.
7. Abrahamsen TC. The worn dentition: pathognomonic patterns of abrasion and erosion. Int Dent J. 2005;55(4 Suppl 1):268-76. https://doi.org/10.1111/j.1875-595X.2005.tb00064.x [Links]
8. Schlichting LH, Resende TH, Reis KR, Magne P. Simplified treatment of severe dental erosion with ultrathin CAD-CAM composite occlusal veneers and anterior bilaminar veneers. J Prosthet Dent. 2016 Oct;116(4):474-82. https://doi.org/10.1016/j.prosdent.2016.02.013 [Links]
9. Yazigi C, Kern M, Chaar MS. Influence of various bonding techniques on the fracture strength of thin CAD/CAM-fabricated occlusal glass-ceramic veneers. J MechBehav Biomed Mater. 2017 Nov;75:504-11. https://doi.org/10.1016/j.jmbbm.2017.08.016 [Links]
10. Magne P, Stanley K, Schlichting LH. Modeling of ultrathin occlusal veneers. Dent Mater. 2012 Jul;28(7):777-82. https://doi.org/10.1016/j.dental.2012.04.002 [Links]
11. Magne P, Schlichting LH, Maia HP, Baratieri LN. In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. J Prosthet Dent. 2010 Sep;104(3):149-12. https://doi.org/10.1016/S0022-3913(10)60111-4 [Links]
12. Johnson AC, Versluis A, Tantbirojn D, Ahuja S. Fracture strength of CAD/CAM composite and composite-ceramic occlusal veneers. J Prosthodont Res. 2014 Apr;58(2):107-14. https://doi.org/10.1016/j.jpor.2014.01.001 [Links]
13. Carvalho AO, Bruzi G, Giannini M, Magne P. Fatigue resistance of CAD/CAM complete crowns with a simplified cementation process. J Prosthet Dent. 2014 Apr;111(4):310- https://doi.org/10.1016/j.prosdent.2013.09.020 [Links]
14. Lima JM, Souza AC, Anami LC, Bottino MA, Melo RM, Souza RO. Effects of thickness, processing technique, and cooling rate protocol on the flexural strength of a bilayer ceramic system. Dent Mater. 2013 Oct;29(10):1063-72. https://doi.org/10.1016/j.dental.2013.07.019 [Links]
15. Ge C, Green CC, Sederstrom D, McLaren EA, White SN. Effect of porcelain and enamel thickness on porcelain veneer failure loads in vitro. J Prosthet Dent. 2014 May;111(5):380-7. https://doi.org/10.1016/j.prosdent.2013.09.025 [Links].
16. Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. Porcelain veneers: A review of the literature. J Dent 2000;28:163-77.
17. Seymour KG, Cherukara GP, Samarawickrama DY. Stresses within porcelain veneers and the composite lute using different preparation designs. J Prosthodont2001;10:16-21.
