

# Two-year Clinical Evaluation of IPS Empress II Ceramic Onlays/Inlays

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## Clinical Relevance

The two-year success rate of restorations reported in the current study demonstrates that IPS Empress II ceramics are clinically acceptable for onlay/inlay restorations on molars.

## SUMMARY

The stronger the ceramic material, the longer the restoration stays in the mouth. The current study evaluated the two-year clinical performance of a strong ceramic system, IPS Empress II, with increased strength on onlay/inlay restorations of molars.

Teeth from 35 patients, including three premolars and 32 molars, were prepared for 28 onlay and seven inlay restorations with IPS Empress II ceramics. The restorations were cemented with a highly viscous, dual-curing luting composite cement (Bifix) and evaluated by two examiners

using USPHS criteria at baseline (one week following insertion), six months, one year and two years.

The baseline scores and recalls were assessed by Wilcoxon signed rank test. Statistically significant marginal discoloration at the Bravo level was found at the 12- and 24-month recalls ( $p=0.046$ ). One debonding was statistically insignificant.

No changes were observed with respect to anamnesis, such as any symptom from the TMJ or masticatory muscles. No restorations were replaced due to hypersensitivity or were missing at the two-year evaluation. Any wear on the restoration, antagonist tooth or any changes of proximal contacts were not observed.

IPS Empress II Ceramics were found to be appropriate as onlay/inlay restorations for clinical use under the conditions of the current study.

## INTRODUCTION

As demand for esthetic restorations in posterior teeth has expanded, the number of restorations using resin

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composites and conventional inlays has been increasing.<sup>1-4</sup> However, the materials used in those restorations have demonstrated being subjected to wear, marginal/bulk fracture fatigue and microleakage and discoloration in *in vitro* and long-term clinical follow-up studies.<sup>1-2,5-6</sup>

Therefore, the current demand for tooth-colored, non-metallic restorations has significantly contributed to the frequent use of ceramic materials.<sup>7-9</sup> Ceramic materials that have more favorable mechanical properties have the potential to function effectively as inlays and indirect or direct (computer-aided design/manufacturing [CAD/CAM]) inlay systems.<sup>10-13</sup> The long-term clinical performance of inlays with some ceramic materials has recently been reported as clinically acceptable.<sup>14-18</sup>

However, there are some major problems associated with using ceramics as inlays, including fracture, possible hypersensitivity, fitness, marginal integrity, microleakage, bond failures and wear of the cement material. Other areas that can affect the clinical performance of ceramic inlays include ceramic or opposing tooth wear, plaque accumulation, gingivitis, secondary caries, color stability, anatomic form and radiopacity.<sup>19</sup> Recently, systems, such as Dicor (Dentsply), Optec-HSP (Jeneric/Pentron), In-Ceram (Vita), IPS Empress (Ivoclar) and Ducergold (Degussa-Huls), have been introduced into the market.<sup>20-23</sup> The IPS Empress system (Ivoclar), with a pressable glass matrix ceramic, was developed at the University of Zurich, Zurich, Switzerland, in 1983. The material used in the system, a leucite-reinforced castable glass ceramic, was designed primarily for single-unit restorations. The main advantage of the system is the injection-molding process, which involves the use of heat and pressure. The incorporation of leucite crystals prevents tensile stresses and thus the formation of microcracks. The leucite crystals also improve flexural strength and fracture resistance. Additionally, the combined use of heat and pressure reduces the amount of shrinkage and, thereby, increases flexural strength. Basic components of these materials include feldspathic porcelain with 63% silicon dioxide and 19% aluminum oxide to which leucite crystals were added. The color of these materials is produced by using a shading technique during the fabrication of inlays and onlays.

