

Extended porcelain veneers in the maxillary anterior region

A retrospective study with an up to 27-year follow-up

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Abstract

Aim: The aim of the present retrospective study was to evaluate the long-term results, including technical and biologic outcomes, of maxillary extended porcelain veneers with an incisal edge thickness above 2 mm.

Materials and methods: Patients treated with extended porcelain veneers performed by a single clinician at University of Geneva between 1990 and 2003 were identified and invited to an examination. Of the 37 identified patients, 10 patients with 50 veneers agreed to be examined and were included. A clinical examination was performed to assess survival rates as well as technical and biologic outcomes (modified United States Public Health Services criteria). Patient records were also reviewed to retrieve patient and reconstruction data and every complication event. Patient-reported outcome measures (PROMs) were evaluated using a visual analog scale to measure esthetic

satisfaction, functional and phonetic comfort, masticatory improvement, tooth sensitivity, and acceptance of restoration replacement in case of failure. Data were descriptively analyzed, and Kaplan-Meier survival estimators were computed for survival rates and complication events.

Results: The survival rate of the veneers was 96% after a mean follow-up of 20.7 ± 3.7 years in function. The technical complication rate amounted to 30%, including two failures, nine repairable fractures, three cracks, and one displacement due to trauma. No cavitated caries lesions or endodontic complications were registered. PROMs were very high for esthetic satisfaction and phonetic comfort.

Conclusions: Within the limitations of the present retrospective study, extended porcelain veneers appear to be a successful long-term treatment option in terms of clinical outcomes and patient satisfaction.

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Keywords

adhesive dentistry, esthetics, ceramics, prosthodontics, restorative dentistry, veneers

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Introduction

Porcelain veneers have become an established treatment option for minimally invasive rehabilitation of the anterior dentition. Initially designed to improve esthetic appearance, veneers are today a conservative approach to improve not only esthetics but also the function of discolored, misaligned teeth with malformations and fractures or wear of the dental substrate.¹⁻⁵ When compared with full-coverage crowns, porcelain veneers have shown similar 5-year clinical outcomes with a mean survival rate of 95.7%, while that of metal-ceramic and all-ceramic crowns ranged from 96.6% to 98.5%, respectively.^{6,7} Furthermore, biologic advantages may also lead to treatment concepts in favor of veneers when compared with more invasive reconstructions. The preservation of sound dental tissue may help to maintain the vitality of the tooth.⁸

The minimum thickness of ceramic veneers can be reduced to 0.3 to 0.7 mm. These thin reconstructions are mostly made of feldspathic ceramic and are very fragile. Hence, they present some risk of fracture during handling due to their brittle nature and reduced thickness. The elastic modulus of the substrate is of the outmost importance, as is the type and quality of the tooth substance, for the long-term outcome of veneers. Studies have shown that veneers bonded to enamel present higher adhesive strength and better survival rates than those bonded to dentin.^{9,10} However, the specific protocol known as immediate dentin sealing (IDS) has demonstrated a significant benefit for the survival of veneers bonded mostly to dentin.¹¹ Adhesive cementation is a crucial step for the long-term survival of these types of reconstructions. A proper luting procedure permits the penetration of the gaps and irregularities between the tooth and the restoration internal surface by inhibiting crack propagation.¹²⁻¹⁴

The use of more resistant ceramics with improved fracture strength (ie, glass-reinforced ceramics)¹⁵ and adhesive luting procedures that focus on better dentin bonding have made possible the extension of the indication of veneers even in cases of major loss of tooth substance (ie, trauma or severe erosion).^{2,9,16-19} Maintaining the minimally invasive approach of the preparation, the minimum thickness of 0.3 to 0.7 mm of the ceramic can be increased up to 4 mm or more depending on tooth substance loss. This results in having more dentin and less enamel as a substrate for the adhesive surface. First clinical results were promising regarding survival rates of extended porcelain veneers.¹⁶⁻¹⁸

