Comparison of posterior indirect adhesive restorations (PIAR) with different preparations designs according to the adhesthetics classification. Part 2: Effects on marginal quality

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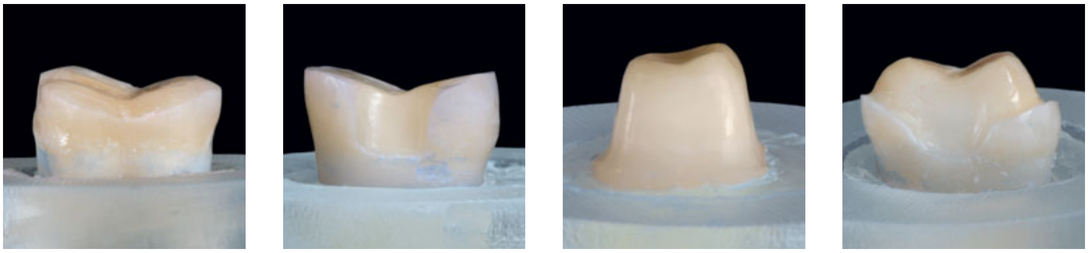

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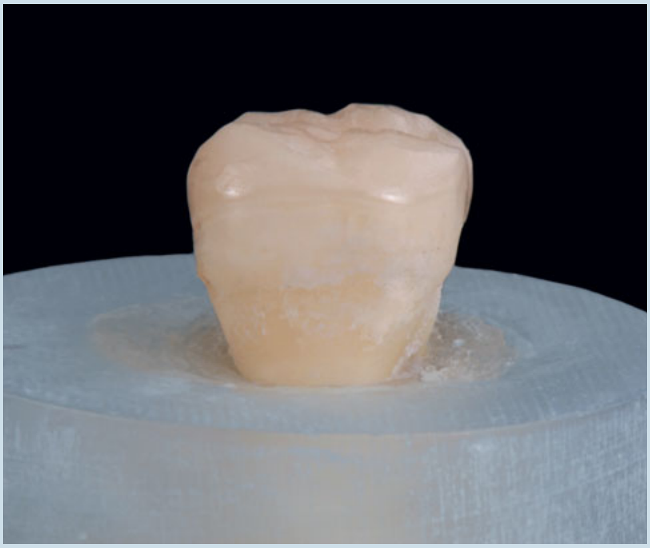
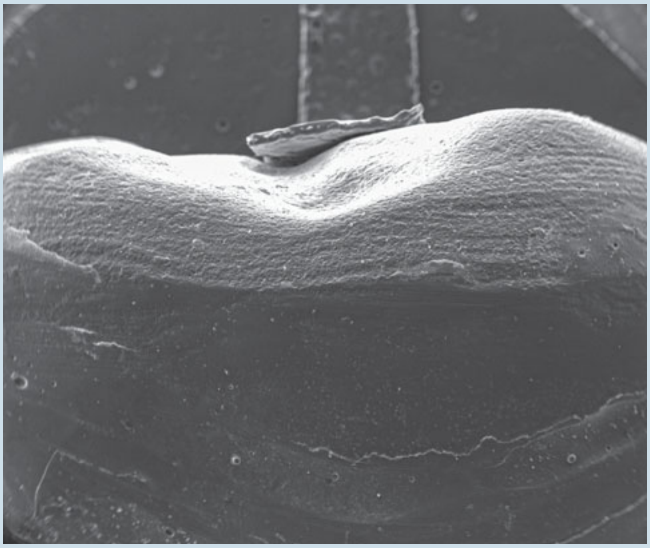
Abstract

Aim: To investigate whether different restoration designs, overlay types, and full crowns in posterior teeth have similarly acceptable marginal sealing and quality.
Materials and methods: For Part 1 of the present study (investigation of fracture resistance), 70 extracted molars were divided into five groups (N = 14), prepared with four different posterior indirect adhesive restoration (PIAR) overlay design types, according to the adhesthetics classification. The groups were: 1. Butt Joint; 2. Full Bevel; 3. Shoulder; 4. Full Crown; 5. Sound Tooth. For Part 2 of the study (present article; marginal quality), there was no group 5, and only 56 of the 70 extracted molars were used. Seven expert dentists performed all the preparation and cementation phases with codified protocols. A CAD/CAM workflow was used to realize the 56 monolithic lithium disilicate restorations. The samples were tested with thermomechanical loading (TML) and the marginal quality evaluated. The data relating to fracture resistance are presented in Part 1 of this study (Int J Esthet Dent 2021;16:2–17).
Results and conclusions: In terms of marginal quality after TML, within the limitations of the present study, in molar teeth (without endodontic treatments) restored with different monolithic ceramic lithium disilicate PIAR designs, it is possible to present the following conclusions:

