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CLINICAL RESEARCH

10.9-year survival of pressed acid etched monolithic e.max lithium disilicate glass-ceramic partial coverage restorations: Performance and outcomes as a function of tooth position, age, sex, and the type of partial coverage restoration (inlay or onlay)

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ABSTRACT

Statement of problem. Long-term clinical data on the survival of pressed lithium disilicate glass ceramic when used with partial coverage restorations and the effect that different technical and clinical variables have on survival are sparse.

Purpose. The purpose of this clinical study was to determine the 10.9-year survival of pressed lithium disilicate glass ceramic partial coverage restorations and associated clinical parameters on outcomes.

Material and Methods. Individuals requiring single unit defect-specific partial coverage restorations in any area of the mouth were recruited in a clinical private practice. Participants were offered the options of partial coverage cast gold or glass-ceramic (lithium disilicate) restorations. Only participants that chose glass-ceramic partial coverage restorations were included in the study. The overall survival of the glass-ceramic restorations was assessed by the clinical factors (participant's age, sex, dental arch, tooth position in dental arch, type of partial coverage restoration, and ceramic thickness) determined at recall. The effect of this clinical parameters was evaluated by using Kaplan-Meier survival curves accounting for attrition bias and other reasons for failure. The statistical significance of differences between parameters was determined by using the log rank test (α=.05).

Results. A total of 304 participants requiring 556 lithium disilicate restorations were evaluated. The mean age for the participant at the time of restoration placement was 62 with a range of 20 to 99 years, 120 were men and 184 were women. A total of 6 failures (bulk fracture or large chip) requiring replacement were recorded with the average time to failure of 2.4 (0.8-9.2) years. The total time at risk computed for these units was 1978.9 years providing an estimated failure risk of 0.3% per year. The 10-year estimated cumulative survival was 95.6%.
The estimated cumulative survival of inlays (n=246) and onlays (n=305) were 93.9% and 98.3%, at 9.9 and 9.8 years, respectively (P<.05). Of the 6, there were 3 failures recorded for the partial coverage inlay restorations. The total time at risk for these inlays was 786.79 years providing an estimated risk of 0.38% per year. The other 3 failures recorded occurred for the partial coverage onlay restorations. The total time at risk for the onlays was 1032.17 years providing an estimated risk of 0.29% per year. The failures occurred in the molar region only. There were no failures recorded for the anterior partial coverage inlays (n=5). The total time at risk computed for the anterior units was 21.55 years providing an estimated risk of 0% per year.
There was no statistically significant difference in the survival of partial coverage restorations among men and women, different age groups, or position in the dental arch. The thickness of the restoration had no influence on the survival of glass ceramic partial coverage restorations.

Conclusions. Pressed lithium disilicate defect-specific partial coverage restorations reported high survival rate over the 10.9-year period with an overall failure rate of 0.3% per year and limited to the molar teeth. Risk of failure at any age was minimal for both men and women. (J Prosthet Dent 2020;■:■-■)

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Clinical Implications

Pressed lithium disilicate partial coverage restorations (hydrofluoric acid etched at the time of placement) provides a treatment of choice with minimal invasiveness and excellent longevity.

Dental caries remains one of the most prevalent oral diseases.[1] Tooth structure loss through attrition, abrasion, erosion, or a combination of these also represents an oral public health problem and is associated with the increased consumption of erosive beverages, elevated stress levels, and longer life expectancy.[2-5] Therefore, primary and/or secondary caries and tooth wear still cause an irreversible loss of tooth structure that needs to be restored.

