Clinical Performance of Lithium Disilicate Glass-Ceramic Onlays For The Treatment of Tooth Defects

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Research Article

Keywords: Glass-ceramic onlays, restorative method, occlusal defect, proximal-occlusive defect, buccal-or lingual-occlusal defect, prosthodontics.

Posted Date: August 27th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-840869/v1

Abstract

Background

The aim of this study was to assess the clinical performance of lithium disilicate glass-ceramic onlays for the treatment of tooth defects and to evaluate the clinical performance and whether they are worth more extensive use as that of the full crown.

Methods

Patients who received treatment by lithium disilicate glass-ceramic onlays at the Western China Hospital of Stomatology were recalled after 1~4 years. The clinical performance and patients' satisfaction of onlays for various tooth defects, cracked or uncracked teeth and endodontically treated or vital teeth were retrospectively evaluated with a combination of modified United States Public Health Service Criteria and questionnaire survey. Statistical analysis was performed by using the chi-squared test, Kaplan–Meier analysis and Log-rank test (a = 0.05) where appropriate.

Results

A total of 154 patients with 166 onlays were recalled for clinical examination. Of the 166 onlays examined, 65 (39.19%) were occlusal onlays, 92 (55.42%) were proximal-occlusive onlays and 9 (5.42%) were buccal-or lingual-occlusal onlays. The clinical performance of O and PO onlays was not significantly different (P > 0.05), according to USPHS Criteria. Kaplan-Meier analysis showed that the 4-year survival rate of O and PO onlays was 95.4% and 97.8%, respectively while there was no failure happened in buccal-or lingual-occlusal onlays. Log- rank test showed that the kinds of defects/onlays, tooth vitality and tooth crack had no influence on the survival rate (P > 0.05). The overall satisfaction rate was more than 98%.

Conclusions

This medium-term analysis indicated that lithium disilicate glass-ceramic onlays achieved satisfactory clinical performance for the restoration of different tooth defects. The survival rate of onlays was comparable to that of full crown. Different kinds of tooth defects, tooth vitality and tooth crack did not influence performance.

Trial registration

The study was approved by the Medical Ethics Committee of West China Hospital of Stomatology of Sichuan University with the approval number: WCHSIRB-D-2021-300. Consent to participate was not applicable.

Background

The most common restorative method for tooth defects of endodontically treated teeth and vital pulp teeth with poor filling treatment effect is full crown [1, 2]. However, full crown restoration has its own disadvantages, and some complications may occur after restoration [3]. First of all, the occlusal surface and the axis walls need to be prepared for full crown restoration, which can reduce 71% tooth structure, and the fracture resistance of tooth was decreased [4]. After preparation, the thickness of tooth wall may be less than 2 mm, which may not be sufficient to support the full crown. Basaran et al. reported that tooth wall with 2 mm was adequate, and support of teeth with 1 mm thick was completely insufficient [5]. In addition, if the margin of full crown restoration close to gingiva is rough, without marginal adaptation or has protrusion, it is probably difficult to conduct oral hygiene measures and stimulate gingival tissue, leading to gingival inflammation, periodontitis, caries, debonding, etc. [6].

In recent years, with the significant developments of adhesive and cementation agents, there have been advances in the bonding technology for glass-ceramic [7, 8, 9]. And using glass-ceramic onlays in the restoration of posterior tooth defect is becoming more popular [10, 11]. Compared to zirconia ceramic material, glass-ceramic [12, 13] has better adhesive property and sound wear resistance which causes less wear of the clutch tooth. In addition, the horizontal stress of the whole occlusal cusp covered by onlay is less than that of the partial occlusal cusp [14]. Moreover, the tooth preparation of onlay is only related to occlusal surface, 45% less than the full crown [4], which can preserve more tooth structure. Sometimes, its preparation [15] will not refer to mesiodistal adjacent areas, preventing food impaction (FI) caused by poor adjacency recovery after repair. And lastly the margin of onlays locates in the occlusal 1/3 of tooth, keeping away from gingival margin which can avoid stimulation, facilitate self-cleaning, and be beneficial to the health of periodontal tissue.

There are few studies on clinical performance of lithium disilicate glass-ceramic onlays compared to that of full crown. The purpose of this study was to evaluate the clinical performance of lithium disilicate glass-ceramic onlays for different kinds of tooth defects. 154 patients referred to and treated at the Department of Prosthetics, West China Hospital of Stomatology Sichuan University, China, from 2017 to 2019, were recalled and 166 onlays were examined for onlay survival and clinical performance.

