

Clinical Evaluation of Three Types of CAD/CAM Inlay/Onlay Materials After 1-Year Clinical Follow Up

Keywords

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ABSTRACT

Objective: To evaluate the clinical performance and the marginal adaptation of inlay/onlay restorations made of lithium of a new lithium disilicate strengthened, lithium aluminosilicate glass-ceramic (LAS) material compared with a conventional lithium-disilicate glass-ceramic (LDS) and new-generation polymer-based CAD/CAM resin composite (CS) materials over one year. *Materials and Methods:* Seventy-five inlay-onlay restorations were placed in 35 patients. The restorations were assigned and randomized to three groups as LDS, LAS, and CS. Clinical evaluations were performed after one week, six months, and one year after the cementation, according to the modified United States Public Health Services (USPHS) criteria. The marginal quality analyses of 21 samples (n=7) were assessed under a scanning electron microscope. The data were analyzed by using Friedman, Wilcoxon Signed Ranks, Chi-square and Paired t-tests ($p < 0.05$). *Results:* No statistically significant difference ($p > 0.05$) was found between groups in the modified USPHS, gingival index, and plaque index evaluations, and the total success rate was 100% for three groups after one year. Following SEM evaluations in all groups, continuous margin percentages were decreased, but these results were not statistically significant ($p > 0.05$). *Conclusions:* Lithium disilicate-strengthened lithium aluminosilicate glass-ceramics can be considered a reliable material for an option for posterior onlay/inlay restorations.

INTRODUCTION

There has been a rapid evolution of restorative materials in digital dentistry over the last decade.¹⁻⁴ All-ceramic inlays and onlays have become popular in restorative dentistry due to their high aesthetic quality, durability, wear resistance, color stability, biocompatibility, and conservative treatment, with high long-term survival rates.⁵⁻⁹ Development with CAD-CAM technology is now commonly used for the fabrication of indirect esthetic restorations, and ceramic restorations can be manufactured in a single appointment. The impressions are taken with digital intraoral scanners and transferred directly to the milling device. Thus, the workflow chain is accelerated, and the process errors arising from impression-taking and model fabrication are eliminated.¹⁰ Several chairside CAD/CAM ceramic blocks have been commonly used for this purpose in routine clinical practice.¹¹⁻¹⁷ There are several ways to classify dental ceramics, including clinical indications, composition, microstructure, etching, processing methods, firing temperatures, translucency, fracture resistance and antagonist wear.^{1-3,11} On the other hand, new restorative materials that have recently been launched in the dental market are not easily classi-

fied in these terms.^{4,9,11,13,14} Gracis *et al.*¹, therefore, introduced a new ceramic classification system with three headings as follows: glass-matrix ceramics, polycrystalline ceramics, and resin-matrix ceramics. Some popular glass-matrix ceramics milling blocks, such as IPS e.max CAD (Ivoclar Vivadent), include lithium disilicate glass-ceramic materials used routinely for inlay/onlay restorations. Even if these CAD/CAM blocks are highly esthetic, these ceramic materials should be glazed with oven firing and require the additional steps causing longer chair time procedures.^{7,8,12} To accommodate the material to the needs of chair-side CAD/CAM production, launching new materials with hand-finish and polish procedures are essential.^{2,11,13-18}

New composite resin nanoceramics CAD/CAM blocks are fabricated by high-pressure high-temperature polymerization resulting in improved mechanical characteristics which might make them suitable as materials for single crown restorations.¹³⁻¹⁶ Cerasmart (CS) is a resin composite material consisting of flexible nanoceramic matrix with an even distribution of nanoceramic; composite resin material 71% silica and barium glass nanoparticles by weight with a flexural strength of 238 MPa. With a revolutionary flexible nanoceramic matrix structure, these materials should provide unique physical properties and impact dispersion due to the entirely homogeneous and evenly distributed nanoceramic network. These materials aim to combine the advantages of ceramics, e.g., structural durability and color stability, and composites, e.g., improved flexural properties and low antagonist wear.^{14,17}

To shorten the chairside time other materials based on lithium disilicate-strengthened lithium aluminosilicate glass-ceramic (LAS) have been introduced. The new LAS material (Institut Straumann) is a lithium aluminosilicate ceramic reinforced with lithium disilicate containing 64-70 % (by weight) SiO₂ and 10.5-12.5% LiO₂. The addition of 10.5-11.5 %wt. Aluminum oxide leads to improved strength.^{12,18}

Esthetic value, fracture resistance, marginal and internal adaptation are the most critical factors for the long-term clinical success of dental restorations.¹⁹⁻²³ The restoration has a glossy surface that has a similar reflection, and refraction characteristics as natural teeth to enhance the esthetic appearance and create a smooth surface to maximize the flexural strength of the restoration. Also, these smooth/glossy surfaces minimize the risk of chipping or fracture and should minimize abrasive wear of opposing teeth/ restorations.²⁰⁻²² The deterioration of marginal fit over time can result in microleakage and plaque accumulation, leading to the adherence of oral bacteria and potentially increasing the risk of secondary caries, endodontic inflammation, post-operative sensitivity, and periodontal problems.²³⁻⁴³

There are few clinical studies that exist for controlled clinical conditions of new chairside CAD/ CAM materials and no clinical study on the LAS-ceramic. Therefore, the purpose of this prospective clinical study was to evaluate the clinical performance and marginal adaptations of posterior inlays and onlays milled from three different CAD/CAM blocks over one year.

