

Clinical performance of indirect esthetic inlays and onlays for posterior teeth after 40 months

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Abstract

Aim: Searches for biocompatible restorative materials with better clinical properties, longevity and esthetics have resulted in the development of several ceramic types. The aim of this study was to evaluate the performance of Ceramco inlays and onlays over 40 months. **Methods:** Thirty ceramic indirect restorations were placed in 10 patients and all were adhesively cemented with a dual resin cement. The clinical performance was evaluated by a calibrated examiner who attributed scores adapted from the Cvar and Ryge criteria: color, marginal adaptation, abrasion, caries recurrence, fracture and postoperative pain. These assessments were performed after cementation of the restorations (T_0 =baseline) and after 4 periods: T_1 (10 months), T_2 (20 months), T_3 (30 months) and T_4 (40 months). Photographs were made in T_0 and T_4 to illustrate the general condition of each restoration. Data were analyzed statistically by Kruskal-Wallis H statistics ($p=0.05$) and results were presented using percentage values. **Results:** Clinical evaluation revealed no color alteration or abrasion (100%); a success rate of 96.7% for caries, fractures and postoperative pain; and 76.7% of failure for marginal adaptation. **Conclusion:** The ceramic restorations did not show alterations that could result in their replacement, although there was a moderate failure in the marginal adaptation.

Keywords: dental materials, inlays, onlays, clinical trial

Introduction

The search for an ideal restoration has led to the development of several restorative techniques and materials. Although metallic alloys were used due to their favorable physicomaterial properties¹⁻², much effort has been made to develop materials with better performance to fulfill clinical requirements³⁻⁵ and meet the patients' esthetic expectations⁵. Restorations with similar characteristics to those of the dental structures, such as color, brightness, and superficial texture, associated to low cost and high durability, are often the patients' desire. The most recent results of this evolution are the composite materials and the non metallic ceramic restorations^{4,6-7}.

Ceramic materials are brittle, with relatively high compressive strength, but present low flexural strength and fracture toughness⁸⁻⁹. Nevertheless, the main disadvantage of this material is the high potential of wearing the enamel or resin restoration of the antagonist teeth. The new ceramic compositions have demonstrated an abrading potential of dental enamel similar to that of natural teeth, which means that they have less aggressive behavior. Moreover, they are biocompatible with the pulp and periodontal tissues, present less biofilm accumulation than the enamel, and transfer less heat and electric current when compared to metallic alloy restorations³.

The restorative technique with dental ceramics has also been enhanced significantly and had its acceptance increased due to the advancement of adhesive systems. The advent of dual

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cure resin cements associated with recent dental adhesives represent a significant improvement in cement adhesion, thus optimizing the retention and stability of ceramic restorations^{3,5,8,10-11}. Despite of all this advantages, the longevity and success of this type of restoration depend on the correct indication, clinical experience of the operator and an accurate work of the laboratory technician¹²⁻¹⁴.

Since only few long-term clinical studies exist under controlled conditions¹⁵⁻¹⁷, it seemed interesting to assess the longitudinal performance of ceramic inlays/onlays restorations over 40 months using a direct evaluation. This study is expected to contribute to a better indication of dental ceramics aiming to contribute to return teeth to a normal condition and promote their reintegration in the stomatognathic system.

Material and methods

Ten undergraduate dental students from the Araraquara School of Dentistry, São Paulo State University aged 18 to 21 years were select for this study. The volunteers should have almost similar buccal and dental conditions, habits, diet, age and indication for an adhesive restoration. Patients with parafunctional habits, poor hygiene and periodontal conditions were excluded from the selected group. The patients were informed of the research protocol and agreed to attend a recall program of 40 months.

Thirty ceramic restorations (12 onlays and 18 inlays) (Dentsply Ceramco, York, PA, USA) were placed in 6 maxillary premolars, 8 maxillary molars, 4 mandibular premolars and 12 mandibular molars. The cavities included O (12), MO (4), OD (3), MOD (6), MOL (1), MODV (2) and MODL (2) preparations. A calibrated professional prepared the posterior teeth for indirect ceramic inlay/onlay restorations using tapered and round diamond burs (KG Sorensen Indústria e Comércio Ltda., Barueri, SP, Brazil). The carious tissue was removed with excavator and the dentin-pulp complex was protected with calcium hydroxide (Hydro C; Dentsply, RJ, Brazil) and glass ionomer cements (Vitrebond; 3M ESPE, Sumaré, SP, Brazil) in deep cavities. All cavities were prepared according to the established principles for adhesive inlays/onlays, which included an occlusal reduction of 1.5 to 2.0 mm, with a wide isthmus rounded internal angles and the axial wall with 1.5 mm of thickness. Gingival margins were prepared entirely in enamel whenever possible at the cemento-enamel

junction¹⁸. Custom trays were used for the 1-step full-arch impressions using vinyl polysiloxane (Reprosil Dentsply, Petrópolis, RJ, Brazil) and the antagonist impression was made with alginate compound (Jeltrate; Indústria e Comércio Ltda.). The casts were placed on an adjustable articulator and all the inlays and onlays fabricated by a dental technician according to the manufacturer's instructions.