Methods

According to the digital records, patients referred for prosthetic treatment and treated by a professional team with lithium disilicate glass-ceramic onlays between 2017 and 2019 (Department I of Prosthetics, West China Hospital of Stomatology Sichuan University, China) were contacted via phone calls and proposed an appointment for a free clinical examination and satisfaction questionnaire survey. According to the lithium disilicate glass-ceramic onlays used for different kinds of defects, onlays were also divided into different kinds: occlusal (O) onlays, proximal-occlusive (PO) onlays and buccal- / lingual-occlusal (BO/ LIO) onlays. The recalled patients were divided into vital teeth (VT) group and endodontically treated (ET) group according to pulp vitality, and cracked teeth (CT) group and uncracked teeth (UT) group according to tooth crack.

Clinical examinations were performed by 2 of the authors, who did not participate in the treatment and did not know who restored the teeth that they were evaluating. Before examination, the patients signed an agreement to participate in the study, and all data were kept confidential.

Survive was defined as presence of onlays without biological and/or technical complications during the entire follow-up period. All onlays were assessed according to modified United States Public Health Service (USPHS) criteria (Table 1) [15, 16, 17], and the examined onlays were divided into 3 ratings, Alpha(A), Bravo (B) and Charlie (C). If there are two or more results for one onlay evaluated at the same time, the highest rating will be chosen.

Table 1
Modified USPHS Criteria

Characteristic	Rating	Criteria
Restoration integrity	A	No fracture of restoration
	B	Minor chippings of restoration
	C	Severe chippings or debonding of restoration
Tooth integrity	A	Intact tooth structure without any cracks
	B	Visible crack with no mobile fracture or defect
	C	Visible defect or mobile fracture
Marginal integrity	A	Absence of discrepancy at probing
	B	Presence of discrepancy at probing, without dentin exposure
	C	Probe penetrates in the discrepancy at probing, with dentin exposure
Marginal discoloration	A	Absence of margin discoloration
	B	Presence of marginal discolor, limited and not extended
	C	Evident marginal discoloration, penetrated toward the pulp chamber
Proximal contact	A	Intact contact area with proper contact
	B	Light contact
	C	Open contact
Secondary caries	A	No evidence of caries contiguous with the margin of the restoration
	C	Caries is evident contiguous with the margin of the restoration
Surface texture	A	Smooth surface
	B	Slightly rough or pitted, can be refinished
	C	Rough, cannot be refinished
Gingival health	A	Gingival tissues are perfect
	B	Gingival tissues are slight hyperemic
	C	Gingival tissues are inflammation

Statistic analysis was performed by using a statistical software program SPSS 23.0. Contingency tables were analyzed by using the chi-squared test. The Kaplan-Meier survival rate analysis was used to calculate the cumulative survival rates of examined restorations, and the Log-rank analysis was used to analyze the relationship between survival rate and possible influence factors such as kinds of tooth defects, tooth vitality and tooth crack (a = 0.05).

Results

Patients and onlays information

154 patients (166 onlays) were recalled and received a free clinical examination and the distribution of examined onlays illustrates that there are 65 O onlays (39.16%), 92 PO onlays (55.42%) and 9 BO/LIO onlays (5.42%). A total of 10 (6.02%) vital teeth were treated for their severe abrasion or cusp defects, but with no pulp inflammation. The distribution of cracked teeth and uncracked teeth were 10.24% and 89.76%.

The Results Of Clinical Examination

The results of 166 onlays examined by modified USPHS Criteria are shown in Table 2. According to the digital records, there were 3 tooth fractures happened and finally extracted before clinical examination. The three cases of tooth fracture failures were O group, all of which were cracked teeth; one was the premolar with vital pulp, and the rest were ET molars. One onlay was completely fractured and needed refabrication, and one was debonded and need rebonding, all of which were ET molars with PO onlays. The above 5 failure cases were rated C. In addition, food impaction was found in 7 cases, and these cases were also rated as grade C. The grade B cases had following problems: slight fracture that did not affect the appearance and function, slight margin unfit, marginal discoloration, and mild gingival inflammation. 95.78% onlays reached grade A in proximal contact, and more than 98% onlays reached A in the other observation criteria. The clinical evaluation results showed that 150 onlays were grade A (90.36%), 4 were grade B (3.01%), and 12 onlays were C (7.83%). All the BO/LIO onlays were A; there are 89.23% O onlays and 90.22% PO onlays reached grade A (Table 3).

Table 2
Clinical evaluation results with modified USPHS criteria (n, %)

Items	A	B	C
Restoration integrity	163(98.19)	1(0.60)	2(1.21)
Tooth integrity	163(98.19)	0	3(1.81)
Marginal integrity	165(99.40)	1(0.60)	0
Marginal discoloration	165(99.40)	1(0.60)	0
Proximal contact	159(95.78)	0	7(4.22)
Secondary caries	166(100)	0	0
Surface texture	166(100)	0	0
Gingival health	164(98.80)	2(1.20)	0

Table 3
Clinical evaluation results of O, PO and BO/LIO onlays (n, %)

Rating	O[a]	PO[a]	BO/LIO
A	58(89.23)	83(90.22)	9(100)
B	2(3.08)	2(2.17)	0(0)
C	5(7.69)	7(7.61)	0(0)
Total	65(100)	92(100)	9(100)
([a]Rating grade of O and PO onlays not significantly; P > 0.05, chi-squared test.)			