The null hypothesis was; There would be no significant difference between LAS and CS and LDS materials for posterior onlays restorations in terms of clinical parameters and marginal adaptation after one-year evaluation.

MATERIAL AND METHOD

In this study, 35 patients (23 females, 12 males) who required esthetic inlay/onlay restorations were selected. Inclusion criteria are adults who need an inlay/onlay restoration for one tooth (that can be isolated with the use of a dental dam and has at least one intact cusp), can tolerate restorative procedures and do not have severe bruxism, periodontal or carious disease or poor oral hygiene. All of the patients were treated at the Department of Prosthodontics of Marmara University Dentistry Faculty. The mean age of the patients was 24 years (range: 18-65 years). The study was implemented according to the human research norms and guidelines and was approved by an ethics committee (Marmara University, Faculty of Dentistry Ethics Committee Istanbul, Turkey. Registration number: 2016-28). All patients are given information about the study and signed written informed consent.

The study included 75 inlay/onlay restorations: 60 onlays and 15 inlays, cemented in 60 molars and 15 premolars. The restorations were assigned to three groups according to the restorative materials used. Each group involved 25 teeth restored with 25 restorations (Table 1). For each patient, the material of restorations was randomized using a sealed envelope.

For the decision to restore teeth for inlay and onlay restorations, the cusp width is the dependent factor. If the cusp width and height were not enough, the inlay is preferred with the proximal box in the minimally invasive approach. If the cusp were not sufficient enough to support the restoration, the cups were reduced approximately 2 mm according to the material thickness and occlusion.²⁴ Onlay is required if the decay has extended to include one or more of the tooth's bumpy structures on the biting surface.³³

The first step of the treatment was the removal of the old filling material or tooth decay in the teeth to be restored. The preparations were performed without beveling the margins and leaving no undercut area using 90-126 µm diamond burs (Acucura GmbH, Germany), followed by final refinement with 25 µm finishing diamonds. A reduction of at least 2 mm for functional cusps and a reduction of at least 1.5 mm for nonfunctional cusps was performed by controlling the interocclusal distance. The restorations were at least 1.5 mm deep, 1.5 mm thick and 2 mm wide at the isthmus with rounded occluso-axial angles. The preparations were checked with a caries indicator (Sable Seek, Ultradent, USA). If needed, dentin areas near the pulp were covered with a calcium hydroxide paste (Dycal; Dentsply, USA).

After preparations completed, Computer-aided impressions (CAI) were taken using the Cerec Omnicam (Sirona, Bensheim, Germany) intraoral scanner, and the data were sent to the laboratory via Sirona Connect software 4.4.4 (Sirona, Bensheim,

Table 1. Distribution of restored teeth in the maxilla and mandible

	Premolar		Molar		Maxilla		Mandible	
	Inlay	Onlay	Inlay	Onlay	Inlay	Onlay	Inlay	Onlay
LDS	2	3	6	14	4	12	4	5
LAS	3	2	5	15	3	13	5	6
CS	2	3	4	16	3	10	3	7
Total	7	8	15	45	10	35	12	18

Germany). The intraoral virtual models were transmitted to the CAD software program, and restoration margins were drawn. Based on the margins, restorations were designed using identical parameter settings. The same operator made all the preparations. A single experienced technician prepared the laboratory phase of the restorations for CAD-CAM restorations.

MILLING PROCEDURES:

For all materials, the appropriate color and size of the block were chosen for each patient, and all restorations were fabricated in the Cerec Inlab MC XL milling machine (CEREC 3D, Sirona Dental Systems GmbH, Bensheim, Germany) according to the manufacturer's instructions.

LDS block was milled in the precrystallized state using its standard milling strategy. After blocks were milled, the restoration was crystallized (The crystallization process gives the glass-ceramic its ultimate strength and esthetic properties) in a porcelain furnace (P300, Ivoclar Vivadent) at 850°C for approximately 30 minutes, following the manufacturer's instructions. The operator polished the restorations using the polishers provided in the sequence and diamond paste (OptraFine, Ivoclar Vivadent).

LAS blocks milling procedures similar to LDS blocks. Besides LAS blocks are fully crystallized after milling procedures, the restorations finished, polished and fitted immediately without requiring additional crystallization firing. The three restorations needed a glazing procedure due to color mismatch; the rest were merely polished. The restorations polished with the polishers provided in the sequence and diamond paste (OptraFine, Ivoclar Vivadent).

The milling program for CS composite resin block materials selected, and after milling, the restorations were finished using the GC ultimate finishing and polishing kit and Diapolisher paste (GC). Also the CS blocks no needed no glazing and no firing. Besides when there was some color adjustment (two restorations) a quick characterization with the stroke of a brush used by using the wear-resistant coloring glaze (Optiglaze Color, GC)

BONDING PROCEDURES

The adhesive cementation was performed for all groups according to the manufacturer's instructions.

Surface treatment of restorations; The inner surfaces of each restoration were treated according to the manufacturer's instructions for each group.

