Aesthetic veneering materials and systems: A Comprehensive Review

Ajit Jankar [1], Suresh Kamble [2], Madhavi Galale [3], Deepali Patane [4], Pooja Langote [5], Pranoti Chinchansure [6]
[1] Professor & HOD , [2]Professor &Principal, [3,4, 5,6] Postgraduate Student
Dept of Prosthodontics, MIDSR Dental College, Latur.

Abstract:
Objective: The clinician must choose the restorative material depending on its composition, optical properties, strength and fabrication processes. This article offers a systematic overview of advanced ceramic materials and technologies, their thorough understanding and effective clinical use.
Overview: Porcelain laminate and veneers have received a substantial attention over the last several decades as one of aesthetic dentistry's most popular restorations. By the advent of new materials and techniques based on aesthetic potential and functional reliability of available bonding procedures, laminates have shown reliability in treatment of defects of teeth with respect to malformations, malposition, discoloration, spacing, fractures and wear of tooth structure. One of the most critical factors for the clinical success of ceramic laminate veneers is the appropriate case selection and choice of material to restore aesthetics.
Conclusion: Porcelain laminate veneers have proven to be restorative technique that offers high clinical success and have predictable patient outcome. Effective provision of veneers requires selection of ideal material ensured by preoperative planning and design, use of advanced and minimally invasive technique, characteristics and properties of materials which should complement clinical requirement.

Keywords All-Ceramic material, Ceramic veneers, Dental Ceramics, Laminate Veneers, Porcelain laminate veneers, Esthetic Restoration.

Corresponding Author: Dr. Deepali Patane, Postgraduate Student, Dept of Prosthodontics, MIDSR Dental College, Latur. Email id.: deepalipatane@gmail.com

INTRODUCTION:

A winsome smile comes up with a self-confidence, personality, social life, and psychological effects in an individual. The growing demands of patient for the tooth-colored restorations, as well as a more alluring smile, has now passed the boundaries of exclusive clinicians.[1] Based on their strength, conservative nature, longevity, aesthetics, and biocompatibility; veneers have been considered one of the most viable treatment modalities as anterior and aesthetic restoration.[2] This has led to its use in the anterior region where more conservative approach can be used to enhance the aesthetics. Dr. Charles Pincus in 1930's introduced thin porcelain veneers to enhance the appearance of the teeth.[3] A porcelain laminate veneer is a thin shell of porcelain applied directly to the labial surface of tooth structure which requires minimally invasive tooth preparation.[4]

Indication for laminate veneers includes teeth discolorations, non-aesthetic tooth shape or contour requiring morphologic modifications, diastema closure, minor tooth alignment, dental fluorosis with enamel mottling, slight chippings, or fracture of teeth. Patients presenting with unfavorable conditions for laminate veneers are anterior deep bite, severe bruxism or other para-functional habits, presence of any soft tissue disease, severely malpositioned teeth, and teeth with extensive existing restorations. Evaluation, diagnosis, treatment planning of case is necessary as it will determine the treatment goals, which in turn will dictate the choice of material and technique.[5]

Wide ranges of materials are available in the market to restore aesthetic/functional defects such as porcelain, resin composite. Each type of material has its distinctive composition, optical characteristics, and fabrication process.[6] several techniques have been developed to fabricate and adapt porcelain as laminate and veneers. Successful bonding of the luting material to both the restorative material and the tooth structure is crucial for the retention and longevity of the restoration.

This article explores the current literature on porcelain laminate veneers and provides clinicians the basis for selecting the suitable application and acknowledging their clinical limitations.

2. Indication ceramic veneers

Magne and Belser presented classification for indications of ceramic veneers as follows:[7]

Type I: Teeth resistant to bleaching

1. Type IA: Tetracycline discoloration
2. Type IB: Teeth that are unresponsive to bleaching

Type II: Major morphologic modifications

1. Type IIA: Conoid teeth
2. Type IIB: Diastema or interdental triangles to be closed
3. Type IIC: Augmentation of incisal length or facial prominence

Type III: Extensive restorations

1. Type IIIA: Extensive coronal fracture
2. Type IIIB: Extensive loss of enamel by erosion and wear
3. Type IIIC: Generalized congenital malformations.

