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Three-Year Clinical Follow-Up of Posterior Teeth Restored with Leucite-Reinforced IPS Empress Onlays and Partial Veneer Crowns

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Abstract

Purpose: The aim of this study was to analyze the survival rate and failure mode of IPS leucite-reinforced ceramic onlays and partial veneer crowns regarding thickness under the following clinical conditions: vital versus nonvital teeth, tooth location, and type of opposing dentition.
Materials and Methods: Teeth were prepared according to established guidelines for ceramic onlays and partial veneer crowns. Before cementation, the restorations were measured for occlusal thickness at the central fossa, mesial, and distal marginal ridges, and functional and nonfunctional cusps. A total of 210 ceramic restorations were cemented in 99 patients within a mean observation period of 2.9 ± 1.89 years. The mode of failure was classified and evaluated as (1) adhesive, (2) cohesive, (3) combined failure, (4) decementation, (5) tooth sensitivity, and (6) pulpal necrosis. Kaplan, log-rank, and Cox regression tests were used for statistical analysis.
Results: The failure rate was 3.33% (7/210). Increased material thickness produced less probability of failures. Vital teeth were less likely to fail than nonvital teeth. Second molars were five times more susceptible to failure than first molars. Tooth sensitivity postcementation and the type of opposing dentition were not statistically significant in this study.
Conclusions: In this study, thickness of the restorations, tooth vitality, and location of teeth in the dental arch influenced restoration failures.

An onlay restoration covers one or more cusps or the entire occlusal surface of a tooth; some of the axial walls are not prepared. A partial veneer crown covers three or more but not all surfaces of a tooth.[1] One of the purposes of onlays or partial veneer crowns is preservation of the residual tooth structure.[2,3] Edelholf and Sorensen[4] reported that onlay preparations remove 39% of the total dental structure, a partial veneer crown 46.7%, and a complete crown between 72.3% and 75.6%.

Restorations with total occlusal coverage are highly recommended on endodontically treated posterior teeth.[5-7] Three materials are commonly used to fabricate onlay and partial veneer crown restorations: metal alloys, composite resins, and glass ceramics.[8-11] During the last decade, glass-ceramic materials have been considered the material of choice for this type of restoration due to esthetics, coefficient of thermal expansion, hardness, a wear resistance similar to enamel,[12-18,20] and the possibility of adhesive cementation.[21-26]

Another important aspect to take into consideration during the selection of a restorative material is the possibility of an optimal match of occlusal morphology and appropriate marginal adaptation.[27] These features have been achieved for many decades by developing functional wax patterns on articulators and then using the lost-wax technique to cast copings. More recently, vacuum injection molding has been used in conjunction with a leucite-reinforced ceramic material (IPS Empress Ivoclar, Vivadent, Schaan, Liechtenstein).[28] Some studies have been published regarding the performance of posterior ceramic onlays with occlusal coverage.[25,29,30-36] Short- and medium-term clinical observations are promising. Because of ceramic's high modulus of elasticity[37,38] one of the major problems with ceramic restorations is the possibility of fracture, especially in posterior areas where heavy occlusal loads are present.[39] The purpose of this study was to analyze the survival rate and failure mode of IPS leucite-reinforced ceramic onlays and partial veneer crowns

Table 1 Evaluation criteria

Date of failure	Type antagonist tooth	Teeth	Vitality		Type of core dowel/core	Thickness	Type of failure
D/M/Y	1 = Enamel		Yes	No	1 = Glass fiber and resin core	T = thin 1.0 /1.4 mm	1 = Adhesive
	2 = Metal				2 = Metallic prefabricated dowel and resin core	M = medium 1.5/1.9 mm	2 = Cohesive
	3 = Ceramic				3 = Custom gold dowel and core	W = thick > 2.0 mm	3 = Combined
					4 = Zirconium prefabricated dowel injected with ceramic		4 = Decementation
					5 = Resin core without dowel		5 = Sensitivity: (a) <8 weeks (b) >8 weeks
							6 = Pulpar necrosis

relative to thickness under the following clinical conditions: vital versus nonvital teeth, tooth location, and type of opposing dentition.

