

# Survival Rates for Porcelain Laminate Veneers: A Systematic Review

Yousra H. AlJazairy<sup>1</sup>

<sup>1</sup>Department of Restorative Dental Sciences, College of Dentistry, King Saud University, Riyadh, Saudi Arabia

**Address for correspondence** Dr. Yousra Hussain AlJazairy, BDS, MSc, Department of Restorative Dental Sciences, College of Dentistry, King Saud University P.O. Box, 60169, Riyadh 11426, Saudi Arabia (e-mail: yousra.aljazairy@gmail.com).

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## Abstract

The aim of this systematic review was to analyze and compare the most up-to-date information available on long-term, medium-term, and short-term survival rates of porcelain laminate veneers (PLVs) and investigate the homogeneity in current studies or lack of it. An electronic search was performed using PubMed, Ovid MEDLINE, Cochrane Library, Web of Science, EBSCO, Science Direct, Wiley, and Scopus databases. Based on the PRISMA guidelines, the main inclusion criteria consisted of research articles published after the year 2000, *in vivo* studies with a follow-up period of at least 1 year and reporting of the Kaplan–Meier estimated cumulative survival rates. Quality assessment of the included studies was performed using the modified systematic assessment list consisting of 24 items. Thirty full-text articles were reviewed in detail. A total of 30 articles met the inclusion criteria and were selected for qualitative synthesis. The remaining 27 publications were retained to discuss the heterogeneity in the current literature and reported longevity of veneer restorations. A conclusive estimation of the longevity of PLVS beyond 20 years is lacking. The availability of evidence in the current literature is limited in terms of sample size and duration of follow-up. However, the majority of studies have concluded that PLVs have high-success rates and predictable patient outcomes. The present literature indicates an increased heterogeneity among research study designs. Researchers should aim for homogeneous study designs that can be included in systematic reviews and meta-analyses.

## Keywords

- ▶ porcelain laminate veneers
- ▶ longevity
- ▶ follow-up
- ▶ failure
- ▶ ceramic
- ▶ restorations
- ▶ homogeneity

## Introduction

In modern dentistry, porcelain veneer restorations (PVRs) have garnered a reputation as one of the most successful modalities of treatment.<sup>1</sup> Porcelain restorations, specifically porcelain laminate veneers (PLVs), are popular among both dentists and patients due to their ability to replicate the life-like appearance and luster of natural teeth.

The success of PLVs can be attributed to the ability of these veneer restorations to closely mimic the balanced relationship between biological, mechanical, functional, and esthetic parameters of natural teeth.<sup>2</sup> Some of these parameters include predictable outcomes, superior esthetics, long-lasting color stability, life-like translucency, high-abrasion resistance, outstanding resistance of fluid absorption, practical compressive,

tensile and shear strengths, exceptional marginal integrity, biocompatibility with gingival tissue, greater conservation of tooth structure with minimal tooth reduction, and excellent long-term durability.<sup>1,3</sup> The last two parameters are highly debatable topics among researchers.

Researchers have credited this success to a clinician's ability to properly, plan a case, select appropriate ceramics to use, select the materials and methods of cementation, conservative preparation of teeth, implement high-caliber finishing and polishing, and effectively plan for the continuing maintenance of the restorations.<sup>1</sup> When applied correctly, these guidelines have been highly effective in remedying clinical defects such as correcting tooth forms and position, closing diastemata, replacing old composite restorations, restoring teeth with incisal



abrasions or tooth erosion, masking enamel defects, and covering or reducing tooth discolorations such as fluorosis and tetracycline staining.<sup>4</sup>

Despite their successful reputation and similar to other alternative restorative treatments, PLVs are also prone to failure. Several clinical trials, systematic reviews, and meta-analyses have reported a wide range of survival rates over the past few decades.<sup>5-9</sup> These reported survival rates, although extremely valuable, are still considered inconclusive or contradictory when viewed by the general consensus of the scientific community. For example, studies with a follow-up period of less than 5 years have reported survival rates ranging from 80.1 to 100%.<sup>10-17</sup> Studies with a follow-up from 5 years up to 7 years have reported a range of 47 to 100%.<sup>18-28</sup> Studies from 10 to 12 years have stated survival rates ranging from 53 to 94.4%.<sup>4,29-33</sup>

