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Published in:
Journal of Prosthetic Dentistry

DOI:
10.1016/j.prosdent.2021.07.008

THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Bilayered ceramic anterior restorations with reinforcement of the incisal edge by using lithium disilicate: A multicenter retrospective survival analysis with a maximum of 6-year follow-up

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ABSTRACT

Statement of problem. The esthetics of anterior lithium disilicate restorations can be enhanced if the buccal aspect is layered with a feldspathic ceramic. However, whether fractures and chipping of this layer are a prevalent complication is unclear.

Purpose. The purpose of this retrospective study was to evaluate the incidence of incisal fracture of a specially designed lithium disilicate reinforcement of the incisal edge for indirect anterior bilayered restorations on both teeth and implants.

Material and methods. A total of 924 anterior bilayered pressed lithium disilicate restorations in 324 patients and made in one dental laboratory were delivered by 4 restorative dentists. The restorations had the palatal side of the incisal edge in monolithic lithium disilicate and the facial side in feldspathic porcelain. The restorations were evaluated for survival and the occurrence of fracture or chipping. Survival analyses were performed by using the Kaplan-Meier and log rank (Mantel-Cox) tests (α=.05).

Results. Of the 924 restorations, 798 (236 complete crowns, 562 partial restorations) were placed on teeth and 126 on implants. The mean observation time was 38 months (3 to 72 months). The survival rate was 96.5%, with 14 failures occurring. The failures were fracture after dental trauma (n=5), ceramic fracture (n=1), debonding (n=6), poor shade match (n=1), and tooth loss (n=2). Restorations in patients with parafunctional habits and endodontically treated teeth showed a significant decrease in survival rate (P=.018). No significant differences were found between the survival of restorations on teeth and implants and between complete crowns and partial restorations (P=.021). No chipping was observed on any restorations in the study.

Conclusions. Modified anterior bilayered ceramic restorations showed good survival rates, and no chipping was observed up to 6 years of follow-up. Parafunctional habits and endodontic treatment had a negative effect on the survival rate of restorations. The support of tooth or implant and the restoration type had no effect on the survival. (J Prosthet Dent 2023;129:718-24)

Ceramic restorations provide excellent esthetics[1-3] and should achieve an esthetic and durable result. Often a high-strength zirconia or lithium disilicate framework is veneered with a feldspathic ceramic with optimal esthetics, but with lower resistance to fracture.[4-6] Chipping of the veneering ceramic is a common complication for anterior restorations and decreases the overall survival rate.[7]

Lithium disilicate glass-ceramics have good mechanical and esthetic properties and are used for complete crowns, implant crowns, and laminate veneers.[5,7] Micromechanical and chemically adhesive bonding is possible with lithium disilicate,[8,9] enabling a more conservative preparation design than complete crowns.[10]

Supported by the University Medical Center Groningen; Oral Design Center Holland; and Excent Dental technology. Administrative support was given by Private Practice Dental Design Center, Blaricum; Private practice Royakkers, Maastricht; Private Practice Tendens Dentists, Amsterdam; and Dental Clinic for Periodontology, Amsterdam.
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Clinical Implications

Reinforcement of the incisal edge by using lithium disilicate may help prevent anterior bilayered restorations from chipping.

Survival rates of lithium disilicate complete anterior bilayered crowns have been reported to range between 86.1% and 97.5% after 5 to 11 years,[7,11-13] and for veneers, between 87% and 100% after an average of 9 years. Survival rates of feldspathic laminate veneers have been reported to range between 82% and 96% after 10 to 21 years.[13-15] Research data on implant-supported bilayered anterior implant crowns are sparse. In most studies, no distinction was made between anterior and posterior restorations, and whether a veneering ceramic was used was not specified.[16,17] A prospective study by Teichmann et al[16] comparing crowns on natural teeth to implant-supported crowns reported higher survival rates for the implant-supported crowns.

The most frequently reported complication in ceramic restorations after 5 years has been chipping of the veneering ceramic (lost due to ceramic fracture 1.1%, ceramic chipping 1.5%) and fracture of the framework (2.3%), followed by marginal discoloration (2.3%), loss of retention (1.0%), and loss of abutment tooth vitality (0.7%).[7] The incisal ceramic has been the most common location of ceramic fracture and chipping, presumably because the greatest forces are applied there during mastication.[18,19]

Sulaiman et al[20] investigated the difference in survival between monolithic and bilayered lithium disilicate crowns but did not distinguish between anterior and posterior restorations. Bilayered lithium disilicate restorations had twice as many fractures as monolithic lithium disilicate restorations. Significantly higher survival rates of monolithic crowns compared with bilayered crowns were also reported with implant-supported crowns.[21] The weaker feldspathic ceramic layer increases the risk of chipping.[7,11-14,16-20] However, it is essential to obtain a natural appearance.[1,3] Therefore, a new framework design was developed in which the palatal surface, including the fragile incisal edge, was completely restored in lithium disilicate. This design had no veneering ceramic in occlusion. However, clinical studies on this anterior restoration design are lacking.