Onlay survial rate

The results of Kaplan-Meier survival rate analysis of O and PO onlays illustrated that 4-year survival rate of O onlays and PO onlays was 95.4% and 97.8% respectively (with 95% confidence interval 95.339% – 95.461% and 97.758% – 97.852%), while there was no failure happened in BO/LIO group.

The result of Log-Rank test analysis showed that the kinds of onlays (according to the kinds of tooth defects), tooth vitality and tooth crack had no influence on the survival rate of restorations (Fig. 1, 2, 3).

The result of Log-Rank test analysis also showed that tooth vitality and tooth crack had no influence on the survival rate of O onlays (Fig. 4, 5).

Results of questionnaire on satisfactory

According to the results of questionnaire (Table 4), no patients were unsatisfied with the appearance of onlays. Overall satisfaction (very satisfied + satisfied) rate was more than 98% in comfort, and more than 90% were satisfied with the functional recovery.

Table 4
Investigation results of satisfaction degrees in 151 patients (n, %)

Items	Very satisfied	Satisfied	Unsatisfied
Appearance	156(93.97)	10(6.03)	0(0)
Comfort	153(92.18)	6(3.61)	7(4.21)
Functional recovery	151(90.96)	2(1.21)	13(7.83)

Discussion

From 2017 to 2019, a total of 154 patients received 166 onlays treatments and were recalled for this retrospective study on clinical performance. Digital records showed that the proportion of PO onlays was the most (55.42%), for most of these teeth need to be repaired after root canal treatment because of the pulp inflammation caused by adjacent surface caries [18]. In this study, lithium disilicate glass-ceramic onlays showed satisfactory clinical performance in the returning visit. 95.76% of 166 onlays were grade A in proximal contact, and more than 98% reached A in the other observation criteria. Group O had the least grade A (89.23%). There were 5 onlays (7.69%) with grade C, including 2 cases with food impaction and 3 cases with the tooth fracture, while there were 7 onlays (7.61%) with grade C in PO group.

The kaplan-Meier survival rate analysis showed that the survival rate of O group and PO group decreased at the second year, but remained at a high level till the fourth year (exceeding 95%), which illustrated satisfactory survival rate in line with other studies [19, 20]. Although Georgia et al. [3] demonstrated that the mean survival rate of onlays and crowns were 93.50% and 95.38% respectively, some medium-term studies (2–5 years) indicated a survival rate of 91–100% of onlays [21]. In this study, the survival rate of onlays is 96.99%, which is comparable to that of full crown.

Log-rank test analysis showed that there was no significant difference in the survival rate among different kinds of onlays (O, PO and BO / LIO). This means that occlusal, proximal-occlusive and buccal-/lingual-defects can all be repaired by lithium disilicate glass-ceramic onlay with ideal survival rate. Tavarez et al. [22] concluded that the preservation of the residual tooth tissue is the decisive factor for the fracture strength of the teeth. Compared with full crown restoration, the residual tooth tissue can be preserved to the greater extent by using onlay, which means onlays are more suitable for tooth defects. Interestingly, some previous studies even reported a better clinical performance of onlays than full crown, especially in survival rates [23, 24].

Two technical complications were observed from this study. One is onlay fracture. Ceramic fractures represented the most common technical complication [3]. Fracture of restoration can be caused by insufficient thickness of onlay. Murgueitio et al. [25] discovered that the thinner the thickness, the higher the risk of restoration fracture, when the thickness was less than 2mm. Della et al. [26] showed that the microcracks generated during polishing may expand under the excessive bite force, which will eventually lead to the fracture of the prosthesis. This fractured onlay happened in PO group in this study. The patient was a middle-aged man, and the tooth is a mandibular molar, thus excessive bite force may be the reason for this failure. When compared to full crowns, onlays showed better fracture resistance. Beier et al. [24] found that 64.86% of failures of crowns were attributed to ceramic fracture, and only 20.00% were of onlays' failures. Another case failed for onlay debonded after being repaired for 1 year in PO group. When the margin of tooth defects was subgingival, gingival crevicular fluid or saliva can contaminate the adhesive interface during the bonding process, which lead to decreased bond strength and finally restoration debonded. Thus, using rubber dam to prevent saliva contamination, and cleaning lithium disilicate glass ceramic surface with orthophosphoric acid or re-etching with hydrofluoric acid can reach reliable bond strength [27].

