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# Factors that affect the success of laminate veneer restorations

## Lamine veneer restorasyonlarda başarıyı etkileyen faktörler

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**ABSTRACT**

Laminate veneers are restorations applied to dental tissue with or without minimal preparation. Laminate veneers have recently been a fairly common treatment in dentistry, with aesthetic concerns coming to the fore in patients. But the indications of these restorations should be taken into account, and treatment should be decided after an accurate diagnosis and planning. With the spread of laminate veneers, research on success rates has also come to the fore. It is believed that the factors affecting success in laminate veneers are multifactorial. Laminate veneers are a conservative form of treatment and require precise technique and attention. There are various types of preparations applied according to the patient in laminate veneers. Different materials can be used in laminate veneer restorations and require a precise simification procedure. In this article, the effects of these factors on treatment and their role in success are examined.

**Keywords:** Laminate veneers, failure of causes,ceramic

**ÖZ**

Lamine veneerler diş dokusundan minimal preparasyon yapılarak ya da preparasyon uygulanmadan yapılan restorasyonlardır. Lamine veneerler son zamanlarda hastalardaki estetik kaygıların ön plana çıkmasıyla birlikte diş hekimliğinde oldukça sık uygulanan bir tedavi olmuştur. Fakat bu restorasyonların endikasyonları dikkate alınmalı ve doğru bir tanı ve planlamadan sonra tedaviye karar verilmelidir. Lamine veneerlerin yaygınlaşmasıyla birlikte başarı oranları hakkındaki araştırmalar da ön plana çıkmıştır. Lamine veneerlerde başarıyı etkileyen etkenlerin multifaktöriyel olduğu düşünülmektedir. Lamine veneerler konservatif bir tedavi şeklidir ve hassas bir teknik ve dikkat gerektirir. Lamine veneerlerde hastaya göre uygulanan çeşitli preparasyon türleri vardır. Lamine veneer restorasyonlarında farklı materyaller kullanılabilmektedir ve hassas bir simantasyon prosedürü gerektirirler. Bu makalede bu etkenlerin tedaviye etkileri ve başarıdaki rolleri incelenmektedir.

**Anahtar Kelimler:** Laminate venerler, başarısızlık nedenleri, seramik

## INTRODUCTION

Since the advent of ceramic restorations in the 20th century, restoring the lost natural aesthetic appearance of teeth has been of great importance to dentists.[1] Since the 1930s, dental veneers have been aesthetically developed, and laminate veneers (LV) have been used as a minimally invasive treatment option as an alternative to full crowns.[2,3] While thicker materials were previously used to mask problems such as discoloration, 1 mm thick cross-linked polymeric veneers were introduced and started to be used in 1975.[4] In the 1980s, adhesive cementation techniques were developed, and after this development, ultra-thin laminates were introduced.[5] Initially, Calamia[6] described in 1984 the treatment of porcelain with hydrofluoric acid and silane to create an adhesive interface that forms the basis of porcelain laminate veneers.

These developments in adhesive systems have supported the growing demand for the treatment of unaesthetic teeth with porcelain laminates as a result of the development of new-generation porcelain technology.[7] The dental literature has long reported various definitions of different preparation designs for ceramic veneers. Replacing lost tissues and gaining aesthetics in prosthetic dentistry has improved in a number of aspects. With the developments in dental ceramics and resin cements, the

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interest in aesthetic restorations has increased.[8] Various treatment options have become possible, especially in anterior teeth. Thus, laminates have been one of the most important developments in terms of providing aesthetics in teeth without excessive substance loss. At the same time, prevention of undesirable conditions such as pulpal irritation, loss of excess material, loss of retention seen in crowns with the emergence of laminates has been an important development for dentistry. Laminate veneers, in particular, require minimal tooth preparation of only 0.3-0.9 mm; this is a very conservative treatment compared to the full crown alternative.[9] Laminate veneers are also biocompatible with periodontal and dental tissues.[10] Laminate veneers provide high aesthetics, and good clinical results have been observed in studies.