IPS Empress II ceramic was recently developed to increase the strength of IPS Empress ceramics from 100 Mpa to 300 Mpa to improve the clinical longevity of ceramic restorations.<sup>24</sup> IPS Empress II was developed by Beall and Echeverria in 1998 to increase the strength of IPS Empress Ceramics. This material has small lithium disilicate crystals 0.5-5  $\mu\text{m}$  and 0.3-0.5  $\mu\text{m}$  in length and small lithium orthophosphate crystals (60% by volume). The materials and diameter of the ceramics are different. The volume of the original

IPS Empress system was increased, while the core produced from the new material, was more condensed than the previous ceramic. Moreover, fluoroapatite glass ceramic is ovened over this ceramic core structure. This process increases the strength of the ceramic.<sup>25</sup>

This condensed crystal structure of IPS Empress II increases the strength against fracture, tensile forces and chemical substances.<sup>26</sup> In addition to the chemical composition and physical properties, the microstructure of IPS Empress II is different from IPS Empress, especially the core structure. Thus, the fracture strength is three times greater than IPS Empress. The addition of glass content in IPS Empress II is relatively low, while the risk of the occurrence of microstructure is eliminated.<sup>27</sup> However, currently there are no reports on the long-term clinical performance of IPS Empress II ceramic materials as onlay/inlay restorations. The purpose of the current clinical study was to perform a two-year clinical evaluation of the performance of IPS Empress II ceramic onlay/inlay restorations.

## METHODS AND MATERIALS

Thirty-five patients (15 women and 20 men), with a mean age of 32.4 years, were treated at the clinics of the Restorative Department of Marmara University, Faculty of Dentistry. Patients with clenching, bruxism, severe malocclusion, periodontitis, pronounced gingival inflammation, poor oral hygiene or a high caries progression, and patients with partial dentures, were excluded from the study.

Two advanced clinicians with 85% agreement evaluated the clinical portion of the study. The clinicians graded the restorations using the USPHS criteria developed by Anusavice<sup>28</sup> and Randall and others.<sup>29</sup> These clinicians evaluated the restorations performed by undergraduate and postgraduate students to rate various criteria using the values Alpha, Bravo and Charlie on each criteria. If there was any disagreement, these clinicians reevaluated the case. The evaluations continued until the clinicians came to an agreement on the rating they gave for the case, with at least 85% agreement being compulsory.

The study sample included 35 restorations (28 onlays, 7 inlays); 7 vital and 28 non-vital teeth needed root canal treatment. Unfortunately, when patients with large cavities presented to the clinics to be treated, they mostly had non-vital teeth, which required endodontic treatment. Since this was the majority of the cases in the clinics, onlays were prepared for those endodontically-treated teeth. Additionally, most of these restorations extended subgingivally. Since this was the reality for the patients to be treated, the ability to restore these lesions and the longevity of the ceramic material was assessed. Twelve ceramic teeth

Table 1: The Number of the Evaluated Restorations

Restorations n=35	Premolars	Molars	Non-vital	Vital	Crown Lengthening
Inlay n=7	3	4	2	5	0
Onlay n=28	0	28	26	2	12

Table 2: The Relation Between the Cavities and the Gingiva Levels

	Supragingival (>2mm) %	Supragingival (0-2 mm) %	At the Gingival Level %	Subgingival %
Mesial	14.3	14.3	65.7	5.7
Distal	11.4	17.1	51.4	20.0
Buccal	40.0	45.7	14.3	-
Lingual	37.1	20.0	37.1	5.7

required and received crown-lengthening procedures before the impressions were taken (Table 1). Table 2 demonstrates the gingival levels and related surfaces of the prepared cavities. The periodontal status was classified as supragingival, gingival and subgingival on four surfaces.