Biological complications observed in this study were three teeth fracture failures, which are all happened in cracked teeth in O group. One is vital premolar, and the rest two are ET molars. But Log-rank test analysis showed that there was no statistical significance in survival rate of between the vital teeth and ET teeth, as well as cracked and uncracked teeth. The traditional viewpoint is that after endodontical treatment, the resistant strength of the tooth will decrease and easy to crack due to poor vascular nourishment. Although the repair is successfully completed, the risk of fracture is still higher than that of vital teeth [28]. Manhart J et al. [29] suggested that pulp vitality is not necessarily the main factor leading to restoration failure. The survival rate was significantly higher (97%) for cracked teeth receiving a full crown after endodontic treatment [30]. Nevertheless few studies reported the survival rate of cracked teeth receiving ceramic onlays. More studies are needed to reveal the long-term survival rate of cracked teeth with ceramic onlays. Fabbri et al. [31] showed tooth fracture accounted for 7.14% for crowns' failure, and 25.00% in the study of Barnes et al. [32] Reich et al. [33] showed that tooth fracture accounted 4.54% for onlays' failure. These studies demonstrated that less tooth fracture occurred in onlays than in full crown, which can be attributed to that onlay restoration preserved more tissue and provided teeth with better fracture resistance.

Food impaction was observed in 7 cases, in which there are two O onlays and five PO onlays. The two O cases and three of five PO cases were horizontal food impaction. The proximal contacts were of suitable tightness when checked by dental floss. The impaction may be related to the atrophy of gingival papilla between teeth. Only two cases were shown to have loose contact to the adjacent teeth in PO group, thus leading to vertical food impaction. When tooth defects were restored by onlays, most often onlays can preserve original adjacent relationship to the largest extent for the margin of onlays was located in the occlusal 1/3 of tooth. But during the tooth preparation of full crown, the original mesio- and distal-adjacency of the tooth were all destroyed. Food impaction can also result in secondary caries and caries accounted for 13.50% of the total failures of crowns [24]. The margin of onlays is visible, and easier to keep hygiene. Thus, secondary caries occurs rarely following onlay restoration.

In the survey of patient satisfaction, no patients were unsatisfied with the appearance of onlays. Except the 5 failure cases, only two patients were unsatisfied in comfort, one for severe food impaction and another for the pain during chewing. And 7 cases showed that the food impaction has influence on functional recovery, but the satisfactory rate was still over 90%. These all showed satisfactory performance of onlays in appearance restoration, comfort and function recovery. Furthermore, when introducing the restoration methods to patients, most of them tend to choose onlay which is more minimally invasive, less tooth tissue preparation.

In addition, the most often used material for posterior full crown is monolithic zirconia [34, 35]. Previous study suggested that enamel antagonized against monolithic zirconia resulting in more height loss when compared to lithium disilicate glass ceramic [36]. Thus, lithium disilicate glass-ceramic onlays also showed better performance in antagonist-friendly aspect.

Conclusions

Different kinds of tooth defects can be repaired by lithium disilicate glass-ceramic onlays and achieve ideal outcomes and patient satisfaction. In this study, the lithium disilicate glass-ceramic onlays showed great clinical performance and survival rate, which suggested that onlays are worth more extensive use as full crown for the treatment of tooth defects, with high survival rate and patient's satisfaction.

Abbreviations

FI: Food impaction

O: Occlusal

PO: Proximal-occlusive

BO/ LIO: Buccal- / Lingual-occlusal

VT: Vital teeth

ET: Endodontically treated

CT: Cracked teeth

UT: Uncracked teeth

USPHS: United States Public Health Service

A: Alpha

B: Bravo

C: Charlie

SPSS: Statistical Package of the Social Science

Declarations

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgements

Not applicable.

Funding

This study has no funding.

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Contributions

SC, ML and ZZ contributed to conception or design; SC and ML collected the data; SC contributed to acquisition, analysis or interpretation of data. SC contributed to draft the manuscript; ZZ and WC critically revised manuscript. All authors read and approved the final manuscript.

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Ethics declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of West China Hospital of Stomatology of Sichuan University with the approval number: WCHSIRB-D-2021-300. Consent to participate was not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

