An Up to 16-Year Prospective Study of 304 Porcelain Veneers

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Purpose: This study aimed to prospectively analyze the outcomes of 304 feldspathic porcelain veneers prepared by the same operator, in 100 patients, that were in situ for up to 16 years. ***Materials and Methods:*** A total of 304 porcelain veneers on incisors, canines, and premolars in 100 patients completed by one prosthodontist between 1988 and 2003 were sequentially included. Preparations were designed with chamfer margins, incisal reduction, and palatal overlap. At least 80% of each preparation was in enamel. Feldspathic porcelain veneers from refractory dies were etched (hydrofluoric acid), silanated, and cemented (Vision 2, Mirage Dental Systems). Outcomes were expressed as percentages (success, survival, unknown, dead, repair, failure). The results were statistically analyzed using the chi-square test and Kaplan-Meier survival estimation. Statistical significance was set at $P < .05$. ***Results:*** The cumulative survival for veneers was 96% ± 1% at 5 to 6 years, 93% ± 2% at 10 to 11 years, 91% ± 3% at 12 to 13 years, and 73% ± 16% at 15 to 16 years. The marked drop in survival between 13 and 16 years was the result of the death of 1 patient and the low number of veneers in that period. The cumulative survival was greater when different statistical methods were employed. Sixteen veneers in 14 patients failed. Failed veneers were associated with esthetics (31%), mechanical complications (31%), periodontal support (12.5%), loss of retention > 2 (12.5%), caries (6%), and tooth fracture (6%). Statistically significantly fewer veneers survived as the time in situ increased. ***Conclusions:*** Feldspathic porcelain veneers, when bonded to enamel substrate, offer a predictable long-term restoration with a low failure rate. The statistical methods used to calculate the cumulative survival can markedly affect the apparent outcome and thus should be clearly defined in outcome studies. *Int J Prosthodont 2007;20:389–396.*

Porcelain veneers were first described by Charles Pincus in 1938 as a method of providing a temporary esthetic improvement in the film industry. However, it wasn't until the early 1980s that enamel etching and porcelain surface treatments[1] allowed this treatment modality to enter mainstream dentistry. The veneer restoration permits the conservative treatment of tooth misalignments (instant orthodontics), unesthetic shape and form, and discoloration. This treatment has evolved to include the restoration of the worn dentition.

Despite its popularity, few long-term studies have evaluated the outcome of veneers bonded to healthy enamel, and even fewer have assessed the outcome when veneers are bonded to significant amounts of dentinal substrate (Table 1). Failure rates ranging from 0% for up to 4 years[2] to more than 50% over 5 years[3] have been reported. A meta-analysis conducted in 1998[4] of clinical studies of porcelain veneer outcomes was only able to quote a probable survival of greater than 90% after 3 years. A review of the literature in 2000[5] reported failure rates of 0% to 5% over 0 to 5 years, with an increased failure rate observed when veneers were partially bonded to retained restorations or when patients had a history of parafunction.

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Table 1 Summary of Survival Outcomes and Cohort Information for Clinical Veneer Studies

Study	Method	Length (y)	No. of studies/ patients/veneers	Veneer type	Survival
Peumans et al 2000[5]	Review	0–7	13 studies	Multiple porcelain veneers	95%–100% (0 to 5 y)
Kreulen et al 1998[4]	Meta-analysis	1.5–5	16 studies	Multiple porcelain, composite, and acrylic veneers	> 90% (3 y)
Shaini et al 1997[3]	Retrospective cohort	≤ 6.5	372 veneers 104 patients	Feldspathic (90% unprepared enamel)	50% (Kaplan-Meier)
Walls 1995[6,9]	Prospective cohort (fractured and worn anterior teeth)	4.2–5.4	54 veneers 12 patients	Feldspathic	72% (5 y)
Peumans et al 1998[8]	Prospective cohort	5	87 veneers 54 patients	Feldspathic	93%
Peumans et al 2004[7]	Prospective cohort	10	87 veneers 54 patients	Feldspathic	64%
Dumfahrt et al 1999, 2000[11,12]	Retrospective cohort	≤ 10.5	205 veneers 72 patients	Feldspathic (variety of incisal preparations)	97% (5-y Kaplan-Meier) 91% (10-y (Kaplan-Meier)
Friedman 1998[10]	Retrospective observational (no account of loss to follow-up and esthetic failures)	≤ 15	3,500 veneers	Variety of veneers and preparations	93%

