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Original article

Evaluating Retention of Onlay *Versus* Complete Coverage Using E.Max-Restoration

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ABSTRACT

This study compared the retention of different types of indirect restorations (only or full coverage) utilized on endodontically treated molars. Fourteen patients requiring restoration of endodontically treated molars were randomly allocated into two groups (n = 7) according to the type of restoration used. lithium disilicate ceramic crowns were given to the control group. While lithium disilicate ceramic onlays were given to the intervention group. The heat pressing technique was used for the fabrication of both restorations. Following the final cementation with adhesive resin cement, the restoration was assessed at three, six, twelve, and twenty-four months using the modified USPHS criteria. Statistical analysis was performed using the chi-square test. Results: At all intervals, there was no statistically significant difference in retention (P>0.05) between the two tested groups. Both groups showed comparable results, with full coverage showing somewhat higher retention after 2 years. Regardless of the type of restoration, the emax-press produced high clinical performance in terms of retention. Compared to full coverage, onlay has proven to be a trustworthy substitute.

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INTRODUCTION

Teeth that have had endodontic treatment frequently exhibit significant coronal mutilation, endangering their structural stability and increasing the likelihood of biomechanical failure compared to healthy teeth [1]. Under such circumstances, the loss of important tooth structure may necessitate the use of full-coverage restorations [2]. As a result, special considerations for the final restoration are frequently necessary to ensure appropriate preservation of the restoration and maximum resistance to tooth fracture [3].

For teeth that have undergone endodontic treatment, complete crown restorations are the most popular restorative technique. Its drawbacks include the necessity of preparing the occlusal surface and axial walls, which can remove up to 71% of the tooth's structure, and a reduction in the tooth's ability to withstand fractures [4]. Less than 2 mm of tooth wall thickness may remain after preparation, which might not be enough to hold the entire crown. Furthermore, it is likely more difficult to maintain good oral hygiene and stimulate gingival tissue if the edge of a full crown restoration is rough, lacks marginal adaptation, or protrudes near the gingiva. This could result in gingival irritation, periodontitis, caries, debonding, etc [4,5].

Based on the availability of intact tooth structure, ceramic inlays and onlays have been offered as alternative restorations for endodontically treated molars [6]. With shorter chair times and fewer interfaces in the restorative system, which reduce stress concentration, ceramic onlays are becoming more and more popular than conventional crowns. They also have better mechanical qualities and superior aesthetics. In contrast to a typical crown, the preparation design is more conservative. Minimal biological width is involved because the supragingival border shields periodontal tissues from disturbance. There is also improved control over the application and polymerization of resins [7,8].

The traditional techniques for restoring endodontically treated teeth, which relied on mechanical retention, have given way to more modern techniques that rely on adhesion. This is a result of current adhesive techniques and the development of composite resins with improved physical qualities. The prognosis of posterior teeth treated with endodontic therapy—whose tooth structure has already been lost—is influenced by the type of coronal restoration. Therefore, the material and restorative technique should be chosen so as to maintain the native tooth substance while also increasing the tooth's clinical survival rate [9].

Lithium disilicate ceramic material is the gold standard for glass ceramic restorations due to its outstanding properties. In conjunction with the adhesive capacity of resinous cements, their high mechanical strength and high fracture toughness (2-4 MPa), low thermal expansion, high thermal resistance, and acid etchability enable the restoration of endodontically treated teeth without the use of cores or intraradicular posts [10].

It was stated that the most frequent reason for a fixed prosthesis to fail was loss of retention, which was followed by periodontal disease and cavities. Of the crowns and FPDs surveyed, 44.82% had looseness, poor retention, or repeated dislodgement [11,12]. When a tooth has cusp defects, more than two residual axis walls, and 45% less tooth structure than needed for a full crown, an onlay is one kind of minimally invasive restoration that can be used. Retention force was increased by using box- or dovetail-shaped retention [13].