According to the current literature, these encouraging results are still too variable and often operator dependent. Initially, extended veneers were also applied in extreme clinical situations with major loss of tooth substance, where previous conventional crowns had already failed.^{1,20} Consequently, research has allowed the understanding of which factors influence the negative outcomes of such reconstructions. It is now generally accepted that proper preparation design and adhesive technique, good accuracy of the restoration, choice of the right material, and isolation of the adhesive field are pivotal factors for veneer predictability.^{5,21,22}

One study that took these factors into consideration reported excellent 4.5-year outcome results of extended feldspathic veneers in complex situations, ie, 100% survival at 4 years.¹⁶ Currently, very few studies with short- or medium-term follow-up are available for extended veneers in the anterior region.^{16,18,23} The purpose of the present retrospective study was to provide more information on the long-term results, including technical and biologic outcomes, of extended porcelain veneers with more than 10 years in function.

Materials and methods

The present study was a single-center retrospective observational study of extended veneers in the maxillary anterior area (intercane region). All patients treated with this type of reconstruction and by the same clinician (PMa) at the University Dental Clinics of Dental Medicine, University of Geneva between 1990 and 2003 were identified. Extended veneers or type III veneers, as previously described,² were defined to have an incisal extension of more than 2 mm with possible coverage of the palatal aspect (Figs 1 and 2).

A light chamfer finish line was created buccally and proximally in the form of a paragingival margin (Fig 3). The palatal finish line either consisted of a butt or a chamfer (Fig 4). All veneers were fabricated by the same dental technician (MM) using a feldspathic ceramic (Creation; Klema, Meiningen, Austria) with a refractory die technique. Adhesive luting procedures were performed under rubber dam whenever possible. The veneers were adhesively cemented after etching, silanization, and the use of a composite resin cement. The detailed clinical procedures and part of the outcomes were reported in a previous publication.¹⁶

The current retrospective study was approved by the local ethical committee (EKNZ BASEC 2016-00971). All the included patients gave their informed consent before inclusion. Unfortunately, of the 37 identified patients, 27 were either no longer available or had no interest in participating in the present study. A total of 10 patients, however, agreed to participate and attended a study examination. A total of 50 anterior extended veneers could be evaluated. All patients had attended regular maintenance visits at the university clinics or at private practices. Besides the clinical follow-up examination, the patient records were also reviewed in order to retrieve patient and restoration data (gender, age, smoker status,



Fig 1 Preoperative frontal view of one included patient.



Fig 2 Preoperative palatal view of one included patient.



Fig 3 Frontal view of tooth preparations of six veneers.



Fig 4 Occlusal view of tooth preparations of six veneers.

medical history, abutment teeth, date of restoration insertion, antagonist dentition) as well as every complication event and respective date.

The clinical examination of the retrospective study was performed by two cali-

brated examiners (JC and PR) and included the assessment of the technical and biologic parameters of the abutment teeth and respective veneers. An intraoral mirror, an explorer probe, and a periodontal probe were used. Intraoral photographs were taken for every case. The technical outcomes of the veneers were evaluated following modified United States Public Health Services (mod-USPHS) criteria in order to assess the presence of cracks, chip-pings, fractures (repairable and nonrepairable), color match with remaining dentition, marginal adaptation and staining, anatomical form, surface roughness, occlusal contacts, and interproximal contacts (Table 1). For the assessment of the biologic parameters, abutment tooth vitality was assessed by means of a sensitivity cold test. Radiographs were performed in the case of a doubtful or negative response to the cold test. The presence of hypersensitivity was registered as well as that of secondary caries lesions. An outcome was rated as Alpha (A) when no problems were found, Bravo (B) when minor but clinically acceptable defects were found, and Charlie (C) when defects reached a level that is no longer clinically acceptable. From a periodontal point of view, pocket probing depth (PPD) was measured at six sites per tooth, and the highest value was recorded and grouped as: 1) 1 to 3 mm; 2) 4 to 5 mm; or 3) ≥ 6 mm. Bleeding on probing (BoP) per tooth was recorded 20 s after probing and grouped as: 0) ≤ 1 site; or 1) ≥ 2 sites. The presence of plaque in the marginal region was also measured per tooth (Plaque Index)²⁴ and grouped as: 0) ≤ 1 site; or 1) ≥ 2 sites.