3. Glass based ceramics:

3.1. Feldspathic porcelain

Traditionally feldspathic porcelain is used for layering veneers and metal substructures.[8] Feldspars are primarily composed of silicon oxide (60%–64%) and aluminum oxide (20%– 23%) and are typically modified in a different manner to create glass that can then be used in dental restorations.[3]

Properties

Feldspathic veneers are generally the most conservative and the most translucent of all-ceramic material, containing silica dioxide (60-64%) and aluminum oxide (20-23%).[8] Its lower mechanical properties and its poor flexural strength ranging from 60 to 70 MPa makes it more susceptible to fracture under mechanical stress because of the high volume of glass particles.

They are indicated in patients where no or minimal tooth preparation is required, including teeth that have: diastema closure, malalignment anterior teeth, fluorosis with enamel mottling and tetracycline stains. They are used when enamel reduction is 0.3 to 0.5 mm or require minimal preparation. The feldspathic veneers present limitations to counteract severe staining, in such situations, additional removal of tooth structure was proposed and required using sub-layer of opaque composite below the layer of translucent porcelain veneer.[9]

Advantages of feldspathic porcelain to fabricate ceramic laminate veneers:

1. Reproducibility of natural tooth color with a thin layer of material,
2. Low laboratory cost
3. Excellent mechanical retentive characteristics after etching with hydrofluoric acid and the presence of an adequate amount of enamel.
4. Superior bonding characteristics with the use of suitable silane bonding agents

Two techniques are used for fabrication of feldspathic porcelain:

1. Refractory die technique

The advantages of the refractory die technique are: No special equipments are required; extremely smooth effects of color and translucency can be obtained through a full-thickness layering technique.

2. Platinum foil technique.

The advantage of the platinum foil technique is that it presents as the closest alternative to the refractory die technique and requires less effort in cast fabrication. Besides, data from the early 1990s repeatedly showed the superior marginal fidelity of platinum foil veneers.[10]

Cementation protocol
The prepared tooth surface is etched with 37% phosphoric acid followed by rinsing with spray and gentle drying and then a thin layer of dental adhesive is applied. The inner surface of prepared feldspathic ceramic etched with 9% hydrofluoric acid for two minutes, immersed in an ultrasonic bath with distilled water. A silane coupling agent applied for 2 minutes and heated with a dryer, a thin layer of adhesive is applied. Finally, cement is placed inside the veneer and placed on the teeth with even pressure.[9]

3.2. Reinforced glass-ceramic restorations
They are similar to feldspathic ceramic in many ways. As compared to feldspathic ceramic, they have improved strength due to proper filler particles that are evenly dispersed throughout the glass. The clinical use of glass-ceramic depends on the type of filler particles.
Properties
Glass-ceramics as compared to feldspathic porcelain have enhanced mechanical fracture resistance, better thermal shock insulation, and resistance to corrosion.[7] Its mechanical properties depend on the size and amount of crystals as well as on the interaction of the crystals and glassy matrix. Glass ceramics may be opaque or translucent depending on the chemical composition and amount of crystals embedded in the matrix.
They have enhanced flexural strength, which depends on the shape and volume. The resistance to flexion of reinforced leucite ceramics and lithium dioxide is 160-300 MPa and 320-450 MPa respectively.[11]
Based on type of glass and its mechanical behavior; the reinforced glass ceramics particles subdivided into two types: [8]

1. Glass-ceramics reinforced with leucite
2. Glass-ceramics reinforced with lithium disilicate

Leucite and lithium are preferred material to fabricate veneers because of their optical properties and acid-sensitive feature. They have a low refractive index of crystals, due to which they become translucent even with high crystalline content.[11] Glass-ceramics are fabricated from lost wax technique and heat pressing methods. In heat pressing method, the restoration is first waxed-up and invested; the ingot is then made using ceramic sintered. Sintered ceramic is softened and pressed into a mould under pressure. The shades of the ingot provide the required shades which can be modified by staining.[10] These materials can be also fabricated using CAD/CAM technology and are available in the form of monochromatic or multicolored.[11]