Therefore, the objective of this multicenter retrospective survival analysis was to evaluate the clinical performance of maxillary anterior bilayered ceramic restorations with a reinforcement of the incisal edge with lithium disilicate (Fig. 1) after a maximum observation period of 6 years. The primary outcome parameters were restoration survival and fracture or chipping. The hypothesis tested was that restorations with reinforcement of the incisal edge would have a low incidence of fracture or chipping.

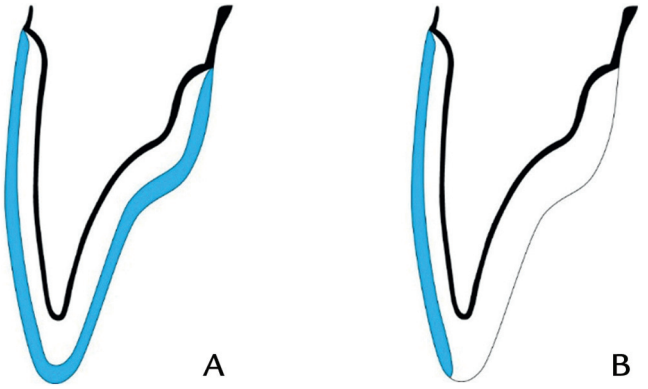

Figure 1. Schematic cross-section representation of bilayered complete crown. A, Conventional design. B, Reinforcement of incisal edge. *Blue*: veneering ceramic; *White*: framework of lithium disilicate.

MATERIAL AND METHODS

This retrospective study investigated the survival and incidence of fracture of bilayered ceramic restorations with reinforcement of the incisal edge with lithium disilicate by evaluating the patient records in 4 private dental offices. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed.[22]

Between February 2013 and August 2018, a total of 324 patients with an age range between 12 and 80 years (227 women, 97 men, mean age 45.7 years) received 924 bilayered maxillary anterior ceramic restorations. All restorations consisted of a lithium disilicate framework with reinforcement of the incisal edge and veneering ceramic on the facial aspect. The restorations included in this study were partial and complete crowns on maxillary anterior teeth and implants. The restorations were placed by 4 restorative dentists (M.C.M., E.J.R., A.C.L.D., P.K.) in private practices. All teeth were evaluated before starting the treatment, and the prognosis of teeth was estimated. Teeth with poor endodontic, periodontal, restorative, or functional prognosis were excluded from the study. Nonvital teeth were not excluded from the study, and the endodontic therapy was retreated when indicated.

Conventional definitive impressions were sent to a single dental laboratory (Oral Design Center Holland). All materials were processed according to the manufacturer's instructions. The framework with the incisal edge of the restorations was made of a heat-pressed lithium disilicate (IPS e.max Press; Ivoclar AG) with a facial window for the veneering ceramic (IPS e.max Ceram; Ivoclar AG) to provide the restoration with a translucency

that replicated the adjacent natural teeth (Fig. 2). The restorations were finished, polished, and returned to the dental office.

The restorations were clinically evaluated and delivered when both patient and dentist were satisfied. The restorations on natural teeth were luted with an adhesive procedure after conditioning the tooth and ceramic (4.9 IPS ceramic etch, Monobond Plus; Ivoclar AG) according to the manufacturer's instructions. The type of resin cement used for luting the restorations varied among the dentists. The implant-supported crowns were mostly screw retained. In patients with a parafunctional habit, an occlusal appliance was fabricated after the restoration had been placed.

The restorations were evaluated clinically every 6 to 12 months during the scheduled periodic evaluations. Complications or patient complaints were noted in the records. Between October 2018 and February 2019, the clinical records of the patients with the included restorations were collected and data processed anonymously in a research electronic data capture program (REDCap; Vanderbilt University).

Any restorations that had been replaced (survival) were considered as an absolute failure. Reasons to replace a restoration included caries, debonding, fracture, chipping, and severe marginal discoloration. The date and the reason for the failure were noted. Other information that was collected in a case of failure was the cement used and the location in the mouth.