Patient-reported outcome measures (PROMs) were evaluated by means of a visual analog scale (VAS) on a scale from 0 to 100 to assess esthetic satisfaction, functional and phonetic comfort, masticatory improvement after treatment, tooth sensi-

tivity, and acceptance of restoration replacement in case of failure (Table 2).

Statistical analysis

Considering the small number of study participants, the data were analyzed to provide descriptive results using SPSS statistical software (IBM SPSS Statistics v26; IBM, Armonk, NY, USA). Descriptive statistics included frequency tables, mean and standard deviation for continuous variables such as observation period, and VAS questions. Veneers were considered to have survived if they were still in situ irrespective of any complication. Time in situ was calculated in years from the date of insertion to the first event (complication or failure) or until the date of the study clinical examination if no failure or complication had occurred. Kaplan-Meier survival estimators were computed in years for complication events and clinical survival.

Results

A total of 10 patients (9 females and 1 male) with a mean age of 65.6 ± 13.8 years (range 42.2 to 87.4 years) restored with 50 maxillary anterior extended porcelain veneers (20 central incisors, 17 lateral incisors, 13 canines) were examined after a mean follow-up period of 20.7 ± 3.7 years (range 14.6 to 27.4 years; Figs 5 to 12). Two of the patients were smokers and four were former smokers. Two patients had been treated for periodontal diseases, while another suffered from gastroesophageal reflux disease.

The survival rate of the reconstructions was 96% (Fig 13), with only two veneers with complete fractures that required replacement. One failure occurred 6 months after insertion due to a trauma in one patient, while the other occurred 21.7 years after cementation. Both patients received new veneers after these events.

Table 1 Modified USPHS criteria for assessment of technical and biologic outcomes

	Parameter	Rating: Alpha (A) Bravo (B) Charlie (C)	Description
Technical outcomes	Color match	A	Restoration matches adjacent tooth in color and translucency
		B	Mismatch is within an acceptable range of tooth color and translucency
		C	Mismatch is outside the acceptable range and restoration has to be altered
	Marginal adaptation	A	No crevice visible Explorer does not catch at the margins
		B	Explorer catches at the margins No visible evidence of a crevice into which the explorer could penetrate No dentin visible
		C	Explorer penetrates into a crevice Dentin or cement visible Cannot be polished
	Marginal staining	A	No staining along margins
		B	≤ 50% affected by stains
		C	> 50% affected by stains
	Anatomical form	A	Restoration continuous with existing anatomical form
		B	Restoration discontinuous with existing anatomical form but missing material not sufficient to expose dentin
		C	Sufficient material loss to expose dentin
	Surface roughness	A	Surface of restoration is smooth
		B	Surface of restoration is slightly rough or pitted but can be refinished
		C	Surface deeply pitted or flaking, irregular grooves, and cannot be refinished or fractured
	Occlusal contacts	A	Normal
		B	Heavy/light
		C	Absent
	Interproximal contacts	A	Good
		B	Light
		C	Absent
Biologic outcomes	Secondary caries lesions	A	No caries lesions
		B	Initial caries lesions at margin of restoration without cavitation
		C	Deep caries lesions
	Vitality	A	Positive
		B	Positive (slow) or negative without radiographic signs
		C	Negative (without endodontic treatment) and radiographic signs
	Sensitivity to temperature	A	Not sensitive
		B	Moderate or low-level pain
		C	Severe (high-level or persistent pain)