3.2.1. Glass-ceramics reinforced with leucite
Leucite reinforced glass ceramics (IPS Empress-Ivoclar Vivadent) contains 50% - 55% of crystal material. The refractive index of leucite is very close to feldspathic ceramics.
Cementation protocol:
The enamel of the prepared teeth should be cleaned using flour of slurry pumice, washed with water, and air-dried. The prepared teeth surface to be etched with 37% phosphoric acid for 15 s; then dentin adhesive to be applied in thin layer for 15 sec and air-dried for 3 sec. Leucite reinforced ceramics have a faster rate of etching than basic glass ceramics, these features allow for resin cement to create a strong micromechanical bond.[11] The inner surface of the ceramic veneers was to be etched with 9% hydrofluoric acid for 4 min, washed thoroughly with water, and air-dried, A silane coupling agent is applied on inner surface of leucite glass ceramic for 30 sec and gently air-blown. A thin layer of bonding agent is applied and air- dried. The cement should now be applied evenly to the inner surface on ceramic and placed on the teeth surface.[12]

3.2.2. Glass-ceramics reinforced with lithium disilicate
Lithium disilicate (IPS Empress II—Ivoclar Vivadent) are glass-ceramics containing 70% of crystal. Its hardness ranges from 360 - 500 MPa. Indication of Lithium disilicate are intrinsically discolored teeth and teeth that required change in shape, size, and color. They possess properties as high fracture resistance, hardness, provide translucency, aesthetic appearance, chameleon effect.[8]
IPS e.max Press (Ivoclar Vivadent) was introduced in 2005 with improved physical properties.[11] IPS e-max PRESS as compared to IPS Empress and IPS Empress

II have different crystalline volume and refractory index and exhibits more translucency.

Cementation protocol

The prepared teeth surfaces should be polished and rinsed and etched with 37% phosphoric acid gel for 15 secs followed by rinsing and gentle drying. The bonding agent to be applied on the etched teeth surfaces for 20 seconds. The inner surface of the ceramic laminates to be etched with hydrofluoric acid-containing gel, rinse with water, A silane coupling agent should be applied, and left to dry. After drying, self-adhesive resin cement should be applied to the inner surface of the laminates, and gently pressed on to the teeth.[5]

4. Alumina based ceramics

The aluminium oxide was the first high strength core ceramic material. They have less glass content, so also called as glass infiltrated aluminum-oxide ceramics. Alumina based ceramic materials are classified into two types i.e. In-Ceram porcelains and Procera All Ceram.

4.1. In-Ceram porcelains

In-Ceram porcelains are fabricated through the slip-casting technique, during firing the die shrinks so it can be withdrawn from the core. At this stage, the core is a weak, porous structure, to improve the strength outer side of the core is painted with a slurry of lanthanum containing glass and refiring it. According to composition, they are divided into In-Ceram Spinell, In-Ceram alumina and In-Ceram zirconia.

4.1.1. In-Ceram Spinell

In-Ceram Spinell was an alternative to the opaque core of In-Ceram Alumina. They have enhanced translucency due to a mixture of magnesia and alumina ($MgAl_2O_4$) in the framework. They have low flexural strength as compared to In-Ceram Alumina, thus recommended for only anterior crowns.

4.1.2. In-Ceram Alumina

In-Ceram alumina was introduced in 1989. They contain 85% aluminium oxide particles. Its resistance to flexion ranges from 400 - 600 Mpa. In-Ceram Alumina ceramics as compared to leucite reinforced glass ceramics and conventional feldspathic have a higher strength and fracture toughness.

4.1.3. In-Ceram zirconia

In-Ceram Zirconia is manufactured using 67% aluminium oxide and 33% partially stabilized zirconium oxide. In-Ceram Zirconia as compared to In-Ceram Alumina has higher fracture toughness and resistance to flexure. Its flexural strength ranges from 600 – 800 Mpa. They have an opaque core that lacks translucency.

4.2. Porcera All-Ceram

Procera is fabricated from copings that contain 99.9% high purity aluminum oxide. These copings are coated with conventional aluminum ceramic. Procera as compared to glass and In-Ceram ceramics have high strength, but its strength is lower than zirconia-based ceramic.