Many of the reported studies have limitations: patient and restoration numbers are small[6–9]; follow-up times are short[2–4,6,8,9]; failure criteria do not include esthetic failures[10]; losses to follow-up are unaccounted for[10]; and inexperienced clinicians skew the results.[3] Two studies have reported follow-up times of up to 10 years, but these show conflicting results as observation time increases: 91% at 10.5 years[11,12] and 64% at 10 years,[7] respectively.

There is no consensus regarding optimal veneer design. Unprepared enamel is a poor substrate for bonding because its aprismatic structure results in an inferior bond. Studies show that there is a trend toward an increased failure rate when restorations are not bonded to enamel,[3,5–7,11] but evidence to guide the choice of margin design (shoulder, chamfer, knife) and incisal finishing design (feather-edged, overlapped) remains lacking. Finite element analysis has been used to study incisal finishing and bonding procedures,[13–15] but clinical studies failed to show a significant difference in outcome,[11] and the parameter was unable to be analyzed in a meta-analysis.[4]

The last decade has seen an explosion in the variety of dental ceramic materials. They can be broadly classified into esthetic ceramics used in veneers and substructure ceramics used as core materials (such as yttrium zirconia). Within the esthetic ceramics[16,17] there are predominantly glassy ceramics (feldspathic glass), moderately filled glassy ceramics (feldspathic glass with 17% to 25% leucite), and highly filled glassy ceramics (feldspathic glass with 40% to 55% leucite).

Although free-formed feldspathic glass was the original esthetic ceramic material of choice for the construction of veneers, the current trend is the use of pressable, leucite-modified feldspathic ceramics (such as Empress, Ivoclar). There are no long-term outcome studies for these pressable materials and no comparison outcome studies. Both the feldspathic glass and pressable leucite-modified materials are etchable. Feldspathic glass can be formed into thinner sections, so a more conservative preparation (0.3 to 0.5 mm reduction) is possible with this material compared to pressable materials (0.6 to 0.8 mm reduction).

The aim of this study was to prospectively analyze the outcomes of 304 feldspathic porcelain veneers prepared with a chamfer margin and incisal reduction by the same operator, in 100 sequential patients, that were in situ for up to 16 years.

Materials and Methods

Inclusion/Exclusion Criteria

All porcelain veneers (n = 304) fabricated for patients (n = 100) by a single prosthodontist in a private specialty practice between 1988 and 2003 were sequentially included in this prospective cohort. All veneers had been in situ for at least 1 to 6 years, 180 for 5 to 11 years, and 61 for 10 to 16 years. Of the patient population, 83% (n = 83) were female, and 17% (n = 17) were male. Eighty-seven percent of the veneers (n = 264) were made for female patients, while 13% (n = 40) were made for male patients.The age of patients at treatment ranged from 15 to 73 years (mean: 41 ± 14.7).

Demographics

Of the 100 patients seeking treatment, 87 presented for discoloration, 6 to restore chips in the incisal edge, 5 to replace failed veneers, 4 to address areas of erosion,