Etching with 5% hydrofluoric acid gel (IPS Etching gel; Ivoclar Vivadent) was applied for 20, 30 and 60 seconds for LDS, LAS and CS restorations respectively according to the manufacturer's instructions. Then rinsed for 60 seconds with running water and dried for 30 seconds with moisture-free air. A ceramic primer containing silane coupling agent (Monobond Plus, Ivoclar Vivadent) was applied to the intaglio surfaces of all restorations and allowed to dry for 60 seconds. After the silane application, the solvent was vaporized with compressed air. Unfilled resin (Adhese Universal; Ivoclar Vivadent) was applied to the internal surface of the restorations and dispersed with compressed air.

Cementation of restorations; All groups restorations were adhesively luted under a rubber dam. Before cementation, the prepared teeth were carefully brushed with a fluoride-free polishing paste. The 37% phosphoric acid gel (Total Etch, Ivoclar Vivadent) was applied to the enamel margins for 30 seconds and dentin areas for 15 seconds and then rinsed for 30 seconds. Adhese Universal (Ivoclar Vivadent) was applied and scrubbed into the tooth surfaces for at least 20 seconds. After dispersal with compressed air, the tooth surface was polymerized for 10 seconds per the manufacturer's recommendations. All inlay/onlays were adhesively luted with Variolink Esthetic DC (Ivoclar Vivadent) automix syringe. The restorations were inserted with moderate pressure and polymerized for two seconds per quarter surface. Excess luting agent was carefully and easily removed with a scaler. Next, the restorations were light-cured, starting with the proximal margins for 40 seconds. After polymerization, the rubber dam was removed, and the occlusion was carefully checked. Diamond finishing burs and the diamond polishing system (Diapol Kit RA305, Eve, Naples FL, USA) were used if necessary. Then the color of the restorations

was visually evaluated, by using Vita A-D shade guide (Vita Zahnfabrik) at the beginning and during the control intervals

CLINICAL EVALUATION

Clinical evaluations were performed at baseline and six months and one year after cementation by two advanced examiners. To assess the inter-rater reliability between examiners "Percent Agreement for Two Raters" methods used. If both examiners agreed, IRR was recorded as 1 (or 100%), and if both examiners disagreed, IRR was recorded as 0 (0%). Modified United States Public Health Services (USPHS) criteria were used to evaluate postoperative sensitive, marginal integrity, marginal discoloration, surface texture, color stability, wear, fracture, and secondary caries at baseline, then after six months and one year (Table 2). The baseline rating was determined immediately after the finishing and polishing procedures using mirrors, probes, and radiographs. Photographs were taken at the beginning, after preparation, cementation, one week, six months, and one year for each group (Figures 1-3).



Figure 1a-c: (LDS restoration). a) Preoperative image b) Baseline c) one year recall

Table 2. Modified USPHS evaluation criteria used in this study

Color match	Alfa: No mismatch in color, shade, and translucency between restoration and adjacent tooth structure
	Bravo: Mismatch between restoration and tooth structure within the normal range of color, shade, and translucency
	Charlie: Mismatch between restoration and tooth structure outside the normal range of color, shade, and translucency
Marginal discoloration	Alfa: No discoloration on the margin between the restoration and the tooth structure
	Bravo: discoloration on the margin between the restoration and the tooth structure
	Charlie: Discoloration has penetrated along the margin of the restorative material in a pulpal direction
Marginal integrity	Alfa: No visible evidence of ditching along the margin
	Bravo: Visible evidence of ditching along the margin not extending to the dentinoenamel junction
	Charlie: Dentin or base is exposed along the margin
	Delta; Restoration is mobile, fractured, or missing
Secondary caries	Alpha: No evidence of caries contiguous with the margin of the restoration
	Bravo Caries evident contiguous with the margin of the restoration
Surface Texture	Alfa: Smooth surface
	Bravo: Slightly rough or pitted, can be refinished.
	Charlie: Rough, cannot be refinished
Postoperative sensitivity	Alfa: No postoperative sensitivity
	Bravo: Postoperative sensitivity
Fracture	Alpha: No evidence of fracture
	Bravo: Evidence of fracture



Figure 2a-c: (LAS restoration). a) Preoperative image b) Baseline c) one year recall



Figure 3a-c: (CS restoration). a) Preoperative image b) Baseline c) one year recall

THE MARGINAL QUALITY DEFINITION (SEM ANALYSIS)

For the marginal quality definition, representative 21 onlay restorations were assessed under a scanning electron microscope (SEM) at 200x regarding marginal changes (7 each group) for baseline and one-year evaluations (Figures 4 and 5). All of the selected restorations had supragingival buccal margins. The tooth and restoration surfaces were cleaned with a 5% NaOCl solution and washed with water. SEM evaluations procedures have followed by the procedures as previously described.²⁴

STATISTICAL EVALUATION

IBM SPSS Statistics for Windows, Version 21.0 (Armonk, IBM Corp, NY, USA) was used for the statistical analyses. Descriptive statistical methods for frequency, percentage, mean, standard were used for the evaluation of the study data. The results were evaluated at a 95% confidence interval and a significance level of $p < 0.05$. The Wilcoxon signed-rank test was used for the determination of differences. The Friedman test was used to determine whether statistically significant differences existed in the time-to-time comparison of the parameters in the LDS, LAS, and CS groups. The clinical parameters at baseline and after six months and one year were compared separately with the chi-square test. For the scanning electron microscope evaluation, differences in the means for continuous measurements at baseline and one-year follow-up were analyzed by the independent samples t-test.