1. All tested PIAR designs showed very good marginal adaptation (mean 98.7% continuous margins) after TML that simulated approximately 5 years of clinical use.
2. The restorations in the Full Crown (99.7%), Full Bevel (99.4%), and Shoulder (98.8%) groups showed better marginal adaptation than those in the Butt Joint (97.1%) group.

(Int J Esthet Dent 2021;16:262–279)





Introduction

Proper marginal sealing to prevent secondary carious lesions is a crucial aspect for a good prognosis in posterior restorations. The present study aimed to investigate the marginal quality of different posterior indirect adhesive restorations (PIAR) realized on different preparation designs (Fig 1) after thermomechanical loading (TML).

Discussed in the first part of this article series (Int J Esthet Dent 2021;16:2–17) was how PIAR, if carefully prepared, can have similar or even better performance in terms of fracture resistance than crowns. In this second part of the article series, what is analyzed is how an adequate preparation, a precise restoration, and a meticulous cementation protocol can make a difference in the clinical success of a restoration over time.

Over the past 20 years, partial ceramic restorations have become very popular and routinely used in clinical practice. Longer-term studies, of a duration of more than 5 years, generally indicate a survival rate of 71% to 98.5%.[1] Typical causes of ceramic failure are fracture, debonding (loss of retention), caries, endodontic or periodontal complications, and tooth extraction. Reviews on ceramic restorations consistently report that fracture is the most frequent type of ceramic restoration failure,[2-4] with the second most common cause being debonding, which reflects failure at the cementation interface.[1] Although the use of adhesives is commonplace in the modern dental practice, the procedure for indirect ceramic bonding remains technique sensitive.[5,6] Factors that complicate ceramic adhesion include etching, cement manipulation, and the adherence to bonding protocols and moisture control. This is even more important in onlays due to the generally less retentive preparation and the greater reliance on the adhesive bonding to retain the restoration. One study noted that clinicians had a different failure rate with regard to ceramic restorations, which may be attributed to different cementation techniques and varying clinical experience.[7] There is agreement that a stable bond between ceramic and dentin is crucial for fracture strength, marginal adaptation, and dentin sealing.[8] Bonding to enamel (etching with phosphoric acid) and ceramic (etching with hydrofluoric acid [HF] and the subsequent application of a silane coupling agent) can largely be considered reliable and unproblematic; bonding to dentin is usually the weakest link in the luting process.[9]

Long-term results must be considered when evaluating prosthesis success. Poor marginal adaptation can lead to microleakage, dissolution of the luting, secondary caries, and gingival inflammation.[10] A recent systematic review by Abduo and Sambrook[1] showed that the commonly observed deterioration patterns were related to marginal integrity, margin discoloration, surface roughness, color match, and anatomical form. The most frequent form of deterioration was associated with marginal quality (integrity and discoloration) in the range of 6.9% to 86.7%.[6,11-14]

Fig 1 Bonded PIAR samples after thermomechanical loading (TML) and before marginal evaluation.

After 11 years of placement, 50% of indirect inlays presented marginal discoloration, against 26% for direct inlays.[15] Marginal integrity and discoloration are most influenced by the marginal fit of the ceramic restoration and the mechanical and chemical degradation of the adhesive interface. A laboratory investigation indicated that a relationship exists between the width of the marginal gap and the depth of the marginal deficiency.[16] A scanning electron microscope (SEM) analysis of cemented inlays reported that a wider gap between the ceramic and tooth structure is associated with increased wear of the cementation composite and the subsequent development of a marginal deficiency.[17]