Materials and methods

Between November 2003 and February 2010, 210 ceramic onlays and partial veneer crowns were cemented in 99 patients (mean age: 42 years) in a private clinic. Permission for conduct of human subject research was obtained from the Colombian Federation of Dentistry. The mean observation period was approximately 3 years. Teeth were prepared according to the established guidelines for ceramic onlays and partial veneer crowns. There were no margins on occlusal surfaces; occlusal clearances were established between 1.5 mm and 2 mm on functional and nonfunctional cusps; gingival margins were prepared supragingivally with heavy chamfer designs. Adequate interocclusal space was verified by means of an interocclusal registration material (EXABITE, GC America Inc., Alsip, IL). The interocclusal record was measured with a neck digital caliper (Digimatic, Mitutoyo USA, Aurora, IL). Full-arch impressions were made in custom trays with poly(vinyl siloxane) impression material (Elite® HD super light fast setting and Elite® HD medium consistency body impression material Zhermack, Badia Polesine Rovigo, Italy). Facebow and wax interocclusal records were made. Interim prostheses were fabricated using PMMA self-curing acrylic resin (Jet Set-4™ Lang Dental Manufacturing Co., Inc., Wheeling, IL), and cemented with a noneugenol provisional cement (TNE-Temrex noneugenol temporary cement, Temrex Corp., Freeport, NY).

The ceramic restorations were produced according to the manufacturer's instructions using the vacuum injection mold technique for leucite-reinforced ceramic material (IPS Empress). Occlusal and proximal contacts were checked with 8 μ and 12 μ thick articulating film (Bausch articulating papers, Bausch, Nashua, NH). Marginal adaptation was assessed using a dental explorer (TU 17/23, Hu-Friedy, Chicago, IL) and dental floss. The color match was verified; the restorations were finished, polished, and glazed.

Before cementation, all restorations were measured for occlusal thickness at the central fossa, mesial, and distal marginal ridges, and at the functional and nonfunctional cusps using a neck digital caliper (Digimatic, Mitutoyo USA). The restorations were classified according to their thickness as thin (1 mm to 1.4 mm), medium (1.5 mm to 1.9 mm), and thick (2 mm or more); the thinnest areas were recorded. Before cementation, the restorations were acid etched for 20 seconds using 5% hydrofluoric acid gel (Ivoclar Vivadent), and ultrasonically cleaned using isopropyl alcohol for 5 minutes. They were then air dried, Monobond-S silane material (Ivoclar Vivadent) applied for 1 minute, and finally one coat of bonding agent (Excite DSC, Ivoclar Vivadent) was applied. Before cementation, tooth preparations were treated as follows: selective enamel etching was used for 20 seconds using 37% phosphoric acid gel (Ivoclar Vivadent), 20 seconds of water irrigation and gentle air drying without desiccation. One coat of bonding agent was applied (Excite DSC), with a waiting time of 20 seconds prior to application of a dual-polymerization resin cement to the restoration (Variolink II, Ivoclar Vivadent). The restorations were seated. Excess resin cement was removed using dental floss and disposable brushes, and then light polymerization was used for 40 seconds from the buccal, lingual, mesial interproximal, distal interproximal, and occlusal surfaces.

Clinical evaluations were performed annually using the USPHS Public Health Service criteria for partial coverage restorations[12] and the evaluation criteria noted in Tables 1 and 2. The mode of failure was classified as: (1) adhesive (clean fracture at the interface between the ceramic material and

Table 2 Data of failed restorations

Tooth	Time of failure (months)	Gender	Vitality	Core foundation	Type of failure
15	6	F	No	5	3
31	24	F	No	5	3
2	26	F	No	5	3
15	34	M	No	5	3
31	38	M	No	5	3
18	56	F	No	5	3
14	76	F	Yes	D*	3

5 = resin core; 3 = combined failure; D* = dentin tissue (vital tooth).