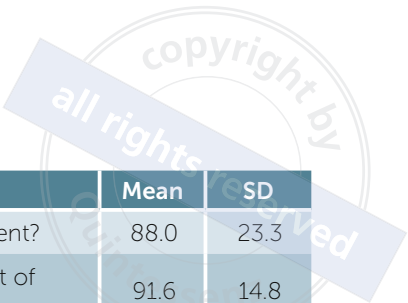


Table 2 General patient satisfaction with the esthetic and functional outcomes

Parameter	Questions	Mean	SD
Esthetic satisfaction	How do you rate your esthetic appearance after the treatment?	88.0	23.3
Functional and phonetic comfort	How did you feel after the treatment from a functional point of view (phonation)?	91.6	14.8
Masticatory improvement	How much has the treatment improved your masticatory capacity?	63.7	45.7
Tooth sensitivity	Are your teeth sensitive to fresh air, hot/cold water, or sweet foods?	30.0	31.9
Acceptance of restoration replacement in case of failure	Would you accept an eventual need for the replacement of a veneer in case of a failure?	77.7	36.0

Mean ± standard deviation [SD] values of visual analog scale from 0 to 100.



Fig 5 Frontal view of the same case of the six veneers shown in Figures 1 to 4, shown here at the 19.3-year follow-up, without apparent complications from the buccal aspect.



Fig 6 Occlusal view of the same case of the six veneers shown in Figures 1 to 4, shown here at the 19.3-year follow-up, with visible crack line in the mesiopalatal angle of the veneer, but apparently stable and with no further complications.



Fig 7 Repairable fracture of distal aspect of veneer on tooth 11 took place after 27 years in function.



Fig 8 After repair by means of rebonding the fractured fragment on tooth 11.



Fig 9 Frontal view of marginal fracture on the cervical aspect of veneer 11, undetected by the patient. Veneers from canine to canine in function for 22 years.



Fig 10 Lateral view of marginal fracture on the cervical aspect of veneer 11, undetected by the patient. Veneers from canine to canine in function for 22 years.



Fig 11 Frontal view of veneers after 25.9 years in function. Crack line visible on the incisal aspect of tooth 21.



Fig 12 Occlusal view of veneers after 25.9 years in function. Crack line visible on the incisal and palatal aspects of tooth 21.