Today, multi-step etch-and-rinse adhesives with dual-curing luting composites represent the gold standard, but the clinical success of ceramic–tooth bond strength is related to a much larger extent to the execution of the correct protocols than to material properties.[18] Not much data exists in the current literature on ceramic adhesive restorations in the posterior region as regards the type of preparation performed, and whether this factor could have an influence on marginal longevity when the adhesive protocols are kept constant. Therefore, the purpose of this in vitro study (codified as ARG2 and performed by the Adhesthetics Research Group in collaboration with University of Trieste) was to provide more information about the deterioration behavior of different PIAR designs according to the adhesthetics codification,[19,20] evaluating the marginal quality of three different overlay design preparations (Butt Joint, Full Bevel, and Shoulder) compared with Full Crown (modified chamfer). The study was undertaken by seven different operators after a thermomechanical fatigue test of 1,200,000 cycles, which simulates 5 years of clinical service. The null hypothesis was that the type of preparation influences the marginal quality of a restoration.

Materials and methods

Specimen preparation

A total of 70 human third molars were used for this study, only 56 of which were used in this part of the study (Part 2). The other 14 molars were used in the Sound Tooth (control) group for Part 1 of this study, which considered fracture resistance and is discussed in the first part of this article series (see: Int J Esthet Dent 2021;16:2–17). The molars, extracted for periodontal reasons and without any caries or fillings, were cleaned and stored in a 0.1% thymol solution. Study participants provided informed consent under protocol 194/2019, approved by the Regional Ethical Committee (CEUR) of Friuli Venezia Giulia, Italy. Following extraction, plaque, calculus, and periodontal fibers were removed, and each tooth was stored in 0.5% chloramine at 4°C for up to 30 days.

The roots of the teeth were mounted in resin cylinders with diameters of 20 mm up to the cervical third of the root; 2 to 3 mm apart from the cementoenamel junction (CEJ), and fixed with transparent acrylic resin (Ortho-Jet; Lang Dental).

Tooth preparation

The teeth were randomly assigned to four test groups, with 14 teeth in each group, according to the preparation technique that would be used for a full-coverage monolithic lithium disilicate restoration (IPS e.max LT A2 CAD; Ivoclar Vivadent). Seven experienced operators in four different dental clinics in Italy (Federico Ferraris, Sergio Cincera, and Michele Tognini in Alessandria; Eliseo Sammarco in Manduria; Gabriella Romano in Casarano; and Tommaso Mascetti and Marco Testori in Milan) performed all the operative phases for sample preparation, dentin sealing, and cementation.

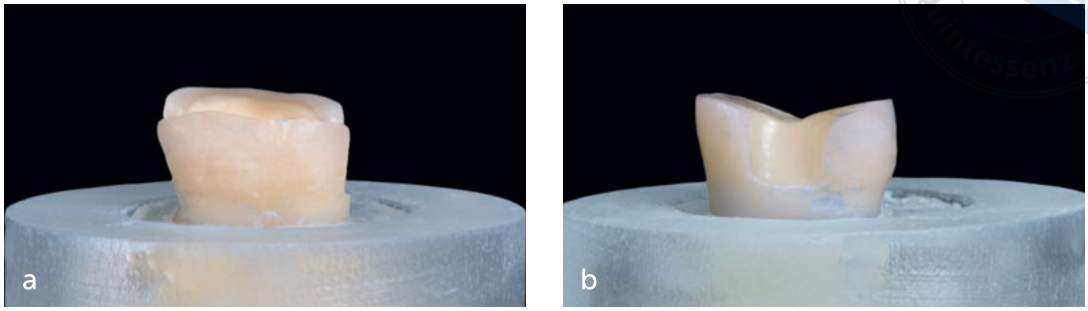


Fig 2a and b Sample after Butt Joint preparation design.

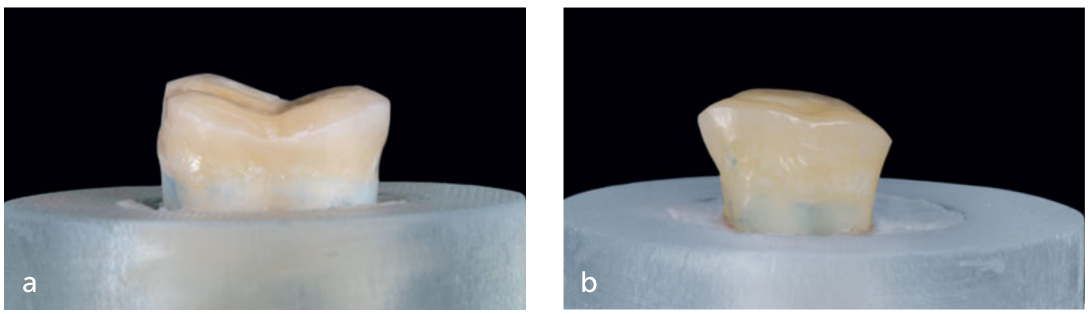


Fig 3a and b Sample after Full Bevel preparation design.