Surface treatment: The inner surface of ceramic abraded with air particles with 50- micrometer aluminium oxide powder at 7 pounds per square inch; later adhesion agent should be applied to contain MDP and dried.

5. Zirconia based ceramics:

Ceramics based on zirconia are polycrystalline material and does not contain glass. The polycrystalline ceramic atoms are compressed into uniform crystalline clusters that form a matrix that is more resistant to cracks compared to less structured and erratic glass networks. Zirconia has high crystalline content and it exists in three crystallographic forms: monoclinic, tetragonal, and cubic phases. Yttria is used to stabilize ceramics in the tetragonal phase.[13] They have high fracture resistance compared to those associated with lithium disilicate and feldspathic veneers and have ability to mask the dark substrate.[14]

Recently, zirconia ceramics having better translucency without significantly losing their property of fracture resistance are introduced. Thus, translucent zirconia is indicated for single crowns, anterior and posterior monolithic fixed prostheses, and veneers and ultrathin veneers. The conventional zirconia contains 0.5%-1.0% of alumina and 3%-6% of yttrium oxide in its weight. Whereas translucent zirconia containing 0.11% to 0.26% alumina and 12% of yttrium oxide in its weight. The strength ranges from 900 to 1200 Mpa and 500 to 800 Mpa for

tetragonal (opaque) zirconia and cubic ultra-translucent zirconia respectively.[15]
Zirconia is less retentive as compared to that of the glass-ceramics, for this reason, many surface treatments have been proposed to modify the surface of zirconia and to optimize adhesion to resin cement. The various surface treatments are: sandblasting with aluminum oxide, cement containing 10-methacryloxydecyl dihydrogen phosphate (MDP) monomer, tribochemical silica coating followed by salinization, feldspathic glass infiltration, selective infiltration etching technique, glaze-on technique, and heating of silanes. Among these treatments, silica coating has presented with some of the best bonding results.[15]

Cementation protocol

The tooth surface is cleaned with pumice and water, and then rinsed and thoroughly dried. Later tooth surface should be etched with 35% phosphoric acid for 20 seconds, rinsed and dried. This surface is ready to be treated with an adhesive system. The intaglio surfaces of the ceramic needs to be abraded with particles of aluminum oxide coated with silica for 20 seconds (2.8 bar, 10-mm standoff distance) and dried to increase surface bonding. Silane should be applied and left to dry for two minutes. Later adhesive agent should be applied without curing. Resin cement is applied to ceramic material and gently pressed on to the teeth. Glycerin gel is applied immediately after removal of excess resin cement to prevent oxygen inhibition layer.[15]

6. Choice of ceramic material according to clinical situation

Two factors are considered for selecting the correct ceramic materials:

1. Effect of functional loading
2. Shade selection

6. 1. Effect of functional loading

High fracture resistant ceramic material is to be used in the maximum functional load tooth surface. The higher tensile and shear stress occurs in case of deep overbites, diastema closure and teeth with chipping or fracture due to the presence of unsupported porcelain, due to bonding veneers to more flexible substrates such as dentin and composite etc. In such cases, the choice of materials is high strength ceramics like alumina-based ceramics and zirconia-based ceramics.[16] In the case of parafunctional habits such as bruxism, choice of ceramic material is monolithic zirconia.[17]
According to Dawson, Anterior guidance restores the functional form through increased anterior relationships. Disocclusion created by anterior guidance plays a very important role in protecting the posterior teeth from protrusive and lateral stresses. Porcelain veneer restorations can be considered as ideal restorations for the corrections of poor anterior relationships and anterior-guidance. Restorations improve the anterior relationships for optimum guidance as well as occlusal maintenance that may require a modification of maxillary anterior teeth morphology. This is achieved by:[18]

1. Modify the palatal surface to correct insufficient horizontal parameters.
2. Incisal lengthening with modified palatal morphology to correct insufficient vertical parameters following the incisal wears.

Unfavourable anterior guidance leads to anterior alveolar bone loss and teeth mobility when there are susceptible periodontal tissues and excessive forces. For the achievement of ideal aesthetics by restoring suitable forms and dimensions should be combined with the re-establishment of correct function.[19] The material used for restoring anterior guidance should have high fracture resistance and tensile strength.