The restorations were evaluated and, when necessary, adjustments were made with diamonds burs (KG Sorensen Indústria e Comércio Ltda.) and fine-grain diamond discs. The adjusted restorations were polished with aluminum oxide discs (Sof-Lex, 3M, Sumaré, SP, Brazil), Enhance abrasive rubbers (Dentsply Indústria e Comércio Ltda.) and pumice slurry. Under rubber dam, the enamel was etched with 37% phosphoric acid gel (Scotchbond; 3M ESPE) for 30 s and the remaining dentin was etched for 10 s. Afterwards, Syntac Primer (Ivoclar Vivadent, São Paulo, SP, Brazil) was applied for 15 s on the dentin and the excess was gently removed with air syringe. Then, Syntac Adhesive was applied for 10 s on the cavity and dried thoroughly with blown air. The restorations were cemented with Dual Cement according to the manufacturer's instructions (Ivoclar Vivadent). Polymerization was performed by the application of a halogen light (Heliomat-Vivadent, São Paulo, SP, Brazil) for 20 s in each tooth face with a fluence rate of 500 mW/cm². The occlusal contacts were checked and, when necessary, teeth were adjusted using diamond rotary cutting instruments. Final polishing was conducted using F and FF diamond finishing rotary cutting instruments (KG Sorensen Indústria e Comércio Ltda.), and rubbers and felt discs with polishing diamond slurry.

All restorations were clinically evaluated on four recalls during 40 months. The periods were: T1 (10 months), T2 (20 months), T3 (30 months) and T4 (40 months). All the restorations of T0 (baseline) were considered satisfactory and received high scores for each variable. The photographs were made with a Dental Eye II camera (Yashica, Sorocaba, SP, Brazil) with the maximum approach only to illustrate the general condition of each restoration.

Clinical evaluations were made by a calibrated professional using an explorer and plain clinical mirror, with the tooth and the restoration previously dried. The variables studied were: color, marginal adaptation, abrasion, caries recurrence, fracture and postoperative pain. All restorations received an adapted score following the description of Cvar and Ryge criteria¹⁹ (Table 1).

Table 1. Criteria used for the clinical evaluation of the ceramic inlays/onlays

Inlay/Onlay Characteristics	A	B	C
Color	Compatible color	Changes on color within an acceptable range of tooth color	Severe defects on color that is outside the acceptable
Marginal Adaptation	Great marginal adaptation	Changes on marginal adaptation: No visible evidence of a crevice into which the explorer could penetrate	Severe defects on marginal adaptation: Explorer penetrates into a crevice that is of a depth that exposes dentin or base
Abrasion	No abrasion	Presence of abrasion: missing material is not sufficient to expose dentin base	Presence of abrasion: Sufficient material lost to expose dentin or base
Caries Recurrence	No secondary caries	Presence of secondary caries	_____
Fracture	No fracture	Presence of marginal fracture	Presence of body fracture*
Postoperative Pain	No postoperative pain	Presence of postoperative pain	_____

*Severe defects that indicate the replacement of the restoration.

Results

The 40-month recall rate was 100% on clinical re-evaluations. In order to evaluate the clinical performance of Ceramco inlays/onlays during the 40 months, Kruskal-Wallis H statistics were applied ($p=0.05$). No statistically significant difference was observed between the periods (T1, T2, T3, T4) (Table 2).

The outcomes observed in clinical evaluations for the Ceramco inlays/onlays during T1, T2, T3 and T4 periods are presented in Table 3. During the 40-month evaluation period, no color alteration or abrasion occurred. Fracture and secondary caries occurred in only 1 restoration, corresponding to 3.3%, which maintain in 96.7% the success index. Postoperative pain was present in 20% of the cases, in T1 period of evaluation. However, postoperative pain was not present on T4, which represents a success index of 100% on that period.

The same success level was not achieved for the marginal adaptation. Twenty-three restorations (76.7%) presented alterations in the restoration/tooth interface. These alterations occurred in the first months of use, and the same level was maintained after the first time of evaluation (T1) until the T4 analysis. Figures 1 and 2 show the general condition of restorations in T0 and T4.