The teeth were prepared using a red ring high-speed handpiece (Lux M 25 L; KaVo) and burs from the Adhesthetics Indirect Kit (LD 1372; Komet), designed by Federico Ferraris (see Part 1 of this article series for a detailed description of the protocol preparation for this study).

One group was maintained as a control for the fracture resistance test, and the four designs for PIAR were represented by:

1. Butt Joint overlay-type restorations with interproximal slots (Fig 2).
2. Full Bevel overlay-type restorations with interproximal bevels (Fig 3).
3. Shoulder overlay-type restorations with interproximal slots (Fig 4).
4. Full Crown Modified Chamfer crown-type restorations with circumferential chamfer (Fig 5).

Immediate dentin sealing (IDS)

Considering the wide area of dentin exposed during the aforementioned four preparation designs, in order to improve the quality of the final bond strength on dentin, an IDS (also called the dual bonding technique) was performed on the exposed dentinal areas before the impression (in this study, a digital scan was performed).[21] This procedure is strongly suggested, especially when the exposed dentinal area is wide.[22] According to the adhesthetics protocols, even more than IDS is advisable. After creating the dentin hybrid layer, a composite resin buildup is performed to obtain a very stable substrate. In the present study it was decided to perform IDS only, considering that no other types of

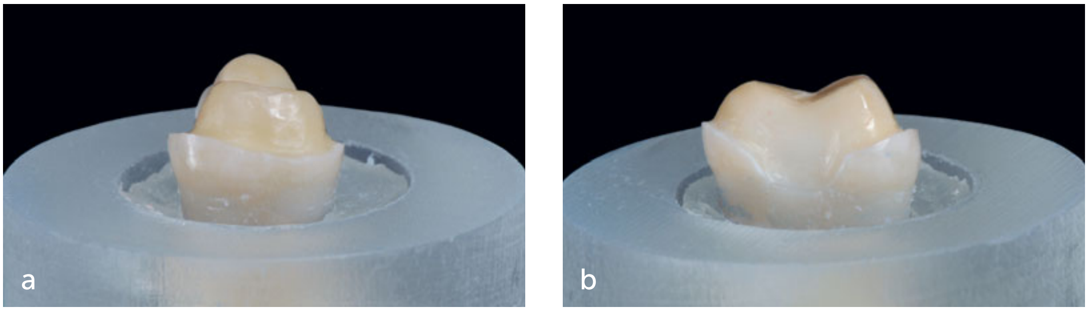


Fig 4a and b Sample after Shoulder preparation design.

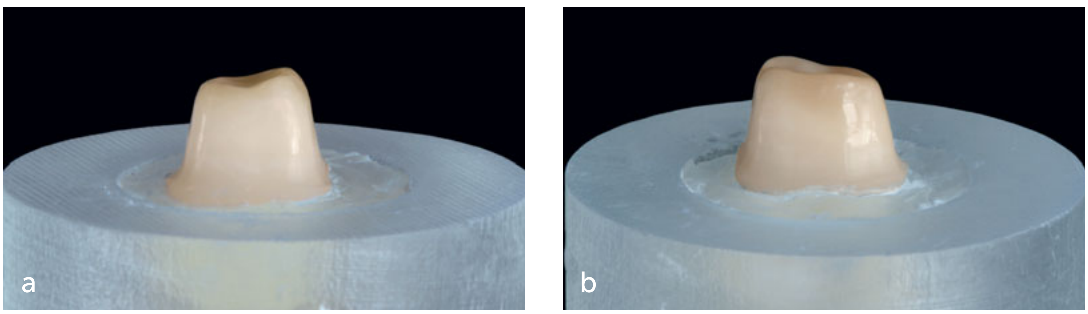


Fig 5a and b Sample after Full Crown Modified Chamfer preparation design.

cavities were present, as no carious lesions occurred, and so no buildups were needed. In this case, to perform IDS without buildups allowed for a better understanding of the behavior of the different preparation designs.