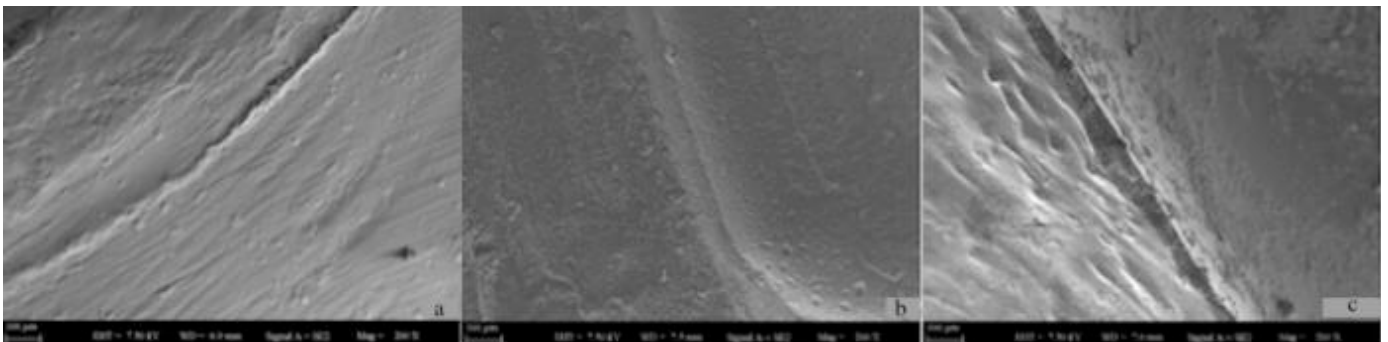


Figure 4: SEM images LDS (a), LAS (b) and CS (c) model after 1 week in situ

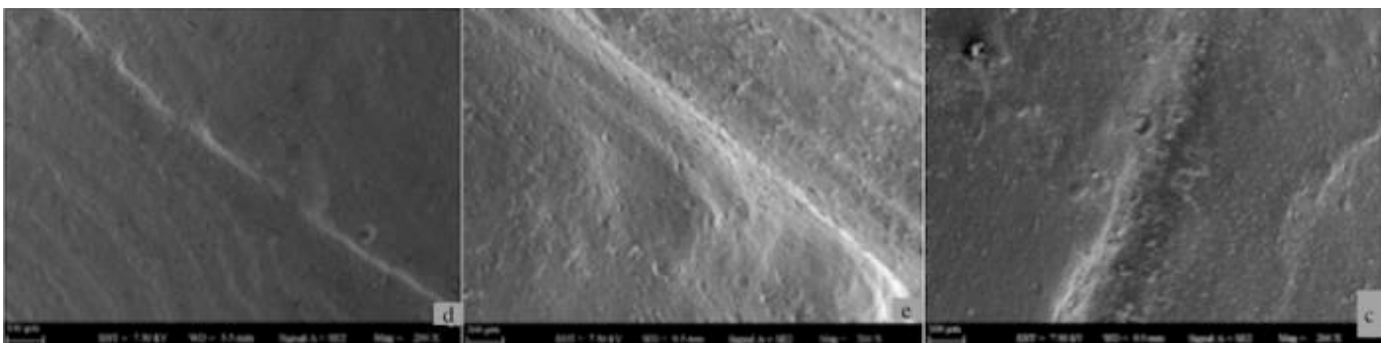


Figure 5: SEM images LDS (d), LAS (e) and CS (f) model after 1 year in situ

RESULTS

In this study, 75 inlay/onlay restorations were fabricated as 22 (29.3 %) inlays, 53 (70.6 %) onlays and luted on fifteen premolar and 60 molar teeth. Forty-five (60%) restorations were in the maxilla, and 30 (40%) were mandible (Table 1). During the following periods, all restorations were in situ were evaluated in 35 patients (Recall rate 100%).

CLINICAL EVALUATION

The percentage distributions of the scores for the modified USPHS criteria –marginal fit, anatomic form, color, surface roughness, marginal discoloration, tooth and restoration integrity - at the baseline, 6-month and one -year follow-up visits are presented in Table 3.

All tested restorations used modified USPHS criteria, and no Charlie or Delta ratings were observed at all intervals during one year's study periods all parameters clinically evaluated.

The color of all restorations was clinically acceptable at the time of placement during the observation period. No secondary caries or endodontic complications were observed in the given recall periods. Only one restoration from the LDS group exhibited minor fractures. The fractured restoration consisted of one onlay located on the mandibular molar region. It is restored without need of replacement only polishing this minor fractured surface. The patients who provided a Bravo rating for postoperative sensitivity at baseline were asked again after six months and reported the absence of pain, transforming the Bravo rating into an Alpha one. The patients for all groups were satisfied with the treatment carried out.

