



Clinical Performance of Porcelain Laminate Veneers: Outcomes of the Aesthetic Pre-evaluative Temporary (APT) Technique



Galip Gurel, DDS, MSD*/Susana Morimoto, DDS, MSD, PhD**

Marcelo A. Calamita, DDS, MSD, PhD***

Christian Coachman, DDS, CDT***/Newton Sesma, DDS, MSD, PhD****

This article evaluates the long-term clinical performance of porcelain laminate veneers bonded to teeth prepared with the use of an additive mock-up and aesthetic pre-evaluative temporary (APT) technique over a 12-year period. Sixty-six patients were restored with 580 porcelain laminate veneers. The technique, used for diagnosis, esthetic design, tooth preparation, and provisional restoration fabrication, was based on the APT protocol. The influence of several factors on the durability of veneers was analyzed according to pre- and postoperative parameters. With utilization of the APT restoration, over 80% of tooth preparations were confined to the dental enamel. Over 12 years, 42 laminate veneers failed, but when the preparations were limited to the enamel, the failure rate resulting from debonding and microleakage decreased to 0%. Porcelain laminate veneers presented a successful clinical performance in terms of marginal adaptation, discoloration, gingival recession, secondary caries, postoperative sensitivity, and satisfaction with restoration shade at the end of 12 years. The APT technique facilitated diagnosis, communication, and preparation, providing predictability for the restorative treatment. Limiting the preparation depth to the enamel surface significantly increases the performance of porcelain laminate veneers. (Int J Periodontics Restorative Dent 2012;32:625–635.)

*Visiting Professor, New York University College of Dentistry, New York, New York, USA; Visiting Professor, University of Marseille, Marseille, France; Private Practice, Istanbul, Turkey.

**Professor of Graduation Program, School of Dentistry, Ibirapuera University, São Paulo, Brazil.

***Private Practice, São Paulo, Brazil.

****Assistant Professor, Department of Prosthodontics, School of Dentistry, University of São Paulo, São Paulo, Brazil.

Correspondence to: Dr Galip Gurel, Tesuiliye Cad Bayer, apto n. 63, PO 34365, Nisantasi, Istanbul, Turkey; fax: 0090 212 231 2713; email: dentis@superonline.com.

Porcelain laminate veneers (PLVs) are a minimally invasive^{1–6} esthetic restorative option with a high rate of long-term success.^{5,7–13} To achieve the best results with these restorations, it is necessary to understand the essential factors involved and apply a clinical protocol that guarantees reliability with regard to esthetics and longevity.

Several clinical factors may alter the success rates of PLVs, such as treatment planning, types of preparations, enamel preservation, tooth vitality, presence of composite resin restorations, selection of appropriate ceramics and composite resin cements, finishing, polishing, and control and maintenance over time. Failure to address these factors can result in fractures, microleakage, and debonding.^{5,6,13–16}

Adhesive cementation is a critical factor for the long-term success of PLVs.¹⁵ Nevertheless, a stable and lasting bond does not depend exclusively on the composite resin cement but on an understanding of the bond interface and, consequently, on the correct choice of the three factors involved.

The first factor at the bond interface is the dental substrate. For many years, cementation was considered a secondary factor for the success of indirect restorations. However, at present, the application of adhesive systems has allowed many concepts to be changed, particularly tooth preparation. Porcelain veneers essentially depend on the bond to dental structures.¹⁷⁻¹⁹ In the case of veneers, the preparations can be confined to only the enamel, with margins in the enamel and little dentin exposure, or minimally in the enamel, with large amounts of dentin exposure and composite resin. Mechanical interlocking with enamel is more stable than the bond to dentin,^{12,15} which has a less homogenous nature, creates humidity, and may have areas of sclerosis. Tooth preparation should preferably not remove healthy tooth structures unnecessarily. This will guarantee a larger quantity of remaining enamel¹² and greater strength of the tooth, since flexion of the tooth may be related to fractures and debonding. Teeth with color alteration may demand a little more depth for the tooth preparation. Teeth with abrasion or erosion and those in older patients may have a thinner layer of enamel since they have lost some of their original volume, and therefore create conditions under which the preservation of enamel is more complicated.^{3,4,20}

The second factor is the ceramic to be selected. Ceramics that undergo a long vitreous phase, and can therefore be acid etched and

silanized, have the best adhesive behavior and consequently allow more conservative preparations and better esthetics because of their translucency.