Excellent survival rates have been reported for complete coverage metal-ceramic and ceramic restorations.[6,7] However, with the development of ceramic materials and adhesive dentistry, adhesively bonded partial coverage restorations are becoming the treatment of choice because of their less invasive tooth preparation.[8,9]

Lithium disilicate with its current formulation was introduced in 2005 as IPS e.max Press (Ivoclar Vivadent AG)[10] and combines excellent esthetics with adequate mechanical properties. A 10-year clinical study reported a 99.1% survival rate for lithium disilicate complete coverage restorations.[6] However, only a few clinical studies, with few participants, limited follow-up times, and no reports of confounding variables have documented the clinical performance of partial coverage restorations.[8,11,12]

In vitro studies may provide essential screening, but long-term clinical studies with appropriate data and the influence of confounding variables are needed to provide reliable clinical evidence for a material and a type of treatment. Based on this recognition, in 2005, a prospective database was initiated in the author's (K.A.M.) practice to assess the effect on clinical survival of specified prosthodontic treatment and risk factors on adhesively bonded lithium disilicate glass ceramic partial coverage restorations. Database parameters and a recall method established in 1982 were adopted from previously published studies from the same group.[6,13-17] Therefore, the purpose of the clinical study was to assess the long-term survival and the clinical factors influencing the outcomes of lithium disilicate partial coverage restorations. The null hypothesis was that none of the confounding variables would influence the long-term survival of pressed e.max lithium disilicate partial coverage restorations.

MATERIAL AND METHODS

Individuals attending a clinical private practice and requiring single unit defect-specific partial coverage restoration in any area of the mouth (Fig. 1A) were recruited. Participants were offered the choice of cast gold, dental amalgam, composite resin, or lithium disilicate restorations. They were cautioned about the fracture risk of lithium disilicate when compared with cast gold restorations. They were also offered the choice of complete coverage restorations with potentially improved esthetics and proven excellent long-term survival. Only participants who chose glass-ceramic partial coverage restorations were included in the study. This study was approved by the Tufts Health Science Institutional Review Board #STUDY00000261.

Inclusion and exclusion criteria

Participants in this study were ≥20 years old with full-mouth plaque score (FMPS) and full-mouth bleeding score (FMBS) <25%. Teeth included in the study had adequate periodontal support, no or limited mobility, and adequate remaining tooth structure for a single unit defect-specific partial coverage restoration.

Participants were excluded who reported poor oral hygiene and uncontrolled periodontal disease or who preferred dental amalgam, composite resin, cast gold partial coverage, or complete coverage restoration. Teeth were excluded if they exhibited marked mobility or inadequate tooth structure to ensure proper support for the partial coverage restoration.

Study protocol

Defect-specific tooth preparations removed all the caries and created proper retention form (Figs. 1B, 2A). Inlay or onlay partial coverage preparation design was then selected based on the remaining tooth structure.[18] Restorations were completed in a conventional manner by using medium-body polyether (Impregum; 3M ESPE AG) impression material. The lost-wax technique and a glass-ceramic pressing system (IPS e.max Press lithium disilicate; Ivoclar Vivadent AG) were then used to fabricate the definitive restorations. All teeth were prepared by a single experienced clinician (K.A.M.) and fabricated in his practice-based laboratory.

After clinical evaluation and necessary adjustment, all restorations were etched (4.5% buffered hydrofluoric acid, IPS Ceramic Etching Gel; Ivoclar Vivadent AG) for 20 seconds, and silane (Monobond Plus; Ivoclar Vivadent AG) was applied for 60 seconds. The teeth were etched with 38% phosphoric acid (Etch-Rite; PULPDENT), coated with a desensitizer (GLUMA Desensitizer; Kulzer GmbH), and dentin bonded (ExciTE; Ivoclar Vivadent AG). The restorations were adhesively luted with a light-polymerizing resin (Variolink II; Ivoclar Vivadent AG) activated with a light-emitting diode (LED) polymerization light (Bluephase Style; Ivoclar Vivadent AG).

Before cementation, the following parameters were determined: type of restoration (inlay or onlay),[18]

Figure 1. Participant with e.max lithium disilicate glass-ceramic partial coverage restoration. A, Carious mandibular premolar. B, Preparation for partial coverage restoration. C, e.max lithium disilicate glass-ceramic partial coverage restoration adhesively luted.