Two of the longest studies conducted to conclude the survival rates of veneers are worth mentioning separately. Friedman in 1998 conducted the longest retrospective cohort study with a follow-up period of up to 15 years.<sup>34</sup> The study reported a straight percentage outcome of 93% for 3,255 veneers. Layton & Walton<sup>35</sup> in 2007 reported the results of their prospective cohort with a Kaplan–Meier estimated cumulative survival rate of 73%. The study included 100 patients treated with 304 veneers with a maximum follow-up period of up to 16 years. However, there is a lack of long-term studies and the wide range of inconsistent results can be observed in some of the studies conducted previously to evaluate the clinical success of PLVs. These varying results can be blamed on the overall heterogeneity of the study designs. More specifically, the conflicting results depend on several influencing factors. The definition of “failure” is the most basic of these factors. The main difference being, some researchers count a veneer as a failure only when it is “irreparable,”<sup>4,31</sup> while others mark a restoration a failure even if it is “reparable.”<sup>29,30</sup> The use of different evaluation criteria (California Dental Association (CDA)/Ryge,<sup>34</sup> US Public Health Service (USPHS),<sup>23,24</sup> FDI,<sup>10,15</sup> Walton's Six Field<sup>35</sup>) is another influencing factor. Other factors that make different reports hard to compare are reporting of survival rates in straight percentages<sup>19,26-28,34</sup> or using a Kaplan–Meier analysis,<sup>29,30,35,36</sup> taking into account or ignoring clustered outcomes<sup>20,21</sup>, prospective<sup>12,14,16</sup> versus retrospective<sup>17,29,30</sup>, direction of trials, and inconclusive or missing information. Finally, use of “modified” criteria (Modified CDA/Ryge,<sup>4,11,31</sup> Modified USPHS<sup>12,13,18,19,25</sup>) and methodologies (modified Kaplan–Meier<sup>35</sup>) have further increased the heterogeneity of the conducted studies.

Despite the heterogeneity of these studies, it can be safely stated that there are ample short- to medium-term studies with high-success rates. However, according to some researchers, the survival rate of PLVs should be no less than 100%, especially for short-term studies.<sup>8</sup> To assess the true longevity of the PLVs, it is perhaps acceptable to describe the overall clinical success of PLVs on the basis of short-, medium-, and long-term definitions. Therefore, this review has focused on investigating studies with a follow-up period of a minimum of 1 year up to more than 20 years. The aim of

this systematic review was to analyze and compare the most up-to-date information available on short-, medium-, and long-term survival rates of PLVs and investigate the homogeneity in current studies or lack of it.

## Materials and Methods

### Standard of Reporting and PICOS Principle

The present systematic review followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guideline. The studies were identified using the following PICOS principle: **P**atients = patients who received ceramic veneers, **I**ntervention = PLVs, **C**ontrol (not applicable in the present study), **O**utcome = estimation of Kaplan–Meier cumulative survival rate and **S**tudy design = prospective or retrospective studies.

### Study Selection

The main inclusion criteria consisted of articles published in the English language, foreign language articles with readily available translations, *in vivo* studies with a follow-up of at least 1 year, both retrospective and prospective randomized controlled trials (RCTs) in humans, and reporting of a Kaplan–Meier estimated cumulative survival rate. Studies were not considered if studies did not report adequate description related to the preparation of PLVs or their bonding procedures, review articles, case reports, abstracts or unpublished data.

### Data Sources

An extensive electronic search was performed using PubMed, Ovid MEDLINE, Cochrane Library, Web of Science, EBSCO, Science Direct, Wiley, and Scopus databases from 1970 to 2020. The search was conducted using different combinations of the following terms: “dental,” “porcelain,” “ceramic,” “laminare,” “veneers,” “PLVs” “survival,” “rate,” “longevity,” “follow-up,” “failure,” “clinical,” “performance,” “retrospective,” “prospective,” and “longitudinal.”

No manual or hand search was conducted. During the initial screening process, all duplicates were identified and removed. Other exclusions included research abstracts, posters, case reports, commentaries, critical appraisals, letters to editors, editorials, conference papers, and review articles. The references of all full-text articles including systematic reviews and meta-analyses were inspected for additional relevant sources. Unpublished studies (*gray literature*) were identified by searching the Open-GRAY database, and references of the included studies (cross referencing) were performed to obtain new studies. One reviewer (YHA) screened the titles and the abstracts of all the results identified through the electronic searches. Full articles were collected for titles requiring detailed inspection.