The majority of the cavities, 65.7% and 51.4%, ended at the gingival level on the mesial and/or distal surfaces, respectively. Mesial proximal cervical margins were subgingival in 5.7% of the cases, while distal proximal cervical margins were located subgingival 20% of the time (Table 2). Teeth with cavities greater than 2 mm in diameter in the bucco-lingual and mesio-distal directions were restored with onlay preparations, following consent of the patients. A pilot study was performed to choose the right laboratory technique. The technician performed both techniques—staining and layering on the four prepared onlay preparations of extracted human teeth. For Empress, staining is the normal method used by the laboratory. However, layering requires the application of ceramic powder over the core made by the technician. The outcome of the four restorations was that the layering technique resulted in more esthetic discoloration than did the staining method. Therefore, the layering technique was used in the current study by both clinicians and the technician.

The preparations were performed with no bevel at the margins, using 80 µm diamond burs (Komet inlay preparation set, Komet, Germany), and they were finished with 25 µm finishing diamonds. The minimum depth was 1.5 mm, with the occluso-axial angles being rounded. For vital teeth, dentin close to the pulp was covered with calcium hydroxide (Life, Kerr Italia Spa, Salerno, Italy) and glass-ionomer cement (Ionoseal, VoCo, Cuxhaven, Germany), which was then light cured. Full-arch impressions were taken using a

polyvinyl-siloxane material (Permagum High Viscosity, ESPE, Seefeld, Germany), with a low-viscosity material (Permagum Garant, ESPE)

used to record the preparation details. Provisional restorations were placed with a eugenol-free temporary cement (Clip, VoCo). The same dental ceramist performed all restorations in the laboratory at Marmara University Faculty of Dentistry. The layering technique was

used for all inlays, as their occlusal distance of more than 1.2 mm allowed for this difficult application.

The operating field was isolated with a rubber dam, and the prepared teeth were cleaned using a rubber cup and pumice slurry. The adhesive surfaces of the restorations were treated with 5% hydrofluoric acid (IPS Empress Ceramic Etch, Ivoclar Vivadent, Schaan, Liechtenstein) for 90 seconds, rinsed with water and coated with a silane coupling agent (Bifix, VoCo). All of the enamel and dentin surfaces of the cavities, except the areas with base, were conditioned (etch and rinse) with 37% phosphoric acid gel (VoCo) for 20 seconds, then washed with water and dried with oil-free compressed air. Following etching, a dentin bonding system was used (Solobond Plus Primer and Adhesive, VoCo). The restorations were inserted using a dual-cured luting composite (Bifix QM, Universal, VoCo) according to the manufacturer’s recommendation, using moderate pressure. Major excess cement was removed by an explorer and dental floss before total curing occurred. The restorations were cured with a halogen light-cured system (Chromalux 75, Mega-Physics Dental, Germany) for 40 seconds at each margin. Following polymerization, the inlays and onlays were checked and finished with 40 µm and 15 µm diamond burs, polishing discs and strips (Sof-Lex, 3M Dental Products, St Paul, MN, USA).

The restorations were independently evaluated with a mirror and probe by two experienced dentists at baseline (after one week following insertion) six-months, one year-and two-year intervals. The restorations were evaluated using the USPHS criteria defined by Anusavice<sup>28</sup> and Randall and others<sup>29</sup> (Table 3). Photographic records of each case were obtained at all evaluations, allowing further judging of the scores at other times. Whenever there was a disagreement, it

Table 3: *The USPHS Criteria by Anusavice<sup>28</sup> and Randall and Others<sup>29</sup>*

Criterion	Methods of Evaluation	Rating
Anatomic Form	Visual and probe	Alpha, Bravo, Charlie
Marginal Adaptation	Visual and probe	Alpha, Bravo, Charlie, Delta
Color Match	Visual	Alpha, Bravo, Charlie
Marginal Discoloration	Visual	Alpha, Bravo, Charlie
Caries	Visual, probe, QLF	Alpha, Bravo, Charlie
Surface Texture	Visual and probe	Alpha, Bravo, Charlie
Anatomic Form at the Marginal Step	Visual and probe	Alpha, Bravo, Charlie
Integrity of the Tooth	Visual and probe	Alpha, Bravo, Charlie
Integrity of the Restoration	Visual and probe	Alpha, Bravo, Charlie
Approximal Contact Relationships	Visual and probe	Alpha, Bravo, Charlie
Occlusion	Visual (articulating paper)	Alpha, Bravo, Charlie