The third factor is the resin adhesive cementation, which is interposed between and interdependent on the other two factors. Clinical follow-ups comparing self-etch and total-etch adhesive systems in PLVs showed a similar behavior over a period of 5 years, but a phosphoric acid agent was applied to the enamel in all samples.¹²

Tooth preparation is an important step because it tries to consider obtaining an adequate thickness of ceramic and tooth structure wear. Basically, there are two different approaches to tooth preparation for veneers: (1) the traditional approach, which is based on the existing tooth structure, and (2) a more recent and sophisticated method guided by the final volume of the restoration. This approach uses wax- and mock-ups.^{3,21}

This paper provides clinical data on the aesthetic pre-evaluative temporary (APT) technique,^{3,4} which takes the final volume of the restoration into consideration. Use of the APT technique, step by step, may guide the clinician from the time of diagnosis, communication, and preparation through the final result, making the treatment predictable. This study retrospectively evaluated the long-term clinical performance of PLVs bonded to teeth prepared using the APT technique over a period of 12 years.

Table 1 Distribution of PLVs according to location		
	No. of PLVs	%
Maxilla		
Anterior	299	72.2
Posterior	115	27.8
Mandible		
Anterior	122	73.5
Posterior	44	26.5

PLV = porcelain laminate veneer.

Table 2 Distribution of PLVs according to the restoration and cementation material		
	No. of PLVs	%
PLV material		
IPS I	201	34.7
IPS II	320	55.2
IPS Esthetic	16	2.7
Creation	43	7.4
Cementation material		
3M Opal	171	29.5
Variolink II	305	52.6
Bisco Choice	14	2.4
Variolink Veneer	41	7.1
Herculite	49	8.4

PLV = porcelain laminate veneer.

Method and materials

Between May 1997 and May 2009, 580 PLVs were cemented. The sample consisted of 66 patients (19 men, 47 women), and the veneers were cemented in the maxilla (299 anterior teeth, 115 posterior

teeth) and mandible (122 anterior teeth, 44 posterior teeth) (Table 1).

Veneers were fabricated using both a pressed ceramic technique (IPS Empress I, II, and Esthetic, Ivoclar Vivadent) and a refractory die technique (feldspathic porcelain; Creation, Jensen Industries).

The following products were used as cementation materials for PLVs: Variolink II (Ivoclar Vivadent), 3M Opal (3M ESPE), Herculite (Heraeus Kulzer), Variolink Veneer (Ivoclar Vivadent), and Bisco Choice (Bisco Dental) (Table 2).



Figs 1a to 1c The patient exhibited a canted smile line.



The preparations were performed according to the APT^{3,4} protocol. In this technique, after a three-dimensional smile design analysis, the dentist creates an immediate mock-up with composite resin, which will provide critical guidelines, such as the position and length of the maxillary incisors, for the technician to execute the diagnostic wax-up. The wax-up is then transferred to the mouth using a silicone index, which is tested esthetically and functionally. Once approved by the restorative team and the patient, the APT restoration is used as a precise guideline to

prepare the tooth structure based on the planned final tooth contours. The tooth structure will undergo only the minimal necessary preparation or even no preparation in certain areas using depth cutter burs through the APT restoration according to the pre-established goals. The previous silicone index is also used to check the preparation depths (Figs 1 to 11).

Photographs, radiographs, and individual clinical forms were used to follow up with patients. A systematic recall was carried out at 1, 6, and 12 years. Pre- and postoperative parameters were evaluat-

ed. All veneers were made by one dentist and rated by three examiners. Rules were established for the clinical examination and rating²²: two dentists made independent evaluations, and the characteristic with the lowest rating determined the category. Descriptive statistics were used in this study.

Results

A total of 580 PLVs were cemented in 66 patients, who were followed for a period of 12 years. Patients and teeth were evaluated according to

Figs 2a to 2c A new smile design was created with the mock-up. Canting was corrected.



Figs 3a and 3b A wax-up was applied on the teeth before preparation as the APT restoration.

preoperative parameters: bruxism (9.1%), abrasion (50.5%), presence of discoloration (61.2%), crowding (10.5%), diastema (10.9%), caries/

fillings (16.2%), and vital teeth (99.7%) (Table 3).

The preparation design was classified as being in the enamel

surface (80.5%), dentin exposure/enamel margin (14.7%), or dentin exposure/dentin margin (4.8%) (Table 4).



Fig 4 Facial tooth preparation was done through the APT restoration using a depth cutter to mimic the exact final contours of the PLVs.



Fig 5 Preparation depths marked with a pencil.



Fig 6 Completed preparation depths through the incisal edges of the APT restoration.



Fig 7 After the preparation depths were completed, the APT restoration was removed for the final detailed preparation.