For IDS on the samples, etching was performed (Ultra-Etch; Ultradent) for 15 s only in dentin, then chlorhexidine (galenic digluconate solution) 2% was applied for 30 s. This was followed by the application of primer (OptiBond FL; Kerr) for 60 s, and then drying. Bonding (OptiBond FL) was used for 30 s, then a light blow of air and light curing (Elipar S10; 3M Oral Care) was done for 30 s. Transparent glycerin (DeOx; Ultradent) was applied, and finally polymerization was done for 30 s (Fig 6).

Design of restorations and manufacturing

The molars were restored using the inLab 16 CAD/CAM system (Dentsply Sirona). Standardized overlays and a crown (first maxillary molar) from the inLab software database were adapted to the scanned teeth using the design tools included in the software. The minimal occlusal thickness of the restorations was 1 mm, and the spacer was set at 80 µm.

The CAD/CAM procedures (design and milling) were performed by Clinica Sammarco in Manduria, Italy. Before cementation, the necessary adaptations were performed on the restorations.

In order to improve the marginal sealing during regular treatment carried out

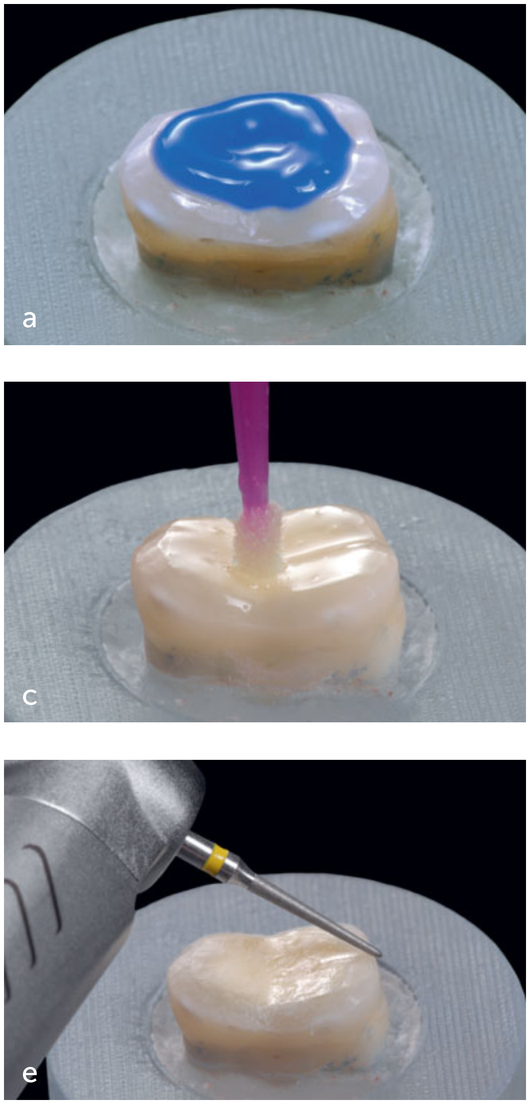


Fig 6a to e Immediate dentin sealing (IDS) steps: phosphoric acid etching on dentin, primer, resin adhesive, air block, and finishing of enamel margins with an ultrafine diamond grit bur.

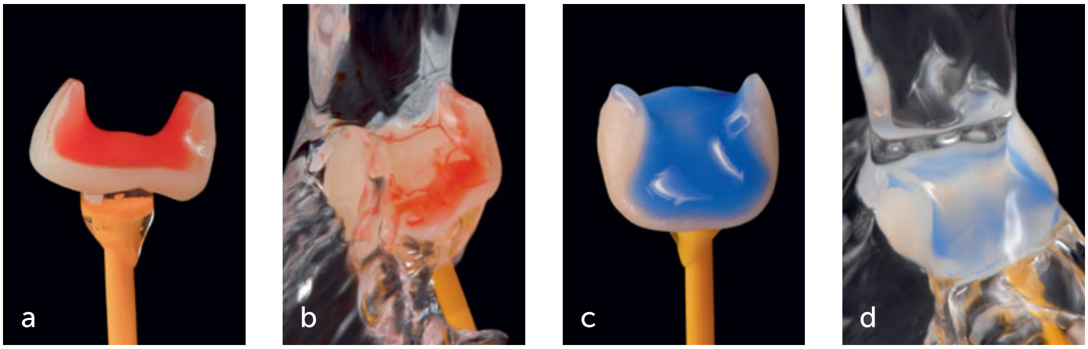
Fig 7 Lithium disilicate PIAR after milling procedures and before cementation.