### Quality Assessment

Quality of all the studies were assessed using a modified systematic assessment list consisting of 24 items.<sup>37</sup> The 24-item list was developed according to the guidelines of publication.

The items consisted of points including the reporting of hypothesis, aims, setting/study design, distribution of study population by age and gender, adequate eligibility criteria, description of treatment, sample size, main outcomes, use of control group, randomization and blinding, calibration performed, adequate statistical analyses, reporting of confidence intervals, adverse effects, and conclusions. For each item, a single mark “x” was given. A percentage value of quality items was analyzed for individual study.

## Results

### Study Selection

Out of the total 120 full-text articles, 65 articles were excluded for various reasons including *in vitro* studies, extracted teeth, CAD/CAM, materials unclear or not ceramic/porcelain, no Kaplan–Meier analysis, missing or unclear data, and missing or unclear conclusions. Another 25 publications were removed, as they were systematic reviews or meta-analyses. The remaining 30 full-text articles were reviewed in depth and used to discuss the heterogeneity in current literature and reported longevity of veneer restorations. The corresponding steps for initial screening and selection of studies are shown in the PRISMA diagram (► Fig. 1).

### General Description of the Included Studies

The general characteristics of the selected studies are reported in ► Table 1. Out of all the studies included, a total of

16 studies were retrospective, while a total of 14 studies were prospective cohort studies. On the basis of follow-up period, nine clinical trials had long-term follow up period ranging from 10.5 years to 50 years. Eight studies had medium-term follow-up ranging from 6 years to 10 years, while 13 short-term studies reported a follow-up period of < 6 years. The included studies initiated from the year 1966 to the year 2016. A total of 2473 patients were included in the included clinical trials. The total number of PLVs studied in the clinical trials were 11,465.

### Main Outcomes of the Studies

#### Long-term Clinical Trials

All long-term clinical trials reported their outcomes based on the Kaplan–Meier analysis. The criteria used for assessing survival were variable. Three studies were author-defined,<sup>29,38,39</sup> two studies used Walton’s Six Field<sup>35,36</sup> and modified CDA/Ryge,<sup>4,31</sup> while only one study used CDA/Ryge.<sup>34</sup> The overall survival rate ranged from 100% to 73% in the included long-term trials. A general trend of reduced survival rate was observed among four studies who reported their survival rates at different time points.<sup>29,31,35,39</sup>

#### Medium-term Clinical Trials

Four clinical trials reported the survival outcomes based on the Kaplan–Meier analysis.<sup>18,22,23,32</sup> One study reported mean percentage of survival rate,<sup>19</sup> while outcomes from the three studies were either unclear or had missing data.<sup>20,21,33</sup>

