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Types of Dental Veneers and Bonding of Veneers to Tooth Structure

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Abstract: Veneer is a thin sheet of material placed on the facial surface of anterior teeth, for aesthetic purposes and protection. It is a thin layer of restorative material that replaces the enamel. Veneers are the restoration of choice for a conservative and esthetic approach as they give the patient a perfect smile. The following article highlights the history of dental veneers, Indications and contraindications of dental veneers, Classification of dental veneers according to the preparation type, application method & the material used, Advantages & Disadvantages of dental veneers, Treatment required for the fitting surface of veneers & tooth surface before cementation and finally Cementation.

Keywords: *dental veneers, ceramic Veneers, thineers, Lumineers and composite veneers*

I. Introduction

Veneer is a thin sheet of material placed on the facial surface of anterior teeth, for aesthetic purposes and protection. It is a thin layer of restorative material that replaces the enamel. Veneers are the restoration of choice for a conservative and esthetic approach as they give the patient a perfect smile.

Lumineer is an exceptionally thin shell like structure (0.3 mm thickness), placed on the tooth structure with a permanent bonding agent. This is one of the most conservative procedures and only a maximum of 0.3mm of tooth structure is removed if required. Lumineers are also called thineers / ultra-thin veneer / no-prep veneers.(1)

In 1928, **Dr Charles L Pincus** introduced the concept of veneering anterior teeth with laminates in Hollywood. This was to enhance an actor's appearance for close-ups in movie industry. Dr Pincus attached these thin veneers temporarily with a denture adhesive powder.

In 1970, after the introduction of light cured composites. Dentists have the necessary working time to properly shape direct laminate veneers.

In 1979, the “Mastique laminate veneer system (caulk)” the pre-fabricated composite veneer. The first commercial veneering system. These veneers were fabricated using indirect acrylic resin and were bonded to the etched enamel using an ultraviolet light–cured resin composite as the cementing layer.

The use of resin composite veneers presented several problems such as loss of luster over time and staining, biological incompatibility, these restorations did not employ any tooth preparation, a bulk of material was necessary to obtain a pleasing appearance thus leading to gingival inflammation due to overcontoured restorations.

In 1975, Rochette explained the concept of acid etching porcelain and bonding to the tooth, and described a technique for making ceramic restorations. Next in evolution came the procedure referred to as ‘laminating’ where veneer facings were bonded to etched tooth structure. Porcelain veneer was a definite improvement over resin veneers but poor bond between the veneer and the tooth still persisted.

In the early 1980s a method of bonding porcelain to acid etched enamel was developed. Etching the porcelain with hydrofluoric acid or a derivative increases the shear bond strength between composite resin luting agent and the porcelain veneer by a factor of four when compared to unetched porcelain.(2)

With the significant improvement in ceramics, luting composites and successful bonding to the tooth structure, this directed clinicians towards minimal invasive dentistry. One such recent modality in veneer is Porcelain Thineer. Porcelain Thineers can be as thin as 0.1 mm and it offers a predictable and successful treatment option in certain cases such as tetracycline staining or mild fluorosis. The aim of the Thineers is to avoid extensive tooth preparation and reinforce the remaining tooth structure present. The advantage of Thineer is preserving the natural tooth structure as much as possible and yet achieving the cosmetic needs of the patient.(1)

II. General indication and contraindication of veneers (3)

Indications:

1. Extreme discoloration that cant be treated by bleaching
2. Small enamel defects as enamel cracks
3. Diastema & multiple spacing between teeth
4. Mal-positioned teeth or tooth shape anomalies.