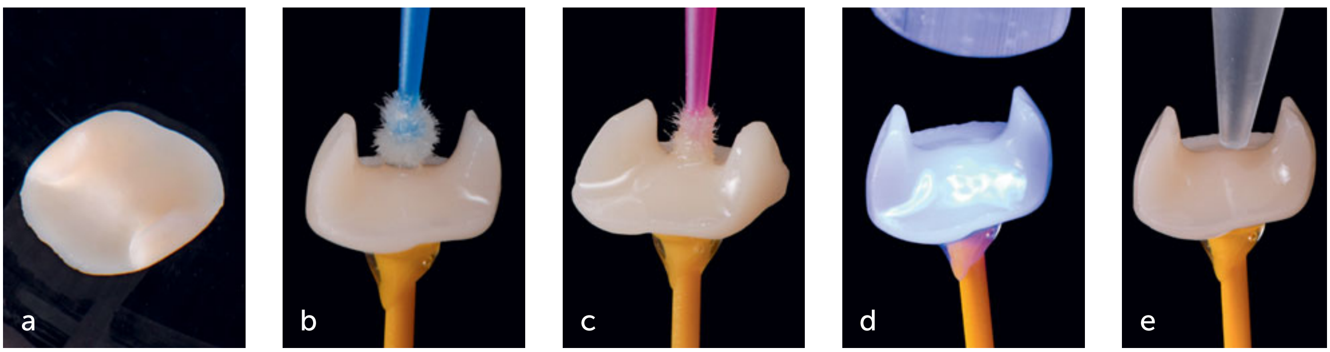
on patients, the adaptation is often done in the laboratory; in the present study, in order to see what type of marginal sealing was achieved by the CAD/CAM process, no marginal modifications were performed, and the marginal quality was observed after milling procedures and adhesive cementation (Fig 7).

Adhesive cementation

Restoration conditioning

Milled ceramic restorations were etched with 5% HF (IPS Ceramic Etching Gel; Ivoclar Vivadent) for 20 s. After rinsing for 15 s, they were dried. The post-etching cleaning step was performed as follows: The





Figs 8 and 9 PIAR lithium disilicate adhesive conditioning for cementation: hydrofluoric acid (HF) etching, post-etching cleaning (phosphoric acid etching, ultrasonic bath), silane coupling agent, resin adhesive, light-curing phase, and dual resin cement.

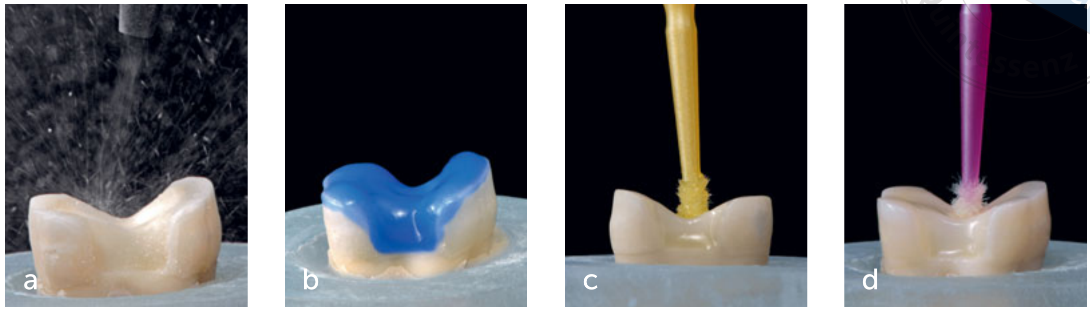
samples were etched using phosphoric acid 35% (Ultra-Etch) for 60 s, followed by rinsing for 20 s, and drying. Then, they were immersed in distilled water in an ultrasonic bath for 4 min. Silane (Monobond-S; Ivoclar Vivadent) was applied for 60 s, and then the samples were dried. A thin layer of bonding (OptiBond FL) was applied for 30 s, then a light blow of air, and light curing (Elipar S10) was done for 30 s (Figs 8 and 9).