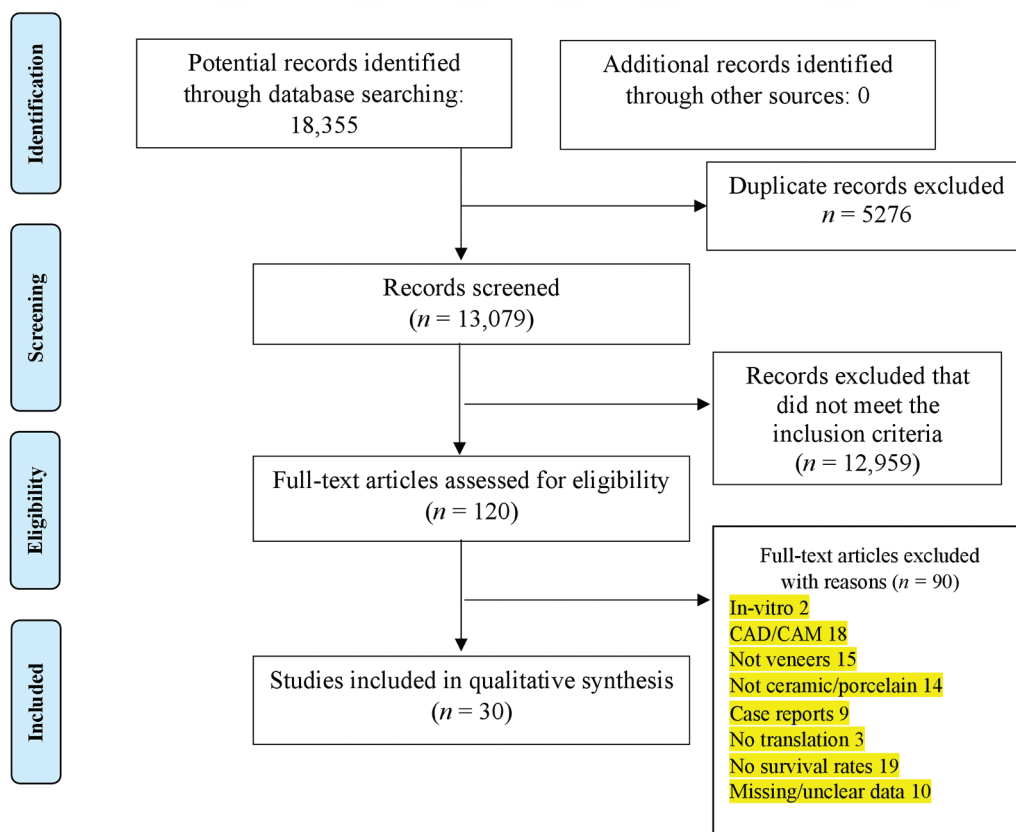


Fig. 1 PRISMA flowchart for the study selection process.

**Table 1** Characteristics of selected articles

#	Author	Period	Max. follow-up	Patients	PLVs	Survival rate	Criteria	Survival method	Study design
<b>Long-term trials</b>									
1	Olley et al (2018) <sup>38</sup>	1966–2016	50 years	*	22	100%	A	KM	RC
2	Layton & Walton (2012) <sup>36</sup>	1990–2010	21 years	155	499	96%	W	KM	PC
3	Beier et al (2012) <sup>39</sup>	1987–2009	20 years	84	318	94.4%–5 years 93.5%–10 years 82.93%–20 years	A	KM	RC
4	Layton & Walton (2007) <sup>35</sup>	1988–2003	16 years	100	304	96%–5 to 6 years 93%–10 to 11 years 91%–12 to 13 years 73%–15 to 16 years	W	KM	PC
5	Friedman (1998) <sup>34</sup>	*	15 years	*	3500	93%	C	%	RC
6	Gurel et al (2013) <sup>29</sup>	1997–2009	12 years	66	580	92%–6 years 86%–12 years	A	KM	RC
7	Fradeani et al (2005) <sup>4</sup>	1991–2002	12 years	46	182	94.40%	MC	KM	RC
8	Granell-Ruiz et al (2009) <sup>30</sup>	1995–2003	11 years	70	323	94%–simple 85%–functional	*	KM	RC
9	Dumfahrt & Schäffer (2000) <sup>31</sup>	1986–1997	10.5 years	65	191	97%–5 years 91%–10.5 years	MC	KM	RC
<b>Medium-term trials</b>									
10	Burke & Lucarotti (2009) <sup>32</sup>	1991–2001	10 years	1177	2562	53%	*	KM	RC
11	Peumans et al (2004) <sup>33</sup>	1990–2000	10 years	25	87	64%	A	*	PC
12	D'Arcangelo et al (2012) <sup>18</sup>	2002–2008	7 years	30	119	97.50%	MU	KM	PC
13	Shao-Ping et al (2012) <sup>19</sup>	2005–2012	7 years	32	206	97.60%	MU	%	RC
14	Smales & Etemadi (2004) <sup>20</sup>	1993–2000	7 years	50	110	95.8%–incisal 85.5%–nonincisal	*	*	RC
15	Magne et al (2000) <sup>21</sup>	1995–1999	7 years	16	48	100%	A	*	RC
16	Shaini et al (1997) <sup>22</sup>	1984–1992	6.5 years	102	372	47%	A	KM	RC
17	Fradeani (1998) <sup>23</sup>	1991–1997	6 years	21	83	99%	U	KM	PC
<b>Short-term trials</b>									
18	Aykor & Ozel (2009) <sup>24</sup>	1991–1997	5 years	30	300	94–95%*	U	*	PC
19	Guess & Stappert (2008) <sup>25</sup>	1999–2006	5 years	25	66	100%–full 97.5%–overlap	MU	KM	PC
20	Murphy et al (2005) <sup>26</sup>	1996–2001	5 years	29	62	89%	*	%	RC
21	Aristidis & Dimitra (2002) <sup>27</sup>	1993–1998	5 years	61	186	98.40%	A	%	PC
22	Peumans et al (1998) <sup>28</sup>	1990–1995	5 years	25	87	93%	A	%	PC
23	Coelho-de-Souza et al (2015) <sup>10</sup>	*	3.5 years	86	196	80.10%	F	KM	RC
24	Fabbri et al (2014) <sup>11</sup>	2006–2010	3.5 years	*	318	97.91%	MC	KM	PC
25	Gresnigt et al (2013) <sup>12</sup>	2007–2010	3.3 years	20	92	94.60%	MU	KM	PC
26	Rinke et al (2013) <sup>13</sup>	2008–2010	3 years	37	130	95.10%	MU	KM	RC
27	Nordbø et al (1994) <sup>14</sup>	1990–1993	3 years	41	135	98.50%	*	*	PC
28	Karagözoğlu et al. (2016) <sup>15</sup>	*	2 years	12	62	100%	F	KM	PC
29	Öztürk & Bolay (2014) <sup>16</sup>	2008–2011	2 years	28	125	91.20%	MU	KM	PC
30	Çöttert et al (2009) <sup>17</sup>	1999–2005	1.5 years	40	200	99.50%	A	KM	RC