Contraindications:

1. Insufficient tooth structure
2. Actively erupting tooth
3. Parafunctional habits
4. Endodontically treated teeth

Magne and Belser classification for the indication of ceramic veneers (3)

Type-1 Teeth resistant to bleaching
Type 1A- Tetracycline discoloration Type 1B- Teeth unresponsive to bleaching
Type-2 Major morphological modification
Type 2A- Conoid teeth Type 2B- Diastema or interdental triangles to be closed Type 2C- Augmentation of incisal length or facial prominence
Type-3 Extensive restoration
Type 3A- Extensive coronal fracture Type 3B- Extensive loss of enamel by erosion or wear Type 3C- Generalized congenital malformation

Type I patients are candidates for conventional ceramics, whereas type II patients require high-resistance ceramics. Type IB patients require simple esthetic facets, although in this case the substrate teeth present color alterations. Therefore, independent of the need for shape modifications, the selected ceramic material must be able to hide the underlying substrate color. In these cases, both the porcelain and cement must present various degrees of opacity to hide the color alterations. In Type II patients, feldspate or alumina ceramics of high resistance, and oxide ceramics are indicated.(4)

III. Classification of dental veneers

III.A) According to type of preparation (3)

1. Window preparation: the incisal edge of the tooth is preserved

2. **Feather preparation**: The incisal edge of the tooth is prepared, but incisal length is not reduced.

3. **Bevel preparation**: The incisal edge of the tooth is prepared Bucco-palatally and the length of the edge is reduced to 0.5 to 1 mm.

4. **Incisal overlap preparation**: The incisal edge of the tooth is prepared Bucco-palatable, and length is reduced to 2 mm; in this case, the veneer is extended to the palatal aspect of the tooth. This places the veneer under compression thus gives better results. Moreover, it allows easier seating of multiple veneers and minimize the risk of fracture. (4)

III.B) According to the application method: (3)

- **Direct laminate veneers**

Laminate composite veneer restoration can be directly applied. In a direct composite technique, the material is directly applied onto the prepared tooth surface followed by intraoral polishing. The disadvantage of the direct composite is its inferior mechanical properties, low resistance to wear, discoloration with time, and fracture.

- **Indirect laminate veneers**

This technique could be done using resin composite or ceramic materials. The indirect composite veneers have advantages of having high resistance against attrition, fracture and discoloration as compared to direct composite veneers but come with a disadvantage of increased dental visits and cost.

- **The direct-indirect technique**

This technique is done using resin composite. It combines both the above technique in which the first layer of high-value opaque hybrid of the resin followed by the second layer of translucent hybrid resin and final layer of translucent microfill composite resin is applied onto the tooth surface and sculpted to desired morphology. It is then teased-off at the veneer-tooth interface and is polished and heat-treated for improving physical properties. After the tooth preparation, veneers are restored onto the tooth using an appropriate luting agent.