Table 4: *Frequency of Scores Judged by Patients at 24-month Recall*

Color	Patient Satisfaction (%)	
	Very good	88.6
Good	11.4	
Satisfactory	-	
Not satisfactory	-	
Surface Texture	Very good	100
	Good	-
	Satisfactory	-
	Not satisfactory	-
Chewing Ability	Very good	82.9
	Good	17.1
	Satisfactory	-
	Not satisfactory	-

was resolved by consensus. Post-operative sensitivity was determined by direct questioning. Bitewing radiographs were taken regularly and color slides were made of selected cases. Periodontal variables, such as plaque and gingival index, were also recorded.<sup>30-31</sup> The patients were instructed on their oral hygiene. Questionnaires were answered by the patients regarding their satisfaction with color match, surface texture, chewing ability, sensitivity and pain during chewing. All the patients were able to participate at each recall.

The USPHS variables evaluated included anatomic form, marginal adaptation, color match, marginal discoloration, caries and plaque accumulation, surface texture, anatomic form at the marginal step, integrity of the tooth and restoration, proximal contact and occlusal contact relationship.

SPSS software (Version 11. SPSS Inc, Chicago, IL, USA) was used to perform the statistical analysis. The baseline scores and recalls were assessed by the Wilcoxon signed rank test. The significance level was set at  $p=0.05$ .

## RESULTS

The patients' opinions about the onlays were positive. No changes were recorded with respect to anamnestic data and symptoms from the TMJ or masticatory muscles as compared with the initial examination. Patient complaints about sensitivity at baseline were 5.7% and were reduced to 2.9% at the six-month recall, with no sensitivity recorded at the 24-month recall. The results of patient satisfaction were 88.6% or "very good" and 11.4% or "good" for color match; 100% or "very good" for surface texture; 82.9% or "very good" and 17.1% or "good" for chewing ability at 24 months (Table 4).

There was no record of plaque accumulation that was clinically detected; nor was there any recurrent caries diagnosed during the 24-month observation period for all surfaces.

Two marginal discolorations, one debonded inlay and one acceptable marginal fracture on the occlusal surface of ceramic

restorations were recorded as failures in this study at six months. Marginal discoloration was detected on the occlusal surfaces of five ceramic restorations at 12 and 24 months. The baseline score for marginal discoloration increased from 2.86% to 14.29% at the Bravo level during the 12- and 24-month recalls, which was the only statistically significant result for the whole study ( $p=0.046$ ). Additionally, color match changed from 17.15% to 28.6% at 24 months ( $p=0.046$ ).

Debonding occurred at the six-month recall. The debonded restoration was rebonded at the same appointment and that restoration remained bonded at the 24-month recall.

One case presented some fracture on the occlusal surface of an onlay. The fracture was so minimal that a slight polishing was sufficient to regain a smooth, acceptable appearance.

Although the color match of ceramic restorations reduced to a 74.28% Alpha score at the 12-month recall, it was not a significant change ( $p=0.083$ ). However, the reduction to 71.4% Alpha score at the 24-month recall was significant ( $p=0.046$ ).

