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CLINICAL RESEARCH

Ultrathin CAD-CAM glass ceramic and composite resin occlusal veneers for the treatment of severe dental erosion: An up to 3-year randomized clinical trial

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ABSTRACT

Statement of problem. Ultrathin bonded posterior occlusal veneers represent a conservative alternative to traditional onlays and complete coverage crowns for the treatment of erosive dental wear. Data regarding the clinical performance of ceramic and composite resin ultrathin occlusal veneers are lacking.

Purpose. The purpose of this prospective randomized clinical trial was to evaluate the influence of computer-aided design and computer-aided manufacturing (CAD-CAM) restorative material (ceramic versus composite resin) on the clinical performance of ultrathin occlusal veneers bonded to worn posterior teeth.

Material and methods. Eleven participants (mean age, 30.4 years) had their posterior teeth restored with 24 ceramic (e.max CAD) and 36 composite resin (Lava Ultimate) ultrathin occlusal veneers. The material type was assigned randomly. The tooth preparations were trial restoration driven and included immediate dentin sealing (OptiBond FL). The intaglio surfaces of the ceramic restorations were etched with hydrofluoric acid and silanated, and the composite resins were airborne-particle abraded and silanated. The tooth preparations were airborne-particle abraded and etched with phosphoric acid before restoration insertion. All restorations were adhesively luted with preheated composite resin (Filtek Z100). The participants were evaluated according to the modified United States Public Health Service (USPHS) criteria at baseline and then each year for up to 3 years. Survival rates were estimated with time to failure (primary outcome of interest) as the endpoint (scores 4 or 5).

Results. No restorations were lost. Five partial failures, in the form of chipping (all scored 4), were observed in the composite resin group (Lava Ultimate). The Kaplan-Meier survival rates were 100% for ceramic and 84.7% (SE 0.065%) for composite resin. Differences between the 2 groups were not statistically significant (P=.124). In the surviving restorations, significant difference (P=.003) was found for surface roughness as restorations in the composite resin group experienced some surface degradation.

Conclusions. The findings of this medium-term clinical trial suggest that ceramic (e.max CAD) and composite resin (Lava Ultimate) CAD-CAM ultrathin occlusal veneers presented statistically comparable performance regardless of the minor partial failures (restorable chipping) observed in the composite resin group. Higher surface degradation was observed in the composite resin group. (J Prosthet Dent 2022;■:■-■)

Dental erosion starts early in life, with the prevalence of pathological erosive wear in the permanent teeth of children and adolescents reported to be 30.4%.[1] During adulthood, severe tooth wear has been observed in 3% of the population at 20 years increasing to 17% at 70 years.[2] Risk assessment and diagnosis are essential in the

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Clinical Implications

CAD-CAM composite resin and ceramic ultrathin occlusal veneers provide optimal and similar clinical performance. If composite resin is chosen, more maintenance might be expected.

contemporary management of erosive tooth wear, which includes preventative measures such as occlusal devices and diet modification.[3] When restorative treatment is essential—because of sensitivity, active caries, difficulty in mastication, compromised oral hygiene, and evidence of progression—strategies based on the maximum preservation of the remaining tooth tissue should be implemented.[3-6]

Direct composite resins are the first choice for restoring small defects. For larger tooth loss, as seen in severe erosive tooth wear, a direct approach is still possible,[3,5,6] yet its success is dependent on the skills of the operator [7,8] and patient tolerance for longer chair time, in addition to higher expected maintenance.[9] When indirect restorations are chosen, ultrathin occlusal veneers (OVs) can address the principles of optimal form, occlusion, and function while abiding by the biomimetic rule of maximum tissue conservation (Fig. 1A, B).[10-12] In patients with severe generalized wear, for which the vertical dimension of occlusion (VDO) is frequently increased, reducing intact tissues may even become unnecessary because clearance is created by the new VDO (Fig. 1C, D).[13,14] However, because of the intrinsic thinness of OVs, only limited increase in the VDO is needed, which is always preferred in patients with class II occlusion.

The ultrathin design also brings simplicity to the indirect restorative method. Their reduced thickness, ranging from 0.4 to 0.6 mm at the fissures to 1.0 to 1.3 mm at the cusp tips, requires a more straightforward approach, essentially driven by interocclusal clearance and anatomic considerations.[10,11] Even thinner designs have been proposed.[8,15-17] Margins should be kept distant from gingiva and without the need to involve proximal contacts.[10-14] As a result, the thickness of the surrounding enamel is retained, resulting in improved bonding.[18] Regarding the restorative material, only ceramics and composite resins are able to satisfy the biomimetic principles of maximum tissue preservation and esthetics. However, these materials will only perform to their full capacity when restoration and tooth structure are ideally bonded to each other[19,20] through an optimized bonded protocol, such as immediate dentin sealing,[21-24] providing an assembly that has been termed the principle of combined action.[25] The development of stronger ceramics such as lithium disilicate,[26] which are machinable and bondable after hydrofluoric acid (HF) etching,[27] has increased indications for bonded restorations. In the early 2000s, a high-performance polymer (HPP) block (Paradigm MZ100 CAD-CAM block; 3M) for computer-aided design and computer-aided manufacturing (CAD-CAM) was introduced,[28] followed by HPP blocks from other manufacturers. Key properties of composite resin restorations include their low abrasiveness to antagonist teeth,[29] better absorption of functional stresses,[30] and better handling properties, including in situ reparability. In vitro accelerated fatigue studies[10,11] have demonstrated that CAD-CAM composite resin OVs significantly increase the fatigue resistance when compared with ceramic OVs. However, data regarding the clinical performance for ceramic and composite resin OVs are lacking.

Therefore, the purpose of this randomized clinical trial was to evaluate the influence of CAD-CAM restorative material (ceramic versus composite resin) on the clinical performance of ultrathin OVs. The null hypothesis was that material selection would not influence the clinical performance of ultrathin OVs.