Fig 8 Using a rounded-end fissure diamond bur, the facial and incisal preparations were completed until the pencil marks disappeared.



Fig 9 Preparation finalized using a sandpaper disk. Note that the composite resin filling at the mesioincisal edge of the left central incisor was also removed.



Figs 10a and 10b Provisional restorations in place.



Figs 11a to 11c The PLVs were bonded and the final smile design was achieved, which mimicked the mock-up and APT restoration.



Table 3 Preoperative parameters

	Patients (n = 66)		Teeth (n = 580)	
	n	%	n	%
Bruxism	6	9.1		
Abrasion	34	51.5	293	50.5
Discoloration	37	56.1	355	61.2
Crowding	8	12.1	61	10.5
Diastema	8	12.1	63	10.9
Caries/fillings	23	34.8	94	16.2
Vital teeth	64	97.0	578	99.7

Table 4 Distribution of PLVs according to preparation design

	No. of PLVs	%
Enamel surface	467	80.5
Dentin exposure/enamel margin	85	14.7
Dentin exposure/dentin margin	28	4.8

PLV = porcelain laminate veneer.

Table 5 Postoperative parameters

	No. of PLVs	%
Crown lengthening		
No modification	270	46.5
Apical	44	7.6
Coronal	266	45.9
Gingival recession		
No recession	497	85.7
Physiologic	83	14.3
Color match		
Very good	549	94.7
Good	31	5.3
Unacceptable	0	0.0
Marginal adaptation		
Very good	546	94.1
Good	34	5.9
Unacceptable	0	0.0

PLV = porcelain laminate veneer.

Postoperative parameters analyzed included crown lengthening (no change, 46.5%; apical, 7.6%; and coronal, 45.9%) and presence of gingival recession (no recession, 85.7%; physiologic recession, 14.3%). In the evaluation obtained

by the patient and dentist, the color match of the veneers was established as being very good (94.7%), good (5.3%), or unacceptable (0.0%). With regard to marginal adaptation, the PLVs were classified as very good (94.1%), good (5.9%),

or unacceptable (0.0%). Problems observed in the PLVs were also evaluated with regard to fracture/chipping, debonding, microleakage, secondary caries, sensitivity, and postoperative root canal treatment (Table 5).

Table 6 Frequency distribution of failures according to preparation design

	E	D/E	D/D	Total
Fracture/chipping	6	9	5	20
Debonding	0	0	12	12
Microleakage	0	2	5	7
Secondary caries	0	0	1	1
Sensitivity	0	0	1	1
Postoperative root canal	0	0	1	1

E = enamel surface; D/E = dentin exposure/enamel margin; D/D = dentin exposure/dentin margin.

Forty-two PLVs (7.2%) were recorded as being failures or unsuccessful within the sample due to fracture/chipping (3.4%), debonding (2.0%), microleakage (1.2%), secondary caries (0.2%), sensitivity (0.2%), and postoperative root canal treatment (0.2%) (Table 6).

Discussion

Variations among materials, operators, and patients can contribute to clinical failures.²³ Therefore, clinical research and studies are important to evaluate the performance of restorative materials and to determine the factors strongly related to failures since certain intraoral conditions cannot be reproduced in a laboratory.¹¹

Studies have used modified United States Public Health Service (USPHS) or Ryge criteria^{2,12,22,23} or

a variation of the USPHS system (modified California Dental Association [CDA]/Ryge criteria)^{8,11,22} to perform postoperative evaluations. However, there are many other factors that can be studied.²³ Thus, some clinical studies have adopted other parameters directed more toward evaluation of the veneers.^{5,8,13} Based on the guidelines described in the literature and on questions arising in daily clinical practice, pre- and postoperative parameters were established in this study in an effort to cover the clinical factors that influence the performance of porcelain veneers in the simplest, most clinical, and direct manner.

Longitudinal evaluations of porcelain veneers have shown excellent results in a period of 5 to 12 years, with success rates ranging between 85% and 98%.^{5,8-13} In the longest follow-up with 3,500 porcelain veneers over 15 years,

the authors found a failure rate of only 7%, two-thirds of which were fractures (22%) or leakage and debonding (11%).⁷ These data, with reference to the high rate of success, are in agreement with the results obtained in this retrospective study.

In this study, a low failure rate (7.2%) was computed during the evaluation period. Fracture/chipping (3.4%) and debonding (2.0%) contributed greatly to this value, although clinically, in many instances, the parts could either be repaired or recemented.