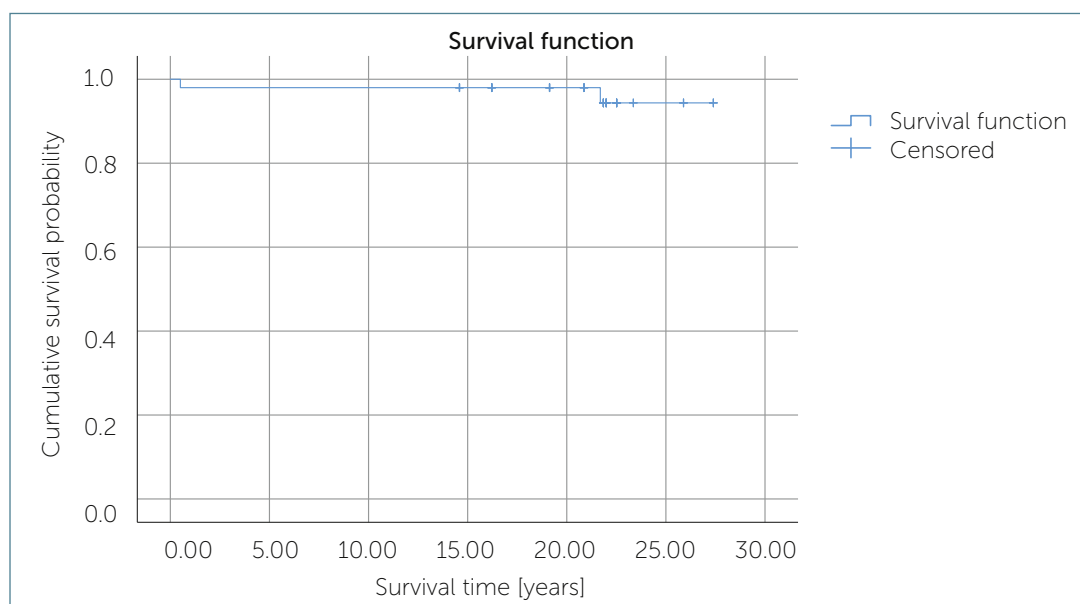
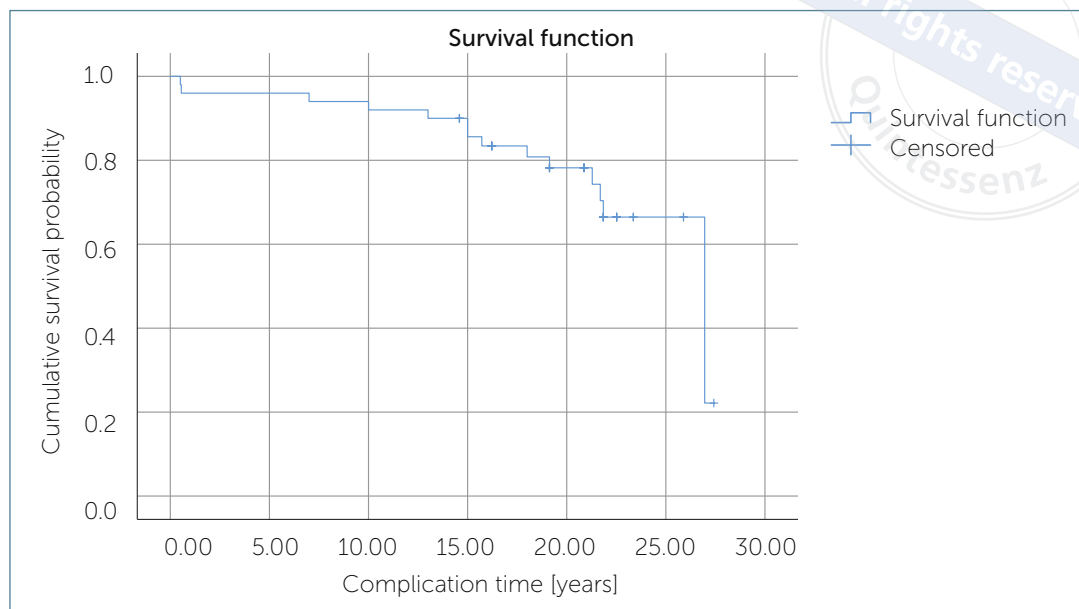


Fig 13 Kaplan-Meier curve for clinical survival.

Fig 14 Kaplan-Meier curve for complication events.



The technical complication rate amounted to 30% (Fig 14), which included two failures due to fatal fractures, nine repairable fractures (Figs 7 and 8) or fractures that did not need to be repaired (Figs 9 and 10), three cracks (Figs 6, 11, and 12), and one veneer displacement as a result of a trauma (Table 3). Following the mod-USPHS criteria, evaluation of color match of the veneers compared with the neighboring teeth was rated as A in 63.8%, B in 23.4%, and C in 12.8% of cases. The marginal adaptation was rated as A in 66.7%, B in 27.1%, and C in only 6.3% of cases, while marginal staining was rated as A in 29.2%, B in 58.3%, and C in 12.5% of cases. Anatomical form was mostly rated as A (79.2%) and in some cases B (20.8%). Surface roughness was mostly rated as A (68.8%), followed by B (20.8%), and in a few cases C (10.4%). Occlusal contacts were rated as A in 29.2%, B in 39.6%, and C in 31.3% of cases. Table 4 provides the detailed results of the technical outcomes.

Regarding the biologic outcomes, no cavitated secondary caries lesions were detected on the abutment teeth; however, 12.5% of cases presented initial lesions with marginal discoloration but without cavitation. No endodontic complications were registered, and all initially vital teeth were still vital at the clinical follow-up visit. No hypersensitivity was detected (Table 5). From a periodontal point of view, 20.8% of the sites presented PPD of > 4 mm, 50.0% of the teeth presented BoP at more than two sites, and 14.6% of the teeth presented two or more sites with plaque accumulation.