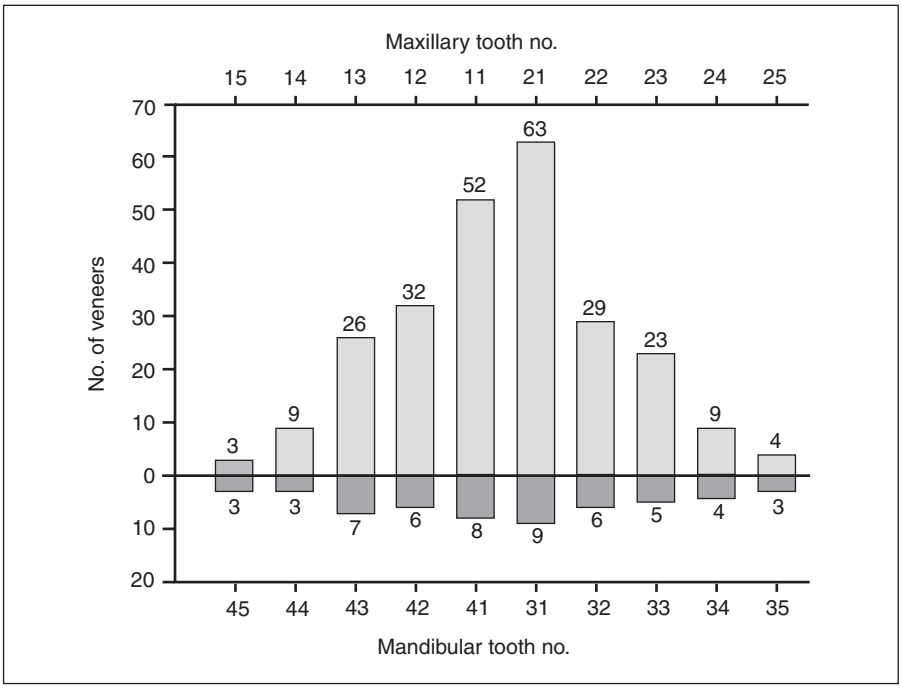

Fig 1 Number of veneers (n = 304) placed on specific teeth. Veneers placed on maxillary teeth (n = 250) are represented by bars above the bisecting line; veneers placed on mandibular teeth (n = 54) are represented by bars below the bisecting line.

and 2 to restore broken teeth (4 presented for more than one reason). Patients received between 1 and 20 veneers each (mean: 3 ± 2.8), with the majority of patients receiving either 1 (n = 36) or 2 (n = 28) veneers. Eighty-one percent (n = 250) of veneers were placed on maxillary teeth (57% incisors, 16% canines, and 8% premolars), while 17% (n = 54) were placed on mandibular teeth (9% incisors, 4% canines, and 4% premolars) (Fig 1).

Clinical Procedure

Patients presenting for treatment were assessed to be suitable for veneers if sufficient enamel substructure was present, the tooth had not lost more than one third of the width of its incisal edge, and the patients were subjectively evaluated not to have a high parafunctional risk. Defective interproximal restorations were replaced. A retraction cord was placed on the labial aspect of the teeth. Initial enamel reduction was completed under water spray with a high-speed diamond bur, using 4× magnification. The final preparations were refined with a tapered diamond bur without water spray. The teeth were prepared with chamfer margins and a 1- to 2-mm incisal reduction with a palatal overlap, which was kept clear of tooth contact in maximum intercuspation. If this was not possible, the palatal overlap continued at least 1 mm past the occlusal contact. Interproximal contacts were reduced on the facial aspects only. The preparations removed approximately 0.5 to 0.7 mm of labial tooth structure. Minimal veneer thickness was not standardized; instead, it was determined on an individual basis to match the original tooth form or adjacent teeth. Small erosive lesions were filled with resin composite. In those few preparations that extended beyond the cementoenamel junction, small undercuts were placed in that region to provide mechanical retention. After preparation, the teeth were subjectively assessed for the amount of remaining enamel and were rejected if greater than 20% of the preparation was in dentin. The amount of remaining enamel was again subjectively assessed following etching and prior to bonding. Thin enamel was differentiated from dentin by its characteristic frosty appearance following etching.

Impressions were taken with addition polyvinyl siloxane (President, Coltene) and poured with dental stone. The margins were marked, the preparations were varnished, and wax was added as a slight spacer 1 mm short of margins, and then duplicated with silicone. The impressions were poured with refractory die material (GC refractory die material), which was degassed and then soaked in water. Feldspathic porcelain (Duceram, Mirage, Fortress, Vita 900) was applied (usually in 3 layers). Minor additions were made, and the veneer was glazed. The restoration was etched (Vita Ceramic Etch: 5% hydrofluoric acid, 10% sulfuric acid), steam cleaned, and delivered. All laboratory procedures were completed by a single commercial laboratory.