Onlay retention is accomplished mainly by bonding, which preserves more residual tooth tissue in comparison to whole crowns. However, particularly in wet environments, lateral force exerted on the nonfunctional cusp of an onlay partially covering an occlusal surface may result in the onlay debonding [14]. The stress distribution was superior for onlays covering the whole occlusal surface compared to those that only partially covered the subsurface. Three-dimensional (3D) finite element analysis showed onlays that completely covered the occlusal surface had a better stress distribution than those that just partially covered the surface [15]. Furthermore, the onlay margin is situated in the occlusal 1/3 of the tooth, away from the marginal gingiva. This prevents stimulation, promotes self-cleaning, and enhances the condition of the periodontal tissues [16]. The purpose of this clinical study was to identify and compare the retention of emax crowns and onlays used to restore endodontically treated molar teeth. The study's null hypothesis stated that there would be no discernible retention difference between IPS e.max press crowns and onlays.

METHODS

Participant's selection

For this study, a total of 14 patients—5 men and 9 women—with ages ranging from 20 to 60 years old were chosen. Their main complaint was that they couldn't eat on the tooth that was damaged. Prior to the commencement of the trial, every patient had a thorough understanding of the entire treatment strategy. They were inspired to maintain a rigorous and appropriate oral hygiene regimen. Before any clinical procedures began, each patient signed an informed consent form. All cases were examined between October 2021 and September 2023. The inclusion criteria included no current periodontal or apical diseases, having an RCT molar in the maxilla or mandible with at least 2–3 mm of tooth structure above the cementenamel junction, and normal occlusal relations.

Prosthetic steps

Diagnostic phase

Both intraoral and extraoral examinations were carried out. Every participant had a pre-operative photo shot. Prior to choosing a hue, scaling and polishing were performed for each patient before shade selection. Using a Vita Easy Shade V spectrophotometer (VITA, Zahnfabrik, Germany), the tooth's color was digitally captured. To create diagnostic wax, an alginate impression of the upper and lower arches (CA 37, Cavex, Haarlem, The Netherlands) was used to create diagnostic castings. This allowed for the creation of a silicone putty index (Elite HD+, Zhermack, Italy) for a temporary restoration.

Tooth preparation phase

In order to guarantee maximum structural durability, tooth preparation was done in accordance with the manufacturer's recommendations. In the control group's; full-coverage IPS e.max press crown restoration (n=7). A 45-degree functional cusp bevel was positioned at the functional cusp as part of the occlusal preparation, which followed the occlusal anatomy and attempted to provide 1.5–2 mm clearance. To accomplish 1.5 mm of axial reduction with a 1 mm thick supragingival deep chamfer finish line, axial preparation was first carried out by freeing the contact with a fine tapered stone (Komet, Germany). This was followed by a round, tapered diamond stone [17,18].

Using finishing stone, all sharp edges and point angles were rounded to complete the preparation and remove any potential stress concentration inside the planned restoration. All preparations were accomplished by a single operator to ensure standardization. A silicon index was used to check the amount of occlusal and axial reduction.

When it came to the preparation of the intervention group's teeth; IPS e.max press onlays (n=7), conventional guidelines were followed, resulting in an occlusal reduction of 1.5–2 mm, a broad isthmus, rounded occlusal-axial angles, and a 1.5 mm thick axial wall. When it was feasible, the gingival margins were prepared entirely in enamel at the cemento-enamel junction. All onlays had rounded internal angles and a divergence between the walls and margins of 6 to 15° with a 90° cavosurface [19] (Figure1).