MATERIAL AND METHODS

This randomized, parallel-group, clinical trial was conducted in the Department of Prosthodontics and Dental Materials of the School of Dentistry of the Federal University of Rio de Janeiro (UFRJ). The study was approved by the Research Ethics Committee of the Hospital Universitário Clementino Fraga Filho at the UFRJ (protocol: 04874713.3.0000.5257) and registered at clinicaltrials.gov (NCT03112278). Details of participant allocation and follow-up are presented in a CONSORT flow diagram (Fig. 2).[31]

Between October 2013 and April 2017, 60 posterior teeth in 11 participants (8 men and 3 women) were restored with 24 ceramic and 36 composite resin ultrathin OVs. The mean participant age was 30.4 years (range, 23.5 to 38.2 years). The sample size was calculated based on the expected difference in survival of composite resin and ceramic of 70%, a power of 0.8, and a significance level of 0.05 (Select Statistical Services). In a previous in vitro study, ultrathin OVs fabricated with MZ100 and e.max CAD presented a survival rate of 90% and 20%, respectively, when subjected to loads of 800 N.[11]

Participants had been referred by the university clinics and by practitioners from both public and private services as a result of an advertising campaign with flyers posted around the university campus and direct communication with dental care providers. Randomization was performed by a computerized random number generator. Given the specific aspects involving the fabrication of the restorations, the blinding of operators (L.H.S. and T.H.R.) was not possible. However, participants and evaluators were not aware of the material assignment. Written informed consent was provided by each

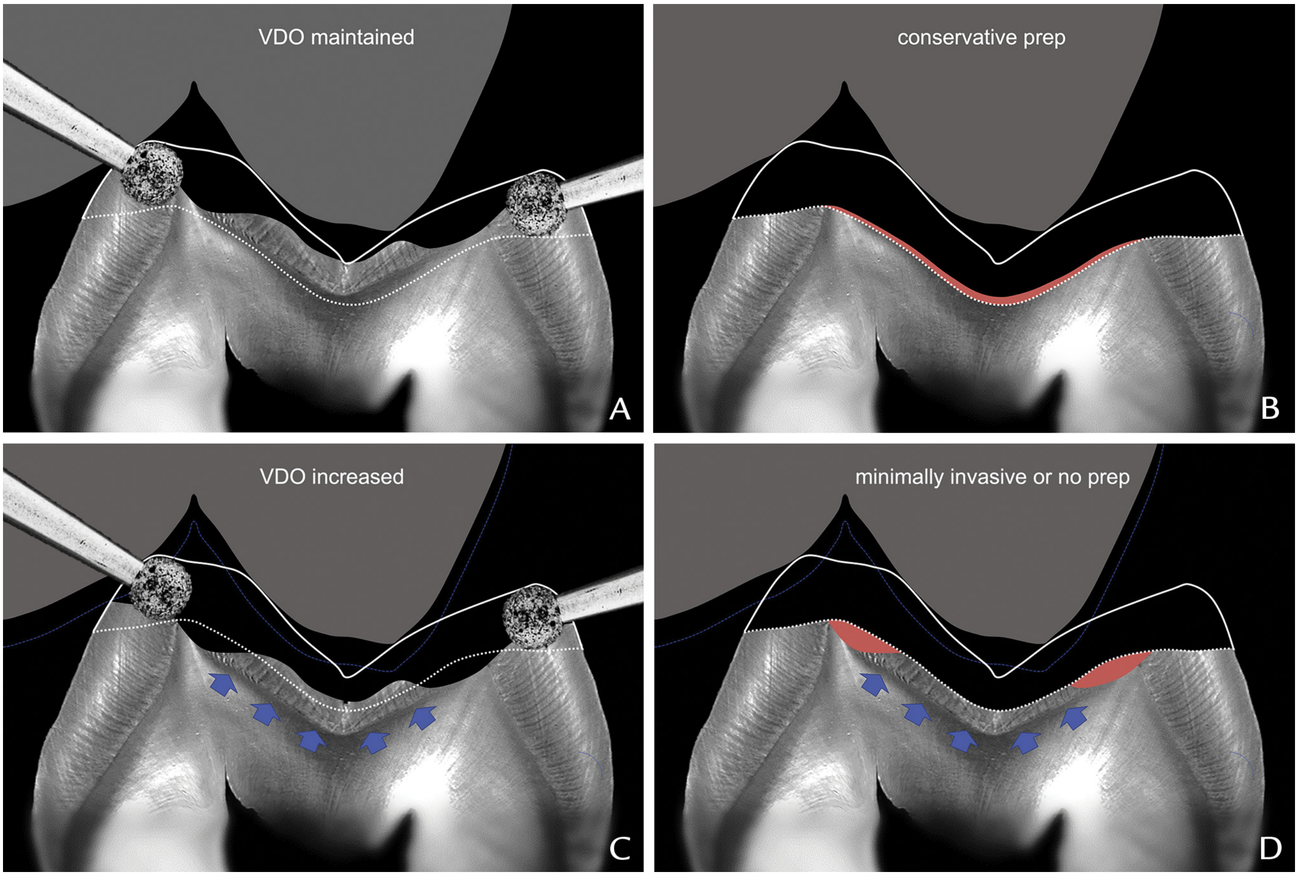

Figure 1. Schematic comparison of 2 OV strategies based on management of VDO. A and B, Ultrathin OVs with VDO maintained, require some preparation (still conservative compared with conventional onlays or crowns). Indicated with localized erosion or wear (single or few restorations). Previous and new dentin exposure from preparation immediately sealed (*red*). C and D, Ultrathin OVs with increased VDO allow for minimal or no preparation (multiple restorations, complete mouth rehabilitation), increasing possibility of preserving intact enamel and dentinoenamel junction (*blue arrows*). OVs, occlusal veneers; VDO, vertical dimension of occlusion.

participant. All the dental treatment, directly or indirectly related to this study, was carried out at no cost to the participants.

Inclusion criteria were a minimum age of 14 years presenting localized or generalized advanced erosive wear (hard tissue loss >50% of the occlusal surface) according to the basic erosive wear examination (BEWE) score system,[32] with good oral hygiene, without active periodontal or pulpal diseases, and willingness to wear an occlusal device upon completion of the restorative treatment. Dentin hypersensitivity associated with dentin exposure subsequent to active erosion was not a reason for exclusion. Exclusion criteria included minimal dental wear requiring only direct composite resin restorations or severe dental wear requiring thicker restorations, such as traditional onlays. Nonvital teeth and the absence of antagonist teeth were also reasons for exclusion.