Discussion

The evaluation of the clinical performance of the Ceramco restorative ceramic system within a 40-month period showed a high success rate for most analyzed variables (color, marginal adaptation, abrasion, secondary caries, fracture and postoperative pain), which is in accordance with the literature²⁰⁻²¹. Although this system has a relatively complex technique and high cost, it has excellent esthetic results and mechanical resistance, in addition to presenting biocompatibility when compared to other restorative materials^{14,22}. In recent years, these features have contributed to the high-quality performance of ceramic restoration, which leads to good acceptance by the professionals.

Table 2. Kruskal-Wallis H Statistics results.

Evaluation period	Median
T1	24.8
T2	27.5
T3	29.8
T4	39.9
H Statistics: 6.41	P-value: 0.0933

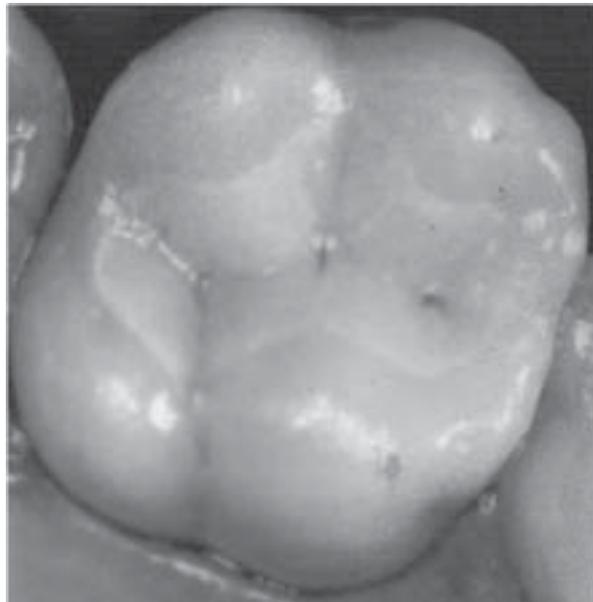


Figure 1: Ceramco inlay photograph taken immediately after cementation (T0). The restoration was considered satisfactory and received high scores color, marginal adaptation, abrasion, caries recurrence, fracture and postoperative pain.

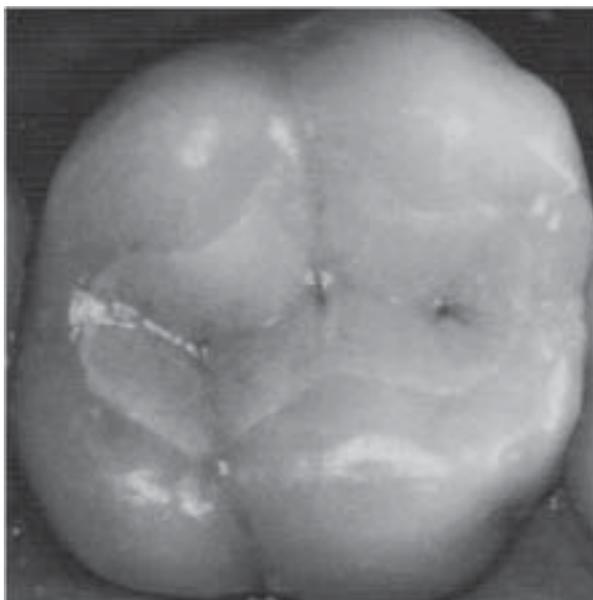


Figure 2: Ceramco inlay photograph evaluated after 40 months (T4). The restoration maintained high scores for each assessed category and continued satisfactory

Table 3. Clinical evaluation of the Ceramco restorations.

	T1			T2			T3			T4		
	A	B	C	A	B	C	A	B	C	A	B	C
Color	30	0	0	30	0	0	30	0	0	30	0	0
%	100	0	0	100	0	0	100	0	0	100	0	0
Marginal Adaptation	7	23	0	7	23	0	7	23	0	7	23	0
%	23.3	76.7	0	23.3	76.7	0	23.3	76.7	0	23.3	76.7	0
Abrasion	30	0	0	30	0	0	30	0	0	30	0	0
%	100	0	0	100	0	0	100	0	0	100	0	0
Caries Recurrence	29	1	0	29	1	0	29	1	0	29	1	0
%	96.7	3.3	0	96.7	3.3	0	96.7	3.3	0	96.7	3.3	0
Fracture	29	1	0	29	1	0	29	1	0	29	1	0
%	96.7	3.3	0	96.7	3.3	0	96.7	3.3	0	96.7	3.3	0
Postoperative Pain	24	6	0	25	5	0	27	3	0	29	1	0
%	80	20	0	83.3	16.7	0	90	10	0	96.7	3.3	0

In addition to these successful rates, the longevity of ceramic restorations is subjected to many factors that can act in a positive or negative form and should be carefully controlled. On these concerns, factors that have the major occurrence were fracture of the restorations, hypersensitivity, loss of retention and fracture of the restored tooth¹⁵. Molin and Karlson²¹ reported that these factors can be originated from misfits, occlusal forces, incorrect cavity designs and imperfections in the cementation technique.