Figure 2. Participant with e.max lithium disilicate glass-ceramic partial coverage restorations as part of complex complete-mouth reconstruction. A, Preparation for partial coverage restorations on maxillary molars and premolars. B, e.max lithium disilicate glass-ceramic partial coverage restorations adhesively luted.

restoration thickness measured by calipers at up to 7 points (mesial, distal, buccal, lingual, mesial-occlusal, mid-occlusal, distal-occlusal), marginal design of the tooth preparation (shoulder, chamfer), tooth position, and age and sex of the participant. The cavosurface angle differentiated a chamfer from a shoulder marginal design.[19] A chamfer met an external axial surface at an approximately obtuse angle, whereas the shoulder preparation met at approximately a right angle. Both marginal designs included a hollow grind rounded internal line angle, recognizing that it would be difficult to maintain a sharp 90-degree cavosurface angle after

Table 1. Effect of type of restoration on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations

Restoration Type	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk	Survivor Function*
Partial Coverage	556	6	1978.90	0.30	NA	95.6
Posterior Partial Coverage Inlay	246	3	786.79	0.38	1.32	93.9
Anterior Partial Coverage Inlay	5	0	21.55	0	0	100
Posterior Partial Coverage Onlay	305	3	1032.17	0.29	1	98.3

*Survivor function at 10.9 years (All), 9.9 years (Posterior Partial Coverage Inlay), 10.9 years (Anterior Partial Coverage Inlay), and 9.8 years (Posterior Partial Coverage Onlay).

Figure 3. Participant with fractured e.max lithium disilicate glass-ceramic partial coverage restoration.

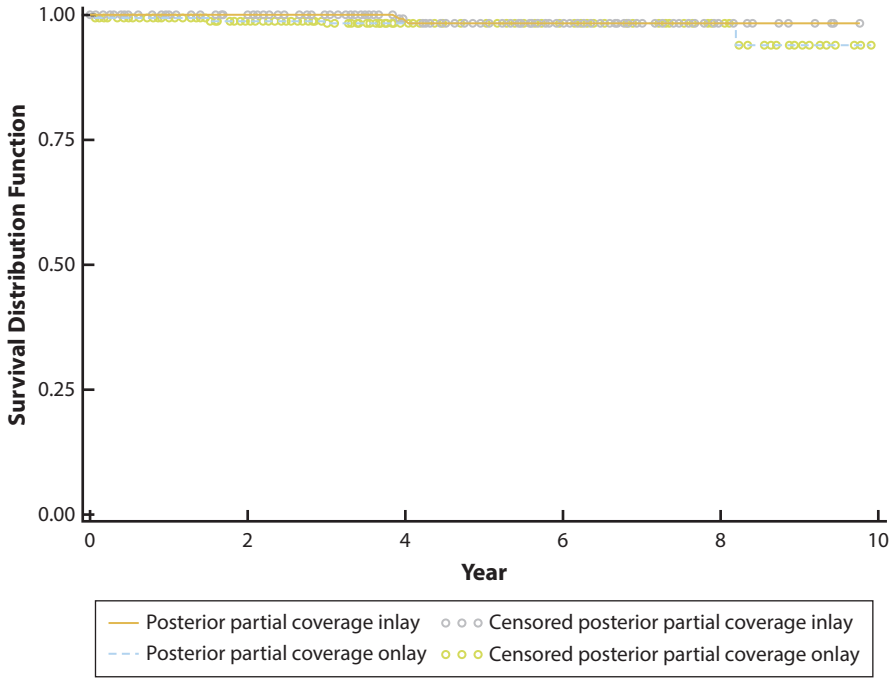

Figure 4. Kaplan-Meier survivor function of e.max lithium disilicate glass-ceramic partial coverage restorations between posterior partial coverage inlay and onlay type of restorations. No significant difference between these 2 groups (P=.998, log rank test).

completing laboratory procedures and to provide an increased etched enamel surface. Although different diamond rotary instruments were used to prepare the 2 marginal designs, both were approximately 1.5 mm in depth and marginal finishing tungsten carbide burs were used.