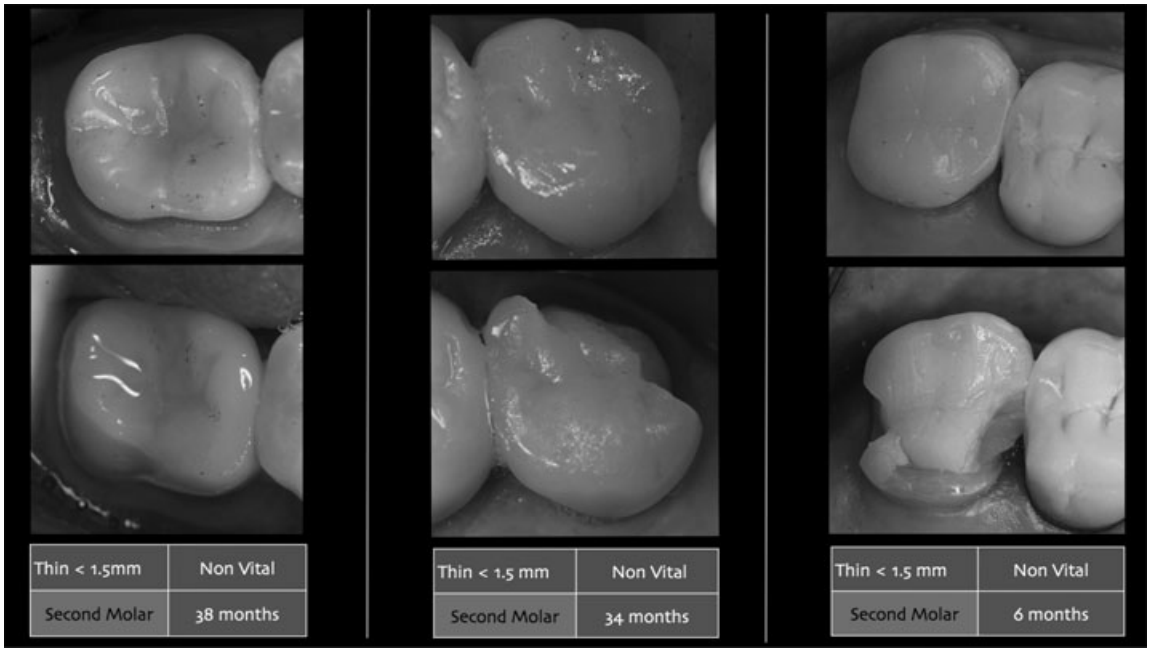
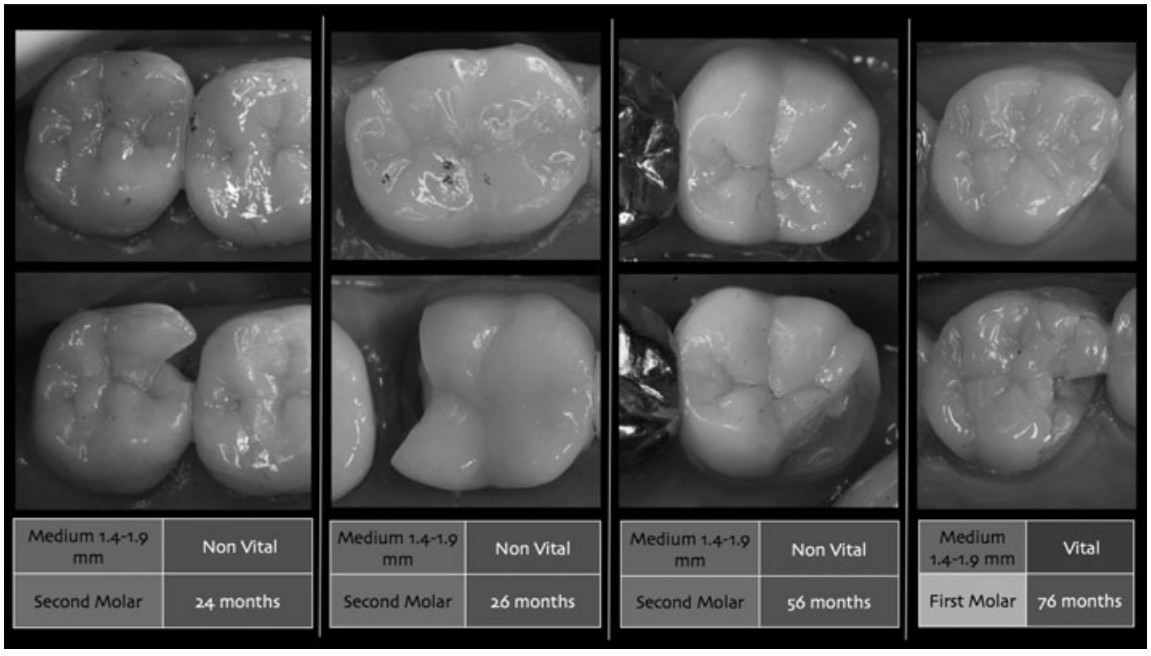