PROMs were measured using a VAS and revealed very high results for esthetic satisfaction with the treatment (88/100) and phonetic comfort (92/100). A substantial improvement after treatment from a masticatory point of view was reported (64/100), with a mostly low rate of reported tooth sensitivity (30/100). In general, patients were amenable to accepting an eventual need of veneer replacement in case of failure (78/100; Table 2).

Table 3 Frequency and percentage of each type of complication

Complications	Frequency [n]	Percentage [%]
Cracks	3	6.0
Repairable fractures	9	18.0
Veneer displacement	1	2.0
Fatal fractures	2	4.0

Table 4 Frequency distribution of technical outcomes in 48 veneers

Parameter	Alpha (A) n [%]	Bravo (B) n [%]	Charlie (C) n [%]
Color match	30 [63.8]	11 [23.4]	6 [12.8]
Marginal adaptation	32 [66.7]	13 [27.1]	3 [6.3]
Marginal staining	14 [29.2]	28 [58.3]	6 [12.5]
Anatomical form	38 [79.2]	10 [20.8]	0 [0.0]
Surface roughness	33 [68.8]	10 [20.8]	5 [10.4]
Occlusal contacts	14 [29.2]	19 [39.6]	15 [31.3]
Interproximal contacts*	33 [78.6]	8 [19.0]	1 [2.4]

Modified USPHS criteria; *Missing data not possible to evaluate due to a presence of a palatal contention wire.

Table 5 Frequency distribution of biologic outcomes in 48 veneers

Parameter	Alpha (A) n [%]	Bravo (B) n [%]	Charlie (C) n [%]
Secondary caries lesions	42 [87.5]	6 [12.5]	0 [0.0]
Vitality*	36 [76.6]	11 [23.4]	0 [0.0]
Sensitivity to temperature*	43 [91.5]	4 [8.5]	0 [0.0]

Modified USPHS criteria; *Missing data due to root canal treatment prior to placement of veneers.

Discussion

The present retrospective study evaluated the longevity and clinical outcomes of extended porcelain veneers in the anterior maxillary region up to 27.4 years in function. To date, only a few studies have reported on the clinical outcomes of extended porcelain veneers.^{11,16,18,23} Although the reported results appeared to be quite positive (between 91.8% to 100%), the mean observation times were limited to a maximum of 11 years.¹¹ In the present study, extended porcelain veneers had a survival rate of 96% at a mean

follow-up period of 20.7 years, which reveals them to be a valuable and durable treatment option.

Regarding optimizing veneer resistance, improved ceramic materials such as reinforced glass-ceramics have been proposed. In one systematic review, the 9-year estimated survival rate was 94% for glass-ceramics and 87% for feldspathic porcelain veneers.²⁵ A more recent review reported a 10-year estimated cumulative survival rate for porcelain veneers of 95.5%.²⁶ These outcomes appear very similar to those of the present study, yet after a much shorter clin-

ical follow-up period. One could expect an increase of failures and complications with time in function.^{23,27-31} A possible reason for this inferior performance may be related to the heterogeneity of the studies included in the systematic reviews in terms of clinicians, clinical protocols, and materials used. Two long-term studies reported 20-year cumulative survival rates between 82.9%³² and 91%²⁷ for feldspathic veneers. Even though the first study showed a reduced survival rate,³² which may have been related to the fact that half of the patients were bruxers, the results appeared encouraging in the long run. Moreover, in both studies the veneers were performed exclusively by one²⁷ or two³² experienced clinicians. Likewise, in the present study, a single operator performed all the clinical procedures following a well-defined protocol. This fact may highlight the importance of clinical experience and the use of strict clinical protocols, specifically regarding the adhesive procedures, in order to obtain a successful outcome.²²