The participants were recalled every 6 months, and the status of the restoration(s) was evaluated and recorded, including the time the restoration was retained in the mouth or the time to failure, if failure had occurred. The 28 parameters recorded for each participant, and restorations are listed in Table 1.[6]

Definition of a failed restoration

A restoration was recorded as a failure if it exhibited a fractured ceramic piece that necessitated the restoration be remade (Fig. 3). In some instances, the restoration was replaced but not because of failure. These were recorded as replaced, without failure (right censored data). For example, an adjacent tooth was lost, and the restored

Table 2. Effect of tooth position on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations

Tooth Position	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk[a]	Survivor Function[b]
Maxilla	–	–	–	–	–	–
Third Molar	1	0	0.83	0	0	100.0
Second Molar	68	2	188.52	1.1	1.93	94.5
First Molar	87	0	325.77	0	0	100
Second Premolar	62	0	239.36	0	0	100
First Premolar	36	0	127.10	0	0	100
Canine	9	0	36.11	0	0	100
Central Incisor	1	0	2.54	0	0	100
Mandible	–	–	–	–	–	–
Lateral Incisor	1	0	3.33	0	0	100
Canine	2	0	12.91	0	0	100
First Premolar	27	0	101.54	0	0	100
Second Premolar	75	0	280.49	0	0	100
First Molar	77	2	209.03	0.9	1.43	94.5
Second Molar	112	2	300.56	0.7	1	90.0
Third Molar	5	0	13.61	0	0	100

No statistically significant difference between tooth positions. [a]Relative risk compared with mandibular second molar. [b]Survivor function at 4.0 years (mandibular first molar), 8.2 years (mandibular second molars, mandibular first premolar), 3.9 years (maxillary second molar), 9.4 years (maxillary first molar), 9.8 years (maxillary first premolar), 9.2 years (mandibular second premolar), 9.4 years (mandibular canine), 9.9 years (maxillary second premolar), 7.6 years (maxillary canine), 4.2 years (maxillary third molar), 8.9 years (mandibular third molar), 2.5 years (maxillary central incisor), and 0.1 years (mandibular lateral incisor).

tooth became an abutment for a fixed dental prosthesis. Any missing data were assigned a missing data value in the database.

Statistical analyses

Data available for the restorations included the variables described. The survival of restorations or subsets of restorations grouped on the basis of variables described in Table 1[,6] were displayed by using Kaplan-Meier survival curves with clustering (frailty model analysis) if there were failures.[20-24] The significance of differences between survival curves was determined by using the log-rank test (α=.05). The total time at risk was computed as the sum of the censoring and survival times for each group. Estimated risk was computed as the number of failures in that group divided by the corresponding total time at risk. Differences in the thickness of the restorations was compared between success and failure by using the Mann-Whitney U test.

RESULTS

Data collection began in Feb 2005 and was truncated for this analysis after 15 years or 180 months. The study included 304 participants and 556 pressed lithium disilicate partial coverage restorations of which 246 were inlays and 305 were onlays. Of 304 participants, 120 were men, and 184 were women. The mean age of the participant at the time of restoration placement was 62 with a range of 20 to 99 years.

Six failures were recorded for the 556 partial coverage units placed, providing a crude estimate of percent failures of 0.30, with the survivor function time at 10.9 years (Table 1). The 6 failures occurred during a cumulative monitoring period of 1978.9 years with an overall survival rate of 95.6%. The average time to failure was 2.4 (0.8-9.2) years.

Survival of partial coverage inlay and onlay restorations

The survival of the lithium disilicate type of partial coverage restoration as an inlay or onlay is summarized in Figure 4 and Table 1. The survival of the lithium disilicate inlay type of restorations used in the posterior dentition was inlays 93.9%, (n=246, 3 failures), onlays 98.3%. (n=305, 3 failures), and in the anterior dentition 100% (n=5).

Survival of partial coverage restorations with dental arch

The survival of lithium disilicate partial coverage restorations placed on maxillary and mandibular teeth is summarized in Table 2. The probability of survival for a typical maxillary restoration was 98.4% at 3.3 years and in the mandible was 88.0% at 9.2 years.

Survival of partial coverage restorations on different teeth

The failure rate per year for partial coverage restoration for each tooth in both arches is summarized in Table 2. Regardless of mandibular or maxillary placement, anterior restorations had no failures. Mandibular first and second molars and maxillary second molars reported the highest failure rates (between 0.7% and 1.1% per year).