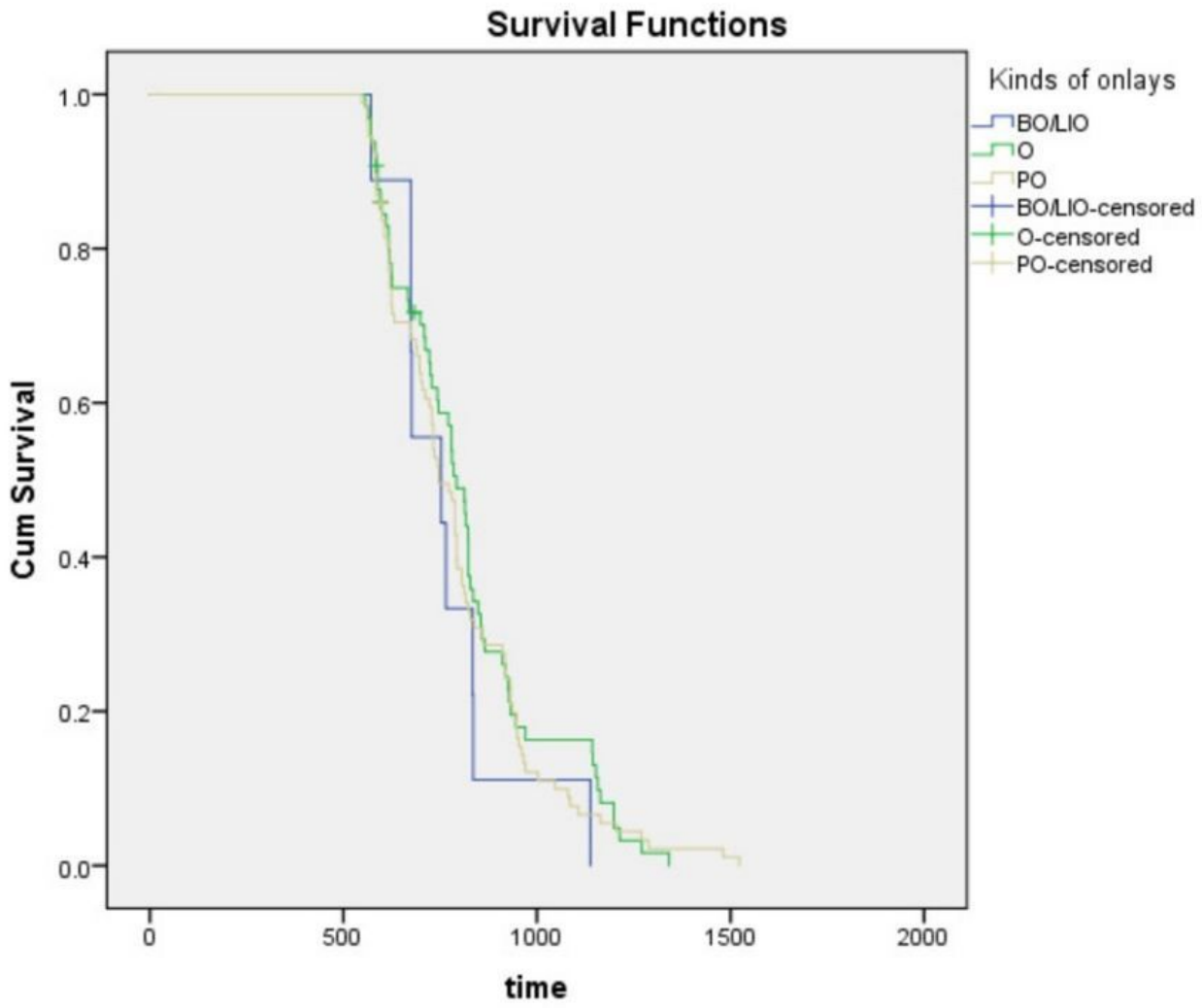

Figure 1

Kaplan-Meier curves of survival rates according to different kinds of onlays (166 onlays). There is no significant difference between 3 groups (P = 0.623, log-rank test).