In terms of all evaluated criteria, there were no significant differences between the groups in comparison with the modified USPHS criteria at the baseline, 6-month, and 1-year evaluations ($p>0.05$).

Also, there was no statistically significant differences with marginal discoloration, marginal integrity, surface texture, and color match were detected between each recall for intra-groups evaluations (The chi-square test, $p>0.001$). Differences over time as regards color, surface roughness, and chewing efficacy parameters in the groups were compared with the Friedman test. There were no significant differences between the restorative materials after the different follow-up periods. ($p>0.05$).

The time-dependent plaque and gingival indexes were compared using the Friedman test. There was no statistically significant differences with plaque and gingival indexes values for each group. The Wilcoxon signed-rank test was used for the determination of differences. ($p>0.05$).

THE QUANTITATIVE MARGINAL QUALITY ASSESSMENT

The results of the marginal adaptation at the interface between the restoration/cement and enamel/cement are shown in Tables 4. No statistically significant differences ($p>0.05$)

found between groups baseline and after one year of cementation for the percentage of "continuous margin" at the total marginal length (Figures 4 and 5).

DISCUSSION

In this prospective controlled randomized clinical preliminary study lithium disilicate glass-ceramic (LDS), lithium disilicate strengthened lithium alumino-silicate glass-ceramic (LAS) and new-generation polymer-based materials; composite resin (CS) manufactured inlay/ onlay restorations were assessed at one year.

During the evaluation of the clinical performance of the three groups within one year, a low failure rate of 1.66% was seen. A general survival rate of 100 % was recorded for LAS and CS and 96.3% for the LDS group after one year. In this study, none of the 75 restorations were lost. In this study with complying with the other studies have reported overall success rates of between 90% and 95% of ceramic restorations investigated up to five years.³⁰⁻³² From the qualitative perspective, the three groups were stable in color match, marginal discoloration, marginal integrity, secondary caries, surface texture, postoperative sensitivity, patient satisfaction and marginal adaptation parameters evaluated for one year of clinical service. The null hypothesis that there would be no difference in clinical performance between three groups was accepted.

To increase longevity and success of dental restorations, patient selection, material selection, and clinical and technical factors should be carefully selected.^{20,21} It is essential to recognize between early failures (after a few weeks or a few months), from a medium time frame (6-24 months) and late failures (after two years or more). The faulty indication, side adverse effects, inappropriate materials selection or postoperative symptoms could be related to early failures. Medium time frame failure is typically related to tooth fracture, marginal discoloration, staining or chipping of restorations and loss of vitality. Secondary caries, predominantly caused bulk fractures of the restoration or the tooth, endodontic complications, wearing of restorations, deteriorations in the restoration material, or periodontal problems are more likely responsible for late failures.^{20,36}

Ceramic fractures and decementation of restorations are the major clinical complications that lead to all-ceramic restoration failures. It is reported that these factors can be originated from misfits, occlusal forces, poor cavity preparation, and improper cementation techniques.^{3-9,12,13,16, 23-40} Attia and Kern⁴¹ reported that factors that have a significant occurrence were the fracture of the restorations, hypersensitivity, loss of retention, and fracture of the restored tooth should be considered. Guess *et al.*³⁴ reported a 100% survival rate for IPS e.max Press and a 97% survival rate for CAD/CAM partial crown restorations over seven years. In our study, no ceramic fractures were observed in the restorations for LAS and CS group, and only one restoration showed repairable fracture for LDS at the one year follow-up.

Table 3. Modified USPHS criteria evaluation of restoration at baseline, 6- month and 1-year follow-up

USPHS criteria in %	Baseline			One year			Two year		
	LDS n:25	LAS n:25	CS n:25	LDS n:25	LAS n:25	CS n:25	LDS n:25	LAS n:25	CS n:25
Postoperative sensitivity									
Alpha	96.7	96.7	94.4	100	100	100	100	100	100
Bravo	3.3	3.3	4.6	-	-	-	-	-	-
Charlie	-	-	-	-	-	-	-	-	-
Secondary caries									
Alpha	100	100	100,	100	100	100	100	100	100
Bravo	-	-	-	-	-	-	-	-	-
Charlie	-	-	-	-	-	-	-	-	-
Color match									
Alpha	97.7	92.4	95.4	95.2	90.4	93.2	93.2	90.0	90.2
Bravo	2.3	7.6	4.6	4.8	9.6	6.8	6.8	10.0	9.8
Charlie	-	-	-	-	-	-	-	-	-
Marginal discoloration									
Alpha	100	100	100	97.4	95.2	94.5	94.5	93.5	90.6
Bravo	-	-	-	2.6	4.8	5.5	5.5	6.5	9.4
Charlie	-	-	-	-	-	-	-	-	-
Marginal integrity									
Alpha	100	100	100	96	95.2	94.2	94.2	95.2	93.5
Bravo	-	-	-	4	4.8	5.8	5.8	4.8	7.5
Charlie	-	-	-	-	-	-	-	-	-
Delta	-	-	-	-	-	-	-	-	-
Surface texture									
Alpha	98.5	96.7	95.4	97.73	95.8	94.2	96.4	95.8	94.2
Bravo	1.5	3.3	4.6	2.3	4.2	5.8	3.6	4.2	5.8
Charlie	-	-	-	-	-	-	-	-	-