Survival of partial coverage restorations in men and women

The probability of survival of lithium disilicate partial coverage restorations in men and women is summarized in Figure 5 and Table 3. Survivor function for partial coverage restoration in men (n=216) was 88.5% at 9.8 years and in women (n=340) 98.9% at 10.9 years, with no statistically significant difference (P>.05). The relative risk was 3.23 when partial coverage restorations were used in men as compared with women (Tables 3–5).

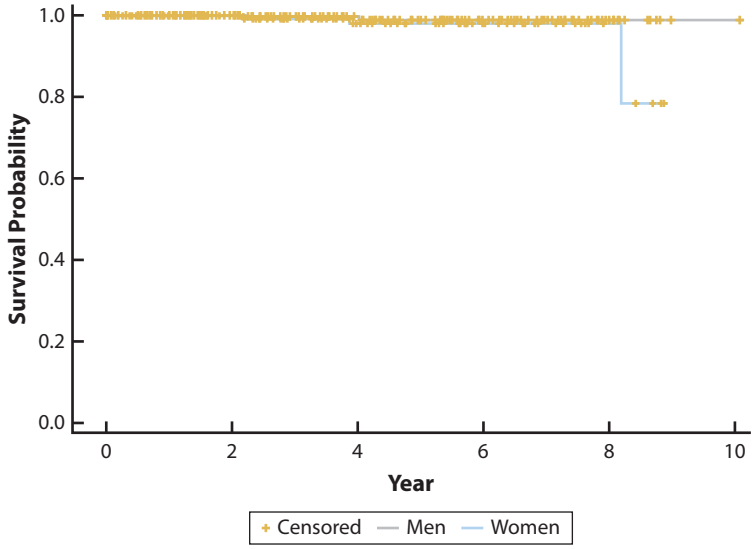

Figure 5. Kaplan-Meier survivor function of e.max lithium disilicate glass-ceramic partial coverage restorations in men and women. No significant difference between these 2 groups (*P*=.92, log rank test).

Table 3. Effect of sex on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations

Sex	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk[a]	Survivor Function[b]
Men	216	4	743.37	0.53	3.23	88.5
Women	340	2	1235.53	0.16	1	98.9

No statistically significant difference between men and women. [a]Relative risk compared with women. [b]Survivor function at 9.8 years (men), and 10.9 years (women).

Survival of partial coverage restorations for participants in 3 age groups, <33 years, 33-52 years, and >52 years

The effect of age on the estimated risk of failure of lithium disilicate partial coverage restorations is summarized in Table 6. Survivor function for partial coverage restoration in the <33 years age group (n=59) was 100% at 9.9 years, in the 33-52 years age group (n=190) 90.92% at 10.9 years, and the >52 years age group (n=307) 98.1 % at 9.7 years, with no statistically significant difference.

Survival of partial coverage restorations with thickness less than or greater than 1.0 mm

The probability of lithium disilicate partial coverage restorations with a thickness less than or greater than 1.0 mm is summarized in Figure 6 and Table 7. No statistically significant difference was found between the thickness categories. The survival of lithium disilicate restorations with all surfaces >1 mm (n=425) was 90.2 % at 9.2 years, with an estimated annual risk of failures of 0.27 and 4 failures in total. The survival of lithium disilicate restorations with at least one surface <1 mm (n=92) was 98.4 % at 2.9 years, with an estimated annual risk of failure of 0.34 and 1 failure in total.

DISCUSSION

The long-term survival rate of 556 pressed lithium disilicate glass ceramic defect-specific partial coverage restorations was evaluated. The overall survival rate was 95.6% over 10.9 years, and the confounding variables had minimal to no effect on the survival of these restorations. Therefore, the null hypothesis that no confounding variables would influence the long-term survival of pressed e.max lithium disilicate partial coverage restorations was not rejected.

Both life expectancy and the number of retained natural teeth has increased.[1,5] At the same time, technological and materials advancements have changed restorative dentistry with a shift toward minimal invasive restorations that preserve as much of the sound tooth structures as possible. Cast gold partial coverage restorations show excellent survival rates and have been the gold standard for years.[25] However, with patients preferring tooth-colored restorations, esthetic restorations are becoming the treatment of choice.