**Table 5: Frequency Distribution of the Scores for the Evaluated USPHS Criteria of Restorations**

	Ceramic Inlay/Onlay (n=35)								Wilcoxon Signed Rank Test P				
	Baseline		6 Month Follow-up		12 Month Follow-up		24 Month Follow-up		Baseline 6 Months	Baseline 12 Months	6-12 Months	Baseline 24 Months	12-24 Months
	Alpha	Bravo	Alpha	Bravo	Alpha	Bravo	Alpha	Bravo					
Anatomic Form	100	-	97.14	2.86	94.28	5.72	94.28	5.72	0.317	0.157	0.317	0.157	1.000
Marginal Adaptation	97.14	2.86	91.42	8.58	91.42	8.58	88.58	11.42	0.157	0.157	1.000	0.083	0.317
Color Match	82.85	17.15	77.14	22.86	74.28	25.72	71.4	28.6	0.157	0.083	0.317	0.046	0.317
Marginal Discoloration	97.14	2.86	94.28	5.72	85.71	14.29	85.71	14.29	0.317	0.046	0.083	0.046	1.000
Caries	100	-	100	-	100	-	100	-	1.000	1.000	1.000	1.000	1.000
Surface Texture	97.14	2.86	97.14	2.86	94.28	5.72	94.28	5.72	1.000	0.317	0.317	0.317	0.317
Anatomic Form at the Marginal Step	94.28	5.72	94.28	5.72	94.28	5.72	94.28	5.72	1.000	1.000	1.000	1.000	1.000
Integrity of the Tooth	100	-	100	-	100	-	100	-	1.000	1.000	1.000	1.000	1.000
Integrity of the Restoration	100	-	100	-	100	-	100	-	1.000	1.000	1.000	1.000	1.000
Approximal Contact Relationships	97.14	2.86	97.14	2.86	97.14	2.86	97.14	2.86	1.000	1.000	1.000	1.000	1.000
Occlusal Contact	100	-	100	-	100	-	100	-	1.000	1.000	1.000	1.000	1.000

(Significant level, p=0.05).

There was no macroscopic wear of the restorative material and/or antagonist teeth, nor were there any changes on the proximal contact relations during the 24-month evaluation.

Regarding evaluation of the proximal contacts of the 35 ceramics, an Alpha score of 97.14% was detected, which was similar to the baseline score. No changes were seen on the occlusal contact at the 24-month recall for all restorations (p=1.00) (Table 5).

The score for the anatomic form was recorded Alpha for 94.28% of the ceramic restorations at the 24-month recall, while the marginal adaptation was 88.58% Alpha. However, these scores were not statistically significant (p=0.157, p=0.083).

The surface texture was recorded as Alpha in 94.28% of the specimens at the 24-month recall (p=0.317).

**Patient 1**

A 21 year-old female patient had a fracture on the maxillary right first molar with old endodontic treatment and an extensive composite restoration applied in the clinic. There was only one cusp left on the crown—the mesio-palatinal cusp. Following retreatment of the canals, the tooth was prepared for a ceramic onlay restoration without any need for gingival surgery (Figure 1).

An onlay cavity design was prepared as conservatively as possible. Full-arch impressions were obtained with a polyvinyl-siloxane material, using a low-viscosity material in syringes to record the preparation details. The ceramic onlay restoration was prepared under laboratory conditions. The restoration was con-



Figure 1. Cavity prepared upper molar of patient 1.

trolled using the low-viscosity impression. Where the impression material was found to be a thin layer, it was trimmed to obtain sufficient thickness for the cement. The operation-field was isolated with a rubber dam. All enamel surfaces of the cavity were conditioned with 37% phosphoric acid gel for 20 seconds and the dentin surfaces were then conditioned with the same concentration for 10 seconds. Following the etch conditioning, the cavity was washed with water and dried with oil-free compressed air. The primer and dentin bonding agents were applied on the tooth surfaces. The inner surfaces of the ceramic restorations were treated with 5% HF for 90 seconds, and the restoration was rinsed, dried and coated with a silane coupling agent. The



Figure 2. Restoration was placed using a dual-cured luting composite cement and inserted with moderate pressure; major excess cement was removed with an explorer and dental floss before curing.



Figure 3. The restoration was evaluated at one week.