Table 4. Comparison of continuous margin percentage of restorations (SEM evaluations)

		Mean ± SD	P value
Restoration-cement baseline	LDS	95.55 ± 1.17	0.063
	LAS	96.31 ± 1.25	
	CS	97.41 ± 1.70	
Restoration -cement 1 year	LDS	93.64 ± 1.65	0.751
	LAS	93.86 ± 1.07	
	CS	92.87 ± 1.25	
Enamel-cement baseline	LDS	98.01 ± 1.40	0.707
	LAS	98.26 ± 1.20	
	CS	97.46 ± 1.25	
Enamel-cement 1 year	LDS	95.54 ± 1.12	0.378
	LAS	96.03 ± 1.02	
	CS	95.03 ± 1.07	

The microscopic analysis was performed with SEM at 200x magnification.²⁴ Continuous margin percentages in both ceramic-cement and enamel-cement interfaces decreased for all groups, but these results were not statistically significant ($p > 0.05$). The use of suitable resin cement provided a proper integration between tooth and restoration, transferring the external forces to the dentin and improving fracture resistance of the ceramic, probably increasing clinical durability of these restorations.⁴¹⁻⁴³ For the cementation of inlay and onlay restorations, conventional etch-rinse systems that are used with dual-cure resin cement are considered to be the gold standard.^{24,31} It was reported that etch-rinse systems resulted in mostly gap-free margins in enamel than all other luting systems.^{24,43} In this study, all inlays/onlays were cemented with a selective enamel etching technique and two-step Variolink Esthetic DC etch and rinse system. Also, in this study, for surface treatment of new-generation polymer-based materials (Cerasmart) the same procedures were used as LDS and LAS ceramic materials. The surface treatment of CS in all currently available *in vitro* studies, found HF acid etching in combination with silane to be a superior pretreatment. The application of HF acid partially dissolves the glass phase and provides undercuts in the micrometer scale for better micromechanical interlocking with a composite cement.⁴⁴ In this study, Monobond Plus used as a silane material. Monobond Plus is a universal primer, containing silane and phosphomethacrylates as well for enhance adhesion to resin composite. The marginal adaptation at the interface between luting composite and restoration was perfect in all groups, both baseline and after one year recall. This should confirm that where HF acid etching and silanization resulted in a very good bond between the LAS, LDS, CS restorations and Variolink Esthetic DC cement. All study groups had clinically acceptable modified USPHS scores and continuous percentages values, and no debonding

occurred in any of the restorations luted with HF/ Monobond Plus /Variolink Esthetic DC combinations (100% survival rate).

Also, secondary caries was reported for the failure of dental restorations in general practice. In this study, no secondary caries was detected around restorations. Also, it was reported that a suitable preparation design could provide the highest resistance to fracture.^{18,32,33} This study showed that CAD/CAM preparation design could decrease the marginal gap and should increased resistance fracture for tested materials.

In this study, shade selection was performed using Vita A-D shade guide at the beginning and during the control intervals. LAS exhibit more opaque color when color shade evaluation while other groups did not. The translucency of LAS was commonly lower than those of LDS and CS restorations. This opaque shade could have resulted from alumina content added for increasing strength. However, this opaque shade was not a problem with the patient. Moreover, this material should be carefully used in maxillary premolar area with the high smile line.

Goujat *et al.*³⁵ evaluated the mechanical properties of recent polymer-based blocks; (Vita Enamic), two composite resin nanoceramics (Lava Ultimate, Cerasmart) and lithium disilicate glass-ceramic (IPS e.max CAD) blocks in their *in vitro* study. Bar-shaped specimens were submitted to a three-point bend test. Moreover, in each group, 15 extracted molar cavities were prepared and optically scanned. The inlay restorations were milled using a CEREC Inlab milling machine. The replica technique and stereomicroscope were used for evaluating internal adaptation, and they reported that the mechanical properties of these CAD/CAM block materials tested were within the acceptable range for the fabrication of single restorations. Moreover, IPS e.max CAD and Cerasmart blocks offer superior flexural strength and produce a better internal fit.

Furthermore, Awada and Nathanson¹⁴ reported that the new-generation polymer-based materials (Cerasmart, Lava Ultimate) showed significantly higher flexural strength and modulus of resilience than the tested ceramic and hybrid materials (Enamic, Vitablocs Mark II, Paradigm MZ1, and IPS Empress CAD). Also, the polymer-based materials tested exhibited smoother milled margins compared to the ceramic materials tested. In this study, Cerasmart resin composite material exhibited similar smooth milled margins compared with the ceramic materials tested.

Lithium disilicate ceramics (LDS) undergo a crystallization process during the production of the restorations. This procedure causes an increase in chair side time. However, for processing LAS and CS materials, no additional sintering/crystallization firing of the restoration was required. This straightforward procedure decreased the total amount of time needed to finish it before delivery. This straightforward procedure should be essential advantages when considering that this material is available for chairside CAD/CAM restorations.