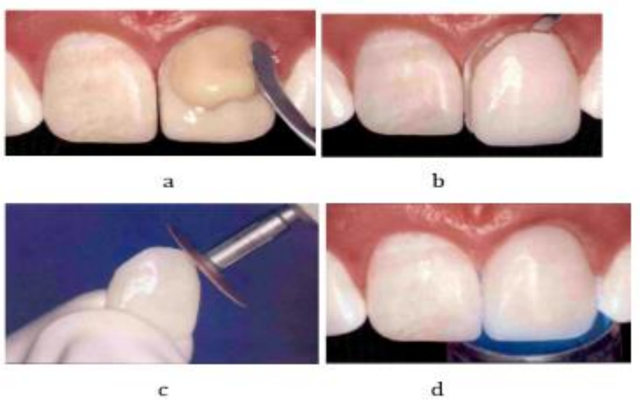
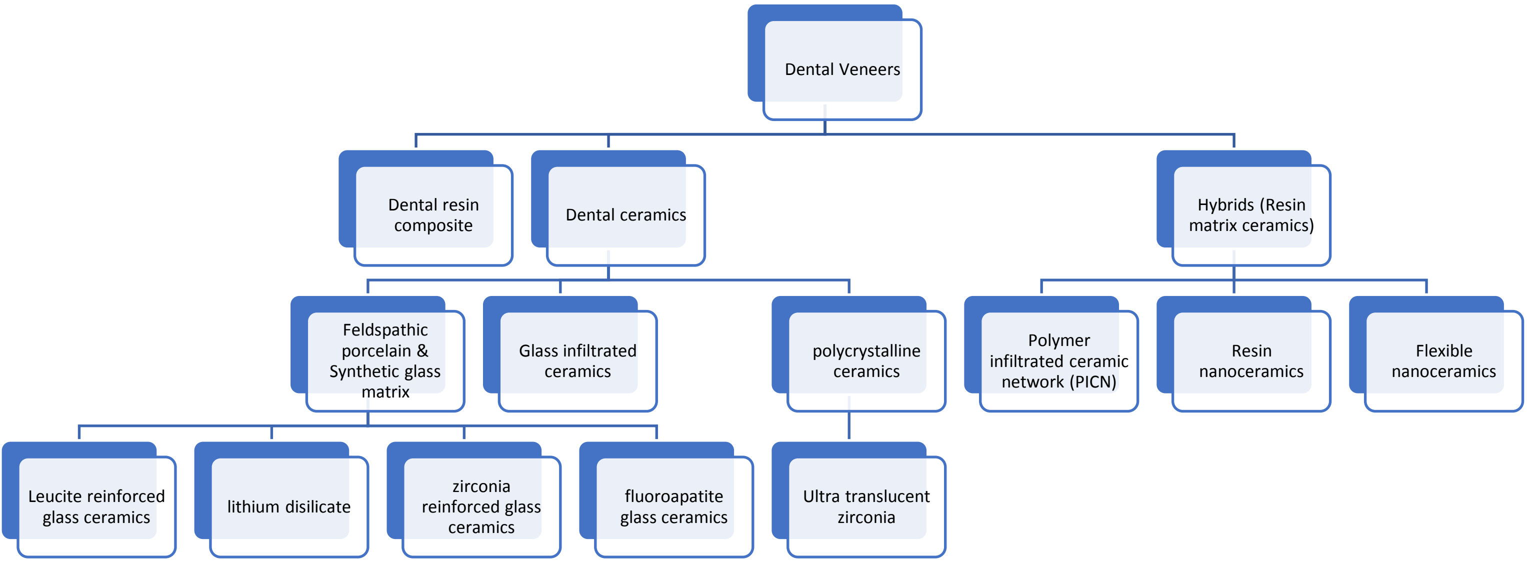


Figure: *Showing a) layer of translucent microfill composite b) teasing off the composite veneers c) polishing and adjustment d) light curing of composite veneer post etching and bonding agent application*

III.C) According to the material used (4)



Dental Resin Composite (5)

Resin-based composites are restorative materials that have mainly the following three compositions: 1) resin matrix 2) inorganic filler 3) coupling agent. The most commonly used monomer in the resin is Bis-GMA which has a higher molecular weight than methyl methacrylate resins. Therefore, the polymerisation shrinkage of Bis-GMA (7.5%) is significantly less than that of methyl methacrylate resins (22%).

The bonding between the resin and the filler is achieved by the use of coupling agents i.e. salines, the most commonly one that is used in resin composite is γ- MPTS.

New generations of composites are introduced by the dental company through the years, aiming for better aesthetic and physical properties as nanosized particles (nanomers 20-75nm and nanoclusters 0.6 µm). This small sized nanoparticles with high filler loading (80%) improved mechanical properties (flexural strengths, elastic modulus, fracture toughness and hardness), reduced polymerization shrinkage, high translucency, better polishability and gloss retention.

- **Advantages**
  - It can be used directly, resulting in less chair time.
  - Composite veneers do not require heavy preparations. Therefore enamel can be preserved for good adhesion.
  - Easier to repair than ceramic veneers
  - Lower cost than ceramics.
- **Disadvantages**
  - Prone to discolouration and wear.
  - The clinician skills in placing, finishing and polishing of the composite plays a major factor in the aesthetic outcome.
  - Needs to be replaced more frequently than ceramic veneers.

Dental Ceramics

1. **Feldspathic veneers** (6, 7)

Composition and microstructure:

Feldspathic porcelains are composed mainly of feldspar (potassium aluminum silicate and sodium aluminum silicate as glassy phase (55–65%) responsible for the translucency of the restoration and silica as crystalline phase. Feldspar is a greyish mineral that can be found in rocks rich with iron and mica.

Properties

Feldspathic porcelain provides great aesthetic value and demonstrates high translucency, just like natural dentition.

Feldspathic porcelain's mechanical properties are low, with flexural strength usually from **60 to 70 MPa**. Due to the nature of the glass matrix materials and the absence of core material, the veneering porcelains are much more susceptible to fracture under mechanical stress.

