The Efficacy of Glass-Ceramic Onlays in the Restoration of Morphologically Compromised and Endodontically Treated Molars

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Purpose: This study evaluated the 4-year clinical performance of IPS Empress II ceramic onlay restorations on extensively restored, endodontically treated molars. ***Materials and Methods:*** A sample of 53 morphologically compromised and endodontically treated molar teeth were restored with IPS Empress II ceramic onlays cemented with a dual-cured luting composite. The molars were evaluated by two experienced clinicians in accordance with the modified United States Public Health Service criteria at baseline and 6-month recalls up to a 4-year observation period. The analyses were carried out using the Wilcoxon signed-rank test and the Kaplan-Meier product limit method. ***Results:*** Four failures were noted. Two onlays debonded; one was reinserted and reluted while the other resulted in lost coronal hard tissue and was restored with a fiber-reinforced post-and-core system followed by a full ceramic crown restoration. The third failure resulted from secondary caries and fracture of the remaining enamel and was restored with a full ceramic crown. The fourth failure was extracted. None of the onlays exhibited wear, fracture of antagonist teeth, or dimensional change at proximal contacts. ***Conclusion:*** Within the limitations of this study's design and short 4-year observation period, IPS Empress II ceramic onlay restorations demonstrated promising results with a 92.5% success rate. *Int J Prosthodont 2013;26:230–234. doi: 10.11607/ijp.2768*

Despite numerous in vitro and in vivo investigations, there is still much confusion regarding ideal restorations for endodontically treated teeth.[1] It is widely accepted that the primary purpose of post placement is to retain the core material and to reinforce the remaining coronal tooth structure.[2] It has also been reported that the majority of clinical failures stem from inadequate restorative therapy followed by tooth loss due to periodontal reasons and apical leakage of oral fluids within the root.[3–6] Recent research in adhesive dentistry has provided esthetic and reliably strong materials and methods for the bonding of porcelain to enamel and dentin.[7] As a result, current all-ceramic systems offer a highly esthetic, biocompatible, and functional alternative to traditional full coronal restorations. However, major concerns for ceramic onlays include material fractures, hypersensitivity, varying degrees of fit and maintenance of marginal integrity, microleakage, bond failures, and cemental wear. Additionally, the clinical performance of ceramic onlays may also be affected by wear of the ceramic material and opposing teeth, plaque accumulation, gingivitis, secondary caries, color stability, anatomical form, and radiopacity.[8–10]

The removal of substantial tissue for tooth preparation may lead to fracture risks. Traditional full coronal restorations in the case of extensive tissue loss require macromechanical retention with a post and the placement of a restored core. The IPS Empress II system (Ivoclar Vivadent) is a multiphase glass-ceramic with a high degree of crystallinity and favorable mechanical properties, which renders the onlay restoration of extensively damaged teeth feasible. Other advantages of the method are predictable long-term esthetic results and excellent adaptation of supragingival cervical margins.

This study evaluated the long-term clinical performance of IPS Empress II ceramic onlay restorations on extensively damaged endodontically treated teeth.

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Materials and Methods

A convenience sample of 53 patients (mean age: 28.3 years, range: 16 to 35) was treated with 53 IPS Empress II onlay restorations (one in each patient) that were placed and supervised by two of the authors (GO and DT) from the Department of Restorative Dentistry at Marmara University. The selected patients did not have histories of parafunctional habits, severe malocclusion, periodontitis, pronounced gingival inflammation, poor oral hygiene, high caries progression, or a removable partial denture. On the other hand, each patient presented with an endodontically treated molar tooth characterized by extensive hard tissue and regarded as a candidate for full crown preparations. All patients were informed about the study's scope and each patient signed an informed consent form with approval from the Marmara University ethics committee. The study began in early 2004 and included 53 restorations in endodontically treated molar teeth (31 in the mandible, 22 in the maxilla). Thirty-three of the restorations were with root canal treatments and retreated by GO, who also supervised the placement of the remaining 20 restorations with primer root canal treatments. All of the selected morphologically compromised teeth had the outcome of their endodontic treatment reassessed, and six molars were found to require retreatment because of the presence of apical radiolucencies and inadequate root canal obturation. In addition, 20 teeth required crown lengthening prior to obtaining baseline impressions. IPS Empress II was the material of choice for the ceramic onlays, and highly viscous and dual-cured luting composite (Bifix, Voco) for the adhesive cementation. These endodontically treated teeth had extensively large cavities with thin cusps in mesiodistal or buccolingual directions with no dentin support. They were reduced in length by at least 0.5 mm at the base of the cusp. The orifices were sealed with cement (GC, Shofu Dental), a retraction cord was placed, and full-arch impressions were taken using polyvinyl siloxane (Permagum High Viscosity, 3M ESPE) and a low-viscosity material (Permagum Garant, 3M ESPE).