Figure 1 Follow-up photographs. Upper images: day of cementation. Lower images: day of failure report.

tooth); (2) cohesive (fracture within the ceramic material); (3) combined failure (combination of adhesive and cohesive failures); (4) decementation of the restoration without fracture; (5) tooth sensitivity (reported pain postcementation); and (6) pulpal necrosis (not responsive to pulp vitality test using thermal test Endo Frost Spray, Roeko Coltene/Whaledent, Langenau, Germany).

Statistical analysis

Data were collected and analyzed with STATA™ 11 (Stata Corp., College Station, TX). Qualitative variables were expressed as percentages. Failure time was estimated using the Kaplan-Meier method. The log-rank and Cox regression tests were used for comparison; p-values < 0.05 were considered statistically significant.



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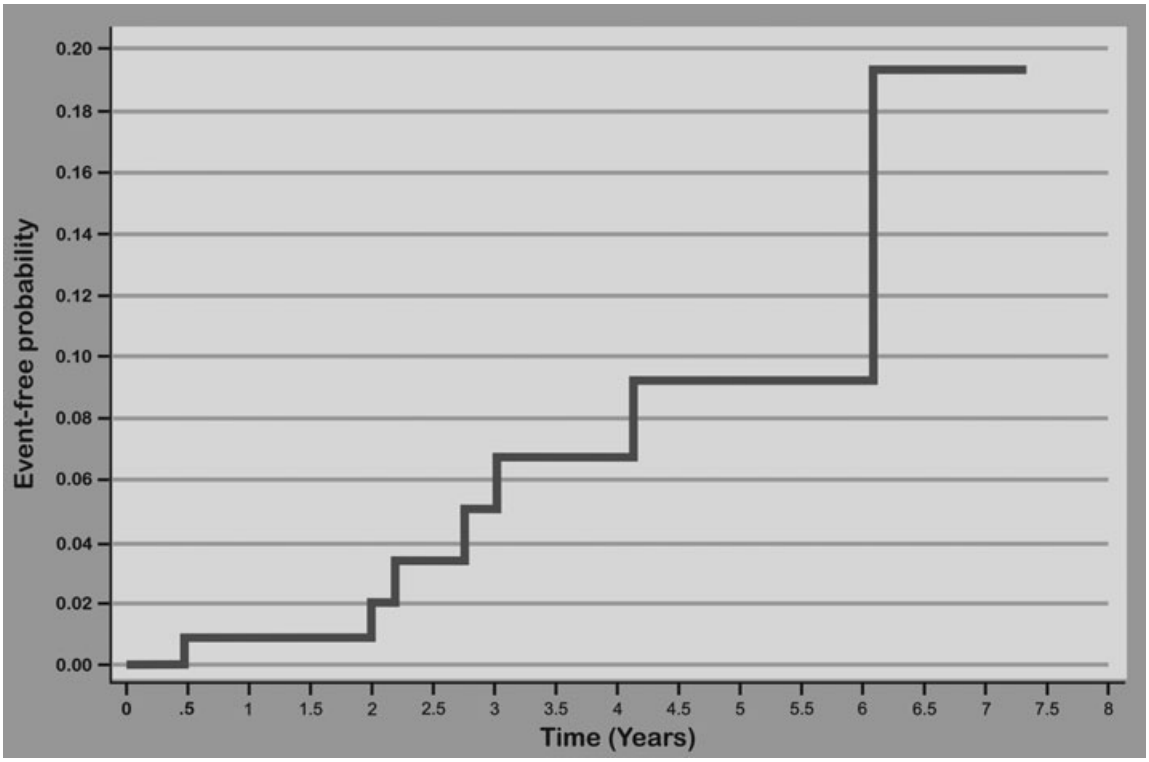

Figure 3 Kaplan-Meier – survival rate related to time of clinical use.