Figure 4. After two years, the restoration was observed.

onlay ceramic restoration was luted with a dual-cured composite cement (Figure 2). Excess cement was removed with an explorer and dental floss before curing. The restoration was evaluated at one week (Figure 3) and two-year recalls (Figures 4).

### Patient 2

A 30 year-old male patient presented with caries on the mandibular right first and second molars. Following removal of the carious lesions, the teeth were still vital (Figure 5). These extensive cavities were restored with IPS Empress II ceramic onlays and the two-year results are shown in Figure 6.

### Patient 3

A 37 year-old male patient with a broken mesio-lingual part of the maxillary right first molar, which extended gingivally, was treated endodontically. A crown-length-



Figure 5. Patient 2—preoperative view of mandibular right first and second molars.

ening operation was performed. Figure 7 illustrates the tooth one week after the operation. Figure 8 demonstrates a palatal view of the onlay at the one-week recall. Figure 9 illustrates the restoration at the two-year recall.

## DISCUSSION

The current study investigated the two-year clinical performance of adhesively-luted IPS Empress II ceramic inlays and onlays. It was the intention of the current study to include the endicated cavities, even with proximal boxes extending below the CEJ. The integrity of the tooth might be important for endodontically-treated teeth, since a treated tooth might become dry and weak when compared to vital teeth. It was the intention of the current study to determine the integrity of the treated teeth. Anatomic form, marginal adaptation,



Figure 6. After two years, the restoration was observed.



Figure 7. Following crown lengthening operation, the cavity preparation was demonstrated.



Figure 8. Palatal view of ceramic onlay at one week following cementation.



Figure 9. Occlusal view of ceramic onlay at two-year recall (second premolar with old crown removed).

marginal discoloration, surface texture, anatomic form at the marginal step, approximal contact relationships, occlusion and integrity of the restoration are not well indicated for teeth prior to endodontic treatment, nor is the clinical longevity of ceramic onlays. It was also the intention of the current study to confirm the relationship between the criteria and the strength of endodontically-treated teeth.

Wassell and others<sup>32</sup> reported a 3% fracture rate of direct composite inlay restorations at five years. van Dijken<sup>33</sup> studied 134 direct and indirect composite restorations and determined occlusal wear, fracture and secondary caries, all of which were similar to Wassell's findings. Fractures in ceramic restorations seem to occur during the first six or eight months. Haas and others<sup>34</sup> demonstrated fractures in six inlays at eight months in their study, with another 10 failures of ceramic and composite inlays due to secondary caries.

In the current study, a negligible amount of fractures at the occlusal surface occurred. In fact, only one ceramic fractured at the six-month evaluation. The fracture of ceramic inlays depends on a number of factors, of which the ceramic system is one of significant interest.<sup>35</sup> Molin and Karlsson<sup>36</sup> reported five initial fractures of their 60 ceramic restorations. Four of the five fractures were Empress inlays, and they mentioned that this result was not in agreement with other studies. Molin and Karlsson concluded that either the dual-cured resin cement showed a systematic failure during the manufacturing process or that post handling was responsible for the fractures. In the current study, there was no major fracture or loss of IPS Empress II restorations. Only one case showed a small fracture, which was clinically acceptable after polishing. Contrary to what Wassell and others, van Dijken,

Haas and others and Molin and Karlsson reported, the current study did not have any fracture except the above mentioned negligible one. This success might be the result of short recalls, one and two years, as compared with five-year recalls in other studies.

On the other hand, the strength of IPS Empress II might be the reason for these improved results. IPS Empress is a leucite-reinforced ceramic material that is primarily a glass with crystalline leucite that can strengthen the ceramic without significantly diminishing its translucency.<sup>37-38</sup> The IPS-Empress II system was purposely developed to increase the strength of the previous ceramics against occlusal stress.