The veneers were tried intraorally with either water or try-in paste. Once assessed by both the clinician and patient for fit, color, and contour, they were washed with water and alcohol and silanated. Retraction cords and rubber dam were not used. The tooth substrate

was cleaned with pumice and water and then etched (37% phosphoric acid). Each veneer was cemented individually with a dual-cure unfilled resin cement (Vision 2, Mirage Dental Systems, Cameleon). Dentin adhesive systems were not employed. The cementation and finishing process was completed for each veneer before the next was cemented. The occlusion was designed with anterior protrusive and canine latrotrusive guidance. Lateral and central incisors were maintained with shimstock clearance (12 μm) in the intercuspal position.

Outcome Measures

The outcome was assessed by the 6-field method (success, survival, repair, death, unknown, failure) at 3 review periods: 1993 (n = 61), 1998 (n = 180), and 2003/2004 (n = 304). These outcomes, as defined by Walton in 1997,[18] are as follows:

1. *Success:* This outcome was designated when review of documentation or patient examination revealed no evidence of retreatment other than maintenance procedures. Maintenance included professional prophylaxis and smoothing of minor porcelain chipping. Smoothing was considered minor when the veneer did not require further repair, the chip did not interfere with the marginal integrity, and the result did not compromise the esthetics as determined by the patient. Occlusal or lingual perforations of a tooth for access to perform endodontic therapy did not compromise the classification of the veneer as successful.
2. *Survival:* This outcome was designated when the patient could not be examined by the operator, but either the referring clinician or patient confirmed that there had been no retreatment other than that previously described for a successful outcome.
3. *Unknown:* This outcome was designated when the patient could not be traced.
4. *Dead:* Any patient who died during the survey period was placed in this category, irrespective of whether they had experienced successful or surviving treatment until their death. However, if previous documentation indicated that some form of retreatment had been carried out before death, the relevant treatment episode was categorized as having a retreatment outcome.
5. *Repair:* This outcome was designated when the veneer required a repair that did not interfere with the original marginal integrity of the restorations.
6. *Failure:* This outcome was designated when part or all of the prosthesis was lost, when the original marginal integrity of the restorations and teeth was modified, or when the restoration lost retention more than twice.

Statistical Analysis

Outcomes were expressed as percentages ± SEs. The data were analyzed as independent proportions, calculating the *P* value, SE, and 95% confidence intervals (CI) with the chi-square test, with 1 degree of freedom. Statistical significance was set at $P < .05$. The Kaplan-Meier survival analysis was used to estimate the cumulative survival with the following variables:

- Number censored during each interval (loss to follow-up and death)
- Number at risk at the end of each interval (number in situ minus number censored)
- Number failed at the end of each interval
- Proportion surviving each interval
- Cumulative survival calculated from the multiple of the proportion (P) surviving at each time interval; for example, the cumulative survival at 5 to 6 years = P(0–1) × P(1–2) × P(2–3) × P(3–4) × P(4–5) × P(5–6)

The SE of the cumulative survival was calculated using Greenwood's formula.

Results

Over the 16-year period, 16 veneers in 14 patients failed. These failures occurred between the first and second years of service and the thirteenth and fourteenth years of service. Failed veneers were associated with esthetics (31%), mechanical complications (31%), periodontal support (12.5%), loss of retention > 2 (12.5%), caries (6%), and tooth fracture (6%) (Fig 2). An insufficient number of failures exist to statistically analyze for associated factors. Of the failures, 5 teeth were reveneered, 5 received full-coverage crowns, 3 were extracted (because of fracture and periodontal disease), and 3 failed in situ (the marginal seal was disrupted, but the veneers were not removed).

Four of the original 304 veneers were assigned an unfavorable prognosis prior to treatment. Three of these 4 veneers failed. One had unfavorable tooth structure. Another 2 with poor supporting structure were extracted and replaced with a full denture. One veneer with unfavorable supporting structure remains in situ with a survival outcome.

The 6-field outcome for 3 groups of patients (0 to 6 years, 5 to 11 years, and 10 to 16 years) shows an increase in the percentage of failure and unknown outcomes and a decrease in the percentage of success and survival outcomes over the treatment period (Table 2). The cumulative survival (Kaplan-Meier method) for veneers was 96% ± 1% at 5 to 6 years, 93% ± 2% at 10 to 11 years, 91% ± 3% at 12 to 13 years, and 73% ± 16% at 15 to 16 years (Table 3, Fig 3).