The participants were initially counseled regarding behavioral risk factors and the changes necessary to prevent the progression of their erosion. Nightguard vital bleaching (Opalescence 10%; Ultradent Products, Inc) was provided when indicated and at the participants' request. Cavitated carious lesions and noncarious cervical lesions (NCCLs) were restored with a direct composite resin (IPS Empress Direct; Ivoclar AG).

An additive diagnostic waxing was provided for all participants from single tooth to complete arch treatments and was used to position silicone guides intraorally for fabricating trial restorations, selective preparation, and interim restorations. The diagnostic waxing also served as the blueprint for the use of the Biogeneric Copy function in the CAD software program (CEREC inLab v4.0.2; Dentsply Sirona) to generate the definitive restorations. The complete sequence has been described in depth in clinical reports by Schlichting et al[13] and Resende et al,[14] including the use of bilaminar veneers in the anterior dentition (combination of palatal composite resin and labial ceramic veneers) when indicated in complete mouth treatments.

The teeth were selectively reduced with tapered diamond rotary instruments (850,314,023; Komet) either through the trial restorations (Fig. 3A, B) or directly (in this

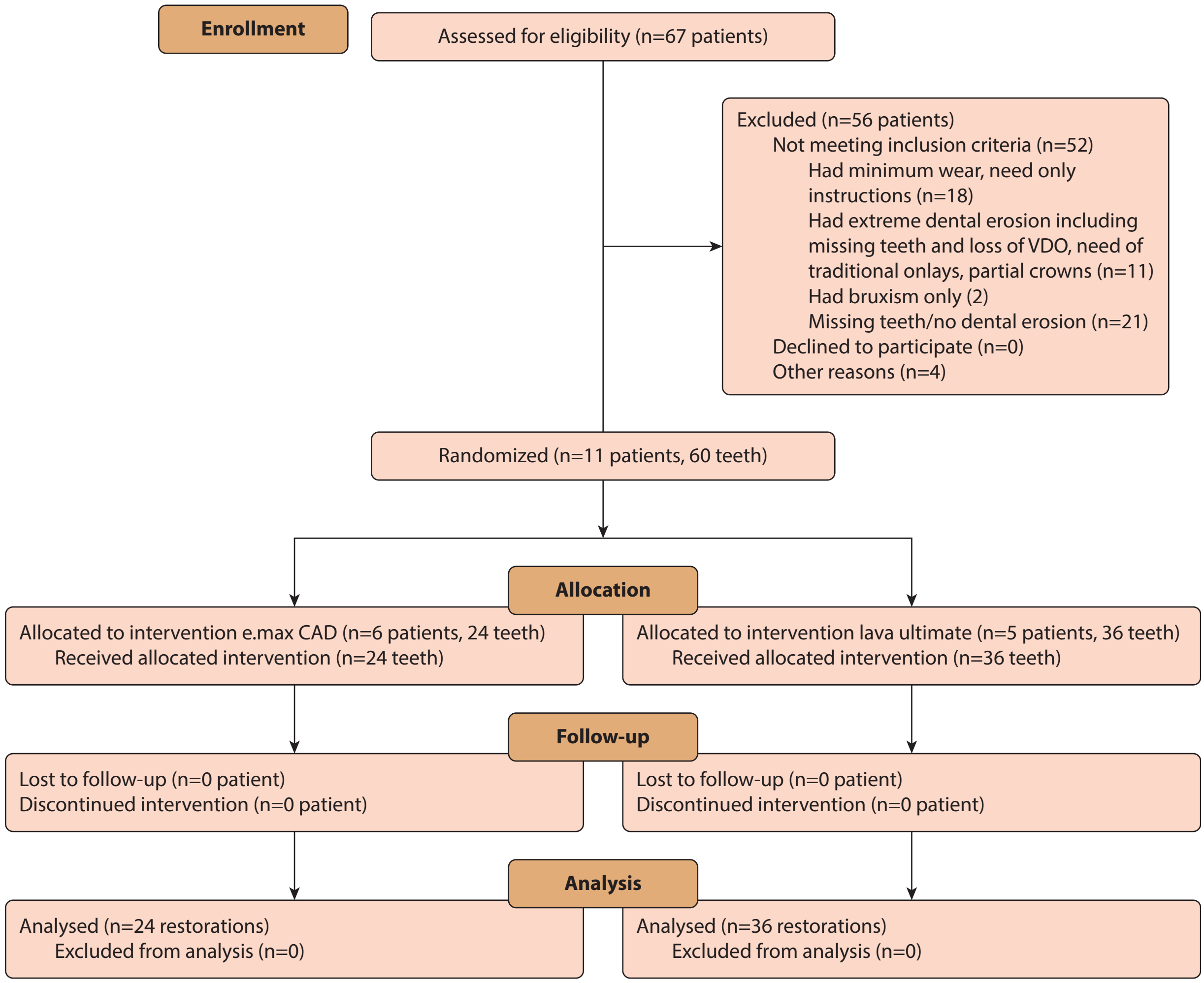

Figure 2. CONSORT 2010 flow diagram showing participant recruitment and follow-up up to 3 years. CONSORT, consolidated standards of reporting trials.

situation, the trial restorations were removed, and the thinnest areas were measured and mapped in the mouth with pencil marks). An average occlusal clearance of 0.4 to 0.6 mm (central groove) to 1.0 to 1.3 mm (cusp tips) was generated for the ultrathin OVs.[13,14] Under dental dam, all areas of exposed dentin were immediately sealed[33-36] (Fig. 3C, D) using a 3-step etch-and-rinse dentin bonding system (OptiBond FL; Kerr Corp). The diagnostic waxing was scanned first for correlation (Cerec Bluecam; Dentsply Sirona), and the prepared teeth were then scanned.

By using the design tools of the CAD software program (CEREC InLab v4.0.2; Dentsply Sirona) set in Biogeneric Copy, the restorations were designed by correlating the diagnostic waxing with the preparations. The ultrathin OVs were milled from a lithium disilicate ceramic (e.max CAD HT; Ivoclar AG) or a composite resin (LAVA Ultimate HT; 3M ESPE). The restorations were inspected for cracks or chips from the milling process. The composition and the batch number of the materials are listed in Table 1.