LAS restorations showed good preconditions for the fabrication of monolithic restorations that are only characterized by staining. This material property should be of clinical benefit for chairside restorations. For restorations requiring more space anteriorly, e.g., in the premolar area, the generation of a tooth-like gradient in the shades from the cervical to the incisal area requires the use of stains in an additional firing cycle.¹⁸ Since this preliminary study was the first clinical trial with LAS restorations, it is not possible to make a comparison with the results for this material.

One limitation of the present study may be the fact that probably 12 months was not ample for the appearance of significant clinical alterations. This study might be considered that the selected patients positively influenced the favorable results and it should be noticed that, although there were no statistically significant results, there was a small tendency of deterioration of the restorations with time. Despite the positive results obtained in the present study, long-term clinical investigations are needed to obtain these new CAD-CAM materials on the performance of the inlay/onlay restorations.

CONCLUSION

Within the limitations of this study, the CAD/CAM onlay restorations fabricated with lithium disilicate-strengthened lithium aluminosilicate glass-ceramic (LAS) material showed similar clinical results and an acceptable level of marginal integrity to that obtained with lithium disilicate glass-ceramic (LDS) materials and new-generation polymer-based materials; composite resin (CS).

In the light of the clinical and microscopic results, Lithium disilicate-strengthened lithium aluminosilicate glass-ceramic CAD/CAM blocks can be considered as a favorable alternative to lithium disilicate glass-ceramic CAD/CAM blocks, as no ad-

ditional time-consuming firing is required. Furthermore, more extended clinical observation periods would be advisable to supplement the data in this study.

REFERENCES

1. Gracis, S., Thompson, V.P., Ferencz, J.L., et al. A new classification system for all-ceramic and ceramic-like restorative materials. *Int. J. Prosthodont.*, 2015;**28**:227-235.
2. McLaren, E.A. and Terry, D.A. CAD/CAM systems, materials and clinical guidelines for all-ceramic crowns and fixed partial dentures. *Compend. Contin. Educ. Dent.*, 2002;**23**:637-652.
3. Guess, P.C., Schulythesis, S., Bonfante, E.A., et al. All-ceramic systems: Laboratory and clinical performance. *Dent. Clin. North. Am.* 2011;**55**:333-552.
4. Santos, G.C., Santos, MJMC, Rizkalla, A.S., et al. Overview of Cerec CAD/CAM chairside system. *Gen. Dent.*, 2013;**1**:36-40.
5. Guess, P.C., Selz, C.F., Steinhart, Y.N., et al. Prospective clinical split-mouth study of pressed and CAD/CAM all-ceramic partial-coverage restorations: 7-year results. *Int. J. Prosthodont.*, 2013;**26**:21-25.
6. Chabouis, H.F., Faugeron, V.S., Attal, JP Clinical efficacy of composite versus ceramic inlays and onlays: A systematic review. *Dent. Mater.*, 2013;**29**:1209-1218.
7. Krämer, N., Taschner, M., Lohbauer, U., et al. Totally bonded ceramic inlays and onlays after eight years. *J. Adhes. Dent.*, 2008;**10**:307-314.
8. Krämer, N., Frankenberger, R., Pelka M., et al. IPS Empress inlays and onlays after four years- a clinical study. *J. Dent.*, 1999;**27**:325-331.
9. Hopp, C.D. and Land, MF Considerations for ceramic inlays in posterior teeth: a review. *Clin. Cosmet. Investig. Dent.*, 2013;**5**:21-32.
10. Seelbach, P., Brueckel, C., and Wöstmann, B. Accuracy of digital and conventional impression techniques and workflow. *Clin Oral Invest* 2013;**17**:1759-1764.
11. Helvey, G.A. Classifying dental ceramics: numerous materials and formulations available for indirect restorations. *Compend.Contin. Educ Dent.*, 2014;**35**:38-43.
12. Laczka, M., Laczka, K., Cholewa-Kowalska, K., et al. Mechanical properties of a lithium disilicate strengthened lithium aluminosilicate glass-ceramic. *J Am. Ceram. Soc.*, 2013;**97**:1-4.
13. Coldea, A., Swain, M.V., and Thiel, N. Mechanical properties of polymer-infiltrated-ceramic-network materials. *Dent. Mater.* 2013;**29**:419-426.
14. Lauvahutanon, S., Takahashi, H., Oki, M., et al. In vitro evaluation of the wear resistance of composite resin blocks for CAD/CAM. *Dent. Mater. J.* 2015;**34**:495-502.
15. Fasbinder, D.J., Neiva, GF. Surface evaluation of polishing techniques for new resilient CAD/CAM restorative materials. *J. Esthet. Restor. Dent.* 2016;**28**:56-66.
16. Spitznagel, F.A., Horvath, S.D., Guess, P.C., et al. Resin bond to indirect composite and new ceramic/polymer materials: a review of the literature. *J. Esthet. Restor. Dent.* 2014;**26**:382-393.
17. Awada, A., and Nathanson, D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. *J. Prosthet. Dent.*, 2015;**114**:587-593.
18. Institut Strauman AD. Straumann® n!ce. Fully crystallized glass-ceramic. n!ce® to meet you. 2018