Variables investigated for their influence on survival included sex, age, dentist, substrate (tooth or implant), location (maxillary central incisor, lateral incisor, or canine), type of restoration (complete crown or partial restoration), endodontic treatment before or after delivery of the restoration, parafunctional habit (based on questionnaire completed by the patient), and use of an occlusal appliance. Survival was analyzed with a statistical software program (IBM SPSS Statistics, v25.0; IBM Corp) by using the Kaplan-Meier and log rank (Mantel-Cox) tests (α=.05 for all tests).

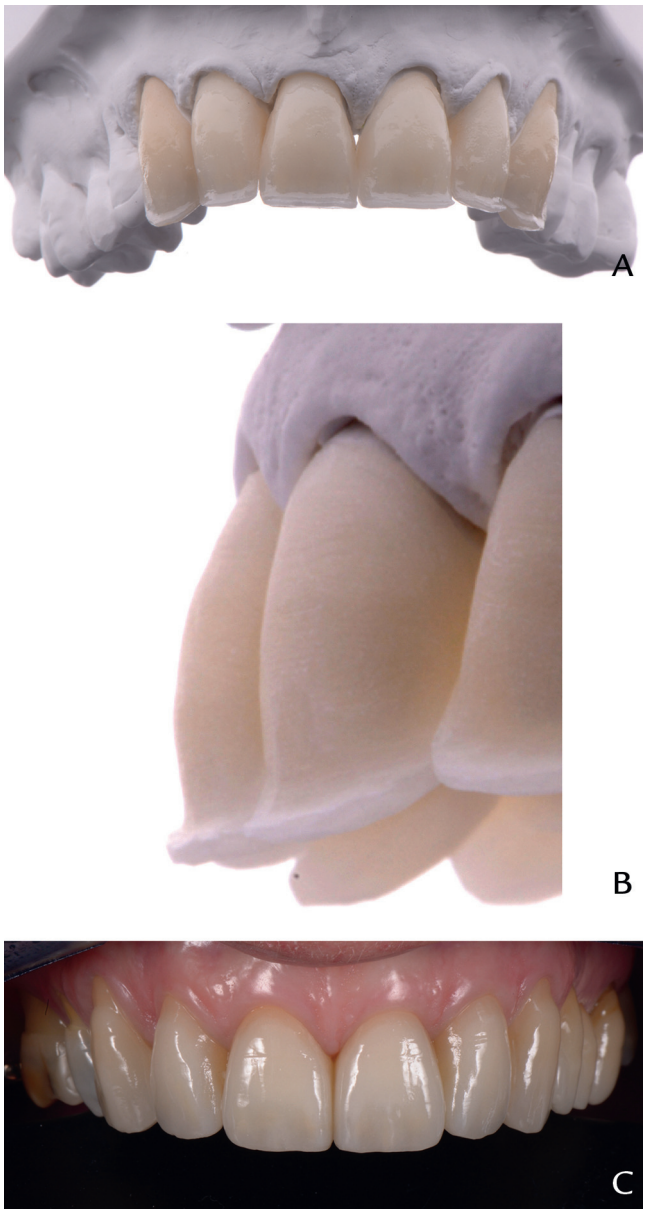

Figure 2. Representative bilayered crowns with reinforcement of incisal edge. A, Lithium disilicate framework on definitive cast with buccal window for veneering ceramic. B, Lateral view. C, Intraoral view at delivery of completed crowns with veneering ceramic.

RESULTS

A total of 324 patients with 924 restorations were included in this study. The mean observation time was 38 months (range 3 to 72 months). The restorations were placed by 4 dentists in 304 male patients and 620 restorations in female patients (aged 11 to 80 years). Of the 924 evaluated restorations, 798 restorations were bonded to natural teeth (562 partial and 236 complete crowns) and 126 were implant-supported crowns. The distribution of the location of the restoration was 445 on maxillary central incisors, 301 on lateral incisors, and 178 on canines. A total of 141 of 798 teeth had been endodontically treated before restoration placement, 329 restorations were placed in patients who had been noted to have parafunctional habits, and 186 restorations were placed in patients who received an occlusal appliance after delivery because of suspected parafunctional habits.