Clinical considerations:

Good bond, in combination with a stiffer tooth substructure (enamel), is essential to reinforce the restoration. Currently, requests for less-invasive treatments and higher levels of aesthetics have enhanced the indication of feldspathic veneers.

It is possible to have a thickness of less than 0.5 mm, with or without preparation in the enamel.

Advantages (5)

- Could be used in **very thin** thickness so it can be almost translucent which result in an appearing natural restoration.
- It requires **minimal tooth preparation**. Therefore enamel can be preserved.
- It is possible to etch feldspathic porcelain with hydrofluoric acid which gives a great bonding strength to the remaining enamel.

Disadvantages.

- Layering method is technique sensitive
- Masking heavy discoloured teeth can be difficult because the porcelain is very thin and highly translucent.

Fabrication method:

- By using a **layering and firing process**, ceramists developed veneers that could be made as optically close to natural teeth as possible.
- **CAD/CAM** method
  - VITABLOCS® are the most used feldspar-based CAD/CAM ceramics with an average grain size of 4μm and flexural strength of **154MPa.**
  - VITABLOCS® TriLuxe (2003) and TriLuxe forte (2007). VITABLOCS® TriLuxe includes three, while TriLuxe forte four layers of different shade intensity from the cervical to the incisal edge, especially suitable for veneers.
  - VITABLOCS® RealLife (2010), multichromatic feldspar ceramic with different colour intensity in three dimensions

2. Synthetic glass-based ceramics (6)

Composition and microstructure:

The glassy phase possesses the usual properties of glass such as translucency, brittleness and non- directional fracture pattern. The crystalline phase improves light scattering and opacity, and provides the ceramic material with strength and stability.

The crystals are "artificially" created by controlled nucleation and crystallisation. The size and distribution of the crystals are determined by the composition and processing of the base glass and the subsequent heat treatment. This process allows "tailor-made" materials to be produced, which exhibit homogeneous structure, good optical properties, appropriate wear characteristics, as well as optimal strength.

Increased strength in glassy ceramics is achieved by adding appropriate fillers that are uniformly dispersed throughout the glass, such as leucite, lithium disilicate, zirconia, and fluorapatite. (6)

- **Leucite-reinforced ceramic** (IPS Empress CAD, Ivoclar Vivadent) consists of leucite crystals (35–45 vol%) that are homogeneously distributed into the glassy matrix.

Properties

Due to the high silica content (60–65 wt%) this ceramic has improved translucency, fluorescence and opalescence, while the crystalline content is responsible for the flexural strength of **160 MPa** and ability to absorb the fracture energy that results in arrested or slowed down crack propagation.

- **Lithium disilicate ceramic** (IPS e.max CAD, Ivoclar Vivadent) is comprised of approximately (70 vol%) of crystalline phase incorporated in the glassy matrix. Which are randomly-oriented, densely distributed, elongated fine-grained lithium disilicate crystals (1.5 μm in length)

Properties

It has excellent mechanical properties and fracture toughness. Flexural strength **360 ± 60 MPa.** It also has a high esthetic due to the relatively low refractive indices of the crystals and good bonding strength.

- **Zirconia-reinforced lithium silicate** is glass-ceramic material enriched with highly dispersed zirconia (Celtra Duo and VITA Suprinity®). The crystalline phase consists of 25 % lithium metasilicate (Li_2SiO_3) and 11% lithium disilicate ($Li_2Si_2O_5$) crystals. zirconia (8–12 %) acts as a nucleating agent but remains dissolved in the glassy matrix.

Properties

Flexural strength of **370-420 MPa** after glazing, due to the lithia and particularly zirconia content.

Zirconia reinforced lithium silicate shows higher translucency when compared to lithium disilicates due to the addition of zirconia that ensures nucleation process, resulting in more homogenous, finer crystals of size (0.5 µm) compared to the needle-shaped coarser crystalline structure (1.5 µm) of lithium disilicate glass- ceramic. (8)

Moreover, natural opalescence & fluorescence are achieved. As crystallites have size of 0.5- 0.7 µm corresponds to the wavelength range of natural daylight thus mimicking the opalescence behaviour of the tooth enamel, and together with the high glass content are responsible for the fluorescence of the restoration.