Calamia and Calamia[11] suggested that a successful porcelain veneer depends on the following factors:

1. Planning the case
2. A conservative (enamel-protecting) preparation on the tooth
3. Proper porcelain selection
4. Selection of suitable material method for cementation
5. A suitable finishing and polishing in the restoration
6. Planning for ongoing regular follow-up of the restoration

However, the first step in obtaining a good clinical outcome is to apply the treatment to the correct indication. These indications include (1) tetracycline discoloration, fluorosis, amelogenesis imperfecta, and discoloration that may occur due to age and other factors; (2) fractured and worn teeth; (3) abnormal tooth morphology; (4) correction of small malpositions;[12,13] (5) in cases of abrasion and erosion that cause enamel loss; (6) teeth with wedge defect due to toothbrush wear; (7) rotation of teeth[14]; and (8) presence of diastema.

In these cases, laminate restorations are considered to be suitable as they will be sufficient to cover only the labial surface instead of covering the entire surface of the tooth. There are 2 types of coloration in the tooth, external and internal. Conditions such as tetracycline discoloration and fluorosis may cause internal discoloration. In addition, due to aging, thinning of the enamel and more pronounced dentin color are likely observed. Bleaching treatment is contraindicated in age-related and internal discolorations. The incisal rehabilitation feature of the laminates can be used in teeth with worn incisal surfaces. Laminate restorations are indicated for these defects, as toothbrush-induced wedge defects are more common on the labial surface. In particular, laminates have been used very frequently in the closure of polydiastemas recently. However, the size of these diastemas is important. In the presence of very large diastemas, the support of ceramic veneers may be insufficient. In these cases, full crowns may be preferred instead of laminate veneers. In addition, full crowns are also preferred in cases where the discoloration of the tooth is too high to be masked with laminate veneers. Contraindication for laminates are as follows: (1) patients with parafunctional habits such as bruxism, (2) deep bite, (3) poor oral hygiene, and (4) insufficient enamel presence.[15,16]

The purpose of laminate restorations is to achieve perfect color and aesthetics with limited enamel preparation. However, these restorations involve a delicate tooth preparation and bonding procedure. At the same time, careful treatment planning and the correct tooth preparation procedure are vital for aesthetics and optimum function.[17] In laminate restorations, appropriate space is required be left to have a good homogeneous thickness in terms of optical properties and material resistance, and it is also necessary to consider preservation of tooth structure.[18]

The harmony between the laminate veneer and the adjacent tooth is essential to achieve a good aesthetic. Long-term color stability is also essential to achieve long-term success in laminate restorations. There are many factors that affect aesthetics in laminates. These factors are basically the fabrication technique of the ceramic, the material, the thickness of the ceramic, the resin cement, and the polymerization method. In addition, there are some complications of laminate restorations. The main complications were found to include debonding (2%), fracture (4%), secondary caries (1%), marginal discoloration (2%), and endodontic problems (2%). Fractures (5.6%-11%), decementation, large marginal defects (12%-20%), and discoloration in ceramic materials are the main clinical failures in porcelain laminate restorations.[19] Interfacial leakage may be the cause of all these clinical failures. It has been reported that success rates decrease by 18%-25% up to 10 years due to low marginal quality and discoloration.[20]

In general, ceramic veneer preparation includes different types of preparations for different surfaces. Buccal surface preparation can be without preparation, with minimal preparation, conservative, and conventional preparation. Çöterta et al[21] divided the proximal preparation design into proximal chamfer and proximal slice and concluded that survival rates were significantly different.

A significant number of studies in the literature have recommended to maintain the interproximal contact. Preservation of the contact allows both more enamel and tooth structure to be retained and cementation to be performed more easily.[22-25] However, removing the interproximal contact may result in better