Lithium disilicate restorations were first crystalized, then characterized (IPS e.max Ceram Shade and Essence; Ivoclar AG), and then glazed (IPS e.max Ceram Glaze Paste Fluo; Ivoclar AG) in a ceramic furnace (Programat P300; Ivoclar AG) according to the manufacturer instructions. The 3 steps were conducted separately. The composite resin restorations were characterized (Kolor + Plus; Kerr Corp) and then polished mechanically (Jiffy Brush; Ultradent Products, Inc).

The restorations were delivered without local anesthesia.[23] The intaglio surface of the ceramic restorations was etched with 10% hydrofluoric acid (Dentsply Sirona) for 20 seconds. After rinsing under tap water for 20 seconds, the restorations were subjected to postetching cleaning using phosphoric acid (Ultra-Etch; Ultradent Products, Inc) with a brushing motion for 60 seconds, followed by air-water spray cleaning for 30 seconds. After air-drying, the intaglio surfaces were silanated with a brushing motion for 20 seconds (Monobond Plus; Ivoclar AG), air dried, and heat dried at 68 °C for about 5

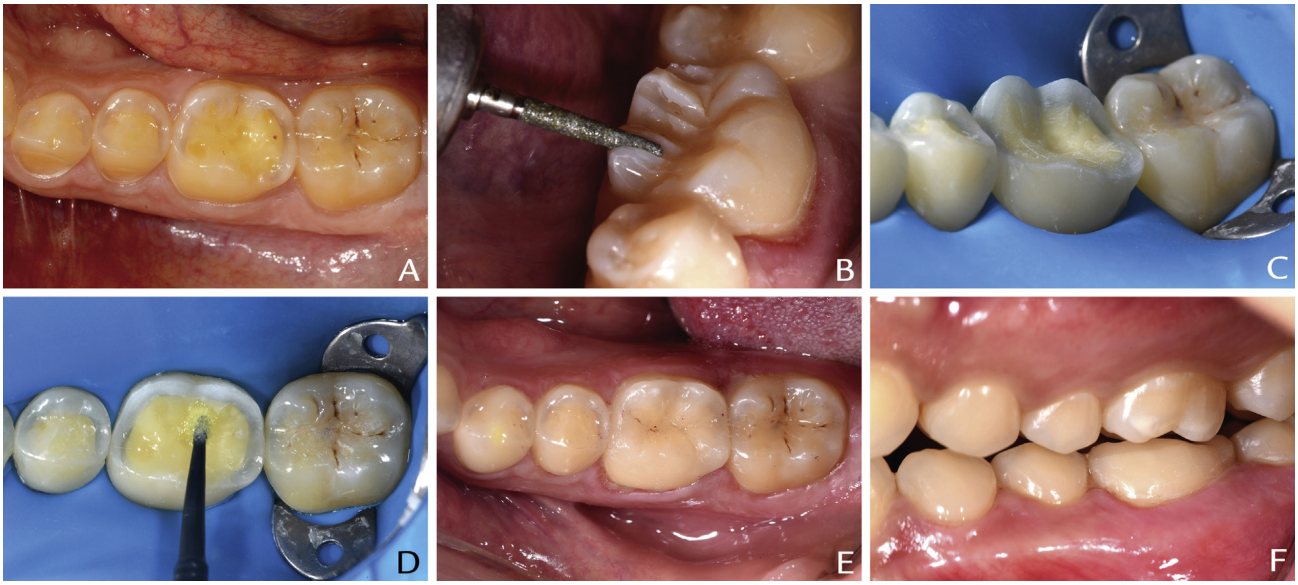

Figure 3. A, Severe erosion of 30-year-old participant possibly associated with combination of intrinsic and extrinsic acids. First molar more affected on occlusal surface while premolars on buccal. B, Preparation driven by trial restoration (Protemp 4; 3M ESPE). C, Preparation completed. D, Immediate dentin sealing (OptiBond FL; Kerr Corp). E and F, Occlusal and buccal views (slightly opened mouth). Note excellent tooth-restoration blending (ultrathin OVs on first molar–e.max CAD A2 HT) on both occlusal and buccal views. NCCLs on first mandibular molar and maxillary and mandibular premolars restored with direct composite resin (Empress Direct; Ivoclar AG). NCCLs, noncarious cervical lesions.

Table 1. Brand names, manufacturers, class, composition, and batch numbers of materials used

Material	Manufacturer	Class	Composition	Batch Number
Ultra-Etch	Ultradent Products, Inc	Phosphoric acid	35% phosphoric acid	30064612
OptiBond FL	Kerr Corp	Etch-and-rinse 3-step adhesive system	Primer: HEMA, ethanol, GPDM, MMEP, water, CQ, BHT Adhesive: TEGDMA, UDMA, GDMA, HEMA, Bis-GMA, filler, CQ, approximately 48 wt% filled	4788192
Porcelain etch	Ultradent Products, Inc	Hydrofluoric acid	Buffered 9% hydrofluoric acid	507351
Monobond Plus	Ivoclar AG	Universal primer	Ethanol, 3-trimethoxysilylpropyl methacrylate, methacrylated phosphoric acid ester	T29123
Filtek Z100 A1/A2	3M ESPE	Micro-hybrid composite	BIS-GMA, TEGDMA, zirconia/silica fillers	N414951
e.max CAD HT A1/A2	Ivoclar AG	Lithium disilicate glass-ceramic	SiO_2, Li_2O, K_2O, P_2O_5, ZnO_2, Al_2O_3, MgO, and coloring oxides	R77046, T24176/R81821, T28586
IPS e.max Ceram Glaze Paste Fluo	Ivoclar AG	Glaze	Oxides, glycerine, butandiol, poly(vinyl pyrrolidone)	T45071
IPS e.max Ceram Stain and Glaze Liquid	Ivoclar AG	Diluent	Butandiol, pentandiol	T44225
IPS e.max Ceram Essence	Ivoclar AG	Stain	Oxides	S00854
Lava Ultimate HT A1/A2/A3	3M ESPE	Nanoparticulate prepolymerized resin composite	Bis-GMA, Bis-EMA, UDMA, TEGDMA, silica particles (20nμ); zirconia particles (4 to 11 nμ); nanoparticle clusters	N574684/N814642
Empress Direct	Ivoclar AG	Nanohybrid	Bis-GMA, UDMA, TCDD, barium alumina fluorosilicate glass, mixed oxide, ytterbium trifluoride	R65565