Abbreviations: %, straight percentage; A, author-defined; C, CDA/Ryge; F, FDI; KM, Kaplan–Meier analysis; MC, modified CDA/Ryge; MU, modified USPHS; P, prospective cohort; R, retrospective cohort; U, USPHS; W, Walton's six field. (\*) Unclear or missing data.

Three studies used their own criteria,<sup>21,22,33</sup> two studies used modified USPHS,<sup>18,19</sup> while one study used USPHS criteria.<sup>23</sup> The overall survival rate ranged from 100% to 47% in medium-term clinical trials.

#### Short-term Clinical Trials

A total of eight trials were of short-term, which estimated the survival rate of PLVs using the Kaplan–Meier analysis.<sup>10–13,15–17,25</sup> Three trials reported the survival rate using

mean percentage,<sup>26-28</sup> four studies used the modified USPHS criteria,<sup>12,13,16,25</sup> three studies using author-defined,<sup>17,27,28</sup> two studies using FDI,<sup>10,15</sup> while one study each using modified CDA/Ryge<sup>11</sup> and USPHS.<sup>24</sup>

### Quality Assessment

The majority of studies achieved > 75% on the quality assessment. The percentage range of the trials selected in the quality estimation ranged from 58% to 96% (► **Table 2**).

### Discussion

Systematic reviews and meta-analyses are the core of evidence-based dentistry.<sup>40</sup> Clinical trials are, in turn, critically fundamental in supporting the quality of evidence synthesis for both systematic reviews and meta-analyses.<sup>41</sup> The homogeneity of studies is therefore of utmost importance in conducting beneficial systematic reviews. Researchers have suggested that reporting in systematic reviews can be improved by universally agreed upon standards and guidelines.<sup>42</sup> For instance, it is worth noting that previously in 2007, Hickel et al<sup>43</sup> have called for evidence-based studies to follow homogeneous study designs in order for future RCTs to be subsequently included in systematic reviews and meta-analyses. In their publication, the authors promoted the use of the FDI criteria and laid out a detailed framework for researchers to follow in designing and conducting their research.

Carrying out RCTs with large sample sizes and over lengthy follow-up periods are often difficult. As an alternative, well-designed systematic reviews can provide reliable answers to research questions by analyzing several RCTs.<sup>44</sup> For example, the questions of longevity of PLVs and precisely predicting their treatment outcomes. On the other hand, researchers find it difficult to combine RCTs with incomparable statistical variables.

The studies examined in this literature review (► **Table 1**) clearly demonstrated that studies with contradistinctive reporting factors are difficult to combine usefully for systematic reviews or meta-analyses. Without inspecting the detailed methods and materials, and only observing three basic factors such as definition of failure, evaluation criteria and statistical methodology, a wide range of disparity can be noticed.