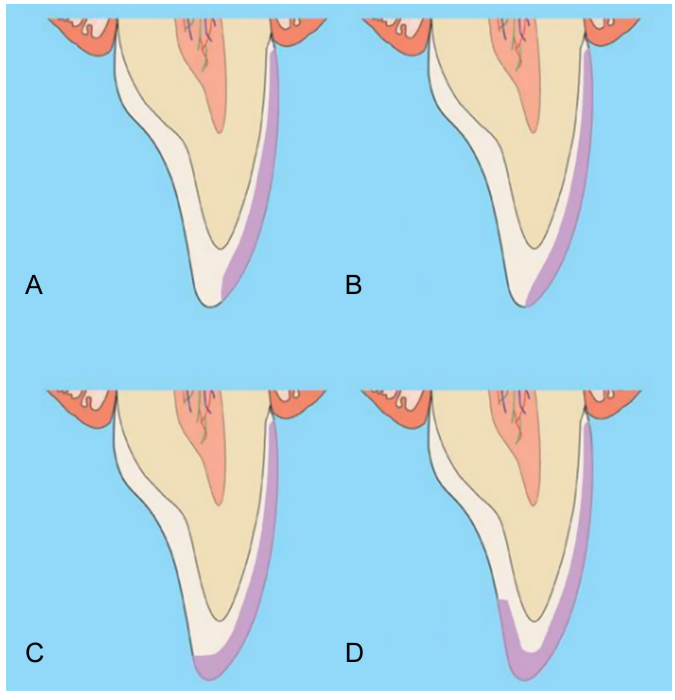


**Figure 1.** Types of incisal preparation (A) window; (B) feather; (C) bevel; (D) incisal overlap.[32]

aesthetic results in cases such as correcting malpositions or diastema.[26,27]

Chamfer and knife edge preparations are performed in cervical preparation. The incisal preparation is basically divided into 2 as overlap and nonoverlap preparation (Figure 1).[28] There are 4 different incisal preparations on the basis that are commonly used and mentioned in the literature:

- (1) Window preparation: in which the incisal edge of the tooth is preserved;
- (2) Feather preparation: in which the incisal edge of the tooth is prepared Bucco-palatable, but the incisal length is not reduced;
- (3) Bevel preparation: in which the incisal edge of the tooth is prepared Bucco-palatable, and the length of the incisal edge is reduced slightly (0.5-1 mm);
- (4) Incisal overlap preparation: in which the incisal edge of the tooth is prepared Bucco-palatable, and the length is reduced (about 2 mm), so the veneer is extended to the palatal aspect of the tooth.[22,29-31]

Window preparation and feather preparation are in the category of nonoverlap preparation, while bevel preparation and incisal overlap preparation are included in overlap preparation.[29,30] The window type preparation is the preferred type of preparation when changes in incisal length are not desired.[33] Overlap preparation is preferred when it is desired to change the length of the tooth. At the same time, if a better translucency is desired to be achieved in the incisal, the incisal edge is reduced during preparation.[22,31]

It is reported that occlusal stress is better distributed in overlap preparation. However, the overlap preparation may be in the form of a palatal chamfer finish line or a shoulder butt joint.[32] Troedson and Dérand[34] and Zarone et al[35] reported that such restorations are required to be finished as a palatal chamfer finish line in order to tolerate occlusal stress. At the same time, butt joint restorations have more than 1 entryway, while restorations finished as a palatal chamfer finish line have a single entryway (Figure 2). Having a single entryway can avoid misplacing the restoration during cementation.[32]

Ben-Amar[36] recommended using the window-type incisal preparation design, as it results in an acceptable ceramic thickness of 0.4- 0.7 mm near the cutting edge and reduces the risk. However, it has not been widely accepted for several reasons,[37] including the difficulty of masking the ceramic finish line[30] and the risk of remaining unsupported enamel at the incisal edges.[29]

In feather edge preparation, reduction of the unsupported incisal edge is only required if the remaining incisal enamel is too thin. This non-overlap incisal preparation design is recommended for patients with normal overbite[38,39] and to avoid direct contact of ceramic veneers with the antagonistic tooth structure.[38] On the other hand, other researchers have noted that the feather edge incisal edge design may cause a weak veneer and the risk of ceramic chipping has the possibility to increase and it may be difficult to fit the veneer.[29,40]

Other reported problems include marginal discoloration and poor marginal adaptation. It has been stated that the palatal chamfer preparation design is appropriate if the incisal edges are buccolingually thin or an increase in crown length is desired, and it has been suggested that the palatal chamfer preparation increases the surface area for bonding and prevents a sharp angle that may cause cracks to spread.[41,42] Sheets and Taniguchi[15] reported that the palatal chamfer preparation has provided sufficient ceramic thickness at the incisal edge.