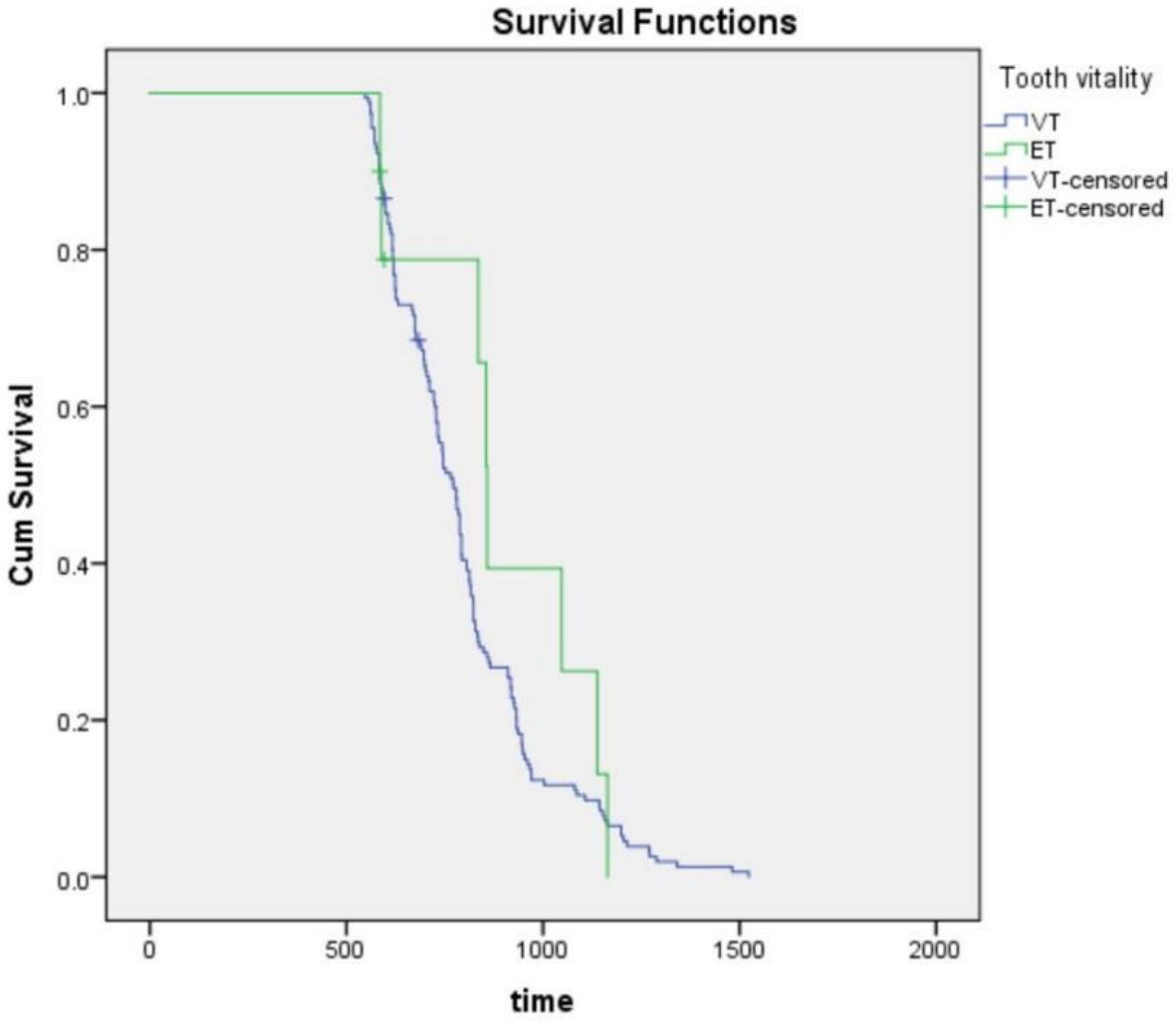

Figure 2

Kaplan-Meier curves of survival rates according to tooth vitality (166 onlays). There is no significant difference between 2 groups (P = 0.326, log-rank test).