Lithium disilicate complete coverage restorations have been reported to be a reliable treatment option with excellent survival rates. In a 10-year clinical study, our group reported 99.1% survival of 1960 units.[6] Nevertheless, there is a shift toward minimizing preparation to preserve tooth structure,[9] making partial coverage restorations an attractive treatment option.

Both Guess et al[11] and Edelhoff et al[8] reported a 100% survival rate of pressed lithium disilicate partial coverage restorations and onlays over 7 and 11 years. However,

Table 4. Effect of tooth position on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations in man participants

Tooth Position	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk[a]	Survivor Function[b]
Maxilla	—	—	—	—	—	—
Second Molar	25	1	77.42	1.3	1.25	90.9
First Molar	40	0	120.07	0	0	100
Second Premolar	21	0	59.79	0	0	100
First Premolar	15	0	66.29	0	0	100
Canine	1	0	17.67	0	0	100
Mandible	—	—	—	—	—	—
Canine	1	0	33.43	0	0	100
First Premolar	7	0	29.36	0	0	100
Second Premolar	25	0	97.86	0	0	100
First Molar	30	1	50.26	2.0	1.27	93.8
Second Molar	48	2	142.53	1.4	1	77.4
Third Molar	3	0	6.54	0	0	100

No statistically significant difference between tooth positions in men. [a]Relative risk compared with mandibular first molar. [b]Survivor function at 7.9 years (mandibular first molar), 9.7 years (mandibular second molars), 6.2 years (mandibular first premolar), 9.4 years (maxillary second molar), 8.5 years (max first molar), 9.7 years (maxillary first premolar), 8.3 years (mandibular second premolar), 5.9 years (mandibular canine), 7.7 years (maxillary second premolar), 7.6 years (maxillary canine), and 8.9 years (mandibular third molar).

Table 5. Effect of tooth position on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations in woman participants

Tooth Position	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk[a]	Survivor Function[b]
Maxilla	—	—	—	—	—	—
Third Molar	1	0	0.83	0	0	100
Second Molar	43	1	111.10	0.9	1.41	97.1
First Molar	47	0	205.70	0	0	100
Second Premolar	41	0	179.57	0	0	100
First Premolar	21	0	60.81	0	0	100
Canine	1	0	18.44	0	0	100
Central Incisor	1	0	26.09	0	0	100
Mandible	—	—	—	—	—	—
Lateral Incisor	1	0	6.23	0	0	100
Canine	1	0	7.48	0	0	100
First Premolar	20	0	72.18	0	0	100
Second Premolar	50	0	182.63	0	0	100
First Molar	47	1	158.77	0.6	1	95.4
Second Molar	64	0	158.03	0	0	100
Third Molar	2	0	7.07	0	0	100

No statistically significant difference between tooth positions in women. [a]Relative risk compared with mandibular first molar. [b]Survivor function at 10.9 years (mandibular first and second molars), 8.2 years (mandibular first premolar), 9.7 years(maxillary second molar), 9.4 years(maxillary first molar), 9.1 years (maxillary first premolar), 9.3 years (mandibular second premolar), 9.4 years (mandibular canine), 9.9 years (maxillary second premolar), 2.7 years(maxillary canine), 4.2 years (maxillary third molar), 8.7 years (mandibular third molar), 2.5 years (maxillary central incisor), and 0.1 years (mandibular lateral incisor).

Table 6. Effect of age on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations

Age Group	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk[a]	Survivor Function[b]
<33	59	0	162.13	0	0	100
33 to 52	190	3	632.13	0.47	1.85	90.2
>52	307	3	1184.64	0.25	1	98.1

No statistically significant difference between age categories. [a]Relative risk compared with age group >52. [b]Survivor function at 9.7 years (>52), 10.9 years (33 to 52), and 9.9 years (<33).

the number of participants and the restorations observed in these studies were less than in the present study, and no confounding variables were differentiated or reported. It is well established that a larger sample size provides more reliable results, with greater power and precision.[26,27] Moreover, when analyzing prosthetic restorations, enough time must be allowed for differences and variables to manifest themselves. Taking into consideration data size and follow-up time, the current study has value.