minutes (Calset; AdDent Inc). The same protocol was used for the composite resin restorations, except that airborne-particle abrasion with 50-μm alumina oxide (Bio-Art) at 0.2 MPa and air-water spray cleaning for 30 seconds were used instead of the hydrofluoric etching step. Under dental dam, the tooth preparations were airborne-particle abraded and etched for 30 seconds with 37.5% phosphoric acid (Ultra-Etch; Ultradent Products, Inc), rinsed, and dried. Adhesive resin (OptiBond FL, bottle 2; Kerr Corp) was applied to both fitting surfaces of the restoration and tooth and left unpolymerized and protected from direct light. The luting material (Filtek Z100; 3M ESPE) was preheated to 68 °C (Calset) and applied to the tooth, and the OVs were seated, followed by the removal of the excess composite resin and initial light polymerization. Each surface was exposed at 1000

Table 2. List of criteria (modified USPHS adapted for this study) used for clinical observations of ultrathin occlusal veneers

	Score		
Category	**Acceptable**	**Unacceptable**	**Criteria**
Surface luster/roughness	1	–	Comparable to that of the surrounding enamel
	2	–	Slightly dull, not noticeable from speaking distance
	3	–	Dull but still acceptable if wet
	–	4	Rough and pitted, simple polishing is not sufficient
	–	5	Quite rough, recycling by finishing not feasible
Surface and marginal staining	1	–	No staining
	2	–	Slight staining, can be polished away
	3	–	Moderate staining, not esthetically unacceptable
	–	4	Obvious staining, cannot be polished away
	–	5	Severe staining
Color match	1	–	Excellent color match
	2	–	Good color match
	3	–	Slight mismatch in shade, brightness, or translucency
	–	4	Obvious mismatch, outside the normal range
	–	5	Gross mismatch
Anatomic form	1	–	Form is ideal
	2	–	Form deviates slightly from the remainder of the tooth
	3	–	Form differs but is not esthetically displeasing
	–	4	Form is unacceptable esthetically
	–	5	Form is completely unsatisfactory and/or lost
Fracture of restoration	1	–	No fractures/cracks
	2	–	Subsurface cracks or cracks smaller than 2 mm in length
	3	–	Minor chip not affecting marginal integrity
	–	4	Crack's length greater than or equal to 2 mm and involving the surface of the restoration and/or chipping fractures affecting marginal quality; bulk fractures with partial loss (less than 1/3 of restoration)
	–	5	Partial or complete loss of restoration
Marginal adaptation	1	–	Restoration is continuous with existing anatomic form; explorer does not catch
	2	–	Explorer catches; no crevice is visible
	3	–	Crevice at margin, enamel exposed
	–	4	Obvious crevice at margin, dentin, or IDS exposed
	–	5	Restoration fractured or missing
Patient's view	1	–	Entirely satisfied
	2	–	Satisfied
	3	–	Minor criticism of esthetics, function (chewing discomfort)
	–	4	Desire for improvement
	–	5	Completely dissatisfied
Postop. hypersensitivity and tooth vitality	1	–	No hypersensitivity, normal vitality
	2	–	Low hypersensitivity of short duration, less than one week
	3	–	Intense hypersensitivity of duration longer than one week but less than six months, premature/intense or delayed/weak sensitivity
	–	4	Premature/very intense or extremely delayed/weak with subjective complaints or negative sensitivity
	–	5	Very intense pulpitis or nonvital
Recurrence of erosion/caries	1	–	No recurrent erosion/caries
	2	–	Very small and localized erosion/demineralization
	3	–	Larger areas of erosion (dentin not exposed)/demineralization
	–	4	Erosion with dentin exposure/caries with cavitation
	–	5	Exposed dentin inaccessible for repair/deep secondary caries
Fracture of tooth	1	–	Complete integrity
	2	–	Hairline crack enamel
	3	–	Enamel split
	–	4	Major enamel split
	–	5	Cusp or tooth fracture

USPHS, United States Public Health Service.

mW/cm^2 (Valo; Ultradent Products, Inc) for 60 seconds (20 seconds per surface, repeated 3 times). The margins were covered with an oxygen blocker (K-Y Jelly; Johnson & Johnson) and light polymerized for an additional period of 20 seconds. Minimal or no occlusal adjustment was necessary. In the following appointment, margins were finished and polished with diamond ceramic polishers (W16Dg, W16Dmf, and W16D; EVE Diapol; EVE Ernst Vetter GmbH) and silicon carbide−impregnated rubber polishers (Jiffy; Ultradent Products, Inc).

The participants were evaluated approximately 1 week after restoration delivery and then once a year. They had been advised to call immediately in case of problems. The restorations and teeth were assessed by 2 experienced independent examiners (A.R.S. and I.C.C.), calibrated before the baseline assessment. Dental mirrors (Single-sided #5; Hu-Friedy), explorers (Double-ended EXD5; Hu-Friedy), and periodontal probes (PCPUNC156; Hu-Friedy) aided vision, tactile discrimination, and measuring, respectively. Transillumination (Microlux; AdDent) was used for crack detection. Moisture control was achieved with cotton rolls and suction and compressed air. The restorations were evaluated according to the modified United States Public Health Service (USPHS) criteria. Failure was considered whenever a restoration received a score 4 or 5 (Table 2). Restorations graded 4 were considered unacceptable but still repairable, while restorations graded 5 were considered failures with immediate need of replacement.[37] The percentage of agreement of scores was 84.1% (kappa coefficient=0.42). Discrepancies were then resolved by consensus.