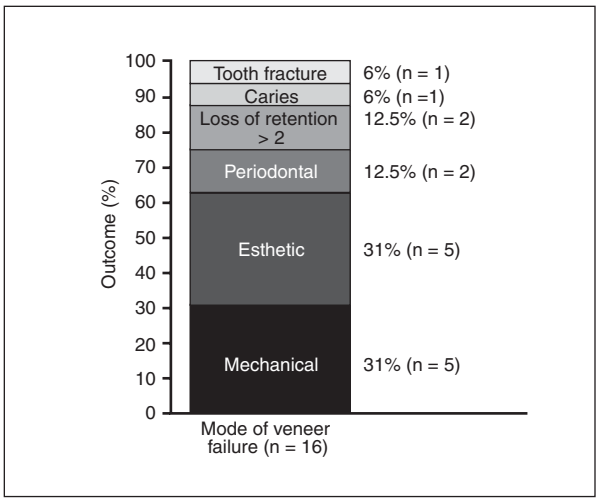

Table 2 No. and Percent of Outcomes for Each Patient Group

	0–6 y		5–11 y		10–16 y	
Outcome	No.	%	No.	%	No.	%
Success	281	92.4	136	75.6	26	42.6
Survival	12	3.9	7	3.9	10	16.4
Repair	0	0.0	3	1.7	0	0.0
Death	0	0.0	0	0.0	5	8.2
Unknown	4	1.3	25	13.9	10	16.4
Failure	7	2.3	9	5.0	10	16.4
Total	304		180		61	

Fig 2 Percentage of mode of failure for all failed veneers (n = 16).

Table 3 Kaplan-Meier Cumulative Survival Table for Veneers In Situ for Up to 16 years

Interval (y)	No. at risk at start of interval	No. censored during interval	No. at risk at end of interval	No. of failures at end of interval	Proportion surviving	Cumulative survival	Cumulative survival (%)	SE
0–1	304	6	298	0	1.00	1.00	100.00	0
1–2	298	0	298	6	0.98	0.98	97.99	0.81
2–3	276	6	270	1	1.00	0.98	97.62	0.89
3–4	254	3	251	2	0.99	0.97	96.85	1.04
4–5	236	10	226	0	1.00	0.97	96.85	1.04
5–6	180	0	180	1	0.99	0.96	96.31	1.16
6–7	147	6	141	2	0.99	0.95	94.94	1.49
7–8	125	0	125	0	1.00	0.95	94.94	1.49
8–9	94	1	93	2	0.98	0.93	92.90	2.04
9–10	77	0	77	0	1.00	0.93	92.90	2.04
10–11	56	0	56	0	1.00	0.93	92.90	2.04
11–12	44	0	44	1	0.98	0.91	90.79	2.89
12–13	21	0	21	0	1.00	0.91	90.79	2.89
13–14	10	5	5	1	0.80	0.73	72.63	16.40
14–15	4	0	4	0	1.00	0.73	72.63	16.40
15–16	3	0	3	0	1.00	0.73	72.63	16.40

Statistical analysis showed that changes in survival over the study period were statistically significant (Fig 4). Veneers in situ for 0 to 6 years had significantly higher survival rates than those in situ for 5 to 11 years (chi-square = 6.02; $df = 1$; $P < .001$; 95% CI: 10.67% to 23.21%) and for 10 to 16 years (chi-square = 8.93; $df = 1$; $P < .001$; 95% CI: 24.85% to 49.88%). Veneers in situ for 5 to 11 years had a significantly greater survival rate than those in situ for 10 to 16 years (chi-square = 3.15; $df = 1$; $P < .001$; 95% CI: 6.75% to 34.11%).

Of the veneers in situ for more than 5 years, 50 were placed on canines or premolars and 128 on incisors. There was no statistically significant difference in the outcomes of veneers placed on different teeth (chi-square = 0.58; $df = 1$; $P = .57$; 95% CI: 3.9% to 10.27%).