A number of researchers have suggested that the type of incisal reduction depends on the buccolingual width of the incisal edge, aesthetic requirements, and patient occlusion[30, 38, 41, 43]

A review investigating survival rates in overlap and non-overlap preparations has revealed that both types are successful, but overlap designs have a higher failure rate. However, this rate has been found to be statistically insignificant.[44]

The finite element analysis has indicated that the overlap incisal design tolerates stress better and distributes it more uniformly, whereas the window-type incisal design collects the stress more in the incisal region.[35,45-47]

The most commonly used materials in laminate restorations are porcelain and resin composites. Each material type has its own unique composition, optical properties, and manufacturing process.[32] There are 4 main criteria in choosing a suitable material: material resistance, biocompatibility, aesthetics, and compatibility.[48] In addition, sufficient level of information about successful production of aesthetic restorations, instructions for use, and optical properties of dental materials is required.[49,50]

Porcelain laminate veneers, in particular, have steadily gained popularity among dentists in terms of the conservative restoration of unaesthetic anterior teeth.[51] While various factors such as porcelain thickness, geometry of the preparation, bonding agent can affect the long-term durability of porcelain laminate veneers, functional and parafunctional activities of the patient and tooth morphology can also affect it.[52]

One of the most commonly used materials for laminate veneers is feldspathic porcelain.[32] Feldspathic porcelain is a naturally

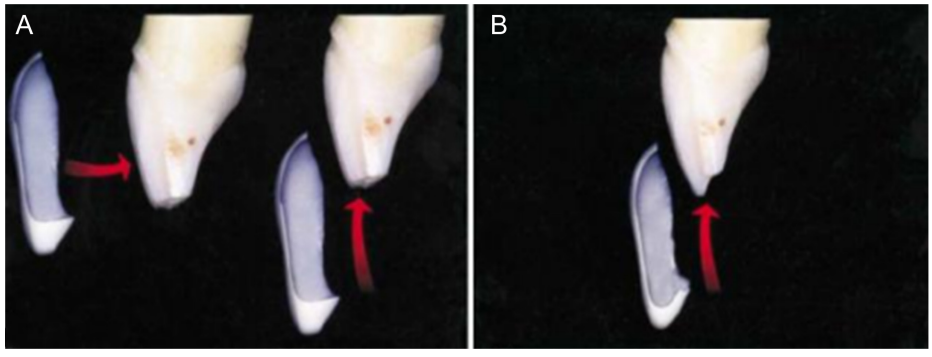


**Figure 2.** (A) Shoulder finish line provides multiple entryways to the restoration. (B) The Chamfer finish line provides a single entryway to restoration.[32]

occurring glass containing silicon oxide, aluminum oxide, potassium oxide, and sodium oxide, the main component of which is feldspar.[53] Feldspathic porcelain has many advantages, the material is very thin, so it is almost translucent, resulting in a natural restoration. It also requires minimal tooth preparation. Therefore, enamel can be preserved. In addition, it is possible to acidify feldspathic porcelain with hydrofluoric acid, which provides greater bond strength to enamel.[53-56] However, feldspathic porcelain has a number of disadvantages. Feldspathic porcelain can be fabricated by 2 methods: the refractory day technique and the platinum foil technique.[29,57,58] These methods are technique sensitive and require a good surface treatment before fabricated veneer bonding.[53] In addition, masking over-colored teeth can be difficult because the porcelain is so thin. In addition, it has been reported that the wear of the inner surface of the porcelain can reduce the flexural strength of the porcelain and cause microcracks that may eventually cause fracture in porcelain.[59] Interest in glass matrix ceramics has increased and various types of all-ceramic systems have been developed since they have high translucency[60] and can be obtained by different production methods, ranging from traditional methods to computer-aided design/computer-aided manufacturing (CAD/CAM) systems.[61-63] Especially recently, new ceramic systems such as IPS e.max press have been developed, and in these systems, lithium disilicate is added to the glass matrix to strengthen the ceramic. Milled or pressed lithium disilicate, a commonly used glass-ceramic system, can be used as a monolithic material in the posterior region and provides good mechanical properties. It has biocompatibility, high flexural strength, and good chemical stability.[60,61] A systematic review of the complication and survival rates of laminates has revealed a higher predictive survival rate for glass ceramics (94%) than for feldspathic porcelain (87%).[62] IPS e.max ceramic is widely used for laminate veneer of anterior teeth due to its unique structure and crystal shape, sufficient high resistance as well as various color shades and high translucency.[65]

