Open Access Maced J Med Sci **electronic publication ahead of print,**
published on December 14, 2018 as https://doi.org/10.3889/oamjms.2018.353

ID Design Press, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences.
https://doi.org/10.3889/oamjms.2018.353
eISSN: 1857-9655
Dental Science - Review

The Success of Dental Veneers According To Preparation Design and Material Type

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Citation: Alothman Y, Bamasoud MS. The Success of Dental Veneers According To Preparation Design and Material Type. Open Access Maced J Med Sci. https://doi.org/10.3889/oamjms.2018.353

Keywords: laminate veneers; anterior teeth; restorative procedure; survival rate of dental veneers

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Received: 01-Aug-2018; **Revised:** 03-Nov-2018; **Accepted:** 04-Nov-2018; **Online first:** 14-Dec-2018

Funding: This research did not receive any financial support

Competing Interests: The authors have declared that no competing interests exist

Abstract

BACKGROUND: Due to their high aesthetic outcome and long-term predictability, laminate veneers have become a common restorative procedure for anterior teeth. However, because of the variety in the preparation designs and the material types, the clinician faces a dilemma of which approach to use.

AIM: To compare the survival rate of dental veneers according to different preparation designs and different material types. The sub-aim is to reach a favourable preparation design and material based on scientific evidence.

METHODS: Comprehensive electronic search of the dental literature via PUBMED, MEDLINE and Scopus databases was performed using the following keywords: “porcelain veneers”, “composite veneers”, “all-ceramic veneers”, “success of porcelain veneers”, “preparation design”, “preparation geometry”, “patient’s satisfaction”. Additionally, references from the selected studies and reviews were searched for more information.

RESULTS: Under the limitations of the available literature, the clinician preference is the decisive factor for choosing the preparation design. Nonetheless, incisal overlap preparation seems to have the most predictable outcome from all the preparation designs.

CONCLUSION: Porcelain veneers show excellent aesthetic results and predictable longevity of the treatment, while composite veneers can be considered as a good conservative option, but with less durability.

Introduction

Since 1930s dental veneers have been used to improve the aesthetic and protection of teeth (Calamia, 1988) [1], the indications of dental veneers include: 1) discoloured teeth due to many factors such as tetracycline staining, fluorosis, amelogenesis imperfect, age and others 2) restoring fractured and worn teeth 3) abnormal tooth morphology 4) correction of minor malposition 5) Intra-oral repair of fractured crown and bridge facings [2], [3], [4]. Unfavourable conditions of dental veneers include 1) patients with parafunctional habits such as bruxism 2) edge to edge relation 3) poor oral hygiene 4) insufficient enamel [5], [6]. Many studies reported positive clinical outcomes veneers, with a survival rate of 91% in 20 years [7] dental veneers are considered a predictable aesthetic correction of anterior teeth.

The materials of dental veneers have evolved remarkably, early materials that had been used had many disadvantages such as the materials needed to be too thick to cover any discolouration, difficulty to polish which can cause abrasion of the opposing dentition and easy to stain [8], [9]. Researchers and dental material manufacturers have aimed to develop new materials with better aesthetic characteristics through the years. In 1975 laminate veneers were introduced as a better material of choice to mask the dentition, the restorations were 1 mm in thickness and were made from a cross-linked polymeric veneer [10]. The use of laminate veneers resulted in a better aesthetic outcome and less chair time [11]. The progress of developing new materials reached porcelain in the 1980s when enamel was etched, and the porcelain surface was treated to improve the bonding [12], [13].

The desire for more durable aesthetic outcomes did not confine to improve the material type only; new preparation designs were introduced to the field of dental veneers. There are four different main designs of teeth preparation commonly mentioned in

the literature (Figure 1): 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 [14], [15], [16], [17].