Fluorapatite glass-ceramics (IPS e.max Ceram and IPS e.max ZirPress, Ivoclar Vivadent) contain fluorapatite crystals $Ca_5(PO_4)_3F$ in various sizes embedded into the glassy matrix. The crystals, responsible for material's opalescence.

Properties

The flexural strength is approx. **120 MPa**.

The flexural strength of IPS e.max Ceram is significantly lower than IPS e.max ZirPress due to the pores present in the material, result of an air-bubbles' incorporation during mixing the ceramic powder with the mixing liquid (due to different fabrication methods).

Fabrication method:

IPS e.max Ceram is a nano-fluorapatite layering ceramic in the form of a powder, used for the production of veneers or as veneering material for glass or oxide ceramics.

IPS e.max ZirPress are pressable ingots suitable for the production of veneers and veneering of zirconia substructures using press-on-zirconia technique.

3. **Glass-Infiltrated ceramics (**7)

Composition and microstructure

The glass-infiltrated ceramics belong to a group of ceramic-glass interpenetrating phase composites as they have at least two interpenetrating phases intertwined throughout the material. The porous ceramic skeleton is infiltrated with lanthanum glass in a second firing, thus increasing the strength of the restoration. (VITA In-Ceram^{TM} SPINELL).

Properties

Flexure strength (**400 MPa**) with very high translucency.

Fabrication method

The ceramic material is fabricated utilising **the slip-casting** or **CAD/CAM** technique.

N.B. The use of this class of materials is abandoned due to the complexity and sensitivity of the manufacturing process, as well as the increased popularity of lithium disilicate ceramic.

4. **Cubic (Ultra-translucent) Zirconia (**7)

Composition and microstructure

Utra-translucent multilayer katana Zirconia blocks

The material shows nano sized crystals with grain sizes ranges from 50 nm to 400 nm contains approximately 95 wt. % ZrO_2 and 0.11–0.26 wt. % Al_2O_3.

Advantages

• The flexural strength approx. **557 MPa**

• It is more translucent than tetragonal zirconia. This is due to the isotropic optical properties of cubic crystals that enable a more uniform transmission of light, in addition to reducing the amount of alumina in the material and decreasing grain size.

Hybrid (Resin-Matrix Ceramics) (7)

1. **Resin nanoceramic**

Composition and microstructure

Lava Ultimate from 3M ESPE has been marketed as ‘Resin Nano Ceramic’ (RNC) as it contains 80% by weight nanoceramic particles (nanomer 4-20 nm in diameter and nanocluster 0.6-10 μm particles) bound in a highly cross-linked polymeric matrix. Both nanomers and nanoclusters are treated with a silane coupling agent so that chemical bonds can be provided between ceramic particles and the resin matrix. The material is processed several hours in a special heat treatment process, which results in highly cured material, so there is no need of further firing after milling.

Properties

Flexural strength (**200 MPa**)

Resin Nanoceramic has flexure strength, fracture strength and wear resistance higher than composite materials (provided by nanoclusters), and with significantly improved polishability and optical properties.

The polymeric resin as a matrix contributes to some properties that composites have: the material is not brittle and is fracture resistant, with shock absorbing characteristics.

2. Polymer Infiltrated Ceramic Network (PICN).

Composition and microstructure

VITA Enamic has two 3- dimensional network structures interpenetrating one in another; the dominant fine-structure feldspar ceramic network (86 wt %) is strengthened by a polymer network consisting of methacrylate polymer (14 wt %). Both of the networks are interconnected through the chemical bonds obtained by the coupling agent.

Properties

The flexural strength of this two-phase material can reach a value of about **150–160 MPa,** significantly higher than that of a porous ceramic (below 30 MPa) and polymer (135 MPa) alone.

3. Flexible Nano Ceramic

Composition and microstructure

CERASMART from GC, referred to as “Flexible Nano Ceramic”, as it has the highest flexural strength in its category. It is composed of nano-sized, uniformly distributed particles of alumina-barium-silicate embedded in a polymer matrix.