The cumulative overall survival rate was 98.5% over 6 years (Fig. 3). A total of 14 absolute failures were observed in the form of debonding (n=6), fracture after dental trauma (n=4), ceramic fracture (n=1), loss of teeth

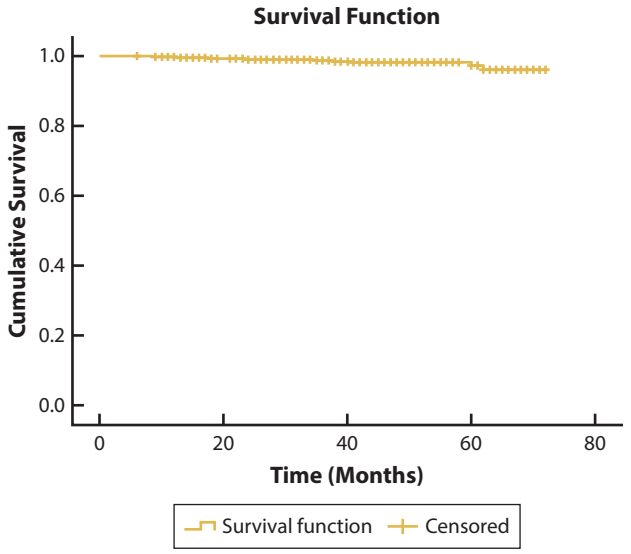

Figure 3. Survival of restorations with lithium disilicate incisal overlap (98.5%; n=924, event n=14).

subsequent to periodontal bone loss or root fracture (n=2), or not satisfied with the color (n=1). One fracture was observed after trauma, but this was repaired with a direct composite resin restoration. No ceramic chipping of the restorations was observed.

All debonding (n=6) incidences were a result of complete adhesive failure between the tooth and the luting cement, which occurred 8 to 62 months after delivery. These failures occurred in 2 complete crowns and 4 partial restorations. All debonded restorations were rebonded. The ceramic fracture was located at the buccocervical area and occurred in a partial indirect restoration on a maxillary canine after 38 months. The patient had a parafunctional habit and received an occlusal appliance after treatment. The traumatic fractures (n=4) occurred 3 to 19 months after cementation. The reasons for loss of these teeth (n=2) were root fracture and loss of the supporting bone. This occurred, respectively, 9 and 60 months after cementation. The failure because of unsatisfactory color concerned an implant-supported crown. After 18 months, the color of the veneering ceramic was corrected, and the crown was replaced.

The influence of all variables on the survival rates is described in Tables 1 and 2. Eleven failures occurred in restorations on natural teeth (98.6% survival), and 3 in implant-supported crowns (97.6% survival). Of the 11 failed restorations on teeth, 4 were complete crowns (98.3% survival) and 7 partial indirect restorations (98.8% survival). Seven failures were located on central incisors (98.4%), 5 on lateral incisors (98.3% survival), and 2 on canines (98.9% survival).

Six failures were experienced in restorations bonded to vital teeth (99.1% survival) and 5 in restorations bonded to endodontically treated teeth (96.5% survival). The difference between vital and endodontically treated teeth was significant (P=.018) (Fig. 4).

Six failures occurred in patients with parafunctional habits who received an occlusal appliance (96.8% survival). A significantly higher survival rate (P=.021) of the restorations was observed in patients with a severe parafunctional habit but who did not wear their occlusal appliance (Fig. 5).

A significant influence on the survival rate of the restorations was not found for the cumulative proportion of absolute failures among sex, age, dentists, substrate

Table 1. Influence of variables on survival rates including all restorations

Variable	Categories	Number of Restorations (Total N=924)	Number of Failures (N=14)	Survival Rate (%)	P (CL=95%)
Sex	Male	304	5	98.4	.572
	Female	620	9	98.5	
Age	11-20 y	5	0	100.0	.514
	21-40 y	277	6	97.8	
	41-60 y	453	7	98.5	
	61-80 y	189	1	99.5	
Dentist	Dentist 1	198	5	97.5	.696
	Dentist 2	255	2	99.2	
	Dentist 3	335	5	98.5	
	Dentist 4	136	2	98.5	
Substrate	Tooth	798	11	98.6	.477
	Implant	126	3	97.6	
Location	Central incisor	445	7	98.4	.918
	Lateral incisor	301	5	98.3	
	Canine	178	2	98.9	
Occlusal appliance	Yes	186	6	96.8	.021*
	No	738	8	98.9	
Parafunctional habits (based on questionnaire)	Yes	329	8	97.6	.069
	No	595	6	99.0	

*Statistically significant (P<.05) based on log rank test (Mantel-Cox).