High aesthetic demand has led to the development and introduction of several new ceramic restorative materials and techniques.[48] Ceramics can be produced with different techniques such as the traditional coating technique (coated with condensation and sintered veneer porcelain), the fully anatomical technique (coated with heat-pressed fluorapatite glass-ceramic or CAD/CAM), or the cut-back technique (partial heat pressing). Despite the advantages of ceramics such as optimal esthetics, these materials are fragile and therefore the demand for stronger ceramic restorations has increased.[67] In this regard, high-resistance zirconium-based ceramics produced with CAD/CAM technology are gaining more popularity.[68] Zirconium has become the material of choice in restorative dentistry due to its excellent mechanical properties. Zirconium oxide is increasingly used in dental restorations.[69,70] It is possible to produce highly thin zirconia laminate veneers via CAD/CAM technology (0.2-0.3 mm). It is also perfectly suited for the restoration of a large diastema or a broken tooth (due to trauma or caries). In teeth that have lost most of their structure and require a restoration >2 mm thick, a zirconia framework is used to support the veneer porcelain. Otherwise, traditional feldspathic porcelain fails to serve the purpose and crown restoration is considered as the only option available.[67] Feldspatic porcelains cannot be used in areas under parafunctional occlusal forces, it is also impossible to use them in areas that create stress during function, such as in deep bite or reverse overjet.[71] However, zirconia is highly opaque due to its high density, presence of chemical elements, and high crystallinity.[72,73] Therefore, the production of zirconia restorations in laminate restorations is limited due to the translucency of zirconia, which is much lower than that of lithium disilicate ceramics. Traditional standard zirconia has 70% of the translucency of lithium disilicate ceramics.[74]

The main advantage of composite veneers is that they can be used directly, resulting in good initial aesthetics and fewer dentist appointments. However, composite veneers are more prone to discoloration and abrasion.

Resin-based composites basically consist of 3 compositions. These are (1) resin matrix, (2) inorganic filler, and (3) bonding agent. The most widely used monomer in resin is Bisfenol-A Glisidil Metakrilat (Bis-GMA), which has a higher molecular weight than methyl methacrylate.[32]

Ceramic veneers have a number of advantages over direct composite restorations. In addition to better wear resistance and aesthetics, its properties such as color stability and thermal expansion similar to natural teeth are superior to composite restorations.[75]

Ceramics can take many forms, from translucent to opaque. The glassy noncrystalline structure appears more translucent, while the crystalline structure appears more opaque. There are also factors that affect translucency other than the crystal structure. These are the conditions such as particle size, particle density, porosity, refractive index.[76]

In a systematic review by Layton and Clarke,[77] the 5- and 10-year cumulative survival rates for non-feldspathic porcelains have been estimated to be 92.4% (95% CI: 89.8%-95%) and 66-94% (95% CI: 55%-99%), respectively. The estimated cumulative survival rate for feldspathic porcelain veneers has been 95.7% (95% CI: 92.9%-98.4%) within 5 years, compared to 95.6% (95% CI: 93.8%-97.5%) within 10 years in another systematic review. In a systematic review by Morimoto et al[64] on the clinical results of veneers performed via different ceramic types, the survival rate for glass-ceramic was 94% (95% CI: 87%-100%) and 87% (95% CI: 82%-93%) for feldspathic porcelain veneers.

Meijering et al[78] have evaluated success of 3 types of materials after 2 years and revealed that porcelain veneers (93%) has had the highest rate, followed by indirect composite (82%). They have also concluded that direct composite veneers (67%) have had the lowest level of success. In contrast, Nalbandian and Millar[79] have found no significant difference in success when compared to composite veneers and porcelain veneers.

The success of laminate restorations is highly dependent on the cementation protocol, in which the surface conditioning of the ceramic and tooth surfaces plays an important role.[80] Despite the successful implementation of cementation protocols, clinical studies have reported that survival rates have ranged from 82% to 96% in 10-21 years.[10, 81]

Resin cements are traditionally used for the cementation of these restorations.[82] The reason for the use of resin cements is that they have optimum aesthetics and low dissolution, as well as optimum properties such as high bond strength and optimum mechanical properties to the tooth structure.[83] Successful bonding increases the fracture resistance of the tooth and restoration and reduces the incidence of microleakage.[84,85] In