6.2. Shade selection

Shade matching is as much an art as a science. For the restoration of the anterior teeth, the most critical factor is that the shade of the replaced tooth should match to adjacent natural tooth. The improper shade selection is the second most common reason for the remake of a ceramic restoration. The oldest method of shade selection is a visual analysis using a commercial shade guide. Another system for shade selection is with the help of instruments. The commonly used instruments are: spectrophotometer, spectropolarimeter, colorimeter, spectroradiometer, and digital camera.[20]
The final color of ceramic restorations depends on many factors such as the thickness of the porcelain veneer, color, and extent of the luting agents and the color of the underlying tooth structure.[21] Translucency is a common, varying phenomenon

among ceramics. Clinicians usually face difficulty in shade selection and replication of optical properties comparable to those of highly translucent adjacent natural teeth, particularly when the prepared teeth are severely discolored. The amount of reflection and scattering of light affects the translucency of ceramic material and influences the shade of final laminate veneer restoration.[22] The amount of light that is absorbed, transmitted, and reflected depends on the chemical nature and size of the particles within the core material.

As translucency has improved with lighter ceramics, it is difficult to disguise the underlying dark tooth structure, and therefore the color match in porcelain laminate veneers is more complicated. Sadaqah et al.[11] classified the patient into two categories for a correct selection of ceramic material with color consideration.

a) Type I patients: These types of patients receive aesthetic changes where teeth present no color alternations. The only aim in these cases is to apply porcelain laminate veneers for shape modifications.
b) Type II patients: These types of patients receive aesthetic changes, and the teeth present color alternations. Restorative material must be able to hide the underlying teeth color.

A. Type I patients

In type I patients, a new aesthetically pleasing external surface is bonded to the tooth without changing the tooth color. The choice of material is conventional feldspathic ceramics due to their excellent optic characteristics that will afford optimum aesthetic results.[11] Generally, feldspathic porcelain materials are indicated where the restoration replaces enamel and minimal preparation within the dentin is done. For example, teeth that have deformed shapes or contours and lack of size and volume, malpositioned teeth, requiring morphologic modifications; diastema closure, alignment of the anterior tooth, restoring localized enamel malformations, and fluorosis with enamel mottling. If tooth reduction is more than 0.5 mm, in such a situation, glass-ceramics should be considered instead of feldspathic ceramics due to their increased strength and toughness, as well as provide enough scope to achieve the desired aesthetics.

B. Type II patients

In these patients, the teeth show moderate to severe discoloration that must be masked by restoration. Less translucent core material should be considered for discolored teeth.[11] In such situations, both the porcelain and cement must provide various degrees of opacity to hide the color alternations. This, in turn, creates difficulty to secure the desired optic effects in terms of translucency and reflectance and consequently aesthetic outcome.[9] Another factor is modification in dental preparation (0.8 - 1mm) and finish line (slightly subgingival). The choice of materials is ceramics that offer the possibility of selecting the opacity of the base material.[9]

The zirconia laminate veneers have an opaque nature. It offers an advantage over traditional feldspathic and glass-based ceramics in masking undesirable tooth color. The color difference between the zirconia core and the adjacent natural teeth should be reduced through the layering technique for the veneering porcelain.[11]

7. Luting agents

The shade of the luting agent also affects the color masking ability of the veneers. Currently, the varieties of shades of resin cement are available for luting ceramic veneers.[21] Luting agents are classified into 3 types depending upon the activation system. They are chemical- cured, light-activated resin cement, and Dual-cured resin cement. The shade of resin cement is determined by the different amounts of opaque ingredients in cement. There may be color difference in final porcelain laminate veneers because of different shade of resin cement.[23] Before cementation, Ceramic veneers should be tried in using a transparent shade try-in paste to assess marginal adaptation and shade. Various try-in pastes available and these are Variolink Veneer try-in paste, Ivoclar Vivadent, Schaan, Liechtenstein etc.[24]