Although two techniques, staining and layering, could be used for producing inlays and onlays as the laboratory process for ceramic restorations, the layering technique was used in the current study. Thus, the color match of the restoration with dental tissue was found to be far better at the one-year recall ( $p=0.317$ ) (Table 5). Additionally, the technician declared the core used in the staining technique was not similar in content and quantity to that used in the layering technique. The ingredients of the cores used in both techniques are exclusively held by the manufacturers. The fact that the core used with the layering technique was found to be stronger against occlusal pressures was one of the reasons that the current authors chose this technique. However, the difference found at two years might also be due to discoloration of the luting cement ( $p=0.046$ ). Although only five restorations showed marginal discoloration, this result appeared to be a big number, since there were only 35 restorations (Table 5). Color match was not as satisfactory, even at the start of the current study, with a 17.15% baseline Bravo score corresponding to six cases. At the 24-month recall, this number increased to 10 cases, with a significance of  $p=0.046$ . The loss of translucency over time might be the result of endodontic treatment. However, the layering technique used at the lab might be the cause of discoloration at the outer layer of the ceramics at 24 months, thus presenting a contrast with tooth tissue. Personal care of those patients may not be constant, causing plaque accumulation and leading to a color change in the outer layer of the ceramics.

Marginal integrity was one of the most important criteria, since the adhesive inlays were inserted into the cavities with resin cements. The gap for the luting cement is susceptible to increased wear, as the mechanical properties of the resin cement are inferior when compared with the highly wear-resistant ceramic and post-cured composite inlays.<sup>39</sup> van Dijken and others<sup>40</sup> reported the greatest marginal breakdown occurred proximally when replicas of composite inlays were evaluated by scanning electron microscopy. van Meerbeek and others<sup>41</sup> also demonstrated that composite luted porcelain and composite inlays showed the best mar-

ginal adaptation when compared with luted glass ceramic inlays. Those authors explained that the glass ceramic subsurface structure at the inlay-lute interface was weakened by etching with ammonium bifluoride.

It has been reported that the chance of finding a restoration with cavo-marginal discoloration had increased from one-in-six to one-in-three. Similarly, marginal adaptation had deteriorated, so that the chance of finding a restoration with a gap had increased from one-in-20 to one-in-10 among composite inlays.<sup>42</sup> In the current study, only four Bravo (11.42%) criteria for marginal adaptation and five Bravo (14.29%) criteria for marginal discoloration were scored after 24 months. Scheibenbogen and others<sup>39</sup> reported a significant difference in the clinical performance of composite and ceramic inlays after one year, in favor of the latter. This result also revealed for the criteria "anatomic form of the surface," "marginal integrity" and "occlusion." Those authors also reported that color match revealed no significant differences after 12 months between composite and ceramic inlays. In the current study, ceramic restorations showed a high score for anatomic form (94.28%, Alpha) after two years. In addition to good color match, Gerdolle and others<sup>42</sup> reported that, when comparing three resin-based luting agents (Variolink II, Panavia F and Resinomer) to Fuji Plus, Panavia F exhibited the lowest significant overall microleakage followed by Variolink II; whereas, the resinomer demonstrated the greatest significant overall microleakage. van Dijken<sup>43</sup> also mentioned that no significant difference in durability was observed between two chemically-cured luting agents after five years. In the current study, no recurrent caries was observed in any restorations at the one- and two-year recalls. This might be the success of the dual-cured luting agent or two years may be too short a time to determine any microleakage and/or secondary caries.

One study reported eight of the 96 restorations investigated had to be replaced due to failure.<sup>44</sup> Contrary to that, none of the restorations in the current study were replaced for failure after 12 and 24 months. As a result, IPS Empress II ceramic material was found to be successful for inlay/onlay restorations under the conditions of this clinical study.

## CONCLUSIONS

The material chosen for clinical restorations should be esthetic and sufficiently strong to withstand intraoral forces. IPS Empress II was evaluated according to USPHS criteria in the current clinical study. The results were promising for IPS Empress II ceramics to be used as inlay/onlay restorations.

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