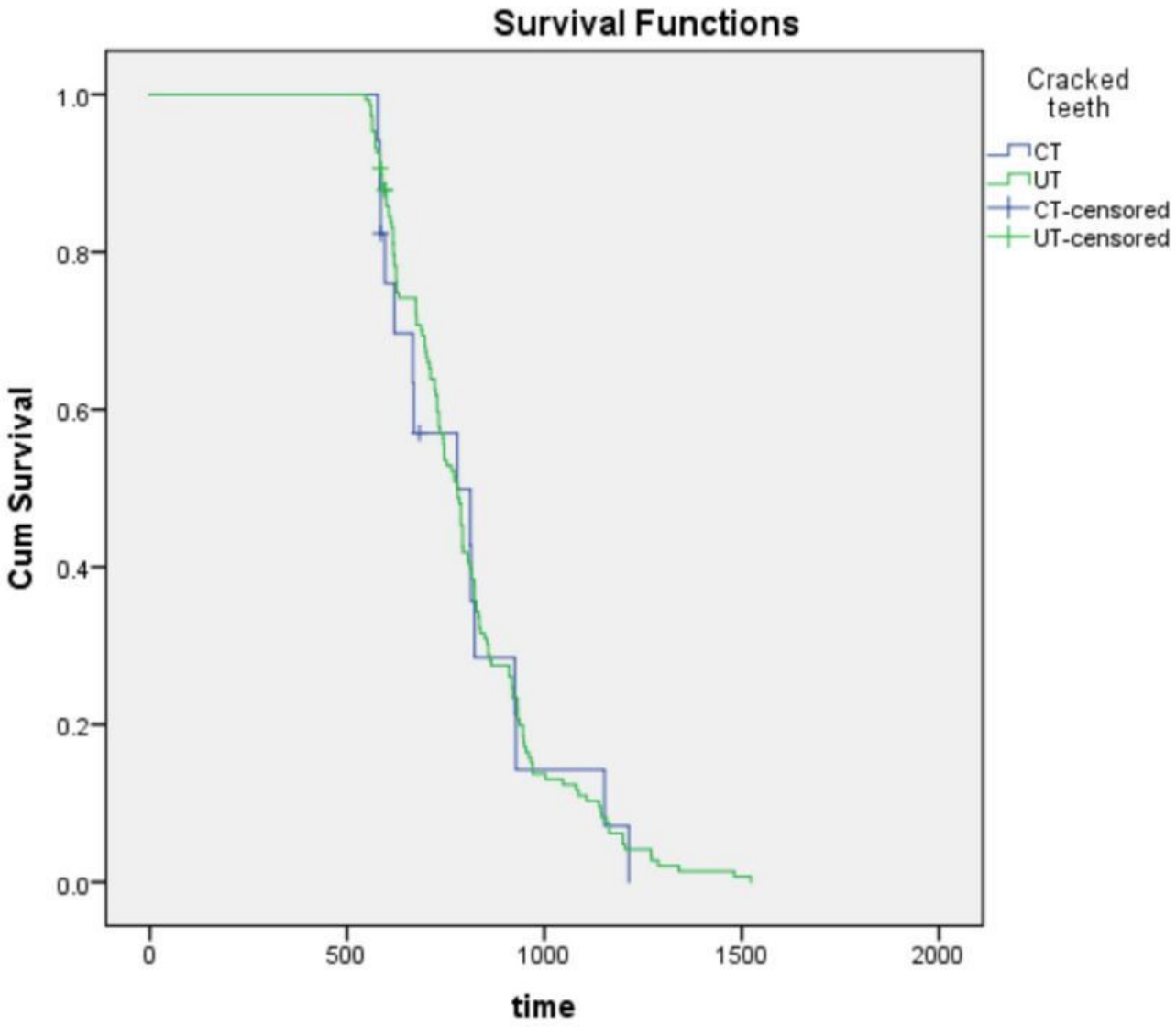

Figure 3

Kaplan-Meier curves of survival rates according to tooth crack (166 onlays). There is no significant difference between 2 groups (P = 0.773, log-rank test).