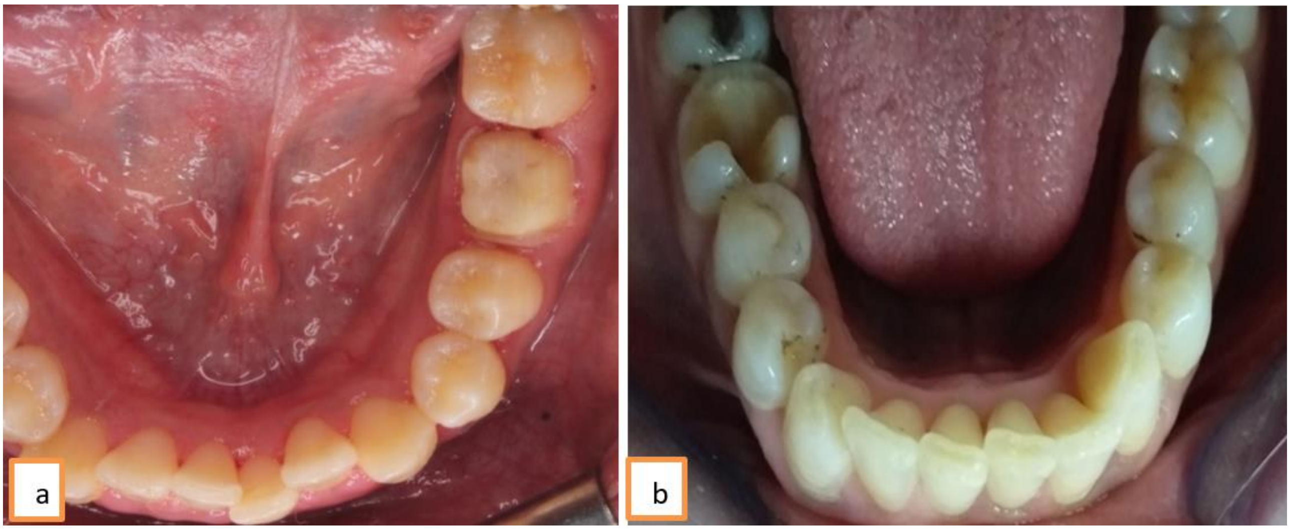

Figure 1. Representative preparation photos of each investigated group a. A case of crown group b. A case of onlay group.

Impression-making phase

Vinyl polysiloxane elastomeric impressions (Elite HD+, Zhermack, Italy) were made using the two-step (putty-wash) impression technique.

Previsualization

Provisional restoration was constructed using the direct technique by injecting CharmTemp material (DENTKIST, Inc., Korea) into the tissue surface of the putty index, then seating it on the prepared tooth, lubricating it and the adjacent gingival margin with petroleum jelly, with up-and-down movement, before removing the index until it set. After finishing and polishing the provisional restorations, they were cemented with non-eugenol provisional cement (RelyX Temp NE, 3MESPE, USA) [20].

Master cast construction

The final impression was poured using Type IV dental stone (GC FUJLROCK EP, GC, America).

Try in phase

Using CAI/CAD/CAM technology, a PMMA crown and onlay were created using extra-oral scanning (a smart optics scanner) and EXOCAD software (ExoCad software 2016, ExoCad GmbH, Germany). A five-axis milling machine (Ronald MC) (Roland DGA Corporation, California) was utilized to mill the restorations.

Laboratory construction procedures

IPS e.max press Ingots LT (Ivoclar Vivadent, Zürich, Switzerland) and a pressing technique were used for all restorations. The same process that was previously employed for the production of PMMA restorations was utilized to design the wax pattern (Adite wax blank, China), which has a typical die spacing of 50 µm. Using an IPS Press VEST premium (Ivoclar vivadent, Liechtenstein), the manufacturer's instructions were followed for sprueing and investing the milling wax crown or onlay. Following the removal of the wax, the investment ring was placed in the center of the fire platform of the heat-pressing furnace (Programat EP 3010, Ivoclar Vivadent AG, Schaan/Liechtenstein). The e.max press ingot of the proper size and color was selected and inserted into the pressing hole. Following the end of the press cycle, after being taken off, the investment ring was placed on a cooling grid and allowed to cool for about an hour. After that, the aluminum oxide 110 µm-equipped sandblaster was used to carry out the diving process in accordance with the manufacturer's instructions. At 1.5 bars of pressure for fine divestments and 2.5 bars for rough divestments, respectively. The restorations were glazed using IPS e.max fluorescent glazing paste (Ivoclar ivadent, Zürich, Switzerland) after all modifications had been made, and lithium disilicate stains (IPS E-max ceram shades, Ivoclar Vivadent, Zürich, Switzerland) were added as needed.