Properties

The flexural strength is approx. **242 MPa**

Advantages of hybrid resin matrix ceramics:

- All hybrids have a modulus of elasticity similar to dentin
- Resilience is significantly higher than feldspar-based and glass-ceramics, thus significantly higher energy can be absorbed without permanent deformation or failure.
- Milling time in the CAM unit is shorter compared to other ceramic materials,
- Longer lifetime oF the milling burs.
- There is no need for sintering or crystallization firing after milling.
- Final gloss and smoothness of the restoration can be achieved by surface polishing.
- Hybrids are wear resistant and “gentle” to the opposite dentition
- Restorations can be easily repaired in the mouth, although these materials are characterized by virtually no chipping.

IV. **Advantages of ceramic veneers** (9)

- **Color:** Porcelain offers natural look and more color stability.
- **Resistance to abrasion**: Porcelain is exceptionally high wear and abrasion resistance as compared to composite resins.
- **Strength:** Porcelain veneer restorations develop high shear and tensile strengths.
- **Periodontal health**: Highly glazed porcelain surface resists plaque accumulation thus maintaining periodontal health

V. **Disadvantages of ceramic veneers** (9)

- **Cost:** It has higher cost than direct composite veneers
- **Time**: Veneering is a highly technique sensitive procedure and require multiple visits.
- **Brittleness:** Veneers are extremely brittle and difficult to manipulate during try-in and cementation stages.
- **Repair:** difficult once veneers are cemented to the enamel.
- **Color:** is difficult to modify once the veneer has been cemented to the enamel surface.

VI. **Treating the Fitting Surface of the Veneer**

The enhancement of bonding through modifying the internal veneer surface is advocated in order to increase the intimacy of the bond; this may be achieved by different methods. The aim of pre-cementation surface modification is to increase the surface area available for bonding and to create irregularities that increase the strength of the bond to the resin luting cement.

The treatment of the veneer fitting surface is different according to its composition.

A. Surface treatment of resin composite veneers:

Roughening the internal surface of indirect resin composite veneers with **sandblasting** or a **diamond bur** is effective to create micro-mechanical retentions. This is followed by cleaning with alcohol.

B. Surface treatment of glass based veneers and Silanization (6)

Feldspathic ceramic, leucite, lithium disilicate, and zirconia-reinforced ceramic. All of these must be conditioned with hydrofluoric acid and silane. Acid conditioning with hydrofluoric acid dissolves the glassy matrix surrounding the crystalline phase,leaving retentive areas between the acid-resistant crystals. It also allows a micro-mechanical bond with resin cement. Moreover, it is efficient in removing superficial defects and rounding off the remaining flaw tips, thereby reducing stress concentrators and increasing the overall strength. The difference between these systems is the period of acid conditioning with hydrofluoric acid.

N.B. The acid should be thoroughly cleansed with air–water spray and ultrasonic distilled water bath for 5 minutes to remove any residues remaining on the surface then dried before silanization step. (10, 11)

Silanization of etched porcelain with a bifunctional coupling agent provides a chemical link between the luting resin composite and porcelain. A silane group at one end chemically bonds to the hydrolyzed silicon dioxide at the ceramic surface and a methacrylate group at the other end copolymerizes with the adhesive resin.

Restorations are dried and silane primer is applied to the fitting surface, which helps provide a chemical covalent bond to the ceramic.

C. Surface treatment of cubic zirconia veneers

Since cubic zirconia is a polycrystalline structure, it cannot be etched by HF as it shows less effective adhesion when compared to silica-based ceramics. Hence, other surface treatments have been offered to modify its surface and optimize the adhesion to resin cements such as; gritblasting with aluminum oxide, and etching with hot strong acids to produce surface roughness, or tribochemical silica coating followed by silanization aiming to obtain chemical bond.

N.B. Thorough cleansing should be done after surface treatment with air–water spray and ultrasonic distilled water bath for 5 minutes to remove any residues remaining on the surface then dried before silanization step. (10, 11)

D. Surface treatment of hybrid ceramic veneers

Most of the currently available in vitro studies revealed that hydrofluoric acid etching with silane application are the ideal pretreatment. The hydrofluoric acid partially dissolves the glass phase and provides micromechanical interlocking with the composite cement.