Out of the total 27 studies, 13 studies were designed as prospective clinical trials and 14 studies were retrospective cohorts. Failure was defined as “irreparable” in 13 studies,<sup>4,11-13,15,18,22,23,25,27,31,34,35</sup> and “reparable but counted as a failure” in nine studies.<sup>10,14,16,17,28-30,32,33</sup> The remaining five studies either did not state or unclearly stated the definition of failure.<sup>19,20,21,24,26</sup> In terms of evaluation criteria, seven studies<sup>17,21,22,27-29,33</sup> used an author-defined criteria, six studies<sup>12,13,16,18,19,25</sup> used the modified USPHS criteria, three studies<sup>4,11,31</sup> used the modified CDA/Ryge criteria, two studies<sup>10,15</sup> used the FDI criteria and another two<sup>23,24</sup> used the USPHS criteria, one study<sup>34</sup> each used the CDA/Ryge criteria and<sup>35</sup> the Walton’s Six Field criteria, while five

studies<sup>14,20,26,30,32</sup> did not report a clear criteria. In utilizing proper survival estimation methodology, five studies<sup>19,26-28,34</sup> used straight percentages, and another five studies reported unclear or undefined statistical analyses.<sup>14,20,21,24,33</sup> Overall, 17 studies, being a definite majority, did utilize the Kaplan–Meier analysis and reported a precise cumulative survival estimation.<sup>4,10-13,15-18,22,23,25,29-32,35</sup>

At the very basic, if the definitions of failure were standardized, the survival times would be the same conceptually. If the studies used the Kaplan–Meier analysis instead of straight percentages, then the statistical results can be aggregated into information, leading to a higher statistical power and conclusions that are more robust. Finally, using the same evaluation criteria could aid in decreasing the researcher bias in judging the state of a restoration and could provide results that could be compared in depth, according to a detailed breakdown of esthetic, functional, and biological properties.

The same can be observed for the three studies retained for qualitative synthesis. All the authors defined their own evaluation criteria. Even though Walton’s Six Field classification has been standardized, it has not been employed in any other study. The only use that can be seen in the current literature is in studies conducted by the same authors.<sup>7,35,36</sup> Survival rate estimations were calculated using the Kaplan–Meier analysis by all three of the studies. However, Layton & Walton<sup>36</sup> used a slightly modified version of the analysis, and Olley et al<sup>38</sup> did not state clearly whether the methodology was used to calculate the survival rate of the veneers or only the crowns, rather defined failure in detail but ambiguously, while the remaining two studies defined failure as an irreparable problem. The specifics of the three studies can be observed in more detail below.

Beier et al<sup>39</sup> in their retrospective study conducted a long-term analysis of up to 20 years. The study was conducted at the Innsbruck Medical University in Innsbruck, Austria. Two associate professors placed 318 silicate glass ceramic veneers in 84 patients (38 males, 46 females). The study population consisted of 42 patients (50%) with bruxism and 23 smokers (27.28%). The restorations were placed between November 1987 and December 2009. The fabrication of PLVs varied according to the placement period and included feldspathic porcelain, leucite heat pressed ceramic, or lithium disilicate heat-pressed ceramic. The veneers were evaluated between March 2010 and July 2010 by using the modified CDA/Ryge criteria. In addition, a papilla bleeding index (PBI) assessment and a customer satisfaction survey were conducted. Out of the total 318 veneers, 152 veneers were observed over 10 years, 75 veneers were observed over 17 years, and only three veneers were observed over 20 years.

Failure was defined as an “irreparable problem.” Twenty veneers failed before the evaluation in 2010 and no clinical data using modified CDA/Ryge was recorded. However, since the type of failure was recorded, the veneers were not censored from the Kaplan–Meier analysis. The authors did provide a breakdown of failures according to CDA/Ryge criteria