Some problems that occur during the first year are generally related to adhesive failure during cementation and appear to occur most frequently in the first 6 months. Afterward, problems decline or stabilize at low rates.² Bond failures may have an influence on marginal staining, gaps, and

fractures of the ceramic since incomplete impregnation or polymerization of the adhesive/cement may accelerate the process of hydrolysis in the short term.¹⁵ Over time, these failures may be more related to fatigue at the bond interface or crack propagation within the ceramic, resulting from either masticatory forces, dissolution of the resin matrix in the oral medium, or the development of gaps due to hydrolysis of the bonds between the components of the ceramic.^{9,14,15,24}

There was a low rate of secondary caries (0.2%) in this study. The location of the PLVs enabled oral hygiene procedures to be performed more easily. Consequently, the occurrence of complications, such as secondary caries and periodontal disease, has not been reported in many studies^{6,12} but could become a significant factor according to the patient's hygiene.⁵

The least common problems associated with PLVs are marginal discoloration and loss of color stability because all margins are in areas in which hygiene is easy to maintain, the porcelain is often easily finished and polished, and its glazed surface is mostly impervious to extrinsic staining.¹⁶ Supragingival preparations also had a positive effect on the survival rate of porcelain veneers.¹³ In this study, marginal adaptation was considered good or very good (100%), and there was minimal microleakage (1.2%), probably because the preparations were situated at the gingival level, which facilitated impressions and

cleaning of the margins. These factors may also have added to the low rate of gingival recession. No gingival recession was observed in 85.7% of PLVs.

The degree of satisfaction with restoration shade is correlated with the patient and dentist, and in this study, no restoration was considered unacceptable (100% good/very good) after the study period with regard to color match. No other material is as capable of reproducing the beauty and naturalness of a tooth as porcelain. The esthetics of these materials is related to color, translucency, luminosity, and metamerism, in which part of the color comes from the adjacent tissues, remaining dental structure, neighboring teeth, coping, and the cementing agent.²⁵

Several clinical factors may interfere with the success of restorations. However, variations in cavity preparation may explain many of these differences.¹³ Traditional approaches to veneer preparation can lead to major dentin exposure since the recommended preparation thickness values are frequently close to the average measurements of enamel thickness.²¹

Enamel preservation can still be achieved with bonded porcelain veneer restorations.^{3,7,10,15,20,21} Although some studies¹³ have found no differences in the success rates of veneers with dentin exposure and those completely confined to enamel, others^{7,8,15,26} have emphasized that there is an increased risk of failure when veneers are bonded to large amounts of exposed

dentin or on an existing filling. Nevertheless, more conservative preparations undoubtedly help to preserve tooth vitality and reduce postoperative sensitivity.²⁷

In addition to compressive strength, the flexural strength of the tooth/porcelain set may be affected. Deeper preparation into dentin, a substrate that has a much lower modulus of elasticity than porcelain, provides a less rigid base for restoration placement than enamel. This approach has resulted in much higher fracture rates than other enamel-supported restorations. The residual dentin thickness after preparation may therefore influence the life expectancy of the restoration.^{16,27}

The APT technique is based on the "additive mock-up" design, which takes into consideration the final volume of the restoration and has allowed a greater number of dental preparations to be completely confined to the enamel (80.5%), whereas without the guide, the dentist resorts to freehand preparation, invariably exposing dentin.^{12,21} The best way to avoid unnecessary overpreparation is to prepare the tooth in accordance with the APT restoration.³

In this study, low incidences of sensitivity (0.2%) and postoperative root canal therapy (0.2%) were obtained. This was because the approaches used preserved the enamel, promoted a superior bond to the dentin, lowered postcementation sensitivity, improved support for the ceramic restoration, and reduced endodontic intervention.^{5,27}

Clinical follow-up of the porcelain veneers has been carried out for long periods with the purpose of obtaining more reliable data on the longevity of the ceramic/silane/resin cement/adhesive/tooth interface, and the esthetic, biologic, and functional results have been considered encouraging.¹ Etched porcelain veneers offer a predictable and safe treatment modality that preserves a maximum amount of sound tooth structure⁸ and have proven to be one of the most successful treatment modalities that modern dentistry has to offer.¹⁶

Conclusions

Within the limits of this investigation, it may be concluded that PLVs present a successful clinical performance in terms of marginal adaptation, discoloration, gingival recession, secondary caries, postoperative sensitivity, and satisfaction with restoration shade after 12 years of function. The APT technique facilitated diagnosis, communication, and preparation, providing predictability for the restorative treatment. With the use of APT restorations, over 80% of tooth preparations were confined to the dental enamel, significantly increasing the clinical long-term performance of PLVs.