VII. Tooth preparation

The preparation of teeth greatly influences the durability and color of the ceramic restoration, since the tooth preparation will determine the inner superficial contour and the thickness of the ceramic material. This stage is determined by the tooth condition, the indications of the clinical situation, and the chosen material. Although early concepts suggested minimal or no tooth preparation, current belief supports removal of varying amounts of tooth structure. Enamel reduction is required to improve the bond strength of the resin composite to the tooth surface. In doing so, the aprismatic surface of mature unprepared enamel, which is known to offer only a minor retention capacity, is removed. In addition and when possible, care must be taken to maintain the preparation completely in enamel to provide an optimal bond with the porcelain veneer. Although the results of the newest generation dentin adhesive systems are very promising, the bond strength of porcelain bonded to enamel is still superior when compared with the bond strength of porcelain bonded to dentin. Thus, one of the main objectives of the technique is to maintain the entire contour in intact enamel whenever possible, because the better the adhesion between the veneer and the prepared tooth, the better the stress distribution in the system enamel–composite–ceramic.

VIII. Treatment of Tooth Surface (Enamel and dentin)(2)

The enamel surface must be conditioned with phosphoric acid (37%) for 20 seconds. This procedure increases the surface energy of the enamel structure and surface roughness, which leads to a perfect wetting of the surface with the bond.

Incase of exposed dentin within the preparation, sealing this structure with a dental bonding agent is suggested immediately after the completion of tooth preparation and before the final impression, because the newly prepared dentin is ideal for the adhesion. This technique is called "**resin-coating technique**," . it is done by adding a layer of low viscosity resin on the dentin immediately after tooth preparation. This procedure increases the **bond strength** and reduces **crack formation**, **bacteria infiltrations**, and **postoperative sensitivity**. Moreover, it allows enamel acid conditioning while avoiding the conditioning of the dentin.(6)

IX. Cementation (4, 6)

The success of the porcelain veneer is greatly determined by the strength and durability of the bond formed between the three different components of the bonded veneer complex: the tooth surface, the porcelain veneer, and the luting composite.

For cementation of porcelain veneers, a **light-curing luting composite** is preferred. A major advantage of light-curing is that it allows for a longer working time compared with dual- cure or chemically curing materials. This makes it easier for the dentist to remove excess composite prior to curing and greatly shortens the finishing time required for these restorations. In addition, their color stability is superior compared with the dual-cured or chemically cured systems.

Nevertheless, it is important that there is enough light transmittance throughout the porcelain veneer to polymerize the light-curing luting composite. The porcelain veneer absorbs between 40% and 50% of the emitted light. The thickness of the porcelain veneer is the primary factor determining the light transmittance available for polymerization. The color and the opacity of the porcelain would have less influence on the amount of absorbed light.

The opacity of porcelain became more important for facings with a thickness of 0.7 mm or more. Consequently, the presence of a porcelain veneer increases the setting time of the resin composite used beneath the veneer.

In case of porcelain with a thickness of more than 0.7 mm, light-cured resin composites do not reach their maximum hardness. A dual-cured luting composite, which contains the initiation systems for both chemically and light-cured composites, is advisable in these situations. With these latter luting agents, a stronger bond can be obtained with the porcelain. Furthermore, higher values of hardness were reported for the dual-cure resin cements than for the light-cured luting composites, because of their higher degree of polymerization.

X. **Clinical Evidence** (4)

The success rate of Ceramic Veneers has been clinically evaluated through a time range up to 20 years. The rate of success reported in these studies varies between 75% and 100%. Fracture, microleakage, and debonding are types of failures seen in Ceramic Veneers. (12-15)

Burke et al reported that survival rates of CVs are **rarely 100%**. The preparation of the teeth greatly influences **the durability** and **color** (translucency and tonality) of the ceramic restoration.

Veneer **preparation into dentin** adversely affects survival.

Tooth preparation will determine the **inner contour** and the **thickness** of the ceramic material.

A veneer requires a minimum of 0.1 mm to 0.3 mm of thickness for each shade change, thus affecting the amount of reduced tooth structure. (16)

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