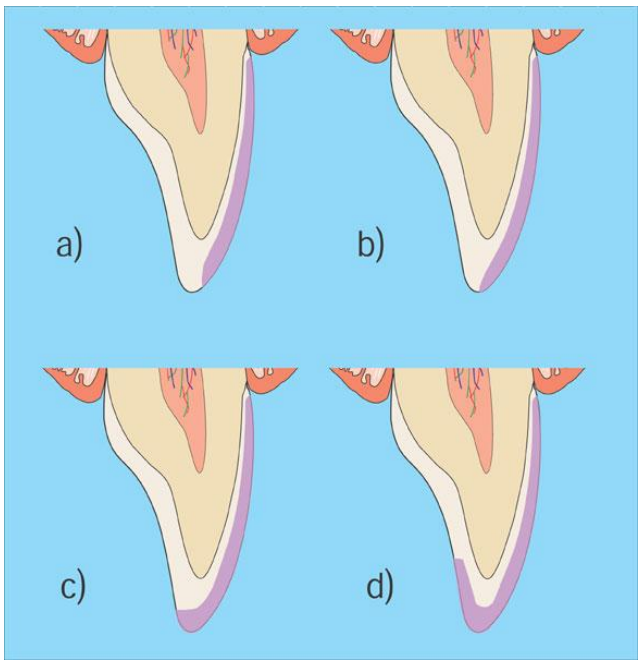

Figure 1: Showing common veneer preparations a) window b) feather c) bevel d) incisal overlap [17]

Influence of preparation design on the survival of dental veneers

Different opinions have been reported about superior preparation design over the others. In fact, due to the great variety in the materials, preparations designs and luting cement, favourable approaches to restore teeth with veneers have been controversial.

This review aims to compare the survival rate of dental veneers according to different preparation designs and different material types. The sub-aim is to reach a favourable preparation design and material based on scientific evidence.

One important aspect to investigate is the tooth preparation of dental veneers and how it might affect the fracture resistant of the material and reinforcement of the abutment tooth. Unfortunately, clinical trials that investigate the survival rate of dental veneers according to preparation designs are few, the criteria of investigation would include more than one factor which can affect the outcome of the treatment [16], [18]. In contrast, many *in vitro* studies have been conducted to evaluate the influence of different preparations design. Although such studies do not mimic the actual clinical environments and factors, they can provide criteria and guidelines for the clinician and further clinical investigations [5]. Table 1 illustrates the results of multiple *in vitro* studies regarding the influence of preparation design.

Table 1: *In vitro* studies that investigated the influence of preparation design on dental veneers

Study	Preparation design	Method of loading	Number of samples	Survival probability	Conclusion	Remarks
(Highton & Caputo 1987) [26]	Incisal overlap-chamfer FL Window preparation Slight labial preparation only Unprepared	Four directions: Central vertical Distal vertical Central inclined Distal inclined	4 (one of each)	High Moderate Low Lowest	Labial, proximal, incisal and gingival reduction is recommended.	Samples were photoelastic teeth
(Castelnuovo *et al.* 2000) [14]	Incisal overlap (1mm)-chamfer finish line Butt joint incisal reduction (1mm) Feather edge preparation Deep incisal overlap(4mm) Unprepared	Static loading at a 90-degree angle to the palatal surface of the sample	50 (10 each)	Moderate High High Low Control	Butt joint incisal reduction and feather edge prep. Provide the best retention to the restoration. Deep incisal overlap is not recommended	-
(Stappert *et al.* 2005) [16]	Incisal overlap (2mm) butt joint Deep incisal overlap (3mm)-butt joint Window preparation Unprepared	Dynamic loading and thermal cycling 135-degree angle in the masticatory stimulator	64 (16 each)	High Low Low Control	Incisal overlap provides the best support. Deep preparation is not necessary.	-
(Zarone *et al.* 2005) [28]	Incisal overlap-chamfer FL Window preparation	Static loading at the long axis of the tooth	4	High Low	Incisal overlap is a better design than window prep.	Samples were 3D computerised models
(Schmidt *et al.* 2011) [31]	Incisal reduction – chamfer FL Incisal reduction – butt joint	Static loading at a 90-degree angle to the palatal surface of the sample	32 (8 each)	Low High	Having a chamfer FL increase the failure rate of the veneer	Amount of existing tooth structure was considered in the study
(Lin *et al.* 2012) [23]	Incisal reduction – butt joint Three quarter preparation	Static loading at a 125-degree angle of the palatal surface of the sample	48 (12 each)	High Moderate	Three-quarter prep. Requires stronger material for support	Influence of restorative materials was included in the study
(Alghazzawi *et al.* 2012) [32]	Incisal reduction – butt joint Three quarter preparation	Dynamic loading at a 135-degree angle of the palatal surface of the sample	60 (30 each)	High High	No significant difference between the two preparations	-