18. Troedson M, Dérand T. Effect of margin design, cement polymerization, and angle of loading on stress in porcelain veneers. J Prosthet Dent 1999;82:518-24. Image
19. Shaini FJ, Shortall AC, Marquis PM. Clinical performance of porcelain laminate veneers. A retrospective evaluation over a period of 6.5 years. J Oral Rehabil1997;24:553-9. Image
20. Meijering AC, Creugers NH, Roeters FJ, Mulder J. Survival of three types of veneer restorations in a clinical trial: A 2.5-year interim evaluation. J Dent 1998;26:563-8. Image
21. Jankar AS, Kale Y, Kangane S, Ambekar A, Sinha M, Chaware S. Comparative evaluation of fracture resistance of ceramic veneer with three different incisal design preparations – An in-vitro study. J Int Oral Health 2014;6:48-54. Image
22. Stappert CF, Stathopoulou N, Gerds T, Strub JR. Survival rate and fracture strength of maxillary incisors, restored with different kinds of full veneers. J Oral Rehabil2005;32:266-72. Image
23. Akoglu B, Gemalmaz D. Fracture resistance of ceramic veneers with different preparation designs. J Prosthodont2011;20:380-4. Image
24. Wheeler RC. Important considerations in porcelain veneer restorations. Ill Dent J 1947;16:131-8. Image
25. Magne P, Kwon KR, Belser UC, Hodges JS, Douglas WH. Crack propensity of porcelain laminate veneers: A simulated operatory evaluation. J Prosthet Dent 1999;81:327-34. Image
26. Shetty A, Kaiwar A, Shubhashini N, Ashwini P, Naveen D, Adarsha M, et al. Survival rates of porcelain laminate restoration based on different incisal preparation designs: An analysis. J Conserv Dent 2011;14:10-5. Image[PUBMED] [Full text]
27. Castelnuovo J, Tjan AH, Phillips K, Nicholls JI, Kois JC. Fracture load and mode of failure of ceramic veneers with different preparations. J Prosthet Dent 2000;83:171-80. Image
28. Magne P, Douglas WH. Design optimization and evolution of bonded ceramics for the anterior dentition: A finite-element analysis. Quintessence Int1999;30:661-72. Image
29. Archangelo CM, Rocha EP, Anchieta RB, Martin M Jr., Freitas AC Jr., Ko CC, et al. Influence of buccal cusp reduction when using porcelain laminate veneers in premolars. A comparative study using 3-D finite element analysis. J Prosthodont Res 2011;55:221-7. Image
30. Bulbule NS, Motwani BK, Tunkiwala A, Pakhan AJ. Esthetic rehabilitation with laminate veneers. J Indian ProsthodontSoc2006;6:101-4.

31. Khatib D, Katamish H, Ibrahim AS. Fracture load of two CAD/CAM ceramic veneers with different preparation designs. Cairo Dent J 2009;25:425-32. Image
32. G. Sannino, F. Germano, L. Arcuri, E. Bigelli, C. Arcuri, and A. Barlattani, "CEREC CAD/CAM chairside system," ORAL & Implantology, vol. 7, no. 3, pp. 57–70, 2014. View at Google Scholar
33. T. Miyazaki, Y. Hotta, J. Kunii, S. Kuriyama, and Y. Tamaki, "A review of dental CAD/CAM: current status and future perspectives from 20 years of experience," Dental Materials Journal, vol. 28, no. 1, pp. 44–56, 2009. View at Publisher · View at Google Scholar · View at Scopus
34. V. Alt, M. Hannig, B. Wostmann, and M. Balkenhol, "Fracture strength of temporary fixed partial dentures: CAD/CAM versus directly fabricated restorations," Dental Materials, vol. 27, no. 4, pp. 339–347, 2011. View at Publisher · View at Google Scholar · View at Scopus
35. W. Mormann and I. Krejci, "Computer-designed inlays after 5 years in situ: clinical performance and scanning electron microscopic evaluation," Quintessence International, vol. 23, no. 2, pp. 109–115, 1992. View at Google Scholar
36. M. Peumans, B. Van Meerbeek, P. Lambrechts, and G. Vanherle, "Porcelain veneers: a review of the literature," Journal of Dentistry, vol. 28, no. 3, pp. 163–177, 2000. View at Publisher · View at Google Scholar · View at Scopus
37. E. Ozturk and S. Bolay, "Survival of porcelain laminate veneers with different degrees of dentin exposure: 2-year clinical results," The Journal of Adhesive Dentistry, vol. 16, no. 5, pp. 481–489, 2014. View at Publisher · View at Google Scholar · View at Scopus
38. Anusavice KJ (2003) Dental Ceramics. Phillips, Science of Dental Materials 12th edition Elsevier Saunders, St. Louis, MO. [Google Scholar]
39. Brodkin D, Panzera C, & Panzera P (September 24, 2002) Jeneric/Pentron, Inc. Pressable lithium disilicate glass ceramics US patent 6,455,451 B1 [Google Scholar]
40. Albakry M, Guazzato M, & Swain MV (2003) Biaxial flexural strength, elastic moduli, and x-ray diffraction characterization of three pressable all-ceramic materials Journal of Prosthetic Dentisty 89(4) 374-80. [Crossref] [Medline] [Google Scholar].