addition, the adhesive cement also strengthens glass matrix ceramics.[86] However, in addition to all these advantages of resin cements, there are application difficulties such as high technical sensitivity. The application requires several stages of tooth surface preparation and has high technical sensitivity. Precision in application and multiple steps can also lead to a relatively high risk of procedural errors.[87] These steps are as follows: For conditioning of glassy matrix ceramics, etching with hydrofluoric acid (HF) is initially performed. Then, silane is applied inside the porcelain to increase the bonding and to increase the wettability.[88] The tooth is roughened with orthophosphoric acid. Cementation is performed through dual or resin-based cements. However, in laminate restorations, photo-polymerized resin composites are recommended in line with most laboratory and clinical studies.[84] Photo-polymerized resin cements have some advantages over dual-polymerized ones. Photo-polymerized resin cements allow the clinician more time for cementation. A number of studies have also reported that photo-polymerized resin cements have higher bond strength compared to dual-polymerized resin cements. In contrast to traditional crowns using dual-type resin cements, it is regarded to be more advantageous to prefer photo-polymerized resin cements in order to prevent color changes that may occur due to chemical changes during polymerization in porcelain laminate veneers. There is no guarantee that the resin cement will polymerize effectively, especially in the 0.2 mm thick laminates known as lens laminates applied without any preparation on the tooth surface.[5] In some studies, it has been reported that photo-polymerized resin cements increase the bond strength more than dual-polymerized resin cements.[87,90,91] However, in cases where the thickness of porcelain laminate veneers will be more than 0.7 mm, dual cure cements may be preferred.[92]

There have been a number of developments in the cementation technique that increase the bond strength between the prepared tooth and the ceramic coating, such as etching the ceramic, applying silane to ceramics,[6] and improving the physical properties of resin cements. In addition, the clinician's ability to placing, finishing, and polishing the composite is an important factor in the aesthetic outcome.[94]

In addition to all its positive features, laminates also have some difficulties. It is important to ensure the correct shade of color in laminate veneers. It is of great importance that the clinician knows the properties of the material and cement to be used. In addition to providing the right shade, long-term preservation is also very important.[72] The color stability of cements under restoration is one of the important factors affecting the success of long-term laminate restorations. The color stability of cements under restoration is one of the important factors affecting the success of long-term laminate restorations.[95] The final color of restorations is affected by color change in the cement after cementation or over time. This problem is particularly evident in thinner and more translucent laminates. This adversely affects the long-term success of such restorations.[96] Especially in IPS e-max ceramic restorations, cement selection and application gains more importance due to the high translucency.

Resin cements have some limitations. Marginal gap due to polymerization shrinkage and consequent leakage at the interface are possible in resin cements.[19]

Polymerization shrinkage, which is the most important limitation of resin cements, is expected to cause a marginal gap between the tooth structure and the ceramic veneer.[19] Another reason that can cause microgap may be the difference in the thermal expansion coefficient among natural teeth, ceramic, and composite resin.[97] This mentioned microleakage is one of the important factors in the long-term success of laminate restorations. The reason why laminate restorations are indicated in teeth with sufficient enamel is that the bonding of enamel and resin cements is more successful than the bonding of dentin and resin cement. Presence of dentin fluid and excess organic content in dentin are the reasons why the bond between dentin and resin cement is more unsuccessful.[19] There are basically 2 adhesive interfaces in ceramic veneers cemented with resin cement. One of them is the ceramic–composite resin interface, while the other is the natural tooth surface-composite resin interface.

Haralur[75] has compared the microleakage between tooth–resin cement interface and enamel–resin cement microleakage in the cervical region and has discussed that the microleakage between tooth–resin cements in the cervical region was significantly higher in all groups. The study has also revealed that microleakage at the tooth–resin–cement interface, which is one of the bonding interfaces, is higher than at the porcelain–resin–cement interface.[19] This study indicates the importance of the presence of enamel in the teeth.

In laminate veneers, it is essential to consider and manage all processing sequences, adhesive systems, porcelains, porcelain etching, light-curing, resin cements, and correct photographic protocol in a planned manner. For the longevity of restorations in laminates, it may be beneficial for professionals to follow all clinical steps carefully and in a planned manner.[5]

The studies highlight that porcelain laminate veneers provide excellent aesthetic results and the treatment is long-lasting. This results in high patient satisfaction. The most important criteria for a successful laminate veneer treatment are the presence of sufficient enamel and thus adequate bonding and exclusion of parafunctional habits in the patient.[32]

## CONCLUSION

In order to achieve success in laminate veneer restorations, the most important step is to allocate sufficient time to diagnosis and planning and to be in cooperation with the patient at every stage. In addition, the effect of factors such as preparation, material selection, and cementation on success is indisputable. Laminate veneer restorations are a form of treatment that satisfies the patients in the right indications, provided that the right material is selected and the right cement is chosen. In this regard, it is highly significant to meet the expectations of the patient and to be in harmony with the patient. It is also highly recommended to fully inform the patient regarding the treatment to be applied.

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