General concepts

Some features of the preparation design are highly recommended in the majority of the literature and lab studies. For example, restricting the preparation to enamel is considered to be a critical factor for a favourable bonding strength, thus more durable outcome [6], [18], [19], [20]. Additionally, preserving the interproximal contact is recommended in most of the literature and studies, this is due to preserving more enamel and tooth structure, allowing a positive seat for cementation in a conservative approach [16], [21], [22], [23]. However, the clinician might face certain situations where removing the interproximal contact can provide better aesthetic results such as malaligned teeth or diastema [24], [25]. Moreover, the amount of labial reduction concurrent at 0.4-0.7 mm for ceramic veneers [1], [3], [15]. This is due to the enamel thickness in the anterior teeth, according to Ferrari *et al.,* (1991) [3], the enamel thickness of 114 extracted anterior teeth was 1.0 to 2.1 mm at the incisal third, 0.6 to 1.0 mm at

the middle third and 0.3 to 0.5 at the gingival third, therefore, minimal preparation is advisable.

Preparation designs

Although there are different opinions and different results in studies that investigate the influence of preparation design on the survival of the restoration. It seems that incisal overlap preparation provides the best support for the restoration and distributes occlusal forces over a larger surface area. In the window preparation, the occlusal stress is highly concentrated on the incisal third which may lead to fracture of the restoration. Also, incisal translucency can be better achieved when the incisal edge is reduced [14], [16], [23], [26]. However, it is controversial whether it is favourable to add a chamfer finish line palatable or have a shoulder finish line (butt joint). Troedson and Dérand (1999) [27] and Zarone *et al.,* (2005) [28] reported that it is required to have a chamfer finish line palatable for the restoration to tolerate the occlusal stress.

In contrast, Castelnuovo *et al.,* (2000) [14] suggested that having a chamfer finish line doesn't add to the longevity of the restoration.

Additionally, they reported that veneers with butt-joint finish line could provide more than one path of insertion (Figure 2). However, having a single path of insertion can be considered as an advantage because it prevents any displacement of the veneer during cementation. Eventually, the study stated that an overlap preparation with chamfer finish line does not decrease the longevity and predictability of the treatment.

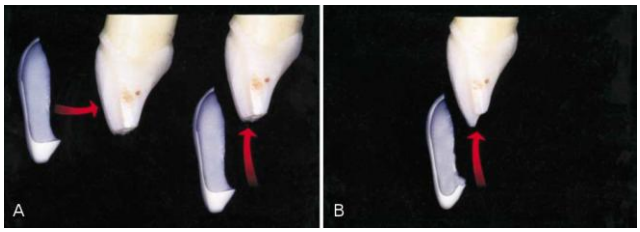

Figure 2: Incisal overlap with shoulder finish line (A) provide more than one path of insertion while incisal overlap with chamfer finish line (B) provide only one path of insertion (Castelnuovo et al., 2000) [14]

Ultimately, the biting force of the anterior teeth is considered to be low (100 – 200 N) (Carlsson 1973) [29] and with the absence of a strong well-conducted clinical study, the decision of preparation design is the clinician preference mainly, while incisal overlap can always be chosen to re-establish anterior guidance (Hahn *et al.,* 2000) [30].