Results

A total of 99 patients (100%) with 210 ceramic onlays and partial veneer crowns returned for follow-up. During the timeframe of this study, 7 of 210 (3.33%) onlays failed due to combined types of fracture (Figs 1–3). Six of the failed restorations had occlusal thicknesses less than 2 mm ($p < 0.014$) (Fig 4). Six of the failed restorations were cemented on nonvital teeth ($p < 0.04$). (Table 2, Fig 5). Failures according to tooth locations were noted as follows: five restorations (11.1%) second molars, two (2.20%) first molars. None of the failures occurred on premolars (Table 2, Fig 6) ($p < 0.003$). The type of opposing tooth had no influence on failure. One hundred one of the restorations restored vital teeth; nine patients reported transient postcementation tooth sensitivity that lasted no longer than 8 weeks. One molar tooth required endodontic treatment 10 weeks after cementation.

Discussion

Gold onlay restorations are the gold standard for occlusal partial veneer restorations[8] for several reasons including: biocompatibility, excellent mechanical properties such as hardness, ductility, modulus of elasticity, and castability, outstanding marginal adaptation, adequate strength in areas equal to or less than 1 mm in thickness, and excellent longevity.[9,12,13,38] Despite these advantages, there has been a decrease in the use of this type of restoration due to the desire of patients to have tooth-colored restorations.[3,15] The use of tooth-colored restorative materials such as composite resins[11] and dental ceramics[3] has increased in the last decade. Composite resin is an appropriate material for small tooth preparations such as class I, narrow class II, and class V cavity preparations.[14]

Various ceramic materials are perhaps better suited for extensive restorations: feldspathic ceramic,[17] leucite-reinforced glass-ceramic material IPS Empress (Ivoclar Vivadent),[10,18] and more recently, disilicate-reinforced glass ceramic e.max (Ivoclar Vivadent). For this clinical study only one ceramic material was used, leucite-reinforced glass-ceramic IPS Empress. It has chemical and physical properties similar to dental enamel,[18] such as hardness, allowing the material to maintain its dimensional stability and similar behavior to enamel regarding wear on the opposing dentition,[19] translucency that provides excellent optical and esthetic properties,[20] the capability of being vacuum-injected into a mold formed from a wax pattern, and excellent marginal adaptation.[28] Additionally, it can be cemented adhesively since it can be etched and silanated, thereby producing a surface to which composite resin cement can be bonded. A number of studies have been published regarding ceramic onlays and partial veneer crowns,[2,25,26,30-36] but these studies have focused on the clinical evaluation of fractures, decementation, sensitivity, marginal adaptation, and wear, but not regarding the restoration thickness. In this study, 45% of the total cemented restorations were classified as either thin (40) or medium (55); 55% of the

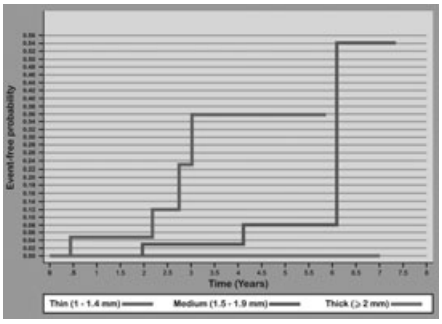

Figure 4 Kaplan-Meier – survival rate regarding the ceramic thickness.

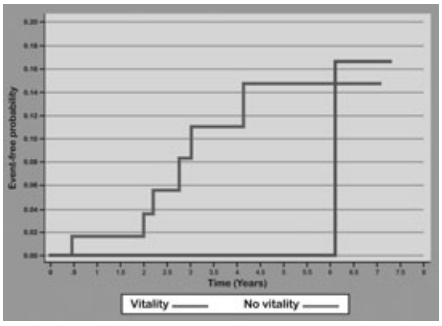

Figure 5 Kaplan-Meier – survival rate regarding vital versus nonvital teeth.