Cementation of the restorations: For isolation, a rubber dam was placed on the tooth. After 20 seconds of etching with 9.5% hydrofluoric acid gel (Porcelain Etch, BISCO, USA), the fitting surface of the pressed restoration was dried for 30 seconds in moisture-free air and rinsed under running water, providing a chalky white appearance**.** A silane coupling agent (Porcelain Primer, BISCO, USA) was then used to condition the etched surface, and it was left to dry for 60 seconds [17, 21]. Subsequently, dual-cure BisCem resin cement was used to cement the repairs (Figure 2).

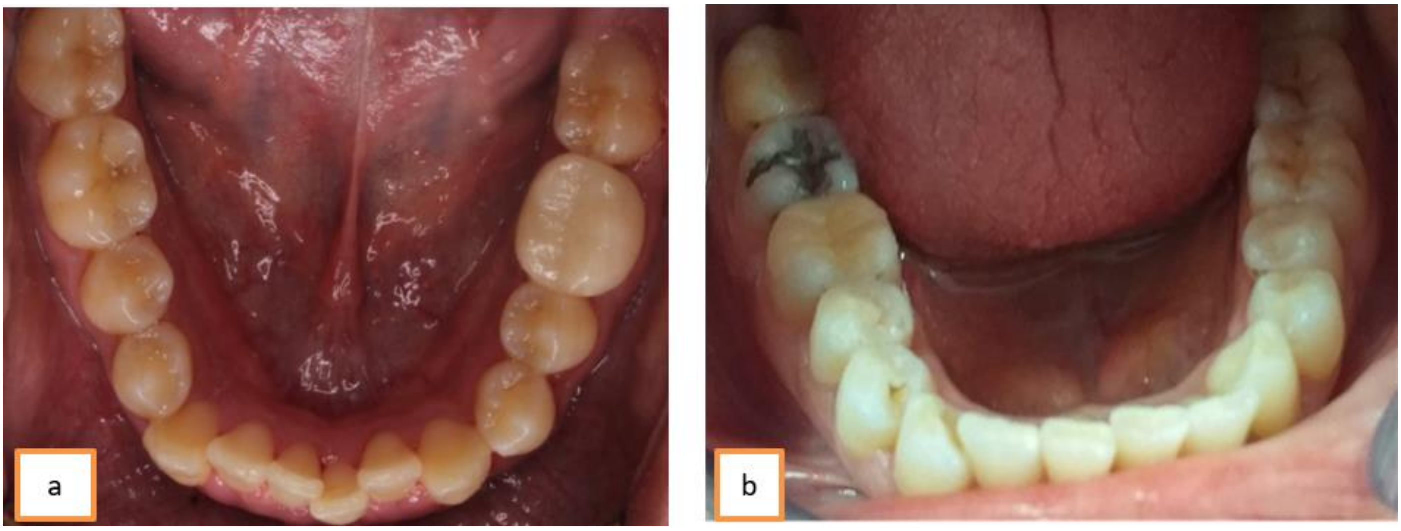

Figure 2. Representative post-operative photos of each investigated group after cementation. a. A case of crown group. B). A case of onlay group.

Postoperative instruction and care

The patients were encouraged to use a soft brush and non-abrasive fluoride tooth paste for daily brushing and flossing.

Follow up protocol

All patients underwent recall exams at 3, 6, 12, and 24 months. All onlays and crowns were evaluated throughout the examination using modified United States Public Health Service (USPHS) criteria [22, 23] (Table 1).

Table 1. The outcome tested in the present study.