Influence of material type on the survival of dental veneers

A range of materials are available in the market to restore aesthetic/functional complications by the mean of veneering teeth; the most common material is porcelain, resin composite. Each material type has its unique composition, optical characteristics and fabrication process. Thus, it can be expected that the treatment outcome and longevity will differ according to the material used (Font *et al.* 2006) [33]. Table 2 shows multiple clinical studies that investigated the survival rate of dental veneers with a variety of material types.

Table 2: Clinical studies are illustrating the survival rate of dental veneers. Adapted from Peumans et al., (2000) [18]

Study	Type of study	Number of veneers (number of patients)	Observation period	Survival rate	Remarks
Porcelain laminate veneers (PLVs)					
(Peumans *et al.,* 1998) [43]	Prospective	87 (25 patients)	5 years	93%	-
(Meijering *et al.,* 1998) [61]	Prospective	263 (112 patients)	2.5 years	100%	-
(Dumfahrt & Schäffer 2000) [62]	Retrospective	191 (72 patients)	1 – 10 years	91% in 10 years	Failure increase when PLVs are bonded to dentin
(Magne *et al,.* 2000) [63]	Prospective	48 (16 patients)	4.5 years	100%	-
(Smales & Etemadi 2003) [48]	Retrospective	110 (50 patients)	Up to 7 years	95%	Compared two different preparation designs as well
(Chen *et al.,* 2005) [64]	Retrospective	546 (not mentioned)	2.5 years	99%	All patients had tetracycline staining
(Granell *et al.,* 2010) [65]	Prospective	323 (70 patients)	3 – 11 years	87% over 11 years	Failure increased with the presence of composites and bruxism
(Beier *et al.,* 2011) [47]	Retrospective	318 (84 patients)	Up to 20 years	94% in 5 y. – 93% in 10 y. - 82% in 20 y.	50% of the patient were diagnosed with bruxism
(Layton & Walton 2012) [7]	Prospective	499 (155 patients)	Up to 21 years	96% in 10 y. 91% in 20 y.	Bonding to enamel is a critical factor for survival
Resin composites- direct and indirect (DC –IC)					
(Peumans *et al.,* 1997) [59]	Prospective	87 (23 patients)	5 years	89%	DC-Main failure due to wear
(Meijering *et al.,* 1998) [61]	Prospective	263 (112 patients)	2.5 years	90% for IC - 74% for DC	Results for DC and IC
(Wolff *et al.,* 2010) [54]	Retrospective	327 (101 patients)	5 years	79%	Result for DC
(Gresnigt *et al.,* 2012) [60]	Prospective	96 (23 patients)	3.4 years	87%	Split mouth design- no difference between composite type- all DC

Porcelain veneers

One of the most common materials that are used to fabricate laminate veneers is feldspathic porcelain (Figure 3).

The main component of feldspathic porcelain is feldspar; a naturally occurring glass which contains silicon oxide, aluminium oxide, potassium oxide and sodium oxide (Layton & Walton 2012) [7]. Feldspathic porcelain has many advantages; the material is very thin so it can be almost translucent which result in an appearing natural restoration. Also, it requires minimal tooth preparation. Therefore enamel can be preserved. Moreover, it is possible to etch feldspathic porcelain with hydrofluoric acid which gives a great bonding strength to the remaining enamel (Calamia 1982, Nicholls 1988, Stacey 1993, Layton & Walton 2012) [7], [12], [34], [35]. Nevertheless, feldspathic porcelain has some disadvantages. The fabrication of feldspathic porcelain can be done by two methods: the refractory die technique and the platinum foil technique (Horn 1983, Plant & Thomas 1987, Clyde & Gilmour 1988) [13], [15], [36], these methods are technique sensitive and the fabricated veneer requires good care prior to bonding (Layton & Walton 2012) [7]. Additionally, masking heavy discoloured teeth can be difficult because the porcelain is very thin. Moreover, it was reported that etching the inner surface of the porcelain can cause micro-cracks which can lead to decrease the flexural strength of the porcelain and eventually fracture the veneer (Yen *et al.,* 1993) [37].