The data were analyzed with a statistical software program (IBM SPSS Statistics for Macintosh, v27.0; IBM Corp). Time to failure was the event of interest. Restorations not presenting failure at the final recall were censored. Kaplan-Meier survival probabilities, standard errors, and 95% confidence interval were estimated for the 2 restorative materials. Differences in survival between the groups were assessed with the Mantel-Cox log rank test (α=.05). A nonparametric test (Mann-Whitney U) was applied for the qualitative evaluation of the data.

RESULTS

The mean follow-up time was 27.1 months (SD, 6.1 months; range, 9.6 to 35.6 months), and no participants were lost to follow-up. At the final follow-up, 16 OVs had been evaluated 4 times (baseline, first year, second year, and third year), 42 OVs were evaluated three times (baseline, first year, and second year), and 2 OVs were evaluated 2 times (baseline and first year). Of these 60 OVs, 9 were bonded to first premolars, 12 to second premolars, 23 to first molars, and 16 to second molars. The average thickness of the restorations was 0.55 mm at the central groove, 0.89 mm at the internal cusp slope, 1.00 mm at the cusp tip, and 0.78 mm at the marginal ridge.

The survival estimate was not statistically significantly different (*P*=.124, CI=95%) for e.max CAD compared with Lava Ultimate (100% versus 84.7%; SE, 0.065%) (Fig. 4). The pooled Kaplan-Meier 3-year survival rate for ultrathin OVs was 88.4% (SE, 0.054%) (Fig. 5).

In the Lava Ultimate group, 5 partial failures (all score 4) were observed as chipping fracture affecting the margin integrity. The first event occurred 8.3 months after baseline on the buccal margin of a mandibular left first premolar (Fig. 6A). The second failure was identified on a mandibular right first molar, with a chip on the distal buccal cusp. A third fracture was also observed in the same patient, same quadrant, on the distal marginal ridge of a first premolar. Both fractures happened 13 months after baseline (Fig. 6B). A fourth chip was seen 23.5 months after baseline on a maxillary left second molar in another patient with loss of the fragment of the mesial lingual cusp. The last event occurred at 30.8 months, on a mandibular right second premolar with a slight chip at the buccal margin. All these fractures were repaired with direct composite resin (IPS Empress Direct; Ivoclar AG) under dental dam isolation. Most of the repaired restorations survived until the last follow-up, except the mandibular right first molar that had to be repaired again at 30.8 months on the same distal buccal cusp.

The performance of restored teeth was also clinically assessed by using the USPHS criteria (Table 2). Comparisons between baseline and the last follow-up revealed significant differences between groups only for the first criterion (Table 3). Composite resin OVs exhibited more surface roughness changes than ceramic ones (Mann-Whitney U=230, *P*=.003) (Fig. 7A, B). Eight of the Lava Ultimate restorations were scored 3 because of increased roughness located at the occlusal contacts. The other criteria did not have statistically significant differences. Surface/marginal staining and color match were slightly better in the ceramic group, but not statistically significant (Mann-Whitney U=468, *P*=.809 and U=318.5, *P*=.280). Postoperative sensitivity−transient pain elicited under stimulation with a cold spray (Endo Ice; Coltène)−was present at baseline in 8 teeth and at the last follow-up in 7 teeth. Recurrence of erosion or secondary caries was not detected.

One tooth with an e.max CAD OV developed an irreversible pulpitis requiring endodontic treatment. The endodontic access was performed through the OV, which was later replaced. Originally, before the preparation and delivery of the OV, this tooth presented a large NCCL that was restored as well as a large class 1

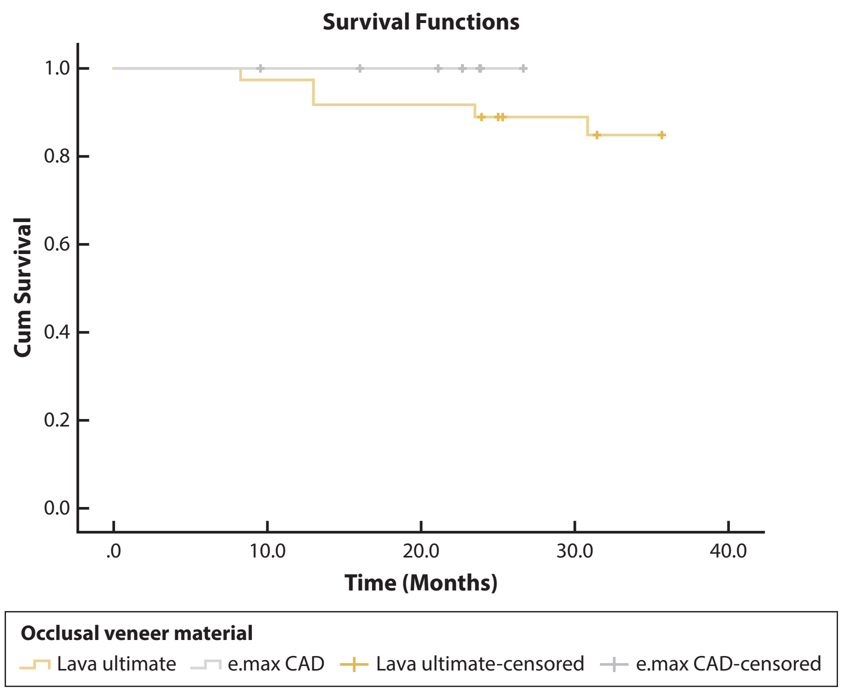

Figure 4. Survival estimate for e.max CAD (100%, events n=0) and Lava Ultimate (84.7%, events n=5) ultrathin occlusal veneers as function of time.