**Table 2** Quality assessment of the included studies

Author	H	S	A/G	IC	EC	T	MO	SS	SSJ	CG	RA	MRA	B	E	ECL	SM	FR	FR80%	LF	M	AN	CI	AE	C	%*
Olley et al (2018) <sup>38</sup>	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	-	-	x	79
Layton & Walton (2012) <sup>36</sup>	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-	-	x	87
Beier et al (2012) <sup>39</sup>	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-	-	x	87
Layton & Walton (2007) <sup>35</sup>	x	x	-	x	x	x	-	x	x	-	x	x	-	-	x	x	-	x	x	x	-	-	-	x	62
Friedman (1998) <sup>34</sup>	x	x	-	x	x	x	-	x	x	-	x	-	-	-	x	x	-	x	x	x	-	-	-	x	58
Gurel et al (2013) <sup>29</sup>	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	-	-	x	79
Fradeani et al (2005) <sup>4</sup>	x	x	-	x	x	x	-	x	x	-	x	x	x	x	x	x	-	x	x	x	x	-	-	x	75
Granell-Ruiz et al (2009) <sup>30</sup>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-	x	92
Dumfahrt & Schäffer (2000) <sup>31</sup>	x	x	-	x	x	x	-	x	x	-	x	x	-	-	x	x	-	x	x	x	-	-	-	x	67
Burke & Lucarotti (2009) <sup>32</sup>	x	x	-	x	x	x	x	x	x	-	x	x	-	x	x	x	-	x	x	x	x	-	-	x	75
Peumans et al (2004) <sup>33</sup>	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	-	-	x	79
D'Arcangelo et al (2012) <sup>18</sup>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-	x	92
Shao-Ping et al (2012) <sup>19</sup>	x	x	-	x	x	x	x	x	x	-	x	x	-	x	x	x	-	x	x	x	x	-	-	x	75
Smales & Etemadi (2004) <sup>20</sup>	x	x	-	x	x	x	x	x	x	-	x	x	-	x	x	x	-	x	-	x	x	-	-	x	71
Magne et al (2000) <sup>21</sup>	x	x	x	x	x	x	-	x	x	x	x	x	-	-	x	x	x	x	x	x	-	-	-	x	75
Shaini et al (1997) <sup>22</sup>	x	x	x	x	-	x	-	x	x	x	x	x	-	-	x	x	x	x	x	x	-	-	-	x	77
Fradeani (1998) <sup>23</sup>	x	x	-	x	x	x	-	x	x	-	x	x	-	-	x	x	-	x	x	x	-	-	-	x	62
Aykor & Ozel (2009) <sup>24</sup>	x	x	-	x	x	x	x	x	x	-	x	x	-	x	x	x	-	x	x	x	x	-	x	x	79
Guess & Stappert (2008) <sup>25</sup>	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	-	x	x	83
Murphy et al (2005) <sup>26</sup>	x	x	x	x	x	x	-	x	x	x	x	x	-	-	x	x	x	x	x	x	-	-	-	x	75
Aristidis & Dimitra (2002) <sup>27</sup>	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-	-	x	87
Peumans et al (1998) <sup>28</sup>	x	x	-	x	x	x	-	x	x	-	x	x	-	-	x	x	-	x	x	x	-	-	-	x	62

(continue)

Table 2 (continue)

Author	H	S	A/G	IC	EC	T	MO	SS	SSJ	CG	RA	MRA	B	E	ECL	SM	FR	FR80%	LF	M	AN	CI	AE	C	%*
Coelho-de-Souza et al (2015) <sup>10</sup>	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	-	-	-	x	79
Fabbri et al (2014) <sup>11</sup>	x	x	x	-	x	x	-	x	x	x	x	x	-	-	x	x	x	x	x	x	-	-	x	x	75
Gresnigt et al (2013) <sup>12</sup>	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	-	-	-	x	79
Rinke et al (2013) <sup>13</sup>	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-	-	x	87
Nordbø et al (1994) <sup>14</sup>	x	x	-	x	x	x	x	x	x	-	x	x	-	x	x	x	-	x	x	x	x	-	-	x	75
Karagözoğlu et al. (2016) <sup>15</sup>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	96
Öztürk & Bolay (2014) <sup>16</sup>	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-	x	83
Çöttert et al (2009) <sup>17</sup>	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-	-	x	87

Abbreviations: A/G, age/gender distribution described; AE, adverse events stated; AN, results stated in absolute numbers; B, blinding performed; C, conclusions stated; CG, use of control group; CI, confidence intervals stated; E, more than one examiner for outcome assessment; EC, exclusion criteria; ECL, examiner calibration; FR, follow-up rate mentioned; FR80%, follow-up rate greater than 80%; H, hypothesis/aim described; IC, inclusion criteria; LF, lost to follow-up; M, main outcomes clearly described; MO, main outcomes to be measured; MRA, method of random allocation described; RA, random allocation to treatment used; S, study setting described; SM, statistical methods described; SS, sample size; SSJ, sample size justified; T, treatment described; x, yes.

\*% of questions answered yes.

by percentages, and the most frequent reason for failure was fracture of the ceramic (44.83%).

The study also reported a significantly higher marginal discoloration among smokers and a significantly higher failure rate among bruxers. In total, approximately 12% of veneers were cemented without dentine bonding, and the authors attributed this to some of the restoration failures. Kaplan–Meier cumulative survival rates were reported for 5 years (94.4%), 8 years (94.1%), 10 years (93.5%), 15 years (85.74%) and 20 years (82.93%).