Figure 3: A case showing before and after the treatment with porcelain veneers (Nalbandian & Millar 2009) [38]

New ceramic systems have been developed recently such as IPS e.max press from Ivoclar Vivadent©, leucite is added to the glass matrix in order to increase the strength of the ceramic (Rasetto *et al.,* 2001) [39], however, such new systems lack well-conducted clinical studies that investigate the success of using them as laminate veneers. Thus, future studies in this field are required.

Adhesion complex

The adhesion complex between porcelain, luting composite and enamel is considered to be a great advantage of porcelain veneers. It has been reported that the bonding strength of that complex is around 63 MPa while the bond between composite and enamel is about 31 MPa and between composite and porcelain alone is 33 MPa (Stacey 1993) [35]. Also, some *in vitro* studies suggest that extracted teeth that are restored with porcelain veneers have regained their original strength (Andreasen *et al.,* 1992, Stokes & Hood 1993) [40], [41]. This can explain the low failure rate (0 – 5%) in clinical studies due to debonding of the porcelain veneer especially when parafunctional habits are missing, (Rucker *et al.* 1990, Kihn & Barnes 1998, Peumans *et al.,* 1998) [42], [43], [44]. Respectively, some authors reported that when porcelain veneers are bonded to composite rather than enamel, porcelain veneers tend to have a higher failure rate (Dunne & Millar 1993, Shaini *et al.,* 1997) [45], [46].

Longevity of porcelain veneers

Many studies investigated the longevity of porcelain veneers. Beier *et al.,* (2011) [47] reported in a retrospective clinical study a survival rate of 94.4% after five years and 93.5% after ten years; they found the main reason for failure is a ceramic fracture. A randomised clinical trial done by Layton and Walton (2012) [7] showed similar results, with a survival rate of 96% after ten years and 91% after 20 years. Also, Smales and Etemadi (2003) [48] reported a survival rate of 95% for porcelain veneers throughout 7 years. It is essential to stress that these studies and others that reported high survival rate of porcelain veneers had a strict assessment of remaining enamel and bonding systems. As a result, careful, conservative preparation and optimum isolation during cementation are required to ensure predictable outcomes.

There are other studies which reported a lower survival rate for porcelain veneers. A retrospective study of 2,563 veneers in 1,177 patients done by Burke and Lucarotti (2009) [49] reported a survival rate of 53% over 10 years. The material type of the veneers was not reported. Moreover, the study evaluated veneers that were done by the general dental service, and thus, it is possible that preparations of teeth did not meet the criteria of specialists' level. Another retrospective study was done by Shaini *et al.,* (1997) [46] reported a survival rate of 47% in 7 years. The veneers were done by undergraduate students and staff member at Birmingham University in the United Kingdom. The study reported that over 90% of veneers were placed on unprepared teeth, this can be a reason for high failure rate as it is suggested that the bond to aprismatic enamel is much weaker than prepared enamel (Perdigão & Geraldeli 2003, Layton & Walton 2012) [7], [50].

The high survival rates that are reported by well-designed clinical studies suggest that feldspathic porcelain can act as a reliable and effective material to restore anterior teeth.

Resin composite

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%). Wide range of fillers such as quartz have been added to composites through the years, the addition of fillers offers many advantages like: 1) reduction of the polymerisation shrinkage 2) reduction of coefficient thermal expansion of the monomer 3) improve mechanical characteristics 4) some metallic fillers such as barium provide better radiopacity. 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. Dental composites can be categorised according to the particle size of the filler traditional composites have a mean particle size of 10-20 μm, on the other hand, micro filled composites have a mean particle size of 0.02 μm. new generations of composites are introduced by the dental company through the years, aiming for better aesthetic and physical properties (Bonsor & Pearson 2012, Van Noort 2013) [51], [52].