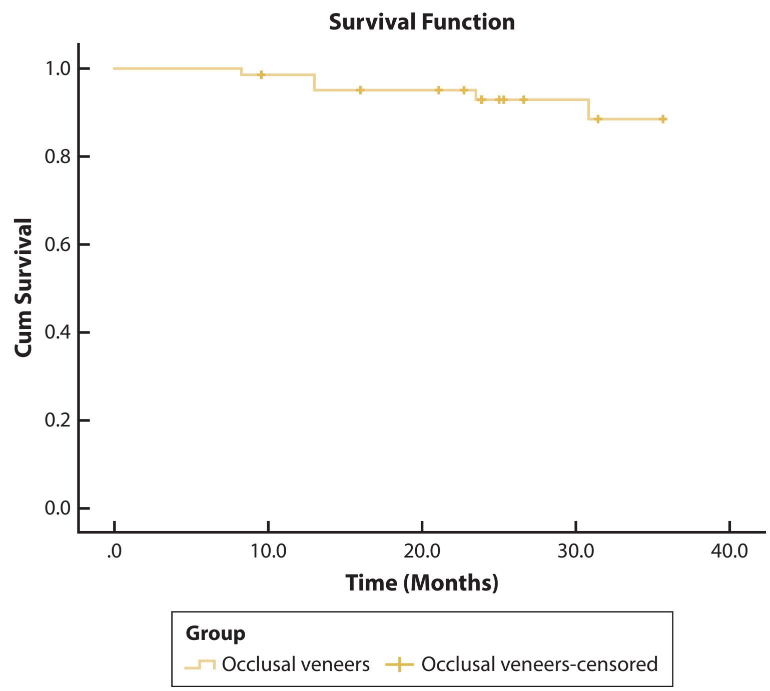

Figure 5. Survival estimate for ceramic and resin ultrathin occlusal veneers (88.4%, events n=5) as function of time.

occlusal composite resin that was replaced owing to hypersensitivity. This tooth was censored for the Kaplan-Meier survival analysis. Regardless, overall patient response was optimal with all participants, except 1 e.max OV (score 3), showing entire satisfaction (score 1).

DISCUSSION

To the knowledge of the authors, this is the first randomized clinical trial on OVs, which constitutes a valuable step after original in vitro studies published in 2010,[10] 2011,[11] and 2012.[12] The null hypothesis that no

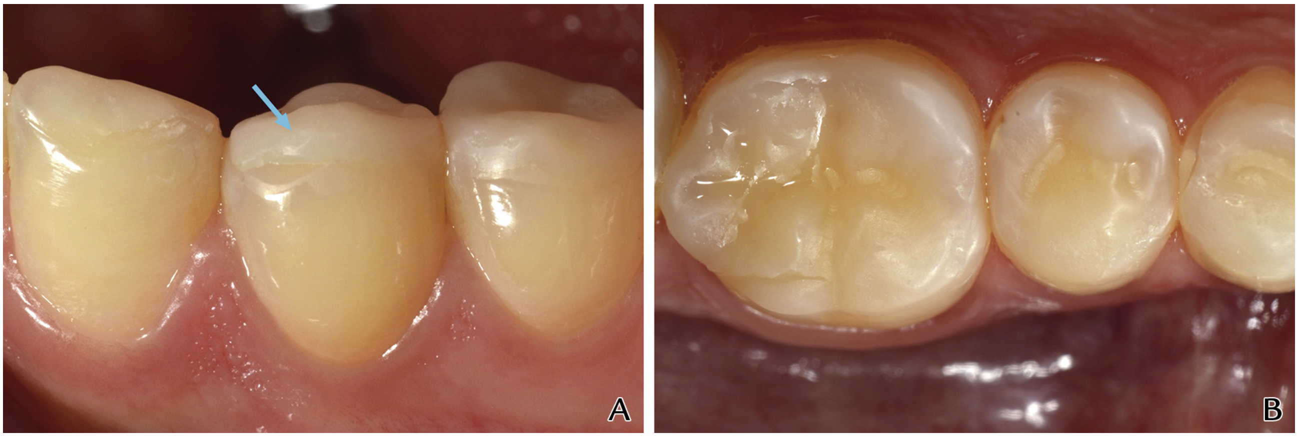

Figure 6. A, Chipping fracture of ultrathin composite OV on mandibular left first premolar. Note that crack started from occlusal contact (wear facet from opposing canine: *blue arrow*). B, Chipping fractures on mandibular right first molar (distobuccal cusp) and first premolar (distal marginal ridge). Observe minor marginal staining in distolingual aspect on second premolar.

significant difference in terms of clinical survival would be found between the 2 materials evaluated in this study for OVs was accepted. The overall survival rate of 88.4% up to 36 months was considered clinically acceptable.

The participant enrollment process was influenced by the strict inclusion criteria and was slower than expected, taking almost 3.5 years to complete the sample size of 11 participants. In addition, some participants presented with multiple worn teeth with an indication for ultrathin OVs. During the planning of the study, a split-mouth design or mixing materials in the same participants was considered. However, the potential for unbalanced wear between different restorative materials in opposing arches or sides of the mouth led to rejection of this study design. The participants and evaluators were blinded except for the 2 operators. The average thickness of the restorations in both groups was similar, suggesting that nonblinded operators had minimum impact in the preparation and design phases, a key aspect in the performance of the ultrathin OVs. Therefore, the internal validity of the study was considered to be acceptable despite the particularities of this RCT. Regarding external validity, the protocol was executed by experienced operators in a university setting under controlled conditions; however, practitioners familiar with conservative techniques and adhering to bonding protocols should be able to replicate the restorations.

All failures in the composite resin group (Lava Ultimate) occurred under the criteria “fracture of restoration.” These 5 chips were limited to the restoration margins without involvement of the remaining tooth structure and rated as unacceptable (score 4), but reparable, which is essential for the long-term survival of the remaining sound tooth structure. The results of the present study conflicted with the in vitro findings by Magne et al[10] and Schlichting et al,[11] who reported that CAD-CAM composite resin ultrathin OVs (Paradigm MZ100) demonstrated increased fatigue resistance when compared with ceramic ultrathin OVs (e.max CAD and Empress CAD), possibly because of differences between MZ100 and Lava Ultimate. At the time of this randomized clinical trial, MZ100 was not available in Brazil, where the study was conducted. Lava Ultimate, however, had been recently introduced to the Brazilian market with supposedly better mechanical properties than its predecessor MZ100.[38,39] Nevertheless, the original indications for Lava Ultimate were subsequently restricted by the manufacturer, who limited its use to partial restorations (inlays and onlays) and recommended only adhesive luting. Additionally, for the original in vitro studies using MZ100 OVs,[10,11] the simulated masticatory forces were applied vertically by the closed-loop servohydraulic simulator to reproduce a highly standardized tripodic contact, but which did not reproduce the typical cusp-tip fossa-to-marginal ridge relationship and did not simulate eccentric movements during parafunction. Many participants in the present study reported a history of bruxism, including one of those who had experienced restoration failures. This participant only started wearing his nightguard after 13 months, which could have made the restorations more vulnerable to the parafunction during this period. The low prevalence of cracks in the central groove area (Table 3) suggests that extreme occlusal loads (for example, higher than 600 N) were not reached in the ceramic group and likely not in the composite resin group, in contrast with the in vitro studies[11,12] when higher loads (up to 1400 N) repeatedly induced cuspal flexure. In contrast, clinical peripheral fractures (chips) were in part a product of repetitive functional or parafunctional loading. As demonstrated by Belli et al,[40] composite resins and ceramics are affected by mechanical aging with similar degradation of their mechanical properties. However, because e.max CAD has a higher initial flexural strength, its residual fatigue