Among the 30 (33%) restorations evaluated in this clinical study, fracture occurred in only one during the analyzed period. Friability is an inherent characteristic of dental ceramics and it has direct influence on their durability^{21,23}. Ceramic fractures have been related to inadequate tooth preparation, occlusal adjustments disrupting the surface and faulty material. Tagtekin et al.²⁴ (2009) found that fractures in ceramic restorations usually occur during the first 6 or 8 months, and the results of the present study agree with this evidence. The fracture observed in our study could possibly be due to the occlusal adjustments done after cementation, although the other restorations were also adjusted. These adjustments might have caused disruption of the superficial glazed layer, generating micro-fractures that became points of crack propagation^{9,15-16,25}. Some special care should be necessary to deal with this problem as an occlusal adjustment of the restoration integrated with a balanced occlusion, an adequate preparation and adhesion technique for cementation. The use of resin cement provided a better integration between tooth and restoration, transferring the external forces to the dentin. Therefore, an increase in ceramic resistance occurred, probably resulting in enhanced clinical durability of these restorations⁵.

The results of this study clearly demonstrate that the major problem is situated at the margin between the restoration and dental structure. Kramer and Frankenberger¹² reported that every clinical trial assessing ceramic inlays revealed a certain deterioration of marginal quality. This might be caused by insufficient bonding to enamel or degradation of the luting agent caused by fatigue. Therefore, it is necessary an adaptation with the dental structure as good as possible for these restorations, including edges and external cavosurface margins⁵. The negative results observed for marginal adaptation occurred in the first months, and showed a tendency to keep the same level (76.7%) until the final analysis (40 months). This fact clearly demonstrates that the main concern with this type of restoration must be the initial adaptation and the friability of ceramic material at the cementation moment and the first months of use, as well as for the material and technique used to cement these restorations²⁶. These results were also observed in other clinical studies^{21,27} where the marginal adaptation was the factor that presented more alteration for indirect ceramic restoration. However, Lange and Pfeiffer²⁸ showed that 93% of the ceramic inlays received score "A" for marginal adaptation after 57 months of evaluation, and the other 7% did not need replacement. The union imperfection can be explained by the incomplete polymerization of the resinous cement, by the low resistance of some cements, lack of acid and silane treatment on the internal surface of the restoration, absence of an adhesive agent, and/or by the possible fatigue that occurs in the adhesive agent after long periods of clinical use and action of occlusal loads, mainly in patients with bruxism³.

Postoperative pain was the second more incident alteration. Ceramic postoperative hypersensitivity has been initially reported to

be problematic due to incomplete sealed of dentin or detachment between material and dentin¹². This was a common occurrence in the majority of the cases, is a transitory characteristic and it is directly related to the wet technique of dentin hybridization, which was used in this study. The need of restoration replacement is rare, similar to what occurred in this study²⁹.

One limitation of the present study may be the fact that probably the period of 40 months was not sufficient for the appearance of significant clinical alterations. However, in recent studies^{18,24,28} a great clinical performance of ceramic inlays/onlays was observed at longer periods of evaluation. Finally, it might be considered that the good results were positively influenced by the selected patients. Nevertheless, it can be noticed that, although there were not statistically significant results, there was a small tendency of deterioration of the restorations with time. This shows that long-term analyses could probably indicate critical alterations that require the restoration substitution^{15,27}.

In spite of the positive results obtained in the present study, long-term clinical investigations are needed to obtain *in situ* information on the performance of the ceramic materials^{22,30-31}. It is also necessary to have studies and improvements on the tooth/restoration interface, as the clinical success with ceramic inlays/onlays depends on the ability to develop a reliable bond of the composite to dental tissues.

This study evaluated 30 Ceramco ceramic inlays and onlays and none of them showed any alteration that could indicate their replacement, although there was a moderated failure of marginal adaptation. Within the limitations of the design and the evaluation time of this investigation, this restoration technique seems clinically acceptable as an esthetic and conservative treatment method for molar and premolar restorations.

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