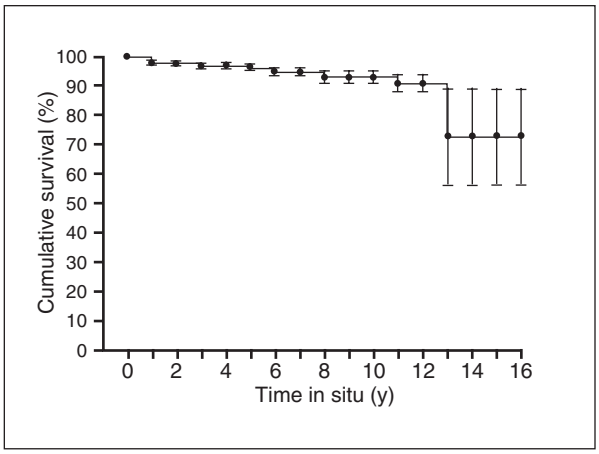

Fig 3 Kaplan-Meier survival curve of the cumulative survival (%) of veneers in situ for up to 16 years. Error bars represent the standard error.

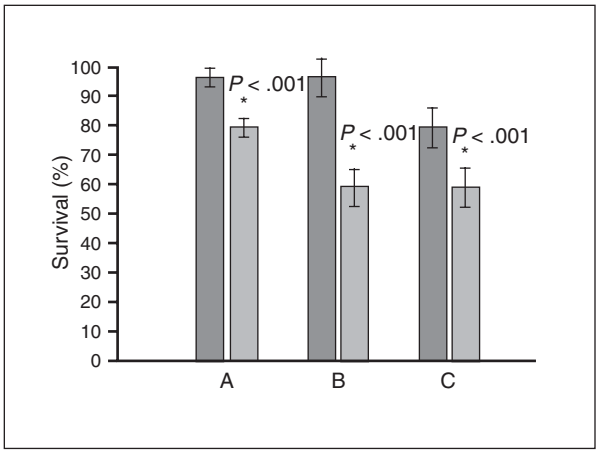

Fig 4 Survival outcomes (%) for veneers A: in situ 0 to 6 years (n = 304) compared with those in situ for 5 to 11 years (n = 180); B: in situ 0 to 6 years (n = 304) compared with those in situ for 10 to 16 years (n = 61); C: in situ 5 to 11 years (n = 180) compared with those in situ for 10 to 16 years (n = 61). Error bars represent the standard error for the differences between survival for each 2-group comparison. Significantly fewer veneers survived as the time in situ increased.

Discussion

The 2005 Glossary of Prosthodontic Terms[19] defines a porcelain laminate veneer as a "thin bonded ceramic restoration that restores the facial surface and part of the proximal surfaces of teeth requiring aesthetic restoration." With the increasing popularity of dentin bonding, the current trend is to use porcelain veneers with a more aggressive preparation, with less emphasis on the importance of enamel as the bonding substrate. There is a high probability that the survival rates of "modern" veneers will be far lower than those currently found with the original protocol. No studies exist to provide clinicians and patients with expected outcome data for these nonclassic techniques. A redefinition of a porcelain laminate veneer to include the type of bonding tooth substrate would help negate this arising confusion of nomenclature.

Should these nonclassic techniques result in a significantly higher failure rate, it would be difficult to justify the provision of these types of veneers over metal-ceramic full crowns, which have an established high survival over the long term,[20] or even over all-ceramic crowns,[21] though these have fewer documented long-term outcomes.

In this study, traditional protocols involving preparation mostly in enamel were employed. Minor defects involving exposed dentin were filled with resin composite to eliminate undercuts. Although a retraction cord was placed in the sulcus during tooth preparation, it was not inserted during the bonding procedure, as it was the operator's experience that use of a retraction cord often resulted in postbonding sensitivity because of etched but uncovered cementum beyond the cementoenamel junction.

The gold standard of a randomized controlled trial with a long-term follow-up to assess the outcomes of restorative procedures, including porcelain veneers, is often unrealistic within both private and public dental settings. However, it is encouraging to see more long-term prospective cohort trials in the literature, with clearly defined outcome measures and industry standard statistical methods.