Table 3. USPHS evaluations of the ultrathin occlusal veneers at baseline and final follow-up (significant differences between materials for *P*<.05)*

		Baseline			Final Recall		
Category and Score		**e.max CAD n=24**	**Lava Ultimate n=36**	***P***	**e.max CAD n= 23**	**Lava Ultimate n=31**	***P***
Surface luster/roughness	1	24	32	.094	22	19	.003 *
	2	0	4	–	1	4	–
	3	0	0	–	0	8	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Surface and marginal staining	1	22	36	.081	20	26	.809
	2	2	0	–	2	5	–
	3	0	0	–	1	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Color match	1	21	27	.194	21	25	.280
	2	3	5	–	2	6	–
	3	0	4	–	0	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Anatomic form	1	15	19	.460	14	16	.449
	2	9	17	–	9	14	–
	3	0	0	–	0	1	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Fracture of restoration	1	24	36	1.000	22	27	.296
	2	0	0	–	0	1	–
	3	0	0	–	1	3	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Marginal adaptation	1	20	31	.770	18	28	.314
	2	4	5	–	5	3	–
	3	0	0	–	0	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Patient's view	1	23	36	.221	23	31	1.000
	2	0	0	–	0	0	–
	3	1	0	–	0	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Postop. hypersensitivity and tooth vitality	1	19	33	.166	21	26	.426
	2	5	3	–	2	5	–
	3	0	0	–	0	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Recurrence of erosion/caries	1	24	36	1.000	23	31	1.000
	2	0	0	–	0	0	–
	3	0	0	–	0	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–
Fracture of tooth	1	13	17	.601	12	14	.613
	2	11	19	–	11	17	–
	3	0	0	–	0	0	–
	4	0	0	–	0	0	–
	5	0	0	–	0	0	–

USPHS, United States Public Health Service.

strength could remain higher than that of Lava Ultimate,[40] explaining the improved behavior of e.max CAD in the areas of high mechanical stress. However, this finding will need to be confirmed with a subsequent clinical trial, which is underway. Additionally, as underlined by Heck et al,[8] the prepared teeth displayed a

Figure 7. A, Occlusal view of ultrathin composite resin OVs (premolars and molars) at baseline. B, Same restorations 31 months later. Note increased roughness located at occlusal contacts. OVs, occlusal veneers.

dentin core with a relative low elastic modulus (16 MPa) surrounded by an enamel rim with a significant higher elastic modulus (80 GPa). From a biomimetic perspective, this restorative scenario would benefit from a material with an elastic modulus (glass-ceramic approximately 65 GPa) similar to that of enamel. The dissipation of high occlusal loads over the enamel ring area would be less natural for a composite resin such as Lava Ultimate with a lower modulus (approximately 13 GPa).

The luting procedure included immediate dentin sealing (sealing the freshly cut dentin with a dentin bonding agent directly after tooth preparation, before the definitive impression) associated with the application of a preheated light-polymerized restorative composite resin material as a luting agent.[24] This has been considered the state of the art in bonding indirect restorations, as demonstrated by Gresnigt et al[41] in a recent clinical trial.

Increased surface roughness at the occlusal contacts was observed in the composite resin OVs (8 of 31, score 3) (Table 3). The increased roughness was detected under air drying and using magnification (Fig. 7). Saratti et al[42] reported a similar pattern of pitted surface in indirect composite resin restorations including a CAD-CAM Lava Ultimate overlay with evidence of occlusal surface degradation from a combined process of matrix cracking (cyclic mechanical fatigue) and matrix-filler interface debonding (hydrolysis from the biofilm). This phenomenon should not be overlooked since microcracks are likely to be associated and eventually become macrocracks. No restoration was repolished since it would have changed the occlusion scheme.

Slight deviation from the ideal anatomic form (score 2) was often perceived between baseline and the final follow-up regardless of the material type and could be attributed to the manufacturing process; grinding tools cannot replicate the sophisticated anatomy of the occlusal fissures. However, this is a limitation that does not significantly compromise masticatory function. In fact, it resembles natural teeth when fissures are sealed, and it protects the occlusal surface from harmful tensile stress concentrations.[43] Further studies are required to assess the clinical performance of ultrathin OVs with endodontic treated teeth as well as to evaluate newly marketed CAD-CAM blocks.

CONCLUSIONS

Based on the findings of this randomized clinical trial, the following conclusions were drawn:

1. The survival rates of ultrathin bonded OVs used to treat posterior teeth subjected to erosive wear, observed up to 36 months, demonstrated high patient satisfaction and provided favorable performance, with a slight advantage for ceramic (e.max CAD) than for composite resin (Lava Ultimate) that was not statistically significant.
2. No restorations were lost. Failures were only partial and easily and successfully repaired up to the last evaluation.
3. Slight surface degradation at the occlusal contact area of composite resin OVs was observed.

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Luís Henrique Schlichting: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Tayane Holz Resende:** Investigation, Resources, Data curation, Project administration. **Kátia Rodrigues Reis:** Investigation, Resources, Funding acquisition. **Aline Raybolt dos Santos:** Investigation, Funding acquisition. **Ivo Carlos Correa:** Investigation, Funding acquisition. **Pascal Magne:** Methodology, Writing – review & editing.

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