The high survival rate of lithium disilicate partial coverage restorations may be attributed to the mechanical properties of lithium disilicate with a flexural strength of 470 MPa and fracture toughness of 2.54 MPa.m$^{1/2}$.[28] Additionally, because of its glassy phase, lithium disilicate is etchable, allowing strong micromechanical bonding to tooth substrate[29] and significantly increasing its characteristic strength.[14,30,31]

The long-term stability of dentin bonding is unclear; however, enamel bonding has been reported to have reliable long-term outcomes.[32-34] In the present study, all the margins were prepared in enamel, which allowed for successful bonding; no incidence of secondary caries was recorded. Similar recommendations have been made based on an in vitro study.[35]

The e.max lithium disilicate is marketed in 2 forms: a pressable ingot (e.max Press; Ivoclar Vivadent AG) and a millable block (e.max CAD; Ivoclar Vivadent AG).[10,29] The present study was conducted with the pressable e.max Press glass-ceramics. Milled restorations could offer a more straightforward and rapid fabrication method. When e.max CAD and e.max Press were compared in the split-mouth study, a lower yet statistically similar survival rate was reported for the milled

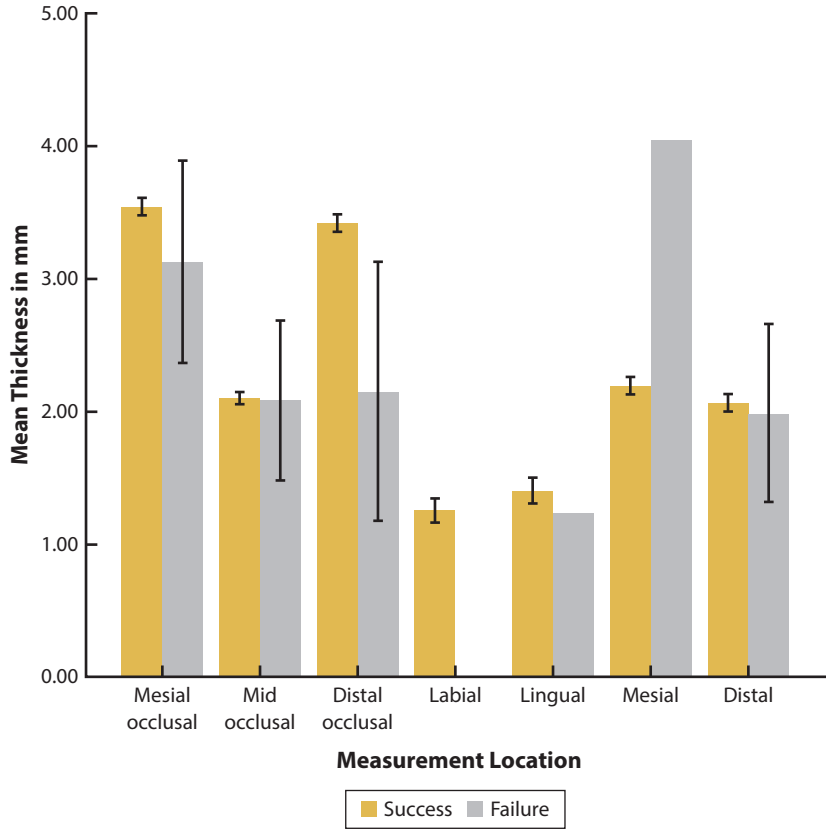

Figure 6. Mean ±standard error thickness of e.max lithium disilicate glass-ceramic partial coverage restorations that failed or were successfully maintained. Differences between success and failure not statistically significant for any of surfaces (P>.05).

restorations.[11] Further studies comparing pressed to milled restorations with more data and longer follow-up times are needed.