Outcome name	Measuring device	Rating	Criteria
Retention	(USPHS) criteria	**Alpha (A)**	Restorations that were present and fully retained.
		Bravo (B)	Restorations that were partially retained with some portion of the restoration still intact
		Charlie (C)	Restorations that were completely missing

Statistical analysis

All quantitative data were presented as mean and standard deviation, while qualitative data were presented as frequency and percentages. The data was presented with 2 tables and 1 graph. A comparison between control and intervention groups retention was performed using the Chi square test. Statistical analysis was performed with SPSS 26® (Statistical Package for Scientific Studies), GraphPad Prism, and Microsoft Excel.

RESULTS

Demographic data

Demographic data for the control and intervention groups were presented in Table 2. In terms of age, there was an insignificant difference between the control group (31.86 ± 8.71) and the intervention group (39 ± 9.33) (P = 0.156). In terms of gender, there was an insignificant difference between the control group (42.9%, 57.1%) and the intervention group (28.6%, 71.4%) regarding males and females, respectively.

Table 2. Demographic data (age, gender) of control and intervention groups

Demographic data		Control group (e-max crowns)	Intervention group (e-max onlays)	P value
Age	M±SD	31.86 ± 8.71	39 ± 9.33	0.16
Gender	Male N (%)	3 (42.9)	2(28.6)	0.31
	Female n (%)	4 (57.1)	5(71.4)	

M: Mean, SD: Standard Deviation, N: Frequency, %: Percentages

Retention

The retention of control and intervention groups at different follow-up visits is presented in Table 3. At the first follow-up after 3 months, both groups revealed no loss of retention (100%). At the second follow-up after 6 months, there was an insignificant difference (P = 0.29) between both groups, as no cases demonstrated loss of retention in the control group (0%), while only 14.3 percent demonstrated loss of retention in the intervention group. At the 3rd follow-up after 1 year, there was an insignificant difference (P = 1) between both groups, as only 14.3% demonstrated loss of retention in the control and intervention groups. At the 4th follow-up after 2 years, there was an insignificant difference (P = 0.51) between both groups, as only 14.3 percent demonstrated loss of retention in the control group and 28.6% demonstrated loss of retention in the intervention group.

Table 3. Retention of control and intervention groups at different follow up visits and comparison between them using the Chi square test

Variables		Retention				Chi square test	
		Control group (e-max crowns)		Intervention group (e-max onlays)		P value	Chi-square
		N	%	N	%		
1st follow up after 3 m	No loss of retention	7	100.0%	7	100.0%	----	-----
	Loss of retention	0	0.0%	0	0.0%		
2nd follow up after 6 m	No loss of retention	7	100.0%	6	85.7%	0.29	1.07
	Loss of retention	0	0.0%	1	14.3%		
3rd follow up after 1 year	No loss of retention	6	85.7%	6	85.7%	1	0
	Loss of retention	1	14.3%	1	14.3%		
4th follow up after 2 years	No loss of retention	6	85.7%	5	71.4%	0.51	0.42
	Loss of retention	1	14.3%	2	28.6%		

N: Frequency, %: Percentages.

DISCUSSION

Based on the data from this study, the proposed hypothesis was accepted. The purpose of this study was to evaluate the clinical outcome of e-max onlays and full-coverage crowns of molars fabricated by the heat pressing technique after 2 years of clinical service. One specific aim of the study was to measure retention using a self-adhesive dual-cure resin cement.

Current techniques based on adhesion represent a paradigm shift from traditional methods of endodontically treated tooth restoration based on mechanical retention [24]. Recent adhesive techniques and the development of composite resins with improved physical qualities are to blame for this. Adhesive restorations preserve the natural tooth structure and are a better option for restoring endodontically treated teeth. Several studies have shown that mechanically retained restorations are dependable options for the restoration of root canal-treated teeth. But they compromise with the biological aspect, whereas adhesive restorations conserve the natural tooth structure and serve as a better alternative for restoring endodontically treated teeth [25, 26].

For teeth that have had root canal therapy, partial coverage restorations such as onlays provide an option to full coverage crowns in terms of strengthening the tooth structure. Compared to full-coverage crowns, onlays have the advantage of conserving the remaining tooth structure and offering cuspal coverage [27].