Following rubber dam application, the adhesive surfaces of the restoration were treated with a 5% hydrofluoric acid (IPS Empress ceramic etch, Ivoclar Vivadent), rinsed with water, and coated with a silane coupling agent (Bifix, Voco). In the meantime, the enamel and dentin surfaces were conditioned with a 35% phosphoric acid gel (Voco). The dentin bonding system (Solobond Plus Primer and Adhesive, Voco) was applied and was not cured. The restorations were inserted with moderate pressure using a dual-cured luting composite (Bifix QM, Voco) smeared on the internal surfaces of the onlays. Restorations were cured by a light-emitting diode curing system at an intensity of 1100 mW/cm^2 (Bluephase C5, Ivoclar Vivadent) for 40 seconds at each margin. Onlays were polished with 40/15 µm diamond burs, polishing disks, and strips (Sof-Lex, 3M ESPE). Two experienced dentists (GO, DT) rated the restorations using a mirror and probe independently at baseline in the week following insertion, within 6 months, and each year for 4 years following insertion with modified United States Public Health Service (USPHS) criteria of Ryge.[11]

Photographic records and bitewing radiographs were taken at each evaluation. SPSS software (version 11, IBM) was used to perform the statistical analysis. The Wilcoxon signed-rank test was used to analyze the change in the follow-up scores of the restorations, and Kaplan-Meier product limit method was used for evaluation of the cumulative success rate. The null hypothesis was tested during all significance tests, and the results were considered significant at a level of $P < .05$.

Table 1 Summary of Failures and Prognosis of the Study Samples at Recalls

	1 y	2 y	3 y	3.3 y	4 y
Debonding (reinserted)	1				
Fracture + debonding (post + full ceramic crown)				1	
Pain (tooth extracted)			1		
Secondary caries + fracture (full ceramic crown)					1

Results

All patients reported positive outcomes regarding their restorations. Problems were observed in four cases (Table 1). One restoration was debonded at the 1-year recall, immediately inserted, and was successful at the 4-year recall. The other one, which had undergone a crown-lengthening operation, was debonded at the 3.3-year recall. It could not be reinserted since there was no available tissue to be bonded. It was restored with fiber-reinforced composite post and core with full ceramic crown. In the third case, secondary caries as well as a fracture on remnant enamel were observed at the 4-year recall. That restoration had to be replaced with a full crown. In the fourth case, the patient complained of pain at the endodontically treated tooth site in the third year.

Table 2 Frequency Distribution of Scores for the Evaluated Modified USPHS Criteria of Restorations

	Ceramic onlay (n = 53)														
	Baseline (n = 53)			1 y (n = 52)			2 y (n = 53)			3 y (n = 52)			4 y (n = 50)		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
Anatomical form	52	1	–	51	1	–	52	1	–	51	1	–	49	1	–
Marginal adaptation	53	–	–	48	4	–	48	5	–	48	4	–	46	4	–
Color match	46	5	2	42	8	2	43	8	2	44	6	2	43	5	2
Marginal discoloration	53	–	–	48	2	2	47	4	2	45	5	2	43	5	2
Caries	53	–	–	52	–	–	53	–	–	52	–	–	50	–	–
Surface texture	51	2	–	50	2	–	50	3	–	50	2	–	48	2	–
Anatomical form at the marginal step	52	1	–	51	1	–	52	1	–	51	1	–	50	–	–
Integrity of the tooth	53	–	–	52	–	–	53	–	–	52	–	–	50	–	–
Integrity of the restoration	53	–	–	52	–	–	53	–	–	52	–	–	50	–	–
Approximal contact relationships	53	–	–	52	–	–	53	–	–	52	–	–	50	–	–
Occlusal contact	53	–	–	52	–	–	53	–	–	52	–	–	50	–	–

*Statistically significant ($P < .05$).

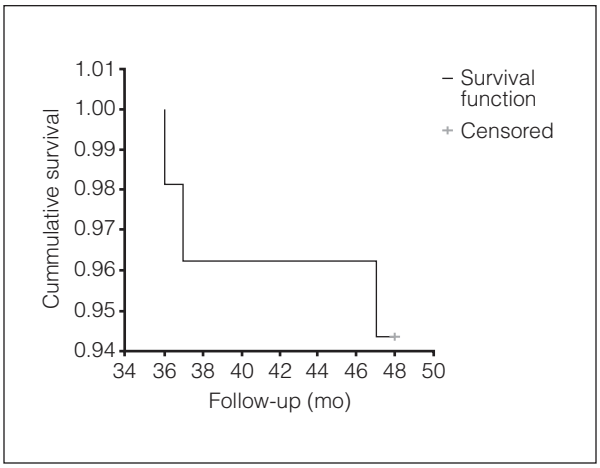

Fig 1 Kaplan-Meier curve for 53 teeth.