The authors used the Cox proportional hazards model to study influence of various risk factors for failures. Instead of accounting for clustering, the authors computed robust standard errors by estimating a correlation between the observations from the same patient using methods described by Lin and Wei.<sup>45</sup>

Layton & Walton<sup>36</sup> in their prospective cohort study analyzed the survival rates of feldspathic porcelain veneers with a follow-up of 21 years. The restorations were placed in a private practice in Australia, by a single prosthodontist, between 1990 and 2010. A total of 499 veneers were placed in 155 patients. Patients with extensive loss of tooth structure through parafunction and unfavorable periodontal prognosis were excluded. Feldspathic porcelain veneers from refractory dies were etched, silanated and bonded. Only teeth with at least 80% enamel remaining were veneered. A total of 499 veneers were observed for the first 5 years, 354 veneers were observed up to 10 years, 239 veneers were observed up to 15 years, 82 veneers were observed up to 20 years, and only five veneers were observed for 21 years. The veneers were

evaluated using the Walton's Six Field criteria and grouped into 5-year intervals. A total of 145 veneers were *in situ* for 1 to 5 years, 115 veneers were *in situ* from 10 to 15 years, 157 veneers were *in situ* for 10 to 15 years, 77 veneers were *in situ* from 15 to 20 years, and only five veneers survived more than 21 years.

Failure was defined as, when part or all of the prosthesis was lost, when marginal integrity was compromised, or when the veneer fell off more than twice. Walton's Six Field classification designates an outcome as "repair," when a veneer needs repair without interfering with the original marginal integrity of the restoration. Thus, it can be assumed that "failure" was defined as an irreparable problem. Eleven patients with 56 veneers experienced more than one outcome from Walton's criteria.

Kaplan–Meier survival rates were analyzed twice. First, for the entire sample of 499 veneers without accounting for clustering and then the outcome was analyzed for one randomly chosen veneer from each patient. This study was one of the very few studies that have emphasized and analyzed a survival rate while accounting for clustered outcomes. For the entire sample, Kaplan–Meier cumulative survival rates were reported for 5 years (98%), 10 years (96%), 15 years (91%), and 20 years (91%). For the randomly selected subsample, survival rates were reported as 5 years (98%), 10 years (96%), 15 years (96%), and 20 years (96%). The authors reported that survival rates were not significantly different for both groups.

Olley et al in their retrospective study investigated the outcome of indirect restorations with a follow-up of up to 50 years.<sup>38</sup> The study was conducted at a mixed National

Health Service (NHS)/private dental practice in London, United Kingdom. One operator placed 223 restorations in 47 patients between 1966 and 1996. The restorations consisted of metal-ceramic crowns (154), gold crowns (25), ceramic crowns (22), and ceramic veneers (22). However, only the 22 ceramic veneers placed in 10 patients are of importance for this review.

Only patients with excellent oral hygiene and favorable periodontal prognosis were included in this study. The only material detail given was that the restorations were feldspathic porcelain laminate veneers. Failure was defined as “issues that affected the survival of the restoration.” Failures also included pulp infections or other periapical complications. The authors did not identify if a standard evaluation criterion was used, nor did they clearly state their own evaluation criteria. The Kaplan–Meier analysis was performed on all restorations, and the authors stated 100% veneers had survived at 50 years. However, it was unclear if the Kaplan–Meier estimated cumulative survival rate for the 22 veneers was 100% or if it was stated as a straight percentage.

The most critical observation that was made in all three of the studies was the small number of restorations evaluated beyond 20 years. It is evident that even though PLVs might have a longevity of 20 to 50 years, the dropout rate in RCTs over these periods is exceedingly high, and the outcomes reported represent a significantly small sample size. Although inconclusive in exact percentages, the majority of studies have concluded that porcelain laminate veneers have high-success rates and predictable patient outcomes.

## Conclusion

A conclusive estimation of the longevity of porcelain laminate veneers beyond 20 years is lacking. The availability of evidence in the current literature is limited in terms of sample size and duration of follow-up. The present literature indicates an increased heterogeneity among research study designs. Researchers should aim for homogeneous study designs that can be included in systematic reviews and meta-analyses.

### Conflict of Interest

None declared.

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