In this investigation, an e.max press was selected for fabricating onlay and crowns using a heat pressing system. The Emax press is a glass ceramic that can be etched and silanated for adhesive bonding using resin cements. By etching the ceramic bonding surface with hydrofluoric (HF) acid to increase microretention and then using a silane coupling agent for chemical bonding, strong and long-lasting resin bindings can be formed [28]. Furthermore, a lithium disilicate-based glass has improved mechanical qualities in addition to desirable translucency and shade diversity, which meet the patient's practical and aesthetic needs [29].

All ceramic full coverage preparation criteria were followed in all teeth in the control group, employing the guidelines of the manufacturer including 1.5mm axial reduction, 1.5-2mm occlusal reduction and a 1mm circumferential deep chamfer finish line. This allowed adequate thickness of the restoration and hence enhanced their durability and resistance to forces [30]**.** The deep chamfer F.L. was selected rather than the shoulder finish line as it provided rounded internal line angles, reducing stress concentrations [31]. The pressing technique was employed in fabricating the final restorations, as it allowed the materials to be pressed under controlled temperature, pressure, and vacuum, creating perfect replication of fine details, particularly at the margins [32]**.** Combining pressing technology and CAD/CAM design of the wax pattern provided restorations with more accurate marginal and internal adaptation and higher mechanical properties than those of conventional pressing techniques [32,33]**.**

Adhesive resin cement was chosen for the final cementation of all restorations (crowns and onlays) in both groups to make use of their ability to minimize marginal discrepancies and enhance restoration retention. In addition, they were able to absorb stresses during load application, which enhanced the restoration’s fracture resistance [34, 35]**.**

Retention was evaluated, as debonding or loss of retention of restoration was claimed to cause 69.5% of its failure**.** So, the prognosis of fixed restoration is directly related to its retention [36 - 38]**.**

The study's findings demonstrated that there was no discernible difference in retention between the two groups at any point in time, with just one restoration from each group exhibiting loss of retention (debonding) after 1 year. Debonded restorations rebonded without the need for new replacements, and it was discovered that they were undamaged with no visible fractures in either the restoration or the tooth structure. In addition to employing sticky resin cement, standardizing preparations with a minimum occlusal divergence (in the intervention group) and minimum convergence (in the control group) may also have contributed to high retention [39,40]. The preservation of tested restorations may have been enhanced by the restorative fabrication technique used. These findings are consistent with another study that found two onlays to have debonded in the first year, resulting in a success rate of 95.0%. The authors noted that in all cases of debonded restorations, cement was still present on the tooth preparation, which may indicate that the link between the partial crowns made of nanoceramic material was weaker [41].

After two years, there was no discernible difference in the retention of the crown and onlay; two onlays showed signs of debonding, but only one crown showed debonding. This is in agreement with Huettig et al. [42], where only three heat-pressed lithium disilicate crowns have lost retention. Once more, only one monolithic lithium disilicate molar crown showed a loss of retention after 2 years that could be reinserted in the Rauch et al., study [22]. The use of self-etch adhesives, which include acid monomers that etch the substrate and simultaneously fill the pores created, may be responsible for the good retention. They claimed that these agents not only have the benefit of requiring fewer clinical steps, which shortens working times and expedites the cementation of indirect restorations, but they also do away with the requirement for the presence of unprotected dentinal collagen because they simultaneously etch and impregnate the substrate [43].

Our results came in agreement with a study held by El Sayed et al., [18], which proved that pressable processing techniques showed better vertical marginal gap distance than CAD/CAM techniques for both monolithic lithium disilicate and zirconia-reinforced lithium silicate restorations. Similar results were reported in the Azar et al., study [44], which confirmed that the milled restorations had inferior marginal fit compared to the pressed ones.