The literature shows a great difference in the reported survival rates of porcelain veneers. The Kaplan-Meier[22] survival probability was used to analyze the data in the present study, because it accounts for both censored data (lost to follow-up) and failures. Other studies[23,24] in different fields have dealt with loss to follow-up with different mathematical methods. Application of the Dawson-Saunders and Trapp[25] actuarial method to the present data resulted in a higher 15- to 16-year survival of 79%, compared to 73% for the Kaplan-Meier analysis. However, the differences in outcome results were not as noticeable in shorter periods with larger numbers. For continuity with other veneer outcome studies, the Kaplan-Meier survival method was chosen. These varying results demonstrate that the method used in analysis should be clearly stated in reported outcome studies.

Following unbiased criteria and ensuring that each patient's outcome is accounted for is essential in the reporting of a study, but the proper interpretation of the data and a discussion of any skewed results are often lacking in the current literature. Five veneers with an unknown outcome were censored 13 to 14 years after delivery because the patient passed away. There is a good chance that these 5 veneers would have a successful outcome if they could be reviewed, but this is clearly unknown. The loss of these veneers resulted in a decrease in the probability of survival from 91% ± 3% at 12 to 13 years to 73% ± 16% at 13 to 14 years. The standard error of the cumulative survival also greatly increased during this time interval (from 3% to 16%), indicating a loss in accuracy in the data. Therefore, the survival at 13 to 14 years, statistically, could have been as low as 57% and as high as 89%. This difference in survival is marked, as there were only 10 veneers in situ when the censorship occurred. Had the 10- to 16-year sample size been greater, the loss of 5 veneers from the sample would not have so dramatically affected the results. While data exist from this study to provide information concerning the survival probability of veneers in situ, the low power of the sample size after 13 years, and thus the external validity of the 13- to 16-year survival rate of 73% to clinical practice, must be recognized.

This study showed a cumulative survival probability of 96% ± 1% at 5 to 6 years. This concurs with the meta-analysis by Kreulen et al[4] (> 90% for 3 years), the literature review by Peumans et al[5] (95% to 100% for 0 to 5 years), and the 5-year clinical results of Peumans et al[7] (93%, 87 veneers, 25 patients) and Dumfahrt and Schaffer[11] (97%, 205 veneers, 72 patients). These results, however, greatly differ from some studies.[3,6,9]

A retrospective analysis by Shaini et al[3] combined outcomes for up to 6.5 years of 372 veneers in 104 patients completed by students (n = 235) and staff (n = 137) in a hospital environment. The student failure rate was 39%, compared to the staff failure rate of 22%. Furthermore, in 90% of cases, these veneers were placed on unprepared surfaces. The combination of inexperienced operators with the use of aprismatic, unprepared enamel resulted in an unexpectedly low 6.5-year Kaplan-Meier survival probability of approximately 50%.

A prospective cohort study by Walls[6,9] used a patient population with a high chance of parafunctional habits and a large amount of dentinal bonding substrate. Fifty-four porcelain veneers were placed on fractured and worn anterior teeth in 12 patients and reassessed 4.2 to 5.4 years after insertion. The combined high risk factors and low patient numbers resulted in a decreased survival rate. The author originally reported complete failure of only 2 veneers. However, a further 13 failures (esthetic, marginal deterioration) with 11 unknowns and 4 repairs resulted in an optimistic estimated 5-year survival rate of 72%. In this compromised patient group, this number is unexpectedly high.

The 10- to 11-year cumulative survival probability for this current study was 93% ± 2%. Again, this concurs with the 10-year survival rate of 91% found by Dumfahrt and Schaffer.[11] The results from Peumans et al,[7] however, show a lower percentage of veneers that required no intervention over the study period (64%). The high number of interventions (repair of marginal defects, treatment of caries lesions, replacement of veneers) was attributed by the authors to the presence of interproximal composite restorations and a high proportion of dentinal substrate, and the lack of modern dentin bonding and cementation technology available at the commencement of the study. They stated that 28% of the clinically unacceptable veneers had repairable defects. These repairs, however, all appear to have involved the marginal integrity, and thus are still considered by the 6-field criteria to be failures.