References

- Dietschi D, Spreafico R. Adhesive Metal-Free Restorations: Current Concepts for the Esthetic Treatment of Posterior Teeth. Chicago: Quintessence, 1997.
- Chen JH, Shi CX, Wang M, Zhao SJ, Wang H. Clinical evaluation of 546 tetracycline-stained teeth treated with porcelain laminate veneers. *J Dent* 2005; 33:3-8.
- Gürel G. Predictable, precise, and repeatable tooth preparation for porcelain laminate veneers. *Pract Proced Aesthet Dent* 2003;15:17-24.
- Gürel G. Porcelain laminate veneers: Minimal tooth preparation by design. *Dent Clin North Am* 2007;51:419-431.
- Granell-Ruiz M, Fons-Font A, Labaig-Rueda C, Martínez-González A, Román-Rodríguez JL, Solá-Ruiz MF. A clinical longitudinal study 323 porcelain laminate veneers. Period of study from 3 to 11 years. *Med Oral Patol Oral Cir Bucal* 2010;15:e531-e537.
- Land MF, Hopp CD. Survival rates of all-ceramic systems differ by clinical indication and fabrication method. *J Evid Based Dent Pract* 2010;10:37-38.
- Friedman MJ. A 15-year review of porcelain veneer failure—A clinician's observations. *Compend Contin Educ Dent* 1998;19:625-630.
- Dumfahrt H, Schäffer H. Porcelain laminate veneers. A retrospective evaluation after 1 to 10 years of service: Part II—Clinical results. *Int J Prosthodont* 2000; 13:9-18.
- Aristides GA, Dimitra B. Five-year clinical performance of porcelain laminate veneers. *Quintessence Int* 2002;33: 185-189.
- Smales RJ, Etemadi S. Long-term survival of porcelain laminate veneers using two preparation designs: A retrospective study. *Int J Prosthodont* 2004;17: 323-326.
- Fradeani M, Redemagni M, Corrado M. Porcelain laminate veneers: 6- to 12-year clinical evaluation—A retrospective study. *Int J Periodontics Restorative Dent* 2005;25:9-17.
- Aykor A, Ozel E. Five-year clinical evaluation of 300 teeth restored with porcelain laminate veneers using total-etch and a modified self-etch adhesive system. *Oper Dent* 2009;34:516-523.
- Cötert HS, Dündar M, Öztürk B. The effect of various preparation designs on the survival of porcelain laminate veneers. *J Adhes Dent* 2009;11:405-411.
- Sadowsky SJ. An overview of treatment considerations for esthetic restorations: A review of the literature. *J Prosthet Dent* 2006;96:433-442.
- Piemjai M, Arksornnukit M. Compressive fracture resistance of porcelain laminates bonded to enamel or dentin with four adhesive systems. *J Prosthodont* 2007; 16:457-464.
- Calamia JR, Calamia CS. Porcelain laminate veneers: Reasons for 25 years of success. *Dent Clin North Am* 2007;51: 399-417.
- Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. *J Dent Res* 1955;34:849-853.
- Bowen RL. Properties of a silica-reinforced polymer for dental restorations. *J Am Dent Assoc* 1963;66:57-64.
- Fusayama T, Nakamura M, Kurosaki N, Iwaku M. Non-pressure adhesion of a new adhesive restorative resin. *J Dent Res* 1979;58:1364-1370.
- Magne P, Magne M. Use of additive wax-up and direct intraoral mock-up for enamel preservation with porcelain laminate veneers. *Eur J Esthet Dent* 2006;1:10-19.
- Magne P, Belser UC. Novel porcelain laminate preparation approach driven by diagnostic mock-up. *J Esthet Restor Dent* 2004;16:7-16.
- Ryge G. Clinical criteria. *Int Dent J* 1980; 30:347-358.
- Jokstad A, Bayne S, Blunck U, Tyas M, Wilson N. Quality of dental restorations. FDI Commission Project 2-95. *Int Dent J* 2001;51:117-158.
- Addison O, Fleming GJP, Marquis PM. The effect of thermocycling on the strength of porcelain laminate veneer (PLV) materials. *Dent Mater* 2003;19:291-297.
- Roulet JF, Herder S. Clinical. In: Roulet JF, Herder S. Bonded Ceramic Inlays. Chicago: Quintessence, 1991:33-86.
- Swift EJ Jr, Friedman MJ. Porcelain veneer outcomes, part I. *J Esthet Restor Dent* 2006;18:54-57.
- Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for anterior teeth. *J Prosthet Dent* 2002;87:503-509.

Copyright of International Journal of Periodontics & Restorative Dentistry is the property of Quintessence Publishing Company Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.