Our study results also disagree with those of Attia et al., [45], where they found that monolithic zirconia-reinforced lithium silicate and lithium disilicate crowns processed using the CAD-CAM technique showed significantly better marginal fit than the pressable one. Although the marginal and internal fit of both restoration types were within clinically acceptable ranges.

Regarding retention, the results also failed to reject the null hypothesis, as both groups revealed an absolute insignificant difference at all intervals; only two restorations of each group lost retention. This might be attributed to the presence of a glassy phase in the structure of the IPS e.max press, which permits the restorations to be efficiently etched and adhesively bonded to the tooth structure, enhancing restoration retention [46, 47]. Furthermore, the large molar surface area available for restoration bonding promotes effective adhesion and allows adequate dissipation of the occlusal forces over the entire intaglio restoration surface, tooth, and supporting structure. Also, obtaining restorations with adequate marginal and internal fit guaranteed their retention [48,49].

These results coincided with those of Halawani et al., [50], who proved that any variations in the marginal adaptation could lead to more concentrated stresses, minimize the restoration strength, and consequently cause its debonding and fracture. Also, this came in agreement with Abou El-Enein et al., [35], who concluded that large and inhomogeneous internal gaps may negatively affect the retention and resistance of the restoration. where their study results revealed a correlation between failure types, as the restoration debonding that occurred might be due to marginal percolation. As such, failure was always preceded by loss of marginal integrity.

Modified USPHS criteria were used for evaluating the clinical performance of both groups regarding retention outcomes, as they enabled multiple parameter assessment and provided reliable information regarding the clinical success of the tested restorations [51,52]. One could argue that this study's shortcoming is its only two-year observation duration, carried on one type of ceramic material (e.max), and relatively small sample size. Patients with bruxism, cavities, or parafunctions were not included in this study, which may have positively impacted the findings.

CONCLUSION

E.max press onlays revealed successful performance similar to e.max press crowns in terms of retention; both crowns and onlays have a very good 2-year retention rate—above 90%. . Compared to full coverage, onlay has proven to be a trustworthy substitute.

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تقييم ثبات التغطية الجزئية مقابل التغطية الكاملة باستخدام تقنية تركيبات الإيماكس

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المستخلص

قارنت هذه الدراســة معدل ثبات أنواع مختلفة من الترميمات غير المباشــرة المســتخدمة في الأضــراس المعالجة لبياً. تم توزيع أربعة عشر مريضـاً يحتاجون إلى ترميم الأضـراس المعالجة لبياً بشـكل عشـوائي إلى مجموعتين (العدد = 7) وفقاً لنوع الترميم المسـتخدم. أعطيت تيجان السـيراميك ديسـيليكات الليثيوم إلى المجموعة الضـابطة. في حين أعطيت صـفائح السـيراميك ديسـيليكات الليثيوم لمجموعة التدخل. تم اسـتخدام تقنية الضـغط الحراري لتصـنيع كلا الترميمين. بعد التثبيت النهائي باستخدام الأسمنت الراتنجي اللاصق، تم تقييم عملية الترميم خلال ثلاثة وستة واثني عشر وأربعة وعشرين شهرًا باستخدام معايير الصـحة العامة في الولايات المتحدة. تم إجراء التحليل الإحصـائي باستخدام اختبار مربع كاي. على جميع الفواصـل الزمنية، لم يكن هناك فروق ذات دلالة إحصـائية في الاحتفاظ ($P < 0.05$) بين المجموعتين الذين تم اختبارهم. أظهرت كلا المجموعتين نتائج مماثلة، حيث أظهرت التغطيـة الكاملة معدل احتفاظ أعلى إلى حد ما بعد عامين. بغض النظر عن نوع الترميم، أنتجت تركيبات الإيماكس أداءً ســريريًا عاليًا من حيث الاحتفاظ. بالمقارنة مع التغطية الكاملة، أثبتت البطانة أنها بديل جدير بالثقة.

الكلمات الدالة. الثبات، التغطية الجزئية، الأضراس المعالجة لبياً، تاج، ايماكس، الضغط الحراري.