Direct resin-based composite restorations may be provided as an alternative treatment method, with lower costs and fewer patient visits. However, concerns have been raised about large direct composite resin restorations in posterior teeth. A comprehensive review and meta-analysis of published clinical studies on composite resin restorations covering the period 1996-2015 indicated an annual failure rate of 1% to 3% for posterior restorations.[36] The data reported the trend of increased failure rates for more extensive restorations. In contrast with these well-controlled clinical studies, a practice-based research study found failure rates for composite resin and dental amalgam posterior restorations to be similar, ranging from 2% to 9% annually across practices and dentists.[37] National insurance databases indicate 4-year annual failure rates ranging from 4% to 9%, with the highest rates for restorations of 3 or more surfaces.[38,39] In addition, a meta-analysis found that the longevity of direct and indirect composite resin restorations are not significantly different.[40] Compared with these high annual failure rates for composite resin (direct and indirect) and dental amalgam, the low overall annual failure rate of 0.30% in the present study indicates that the additional time and expense of glass-ceramic inlay and onlay restorations is justified. Additionally, the wear of composite resin restorations is greater than that of tooth structure, but lithium disilicate restorations have similar wear rates to enamel,[41,42] suggesting longer lasting occlusal schemes.

Table 7. Effect of thickness on estimated risk of failure of e.max lithium disilicate glass-ceramic partial coverage restorations

Thickness Group	Units	Failures	Cumulative Monitoring Years	Estimated Annual Risk of Failures (%)	Relative Risk	Survivor Function*
All surfaces >1 mm	425	4	1480.99	0.27	1	90.2
At least 1 surface <1 mm	92	1	292.22	0.34	6.85	98.4

No statistically significant difference between thickness categories. *Survivor function at 9.2 years (>1 mm) and 2.9 years (at least 1 surface <1 mm).

In the current study, confounding variables such as age, sex, or type of restoration had no statistically significant effect on the survival of lithium disilicate partial coverage restorations. This is encouraging for the choice of treatment in everyday practice. A restorative dentist can use a minimally invasive defect-specific preparation, regardless of the patient's age or sex.

The variable thickness also had no statistically significant influence on the survival of the partial coverage

restorations. Similar findings on complete coverage restorations were previously published by our group.[13] While fracture resistance theoretically depends on thickness,[43] an in vitro study reported that the fracture rate of posterior partial coverage restorations was not affected by the thickness of glass-ceramic when luted adhesively.[44]

Although the effect was not statistically significant, all the failures occurred in molars, that are subject to the highest occlusal loads.[45] Nevertheless, the number of failures was low (n=6) (Table 1), and thus, glass-ceramic partial coverage restorations in the molar region seem to be a reliable treatment method. Interestingly, the range of failure times suggested that the failures occurred after a random event rather than related to cumulative fatigue damage. However, with the small number of failures, no definitive inferences can be made.

Partial coverage restorations are conservative, and the preparation is typically confined to the existing tooth structure defect.[9] Nevertheless, how the extent of the defect might influence the overall long-term survival is unclear, and this should be studied further.

Limitations of the present study include that 1 experienced prosthodontist provided all the restorations, making extrapolation to other dentists with different skills or practice settings difficult. However, findings from a single clinician eliminated the major potential confounding variable of different clinical skill levels.

The use of the Kaplan-Meier survivor functions in the present investigation was based, in part, on their immediate interpretability by the reader and in part on the nature of the data that were available. The data were gathered in a private practice setting in which all participants did not enter the study at the same time. Some participants left the study, for a variety of reasons, before its conclusion (and typically before failure of the restoration). Participants dropped out for different reasons, including death, relocation, and economic necessity. These constraints led to the genesis of censored data; that is data that were gathered at irregular intervals and for different periods of time. One advantage of the Kaplan-Meier approach was that all available data could be used. Data were not discarded after some arbitrary designated time point. However, because of loss of participants over time, the confidence intervals of the estimates at later time points in the study were much larger than at early periods.

CONCLUSIONS

Based on the findings of this clinical study, the survival of 556 lithium disilicate partial coverage restorations placed in 304 participants was evaluated at 10.9 years, and the following conclusions were drawn:

1. Only 6 failures were recorded with a 10-year cumulative survival of 95.6%.
2. The data indicated that acid-etched and adhesively bonded monolithic IPS e.max pressed lithium disilicate partial coverage restorations exhibited excellent survival.
3. Potential confounding variables of tooth position, sex, age, or type of partial coverage restoration reported little to no effect on survival.
4. Taking into consideration the data size and follow-up time, the current study can guide clinicians in choosing minimally invasive, esthetic restorations.

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