41. Höland W, Schweiger M, Frank M, & Rheinberger V (2000) A comparison of the microstructure and properties of the IPS Empress 2 and the IPS Empress glass-ceramics Journal of Biomedical Material Research 53(4) 297-303. [Crossref] [Medline] [Google Scholar]
42. Guarda GB, Correr AB, Gonçalves LS, Costa AR, Borges GA, Sinhoreti MA, & Correr-Sobrinho L (2013) Effects of surface treatments, thermocycling, and cyclic loading on the bond strength of a resin cement bonded to a lithium disilicate glass ceramic Operative Dentistry 38(2) 208-217. [Abstract] [Google Scholar]
43. Giordano R, & McLaren EA (2010) Ceramics overview: Classification by microstructure and processing methods. Compendium of Continuing Education in Dentistry 31(9) 682-684. [Medline] [Google Scholar]
44. Buonocore MG (1955) A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces Journal of Dental Research 34(6) 849-853. [Crossref] [Medline] [Google Scholar]
45. Marocho SM, Ozcan M, Amaral R, Bottino MA, &Valandro LF (2013) Effect of resin cement type on the microtensile bond strength to lithium disilicate ceramic and dentin using different test assemblies Journal of Adhesive Dentistry 15(4) 361-368. [Medline] [Google Scholar]
46. Layton DM, & Clarke M (2013) A systematic review and meta-analysis of the survival of non-feldspathic porcelain veneers over 5 and 10 years International Journal of Prosthodontics 26(2) 111-124. [Crossref] [Medline] [Google Scholar]
47. Pippin DJ, Mixson JM, & Soldan-Els AP (1995) Clinical evaluation of restored maxillary incisors: Veneers vs PFM crowns Journal of the American Dental Association 126(11) 1523-1529. [Crossref] [Medline] [Google Scholar]
48. Beier U.S., Kapferer I., Burtscher D., Dumfahrt H. Clinical performance of porcelain laminate veneers for up to 20 years. Int. J. Prosthodont. 2012;25:79–85. [PubMed] [Google Scholar]
49. Calamia J.R., Simonsen R.J. Effect of coupling agents on bond strength of etched porcelain. J. Dent. Res. 1984;63 (abstract 79) [Google Scholar]
50. Castelnuovo J., Tjan A.H., Phillips K., Nicholls J.I., Kois J.C. Fracture load and mode of failure of ceramic veneers with different preparations. J. Prosthet. Dent. 2000;83:171–180. [PubMed] [Google Scholar]
51. Chen J.H., Shi C.X., Wang M., Zhao S.J., Wang H. Clinical evaluation of 546 tetracycline-stained teeth treated with porcelain laminate veneers. J. Dent. 2005;33:3–8. [PubMed] [Google Scholar]
52. Christensen G.J., Christensen R.P. Clinical observations of porcelain veneers: a three-year report. J. Esthet. Dent. 1991;3:174–179. [PubMed] [Google Scholar]
53. Christensen G.J. Thick or thin veneers? J. Am. Dent. Assoc. 2008;139:1541–1543. [PubMed] [Google Scholar]
54. Dumfahrt H., Schäffer H. Porcelain laminate veneers. A retrospective evaluation after 1 to 10 years of service: part II—clinical results. Int. J. Prosthodont. 2000;13:9–18. [PubMed] [Google Scholar]
55. Fradeani M. Six-year follow-up with Empress veneers. Int. J. Periodont. Restorat. Dent. 1998;18:216–225. [PubMed] [Google Scholar]
56. Friedman M.J. 1998. A 15-year review of porcelain veneer failure—a clinician's observations. Compend. Contin. Educ. Dent., 19:625–638. [PubMed] [Google Scholar]
57. Giordano R., McLaren E.A. 2010. Ceramics overview: classification by microstructure and processing methods. Compend. Contin. Educ. Dent., 31:682–684. [PubMed] [Google Scholar].

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