That restoration was already a 5-year-old endodontic treatment when the onlay restoration was prepared. Although the resection was performed at the apical aspect, the pain continued for 3 months, and the tooth was eventually extracted. The cumulative success rate at the end of the 48-month period following the restorations was 94.34 % (Fig 1). There was no report of recurrent caries at the 4-year recall. Table 2 demonstrates the frequency distribution scores of the modified USPHS criteria of the restorations. Marginal adaptation was statistically different at all recalls, 1-, 2-, 3-, and 4-years successively ($P = .04$, $P = .02$, $P = .04$, $P = .04$). However, due to these differences, the score changed from 0 to 1 within acceptable margins, ie, no visible crevice into which explorer will penetrate. Some marginal discoloration was detected on the occlusal surfaces of four restorations. The same was observed on six restorations at the 2-year recall and on seven restorations each at the 3- and 4-year recalls. Two-year, 3-year, and 4-year recalls of marginal discoloration were statistically different ($P = .02$, $P = .001$, $P = .01$, respectively). After the 4-year clinical service, five onlays were recorded as score 1 and two onlays as score 2 for discoloration. The score 2 discoloration was seen in 7.5% of restorations at the 1-year recall and in 13.21% at the 4-year evaluation, all of which were acceptable based on the criteria that were used for evaluation. The patients' self-evaluation was based on color, chewing ability, and pain. Color match was different at the 2-year recall ($P = .02$), chewing ability was different at the 3-year ($P = .02$) and 4-year ($P = .04$) recalls, and between the 1- and 3-year recalls compared with baseline ($P = .02$).

Among those patients, a 42-year-old woman suffering from pain and fracture on her maxillary right first molar, with an extensive composite restoration, was retreated. An onlay cavity design was prepared (Fig 2a). The onlay ceramic restoration was evaluated at baseline (Figs 2b and 2c) and at the 4-year recall (Fig 2d).

Wilcoxon signed-rank test (*P*)									
Baseline to 1 y	Baseline to 2 y	Baseline to 3 y	Baseline to 4 y	1 to 2 y	1 to 3 y	1 to 4 y	2 to 3 y	2 to 4 y	3 to 4 y
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
.04*	.02*	.04*	.04*	.32	.32	.32	1.00	1.00	1.00
.08	.18	.65	.65	.32	.32	.32	.32	.32	1.00
.06	.02*	.01*	.01*	.15	.08	.08	.32	.32	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	.32	1.00	1.00	.32	1.00	1.00	.32	.32	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	.32	1.00	1.00	.32	1.00	.32	.32
1.00	1.00	.32	.32	1.00	.32	.32	.32	.32	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
.32	.16	.16	.32	.32	.32	1.00	1.00	1.00	1.00

Fig 2a Preparation of onlay cavity design.

Figs 2b and 2c The onlay ceramic restoration at baseline.

Fig 2d The onlay ceramic restoration at the 4-year recall.

Discussion

The results match those of Salehrabi and Rotstein[12] and suggest that the high success rate of ceramic onlays in 4-year evaluations was partially due to the cuspal coverage obtained with onlay restorations. Fokkinga et al,[13] over a 17-year observation period, showed that endodontically treated teeth with posts and cores and coronal restorations showed survival rates of 71% to 80% for restorations and 83% to 92% for teeth. The present cumulative onlay success rate of 94.34% may be attributed to the layering technique used in the laboratory process and based on the manufacturer's suggestion.

Van Dijken et al[14] suggested that the main reason for failure in dual-cured composite and conventional glass-ionomer groups was partial fracture or total loss of the inlays, and it appears that longer evaluation periods are necessary to observe the longevity of ceramic inlays. In this study, two restorations were debonded, one at the 1-year recall, but were successfully retained at the 4-year recall. The second fractured onlay could not be rebonded since there was not enough tissue available and was treated with a full crown restoration. There was only one fracture related to an underlying caries lesion. In addition, one apically resected tooth demonstrated continuous pain and was extracted.

A previous study[15] reported an increased baseline score for marginal discoloration (from 2.86% to 14.29% at Bravo level) at the 1- and 2-year recalls, while this study had six onlays recorded for discoloration at the 2-year recall (P = .046). The importance of this is that the extensive cavities were not left for additional tissue loss, but were prepared for the adhesive systems and restored with large glass–ceramic restorations extending into orifices and the pulp cavities. Therefore, the obtained 4-year results of such large onlay restorations are very important for the primary consideration of such conservative treatment choices.

Conclusion

Under the conditions of this clinical study, IPS Empress II ceramic onlay restorations performed successfully for 4 years with promising results on extensively damaged teeth with endodontic treatment.

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