The cumulative survival probability for the current study was 91% ± 3% at 12 to 13 years and 73% ± 16% at 15 to 16 years. This appears to be far less than reported by Friedman[10] in an up to 15-year study of 3,500 veneers. Friedman's study, however, did not account for loss to follow-up and did not include veneers that were replaced for esthetic reasons as failures. The evaluation criteria assessed only caries, retention, and postoperative sensitivity. Thus, the reported survival rate of 93% over 15 years was biased by this narrow study design.

The survival rate for 1 to 6 years in this study is high. Therefore, to analyze differences between survival of anterior veneers compared with canine/premolar veneers, only the veneers that were in situ for more than 5 years were considered. Eleven of the 128 veneers on incisors failed (8.6%), compared with 3 of the 50 veneers on canines/premolars (5.8%). No statistical difference was found between these groups. It must be acknowledged that not every premolar/canine/incisor presenting for restoration was veneered. Therefore the sample included in this study shows bias toward teeth that when assessed subjectively by a specialist were considered to have a favorable long-term veneer prognosis. Thus, the similar outcomes in survival for veneers on incisors compared with veneers on premolars/canines cannot be applied to teeth in general.

Conclusions

- When bonded to enamel substrate, feldspathic porcelain veneers offer a predictable long-term restoration with a low failure rate. The cumulative survival rate was 96% ± 1% at 5 to 6 years, 93% ± 2% at 10 to 11 years, and 91% ± 3% at 12 to 13 years.
- The cumulative survival rate was 73% ± 16% at 15 to 16 years; however, low veneer numbers during this time period skewed the results.
- Significantly fewer veneers survived as the time in situ increased.
- Of the 304 veneers, 3 were repaired, 16 failed, 32 were unknown, and 5 were lost to follow-up because of death.
- Failed veneers were associated with esthetics (31%), mechanical complications (31%), periodontal support (12.5%), loss of retention > 2 (12.5%), caries (6%), and tooth fracture (6%).
- The statistical methods used to calculate the cumulative survival can markedly affect the apparent outcome and thus should be clearly defined in outcome studies.

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Literature Abstract

Antagonist enamel wears more than ceramic inlays

The aim of the study was to evaluate ceramic wear, antagonist enamel wear, and luting cement wear over 8 years. The 2-fold null hypothesis was that there would be *(1)* no difference in wear behavior between ceramic and enamel and *(2)* no influence of filler content of luting composites on composite wear. Seventeen inlays and their corresponding antagonists in 10 patients were included to test the first hypothesis. Criteria for inclusion were as follows: *(1)* the restorative situation of the antagonist and adjacent teeth had to be unchanged over the whole period, and *(2)* the contact area of the ceramic inlay had to be exclusively in enamel. Dies in Fuji Rock were made from impressions made at recall sessions at 6 months, 1 year, and 2, 4, 6, and 8 years. One-year assessments were defined as baseline, with 4-, 6-, 8-year dies serving as follow-up. Dies were scanned with a 3-dimensional laser scanner. Thirty-six inlays (with cusp inclinations below 45 degrees) from 16 patients were selected to test the second hypothesis. Twenty of these inlays were luted with a light-cured hybrid-type resin composite (filler 82 wt %), and 16 were luted with a dual-cured luting composite Variolink Low (filler 72 wt %). Three-dimensional scanning of luting gaps was done using a profilometer. Occlusal contact areas were excluded from the measurement. Data concerning the comparison of ceramic versus antagonist wear were normally distributed (Kolmogorov-Smirov test) and were therefore analyzed with paired *t* tests. Significant changes in wear were computed using Friedman 2-way analysis of variance (ANOVA) ($P = .05$). Differences between groups in the luting gap analysis were evaluated using pair-wise with the Mann-Whitney *U* test ($P = .05$). Differences over the investigation period were calculated using Friedman 2-way ANOVA. Linear regression analysis was used to assess the correlation between width and depth of the luting gap. Ceramic and enamel wear increased between 4 and 8 years, with significantly higher values for enamel after 6 years ($P < .05$). Luting gap wear increased continuously up to 8 years ($P < .05$), with no influence of luting composites ($P < .05$) or location of teeth ($P < .05$).

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