Chemically polymerized resin cement does not provide appropriate shade and translucency; therefore are not used for laminate veneers. Nowadays for the cementation of PLVs, a light-curing luting composite is preferred. It is indicated when the ceramic is thin and fairly translucent, allowing the transmission of light through it to reach the resin cement.[25] Light- cure composite cements as compared to dual-cure or chemically cured composites have longer working time. This allows sufficient time to remove excess composite before curing and thus reduces the finishing procedures. Light-cure composite has much better color stability compared to dual-cure or chemically cured composites because of the absence of the aromatic amine as a self-curing catalyst.[26]

Dual-polymerized resin cement is indicated where the ceramic material is thick or opaque to allow transmission of light through it.[25] They have superior mechanical properties such as flexural strength, hardness, elastic modulus, and degree of conversion as comparison to light- activated or chemical curing. Dual cure resin cement contains tertiary amines that compromise the color stability (amine discoloration); thus, they are normally contraindicated with thin and translucent porcelain laminate veneers.[26] In the case of ceramic with a thickness of more than 0.7 mm, light-cured resin composites do not reach their maximum hardness. In these situations, a dual-cured luting composite is advisable.[11]

8. Discussion

Over the last three decades, dentistry has undergone an evolution of all ceramic systems for aesthetic rehabilitation. Conventional feldspathic porcelain was considered the best material for providing optimum aesthetic results for porcelain veneers for many years.[27]

In recent years, developments in dental ceramics has resulted in higher-strength porcelain, but such products appear to have limited translucency. In a given clinical scenario, the question is how much translucency is required. Various ceramic systems developed for porcelain veneers have differing degrees of translucency, and traditional feldspar porcelain is the most transparent of them, and the texture and shade of lithium disilicate ceramic influence its translucency; nevertheless, the thickness has the most significant effect. Translucent ceramics are indicated in full coverage and partial coverage crowns. They are aesthetic but have properties that are weaker in strength. Opaque ceramics are stronger and lack translucency. Hence, are not sensitive to the shade of luting cement.[28] Examples of translucent materials include traditional sintered feldspar porcelain produced from refractory dies or platinum foil, pressable ceramics (e.g., IPS Empress Esthetic) and some in-office machinable ceramics produced from computer-aided design / computer-aided manufacturing (e.g. Vitablocs Mark II).[29] On the opposite, Silva et al[30] stated that the lithium disilicate glass-ceramic crown (IPS E-max CAD) offers a higher fatigue load to exceed the failure value than the zirconium oxide crown (Y-TZP). An early veneer failure of IPS E-max ZirCAD was found in another study which also compared the fatigue behavior of the monolithic disilicate lithium against the veneered Y-TZP crown (IPS E-max ZirCAD).[31] One of the most common problems triggered by the restoration of zirconium is the chipping or fracturing of veneering ceramics.[32] The lithium-disilicate restoration, on the contrary, can be fabricated without the need for ceramic veneering as a single unit (monolithic). No significant differences in marginal adaptation were found. IPS E-max Press and IPS E-max CAD using extra-oral digital impression technique, whereas significant differences were encountered when IPS E-max CAD was fabricated using two different intraoral digital impression techniques.[33] Study conducted by Tidehag et al[34] observed fabricated by CAD/CAM technique had better marginal fit than prosthesis fabricated by lost wax technique. Anadioti et al[35] had the contradictory results showing marginal fit was better with IPS E-max Press as compared to than IPS E-max CAD.

Alkadi and Ruse et al.[36] conducted a comparative study on the fracture toughness of pressable IPS E-max and machinable IPS E-max according to the type of manufacturing process. The result showed that lithium disilicate which was fabricated by press technique and CAD-CAM technique has 400 Mpa and 360 Mpa of facture toughness, respectively.[37] Lower mechanical properties of machinable IPS E-max are due to reduces crystal size and crystal phase of lithium disilicate. Pressable IPS E-max has a high survival rate for thineers, partial and full veneer crowns, no-prep veneers. Machinable IPS E-max are indicated for inlay, onlay, partial coverage crowns, anterior and posterior crowns. An approach to

CAD/CAM machining 40% partially crystalized lithium metasilicate in the lithium silicate system increased flexural strength and resulted in less shrinkage of material. Consequently, lithium disilicate behaved perfectly with no fracture, chip or sensitivity. These findings offer many benefits for the restoration of natural teeth.[38]

9. Conclusion

A correct diagnosis and a multidisciplinary treatment plan are essential to improve the treatment prognosis and patient satisfaction. The use of porcelain laminates to improve smiles with aesthetic or functional problems has presented as recommended option. Clinicians must be aware of different types of all-ceramic material that are available in the market, have knowledge about the different ceramic system, characteristics, and properties of the material, in order to offer the suitable, esthetic and long-lasting cosmetic treatment.