The observed technical complications in the present study included ceramic fractures, cracks, and veneer displacement following a trauma event. While no debonding events were registered, an incidence of 18% of ceramic fractures was observed (nine fractures). This number of fractures could be explained by the omission of proper porcelain cleaning after etching and the lack of IDS (not performed in the early cases). Both elements appear to have had a significant influence on the bond strength¹⁰ and survival rate of those veneers.¹¹ A significant presence of dentin can reduce the adhesive potential and decrease the overall resistance of the ceramic, inducing material fracture.³³ Moreover, the non-ideal geometric configuration and the significant extension of the veneers to the palatal side may increase the mechanical stresses applied and contribute to failure. Nevertheless, 70% of the veneers had no complications after a long follow-up

in the present study. In addition, most of the ceramic fractures could be repaired with the retrieval and bonding of the fractured fragment. Moreover, post-bonding cracks can also be repaired by resin infiltration to avoid staining in the long term.³⁴

Even though a cluster analysis was not performed in the present study due to the small cohort, to a certain extent a clustering effect may be considered.²⁷ In one patient, five out of six veneers presented ceramic fractures, which could be explained by patient- or environment-related factors.²⁷ The same applies to another patient who suffered a trauma event, which resulted in the complete fracture (failure) of one veneer and the displacement of another.

In the present study, almost half of the veneers did not fully match the adjacent teeth in terms of color and translucency. Substantial changes in the color of natural teeth over a long period of time can result in a color mismatch developing between the reconstruction and the adjacent teeth,³⁵ which may partially explain this lower rate compared with other studies.^{5,11,22} In addition, most color mismatches (13 out of 17 veneers) were found in smokers and former smokers, while all the color mismatches outside an acceptable range (C) were found in the same patient, a current smoker. The majority of the veneers presented good or acceptable margin adaptations, with only three reconstructions where the explorer could penetrate a crevice. This result is compatible with other studies with shorter follow-up periods.^{28,36} In the present study, more than two thirds of the veneers showed stains along margins. Some authors have correlated marginal discolorations with the aging of veneers,⁵ reporting a high rate of marginal discoloration.^{28,31} However, most of the stains were on the palatal aspects and could be easily repolished or repaired.²¹ In terms of surface roughness, the present study results were slightly lower than those

of other studies that reported acceptable surface roughness rates of 99% and 97%.^{11,32} One of the reasons for this may be related to the fact that four out of five veneers with unacceptable results occurred in the same patient after rebonding of the fractured veneer fragments.

From a biologic point of view, no deep carious lesions or endodontic problems were found. These results appear very positive considering the extension of the veneers on dentin that resulted from the previous loss of tooth substance. One possible reason is based on the fact that the observed patients were attending regular professional controls (dentist or hygienist). Although some initial discolorations were detected in the restoration margins, treatment was not indicated in any of these cases.

A few authors have assessed PROMs after veneer reconstructions.^{5,11} The present results confirm high overall patient satisfaction in terms of esthetics, phonetic comfort, mastication, and tooth sensitivity, which suggests that patients felt satisfied with this treatment even after a long time. Nevertheless, these results should be interpreted with caution since a selection bias may have occurred, resulting in the inclusion of patients who were mainly satisfied with the received treatment.

As a retrospective study, some limitations include the fact that a considerable number of treated patients could not be

reached or clinically observed, which led to an inclusion of only 10 patients. This high dropout rate is certainly related to the long-term follow-up and to the fact that many patients were not in maintenance at the university clinics but rather at private practices. Some patients had moved away and were not available to attend a study clinical examination. Although the number of included patients was low, the very long-term follow-up of this particular type of restoration justifies the relevance of the present analysis. Another limitation was that the patients were treated during an extended period of time. Although the procedures were always performed by the same clinician using the same treatment concept and techniques, some evolution of the clinical protocol and operator experience cannot be ignored. For these reasons, further long-term studies, ideally with prospective designs and a higher number of patients, are needed to further elucidate the possibilities and limitations of the present type of reconstructions.

Conclusions

Within the limitations of the present retrospective study, extended porcelain veneers in the maxillary anterior region presented a very high survival rate after a long-term follow-up with some repairable technical issues but no biologic complications. Patients appeared to be satisfied with this treatment option in the long term.

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