It was thought once that composites in the anterior area would be replaced with porcelain veneers due to their success (Garber 1989) [53]. However, the aesthetic and physical properties of resin composite have improved remarkably lately. Thus, it has been used extensively in clinical practice (Wolff *et al.* 2010) [54]. The main advantage of composite veneer is that it can be used directly, resulting in less chair time with good initial aesthetic. Nonetheless, composite veneers are more prone to discolouration and wear (Wakiaga *et al.* 2004) [55]. Additionally, the clinician skill in placing, finishing and polishing the composite plays a major factor in the aesthetic outcome.

Composite veneers do not require heavy preparations. Therefore enamel can be preserved for good adhesion. It is documented that the bonding strength between etching porcelain and enamel is greater than resin composite and enamel (Lacy *et al.,* 1988, Nicholls 1988, Lu *et al.,* 1992) [34], [56], [57]. Correspondingly, it has been reported that composite veneers do not significantly restore the stiffness of the prepared tooth (Reeh & Ross 1994) [58]. Although composite veneers can be made indirectly in dental laboratories, the used composite is essentially the same one that is applied directly. Thus, it shares the same physical properties and limitations of direct composite restorations such as polymerisation shrinkage (Van Noort 2013) [52].

Longevity of composite veneers

The survival rate of composite veneers in many clinical studies is constant. Peumans *et al.* (1997) [59] placed 87 direct composite veneers for 23 patients; they reported a survival rate of 89% after 5 years. Wolff *et al.,* (2010) [54] did a retrospective study on 327 direct composite veneers for 101 patients; the estimated survival rate was 80% after 5 years. A recent randomised control trial to compare two different types of composites reported a survival rate of 87% in over 3 years (Gresnigt *et al.,* 2012) [60]. The use of resin composite to veneer the anterior teeth is justifiable; it is a fast procedure with the good aesthetic outcome and reasonable longevity (Figure 4).

Figure 4: A case showing before and after treatment with direct composite veneers (Nalbandian & Millar 2009) [38]

Patients' satisfaction

Generally, aesthetic satisfaction is a complex process as it is considered subjective [38], [61]. However, some factors may play an important role in patients' satisfaction such as the durability of the final aesthetic outcome, the required amount of teeth preparation for the material type and the cost of the treatment.

Many clinical studies that evaluated the longevity of porcelain veneers have also considered patients' satisfaction of the treatment, the range of satisfaction in these studies is 80-100 % [43], [44], [46]. Other studies have been conducted to evaluate patients' satisfaction with different material types for veneers. Meijering *et al.,* (1997) [67] compared patients' response to three different types of veneers restorations after two years: feldspathic porcelain, direct composite and indirect composite. Porcelain veneers had the best response from patients (93%) followed by indirect composite veneers (82%) and lastly direct composite veneers (67%). In contrast, Nalbandian and Millar (2009) [38] found no statistical difference between patients' response to composite veneers and porcelain veneers. These two studies might be subjected to bias, the degree of preoperative discolouration or malposition can affect the grade of transformation postoperatively, and thus, affect the response of the patient.

From the result of the previous studies, it can be concluded that porcelain veneers can provide a predictable aesthetic acceptance, while composite veneers can be the treatment of choice for patients who appreciate minimally invasive approaches.

Conclusion

The influence of preparation design and material type on the success of dental veneers is controversial. Usually, the clinician preference decides the preparation geometry. Nevertheless, veneers with incisal coverage seem to have better aesthetic and more predictable outcomes, while having a chamfer finish line palatable seems to be unnecessary and limiting the preparation to a butt-join finish line is more sensible. According to multiple clinical studies, porcelain veneers have excellent aesthetic results, the longevity of the treatment and patient's satisfaction; the most critical factors to ensure a successful treatment are to obtain bonding to enamel and absence of parafunctional habits. Respectively, composite veneers provide good aesthetic outcome and patient's satisfaction; however, due to its physical properties and to the bonding strength when compared to porcelain veneers, composite veneers tend to fail significantly faster than porcelain veneers. Further clinical trials are needed to evaluate different types of composites and new ceramic systems for longer observation time.

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