Acknowledgement

Financial support and sponsorship: The authors received no specific funding for this work.

Conflicts of interest: There are no conflicts of interest.

REFERENCE

1. Kumar N, Srivastava S, Majumdar DS, Loomba K. Veneer in restorative dentistry. Asian J Oral Heal Allied Sci. 2012;2(1):17-25.
2. Pini NP, Aguiar FH, Lima DA, Lovadino JR, Terada RS, Pascotto RC. Advances in dental veneers: materials, applications, and techniques. Clin Cosmet Investig Dent. 2012;4:9.
3. Ustun O, Ozturk AN. The evaluation of stress patterns in porcelain laminate veneers with different restoration designs and loading angles induced by functional loads: A three-dimensional finite element analysis study. Nigerian journal of clinical practice. 2018;1;21(3):337.
4. Abo-Elmagd AA. IPS-emax Press ceramic laminate veneer restoration. International Journal of Science and Research. 2019;7(2):32-7.
5. Varma A. Smile makeover in a Patient with severe dental fluorosis using ceramic laminate veneers: A Case Report. International Journal of Science and Research.2019;
6. Abuzenad BM, Alanazi AS, Al saydali WM, El-Marakb AM, Koshak HA, Alharthi AA Current classifications and preparation techniques of dental ceramic laminate veneers (review article). Int J Adv Res. 2017;5(12):1973-9
7. Vanlıoğlu BA, Kulak-Özkan Y. Minimally invasive veneers: current state of the art. Clin Cosmet Investig Dent. 2014;6:101
8. Patricia UV. Clinical consideration, lens and ceramic veneers, and its applicable ceramic material. EC Dental Science 18.4 (2019): 794-806.
9. Faus-Matoses V, Faus-Matoses I, Ruiz-Bell E, Faus-Llácer VJ. Severe tetracycline dental discoloration: Restoration with conventional feldspathic ceramic veneers. A clinical report. J Clin Exp Dent. 2017;9(11):1379-82.
10. Sajjad A, Bakar WZ, Mohamad D, Kannan TP. Porcelain laminate veneers: A conservative approach for pleasing esthetics-An overview. 2017;3:3.
11. Sadaqah NR. Ceramic laminate veneers: materials advances and selection. Open Journal of Stomatology. 2014;4:268-279.
12. Chaipattanapruk T, Chalermpol Leevailoj DD, Sirivimol Srisawasdi DD. The use of ceramic veneers to mask moderately tetracycline-stained teeth: a case report. CU Dent J. 2014;37:207-4.
13. Luthardt RG, Sandkuhl O, Reitz B. Zirconia-TZP and alumina--advanced technologies for the manufacturing of single crowns. Eur J Prosthodont Restor Dent. 1999;7(4):113-9
14. Kelly JR. Dental ceramics: what is this stuff anyway? J Am Dent Assoc. 2008;139:S4-7.
15. Souza R, Barbosa F, Araújo G, Miyashita E, Bottino MA, Melo R, Zhang Y. Ultrathin monolithic zirconia veneers: reality or future? Report of a clinical case and one-year follow-up. Operative dentistry. 2018;43(1):3-11.
16. Font AF, Ruiz FS, Ruíz MG, Rueda CL, González AM. Choice of ceramic for use in treatments with porcelain laminate veneers. Med Oral Patol Oral Cir Bucal. 2006;11(3):297-302.
17. Moreira A, Freitas F, Marques D, Caramês J. Aesthetic rehabilitation of a patient with bruxism using ceramic veneers and overlays combined