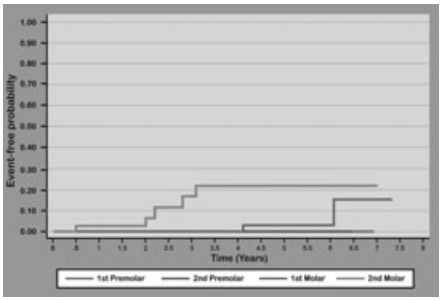

Figure 6 Kaplan-Meier survival rate regarding the tooth location.

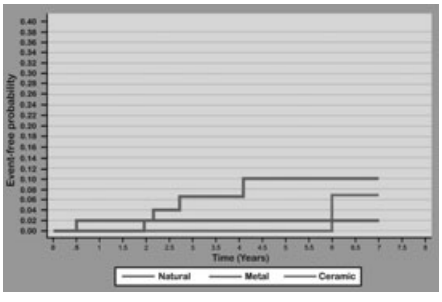

Figure 7 Kaplan-Meier survival rate regarding the type of the opposing tooth.

restorations were classified as thick (115). During the clinical observation period, it was noted that all fractures were of the combined type (Figs 1and 2). Seven failures occurred in thin restorations, and two occurred in medium thickness restorations. This was statistically significant ($p < 0.014$) (Fig 4). In this clinical study of the 210 restorations, 101 restored vital teeth. This accounted for almost half the total restorations. One of the main objectives in dentistry is the preservation of pulp vitality, which can be challenging while trying to obtain enough tooth reduction for restorative material.[35] This is why the authors recorded the occlusal restorative thickness. Of the seven fractured restorations, six (28.5%) failed in nonvital molars ($p < 0.04$) (Fig 5). One possible reason is that nonvital teeth have more cuspal deflexion and reduced stiffness due to endodontic access and restorative procedures.[6,7] Six of the fractured restorations were cemented on composite resin core restorations. Some researchers have concluded that these materials are unstable due to their high water sorption properties and high variability of the coefficients of thermal expansion, which do not offer enough support for restorations such as IPS Empress. Another important factor taken into consideration in this study was the behavior of the material as related to the location of the restoration (premolars vs. molars). None of the 74 (35%) restorations made for premolars fractured (Fig 6), even though they had different thicknesses, and were either vital or nonvital. Five of the seven failed restorations restored second molars, where heavy occlusal loads are known to be present.[39] Other studies have suggested using metallic restorations on these teeth.[38] In this study, there was no correlation between failure and type of opposing dentition (Fig 7). This needs to be further explored with long-term follow-up.

Regarding tooth sensitivity postcementation, it is important to mention the cementation technique. Basically two options are available for clinicians: partial etching and total etching. The tooth-etching technique used in this study was partial etching, contained as much as possible to the enamel. This resulted in 7% postcementation sensitivity; this was noted to decrease rapidly. In six patients, sensitivity was eliminated within 8 weeks postcementation, whereas three patients required more than 8 weeks for the sensitivity to resolve. One patient required endodontic treatment. The other technique commonly used is the total-etch technique (enamel and dentin). Since this procedure was not used in this study, it will not be discussed. Kramer et al[26] in an 8-year follow-up on 94 ceramic inlays and onlays, compared two adhesive systems and their respective cements (EBS multi and composite, Syntac, and Variolink II) using total and partial ecthing techniques. They found more postcementation sensitivity in the total-etch group, even though there was no statistical difference noted between the two protocols. Short- and medium-term clinical studies are important as they may help to detect early failures and generate important information to take into consideration for clinical practice. It is necessary to conduct long-term evaluations to validate the efficacy of this type of treatment.

Conclusions

Within the limitations of this study (3 years) and its research design, it can be concluded that the survival rate of

leucite-reinforced ceramic onlays was 97.1%. Occlusal surface thickness of the restorations, tooth vitality, and tooth locations in the dental arch influenced restoration failure, and minimal postcementation sensitivity occurred when using the partial etching technique.

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