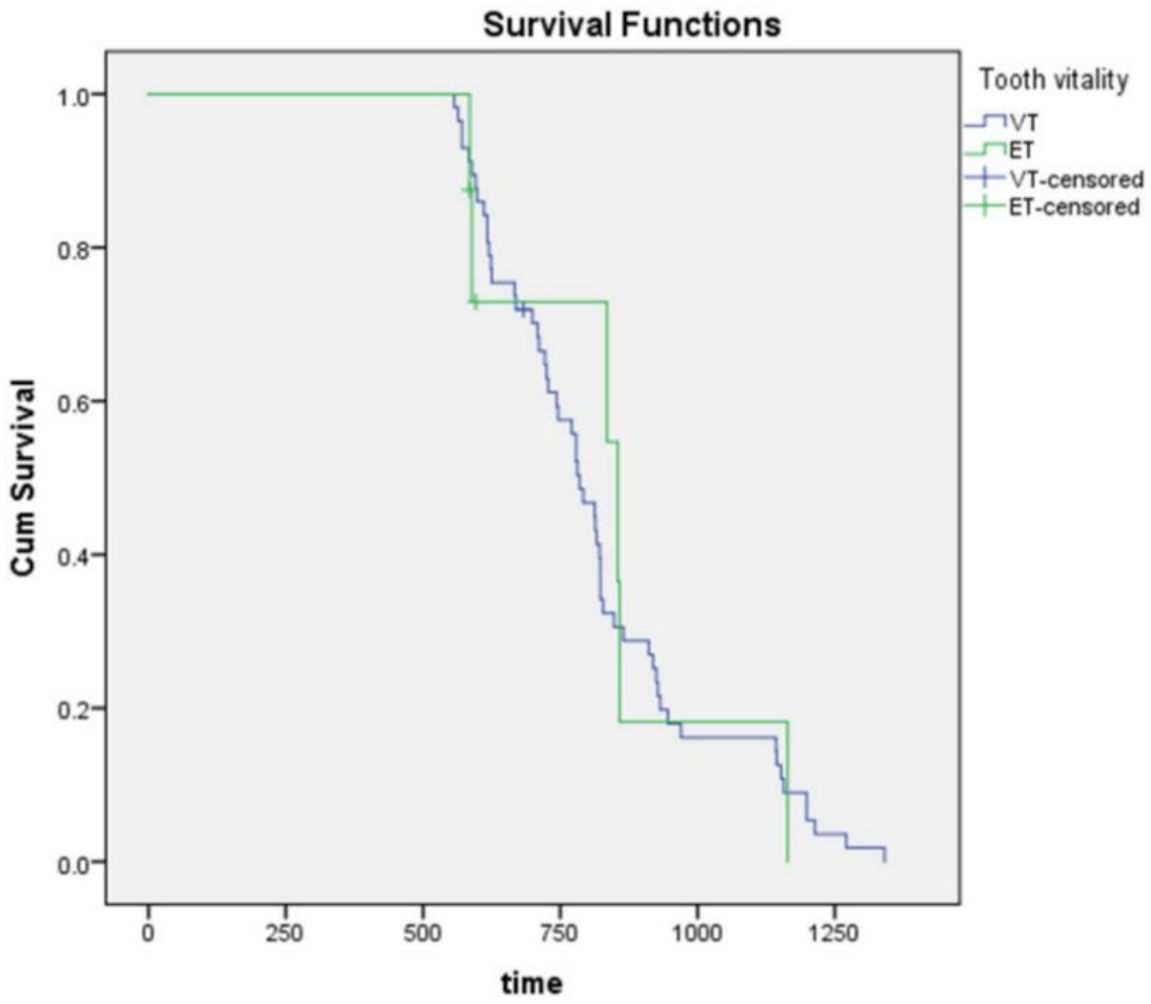

Figure 4

Kaplan-Meier curves of survival rates according to tooth vitality (65 O onlays). There is no significant difference between two groups (P= 0.905, log-rank test).

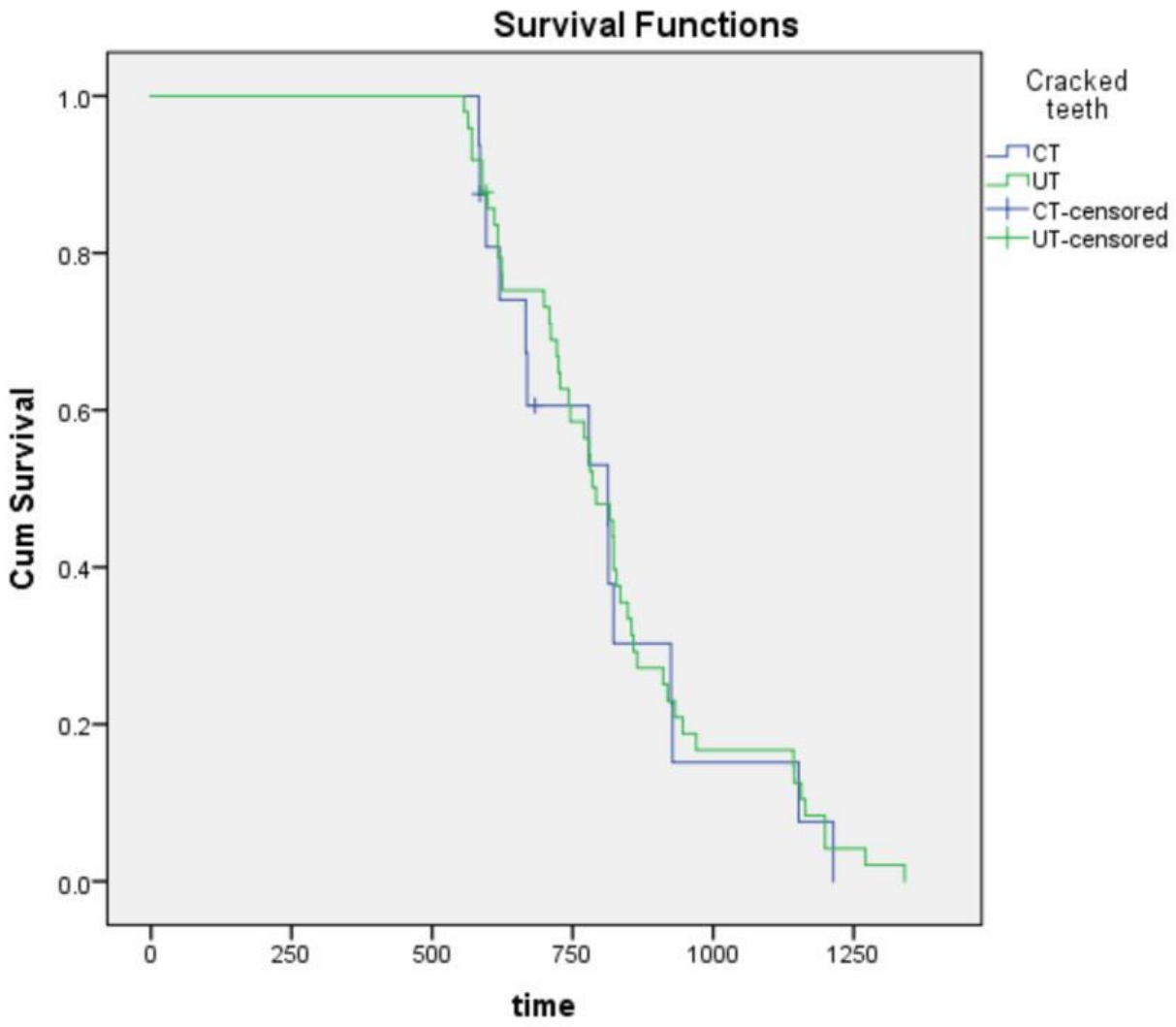

Figure 5

Kaplan-Meier curves of survival rates according to tooth crack (65 O onlays). There is no significant difference between two groups (P= 0.731, log-rank test).