Table 2. Influence of variables on survival rates, including all restorations on tooth

Variable	Categories	Number of Restorations on Tooth (Total N=798)	Number of Failure (N=11)	Survival Rate (%)	P (CL=95%)
Type of restoration	Complete crown	236	4	98.3	.552
	Partial restoration	562	7	98.8	
Endodontic treatment before cementation	Yes	141	5	96.5	.018*
	No	657	6	99.1	
Endodontic treatment after cementation	Yes	7	0	100.0	.726
	No	791	11	98.6	

*Statistically significant (P<.05) based on log rank test (Mantel-Cox).

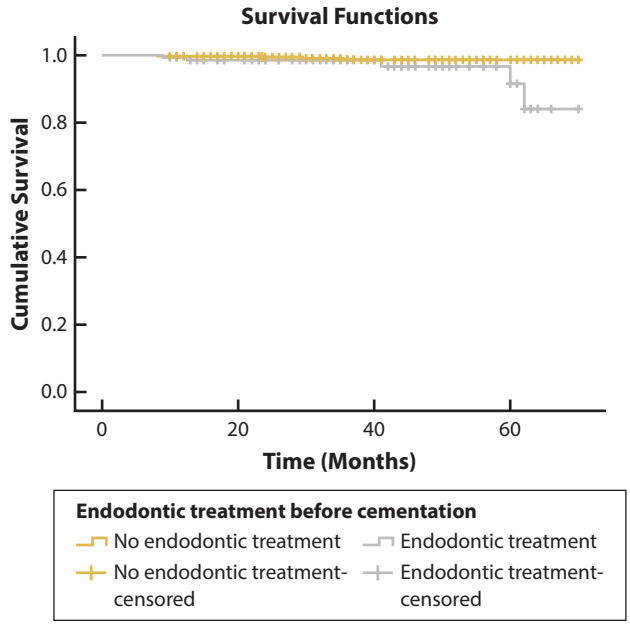

Figure 4. Indirect restorations with and without endodontic treatment (without endodontic treatment: 99.1%; n=657, events n=6; with endodontic treatment: 96.5%; n=141, events n=5).

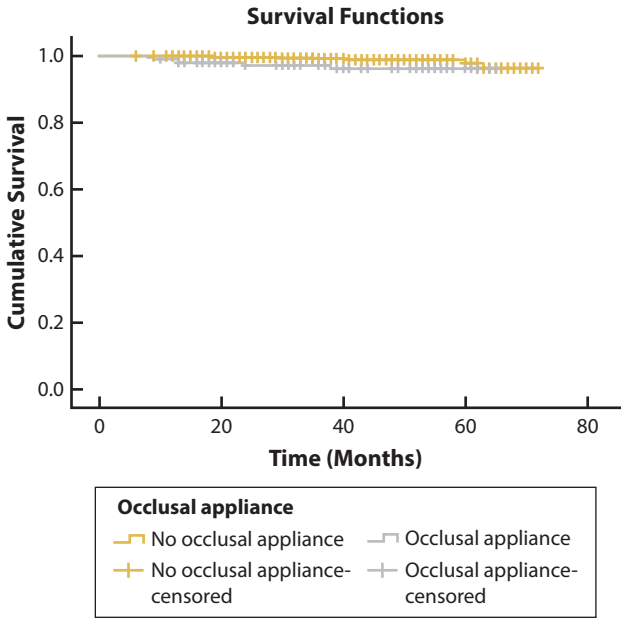

Figure 5. Survival of restorations with and without occlusal appliance (without occlusal appliance: 98.9%; n=738, events n=8; with occlusal appliance: 96.8%; n=186, events n=6).

(tooth or implant), type of restoration, and location. The survival rate between patients with parafunctional habits (97.6% survival) and without (99.0% survival), based on a questionnaire completed by the patient, was not significantly different (*P*=.069). In addition, the survival rate was not significantly different (*P*=.726) between no need (98.6% survival) or the need for endodontic treatment after bonding the restorations (100.0% survival).

DISCUSSION

In this retrospective study, the performance of bilayered anterior indirect restorations with a new framework design of lithium disilicate was evaluated on teeth and implants. The authors are unaware of a previous study in which this framework design was investigated in lithium disilicate restorations with an observation time up to 6 years. In total, 98.5% of the restorations required no intervention, considered clinically acceptable, and therefore, the hypothesis was accepted. Significant differences were observed in subgroups where endodontic treatment and severe parafunctional habits in patients who did not wear their occlusal appliance had an influence on the survival of anterior bilayered lithium disilicate restorations.