19. Anusavice, K.J., Kakar, K., and Ferree, N. Which mechanical and physical testing methods are relevant for predicting the clinical performance of ceramic-based dental prostheses? *Clin. Oral Implants Res.* 2007;**18**:218-231.
20. Hickel, R., Roulet, J.F., Bayne, S. Recommendations for conducting controlled clinical studies of dental restorative materials. *Clin. Oral Invest.* 2007;**11**:5-33.
21. Blatz, M.B. Long-term clinical success of all-ceramic posterior restorations. *Quintessence Int.* 2002;**33**:415-426
22. Heintze, S.D., Cavalleri, A., Forjanic, M., et al. wear of ceramic and antagonist—a systematic evaluation of influencing factors *in vitro*. *Dent. Mater.* 2008;**24**:433-449.
23. Soares, C., Martins, L., Pfeifer, J., Giannini, M. Fracture resistance of teeth restored with indirect-composite and ceramic inlay systems. *Quintessence Int.* 2004;**35**:281-286
24. Emiroglu, S.A., Evren, B. and Ozkan, Y.K. Effect of cements at different temperatures on the clinical performance and marginal adaptation of inlay-onlay restorations *in vivo*. *J. Prosthodont.*, 2016;**25**:302-309.
25. Van Dijken, J.W. and Hasselrot, L. A prospective 15-year evaluation of extensive dentin-enamel-bonded pressed ceramic coverages. *Dent. Mater.*, 2010;**26**:929-939.
26. Santos, MJMC, Freitas, M.C., Azevedo, L.M. et al. Clinical evaluation of ceramic inlays and onlays fabricated with two systems: 12-year follow-up. *Clin. Oral Invest.*, 2015;**20**:1683-1690.
27. Hayashi, M., Tsuchitani, Y., Kawamura, Y. and et al. Eight-year clinical evaluation of fired ceramic inlays. *Oper. Dent.*, 2000;**25**:473-481.
28. Otto, T. and De Nisco, S. Computer-aided direct ceramic restorations: a 10-year prospective clinical study of cerec CAD/CAM inlays and onlays. *Int. J. Prosthodont.*, 2002;**15**:122-128.
29. Otto, T. and Schneider, D. Long-term clinical results of chairside cerec CAD/CAM inlays and onlays: a case series. *Int. J. Prosthodont.*, 2008;**21**:53-59.
30. Peumans, M., De Munck, J., Van Landuyt, K., et al. Two-year clinical evaluation of a self-adhesive luting agent for ceramic inlays. *J. Adhes. Dent.*, 2010;**12**:151-161.
31. Taschner, M., Krämer, N., Lohbauer, U., et al. Leucite-reinforced glass ceramic inlays luted with self-adhesive resin cement: A 2-year *in vivo* study. *Dent. Mater.*, 2012;**28**:535-540.
32. Vagropoulou, G.I., Klifopoulou, G.L., Vlahou, S.G., et al. Complications and survival rates of inlays and onlays v.s complete coverage restorations: A systematic review and analysis of studies. *J. Oral Rehabil.*, 2018;**45**:903-920.
33. Vianna, ALSV, Prado, C.J.D., Bicalho, A.A., et al. Effect of cavity preparation design and ceramic type on the stress distribution, strain and fracture resistance of CAD/CAM onlays in molars. *J. Appl. Oral Sci.*, 2018; **26**:e20180004.
34. Guess, P.C., Vagkopoulou, T., Zhang, Y., et al. Marginal and internal fit of heat pressed versus CAD/CAM-fabricated all-ceramic onlays after exposure to thermo-mechanical fatigue. *J. Dent.*, 2014;**42**:199-209.
35. Goujat, A., Abouelleil, H., Colon, P., et al. Mechanical properties and internal fit of 4 CAD/CAM block materials. *J. Prosthet. Dent.*, 2018;**119**:384-389.
36. Goldstein, G.R. The longevity of direct and indirect posterior restorations is uncertain and may be affected by a number of dentist-, patient-, and material-related factors. *J. Evid. Based Dent. Pract.* 2010;**10**:30-31.
37. Fuzzi, M., Rappelli, G. Survival rate of ceramic inlays. *J. Dent.*, 1998; **26**:623-626.
38. Krämer, N., Frankenberger, R. Clinical performance of bonded leucite-reinforced glass ceramic inlays and onlays after 8 years. *Dent. Mater.*, 2005;**21**:262-271.
39. Santos, MJMC, Mondelli, R.F.L., and Lauris, JRP Clinical evaluation of ceramic inlays and onlays fabricated with two-systems: Two-year clinical follow up. *Oper. Dent.* 2004;**29**:123-130.
40. Lindberg, A, Van Dijken, J.W.V. Hörstedt, P. In vivo interfacial adaptation of class II resin composite restorations with and without a flowable resin composite liner. *Clin. Oral Invest.* 2005;**9**:77-83.
41. Attia, A., and Kern, M. Influence of cyclic loading and luting agents on the fracture load of two all-ceramic crown systems. *J. Prosthet. Dent.* 2004;**92**:551-556.
42. Quanto, A.F., Oliveira, F., Bottino, M.A. The vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: An *in vitro* evaluation. *J. Prosthet. Dent.* 2014;**92**:250-257.
43. Kern, M., Schaller, H.G., Strub, J.R. The marginal fit of restorations before and after cementation *in vivo*. *Int. J. Prosthodont.* 1993;**6**:585-591