with Four-Point Monolithic Zirconia Crowns for Occlusal Stabilization: A 4-Year Follow-Up. Case reports in dentistry. 2019;20;2019.
18. Gürel G. The science and art of porcelain laminate veneers. London: Quintessence,; 2003.
19. Nagarsekar A, Aras M. Role of anterior guidance in esthetic and functional rehabilitation. J. Indian Prosthodont. Soc. 2008;1;8(4):225.
20. Miyajiwala JS, Kheur MG, Patankar AH, Lakha TA. Comparison of photographic and conventional methods for tooth shade selection: A clinical evaluation. J Indian Prosthodont. Soc. 2017;17(3):273.
21. Rathee M, Bhoria M, Malik P. Shade matching in aesthetic dentistry: An overview. Medical Science. 2014 Sep;3(9).
22. Heffernan MJ, Aquilino SA, Diaz-Arnold AM, Haselton DR, Stanford CM, Vargas MA. Relative translucency of six all-ceramic systems. Part I: core materials. J Prosthet Dent. 2002;88(1):4-9.
23. Kandil BS, Hamdy AM, Aboelfadl AK, El-Anwar MI. Effect of ceramic translucency and luting cement shade on the color masking ability of laminate veneers. J Dent Res. 2019;16(3):193.
24. El Mourad IS. Aesthetic rehabilitation of a severe dental fluorosis case with ceramic veneers: A step-by-step guide. Case reports in dentistry. 2018; 2018.
25. Vargas MA, Bergeron C, Diaz-Arnold A. Cementing all-ceramic restorations: recommendations for success. J Am Dent Assoc. 2011; 142:20S-4S.
26. Muhamad AH, Abdulgani M, Ayah J, Ameer S, Abdulgani A. Porcelain laminates: the future of esthetic dentistry. OSR-JDMS Journal of Dental and Medical Sciences. 2017; 16(5):68-75.
27. Magne P, Belser U. Bonded porcelain restorations in the anterior dentition: a biomimetic approach. Chicago: Quintessence; 2002. p. 293-334.
28. Malament KA, Socransky SS. Survival of Dicor glass-ceramic dental restorations over 16 years, part III: effect of luting agent and tooth or tooth-substitute core structure. J Prosthet Dent 2001;86(5): 511-519.
29. Spear F, et al. which all- ceramic syatem is optimal for anteriaor esthetics?. J Am Dent Assoc 2008; 139: 195-235.
30. Silva NR, Thompson VP, Valverde GB, Coelho PG, Powers JM, Farah JW, et al. Comparative reliability analyses of zirconium oxide and lithium disilicate restorations in vitro and in vivo. J Am Dent Assoc. 2011; 142: 4-9
31. Guess PC, Zavanelli RA, Silva NR, Bonfante EA, Coelho PG, Thompson VP. Monolithic CAD/CAM lithium disilicate versus veneered Y-TZP crowns: comparison of failure modes and reliability after fatigue. Int J Prosthodont. 2010; 23: 434-442.
32. Ritter RG. Multifunctional uses of a novel ceramic-lithium disilicate. J Esthet Restor Dent. 2010; 22: 332-341.
33. Kim JH, Jeong JH, Lee JH, Cho HW. Fit of lithium disilicate crowns fabricated from conventional and digital impressions assessed with micro-CT. J Prosthet Dent. 2016.
34. Tidehag P, Ottosson K, Sjogren G. Accuracy of ceramic restorations made using an in-office optical scanning technique: an in vitro study. Oper Dent. 2014; 39: 308-316.
35. Anadioti E, Aquilino SA, Gratton DG, Holloway JA, Denry IL, Thomas GW, et al. Internal fit of pressed and computer-aided design/computer aided manufacturing ceramic crowns made from digital and conventional impressions. J Prosthet Dent. 2015; 113: 304-309
36. Alkadi L, Ruse ND. Fracture toughness of two lithium disilicate dental glass ceramics. J Prosthet Dent. 2016; 116: 591-596.
37. Tinschert, J.; Zwez, D.; Marx, R.; Anusavice, K.J. Structural reliability of alumina-, feldspar-, leucite-, mica- and zirconia-based ceramics. J. Dent. 2000, 28, 529–535.
38. Qamheya AHA, Qamheya M and Arisan V. Lithium Disilicate Restorations: Overview and A Case Report. J Dent & Oral Disord. 2016; 2(9): 1047.