The overall survival rate was 98.5% (n=19 failures; Fig. 3) with a mean observation period of 38 months. The main reasons for failure were debonding (n=6) and fracture (n=5). If the failed restorations subsequent to dental trauma are omitted, an even higher survival rate of 98.9% would have been reached (n=10 failures). Only 1 restoration showed a fracture without dental trauma at evaluation. The survival rates of the bilayered crowns in this study were comparable with those of other clinical studies and ranged between 86.1% and 97.5% after 5 to 11 years.[7,11-14] The results of the bilayered veneers were also comparable with those of other clinical studies with an 87% to 100% survival rate after an average of 9 years. As research data on bilayered anterior implant crowns are sparse, no comparisons could be made with the results of this study.[7,11-14] Fractures of the framework (2.3%) and chipping of veneering ceramic (2.6%) were the most frequently reported reasons of complication after 5 years.[7] In the present study, fracture occurred in 0.5% of all restorations, and no chipping was observed. These results suggested that a reinforcement of the incisal edge by using lithium disilicate prevented incisal fracture and chipping.

Debonding was observed in 6 restorations 8 to 62 months after delivery. The percentage of 0.6% debonding is comparable with that of other studies.[7,13] All debonded restorations could be rebonded and were in function at the end of the study, but these restorations were scored as a failure. Of these restorations, 3 patients had parafunctional habits, and 2 patients had an occlusal appliance which might have increased stresses and, therefore, decreased functional success.[11,23]

Fracture occurred in only 1 partial restoration in the buccocervical region of a canine (38 months) in a patient with a parafunctional habit who did not wear his

occlusal appliance. In patients with parafunctional habits, a lower survival rate was observed (parafunctional habits 97.6%, no parafunctional habits 99.0%), but these differences were not statistically significant. Parafunctional habits of patients were evaluated from the responses in the medical questionnaire completed by the patients. When clinical signs were present, such as wear facets or hypertrophic muscles, an occlusal appliance was provided. The variable of the presence of an occlusal appliance was used to determine the relationship between bruxism and survival. Six failures occurred in patients who received an occlusal appliance (96.8% survival) compared with 8 failures in patients who did not receive an occlusal appliance (98.9% survival), which was statistically significant (P=.021). A low compliance rate could have played a role in the survival of the restorations.

Endodontically treated teeth (96.5% survival) had a significantly lower survival rate than vital teeth (99.1% survival) (P=.018). Similar results were obtained in other studies.[24] In the present study, all biological failures (loss of the supporting vestibular bone and root fracture) occurred in endodontically treated teeth. In vital teeth, only technical complications were observed.

In this retrospective study, no fracture or chipping of the incisal edge was observed. This positive finding could also be related to the design of the study as records were used to obtain the data. This could have had a positive influence on the survival rate and success of the restorations, as failures might have been missed. Probably all severe failures and severe adverse events were noted in the records, but small defects may not have been recorded. The positive side of this study and data was that all patients had follow-up appointments every 6 to 12 months, and failures or defects visible should have been noticed by the patients or dentists. All restorations were made by experienced restorative dentists, and this could have been contributed to the high survival rate as the procedure is technique sensitive.[25,26] Often the operator factor has a significant influence on the outcome; however, in this study, no differences were seen among the 4 restorative dentists. In future studies, a different methodology could be more appropriate in comparing the restorations with a modified framework to those with a conventional framework in a prospective randomized clinical trial.

CONCLUSIONS

Based on the findings of this retrospective chart clinical study, the following conclusions were drawn:

1. Bilayered anterior lithium disilicate restorations on teeth or implants with a reinforcement of the incisal edge showed a good survival rate, and no chipping was observed after a maximum observation period of 6 years of clinical function.
2. Endodontic treatment and parafunctional habits (in patients who received an occlusal appliance) negatively influenced the survival rate.

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Audrey L. van Erp: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing - original draft. **Eric van der Winden:** Conceptualization, Data curation, Investigation, Project administration, Resources, Writing - review & editing. **Martijn C. Molenaar:** Data curation, Writing - review & editing. **Eric-Jan Royakkers:** Data curation, Writing - review & editing. **Alwin C.L. van Daelen:** Data curation, Writing - review & editing. **Paul de Kok:** Data curation, Writing - review & editing. **Marco M.M. Gresnigt:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Supervision, Validation, Writing - original draft, Writing - review & editing.

https://doi.org/10.1016/j.prosdent.2021.07.008