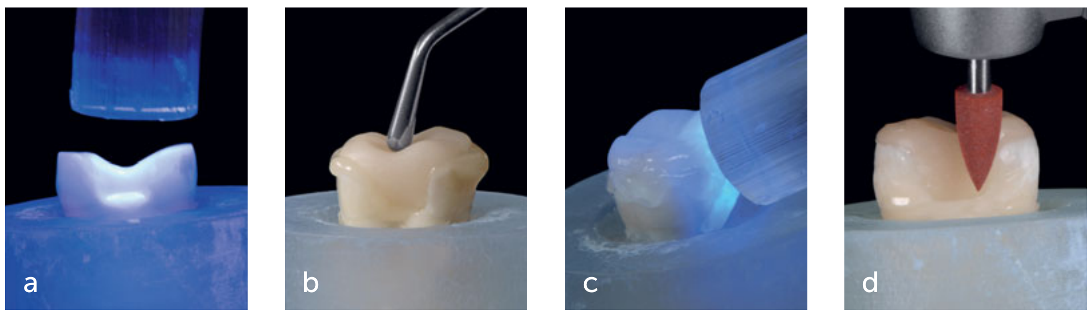
Tooth conditioning

The teeth were rehydrated in physiologic solution for at least 7 days. Airborne particle abrasion with a specific device (CoJet Prep; 3M Oral Care) was performed with 30 µm aluminum oxide powder for 10 s (2.5 bar/30 to 42 psi, perpendicular, and at a distance of 10 to 15 mm), both on the tooth and on the bonding (of the previous IDS). Etching with 35% phosphoric acid (Ultra-Etch) was performed for less than 30 s only on the enamel and on the IDS bonding, then rinsing for 15 s, and drying. Application of primer (OptiBond FL) for 30 s was done, and then drying (considering that IDS was performed, it is possible that priming is not useful; however, it was performed in case of some undesired further exposed dentinal areas and to increase the wettability; it was also applied in cementation). A thin layer of bonding (OptiBond FL) was applied for 30 s, then a light blow of air, and light curing (Elipar S10) was done for 30 s (Fig 10).

Adhesive cementation

A dual resin cement (RelyX Ultimate, A1 shade; 3M Oral Care) was positioned on the restoration, kept in position while the excesses were removed, then polymerized with a light curing machine (Elipar S10), with three cycles for each side (occlusal, buccal,





Figs 10 and 11 Tooth conditioning for the adhesive cementation of PIAR: Sandblasting with aluminum oxide powder 50 µm (10 s), total etching with 35% phosphoric acid (30 s). Application of primer (30 s, considering the previous IDS was not mandatory), and bonding and light curing (30 s). A dual resin cement, A1 shade, was applied, then excesses were removed, and polymerization took place for 90 s. Rebonding and block out was then carried out, and then finishing with a rubber polisher on the margins.

and palatal), 30 s for each one. Rebonding (Optibond FL) and polymerization for 30 s were performed. Block out with glycerin (DeOx) was applied, and then polymerization was done for 30 s. Finishing was then performed with a rubber polisher (9608 314 030; Komet) on the margins (Fig 11).

After cementation, all the PIARs were ready (Figs 12 to 15) to be tested with functional loading in order to simulate 5 years of clinical service.

Functional loading

Specimens were incubated in distilled water at 37°C for 24 h and were then cleaned for 10 min by sonication. A CS-4.4 chewing simulator (SD Mechatronik) was used for thermomechanical aging of the specimens. To simulate periodontal ligaments, a 2.5-mm–thick, even layer of Express 2 (3M Oral Care) was added to surround the specimens. A 6-mm–diameter steatite sphere was applied using an occlusal load of 50 N, a frequency of 1 Hz, and a downward speed of 16 mm/s. All specimens possessed a standardized anatomy and were similarly positioned for the sphere to be loaded onto the mesiobuccal, distobuccal, and palatal cusps (tripod contacts). The masticatory process was simulated through horizontal (0.3 mm) and vertical (6 mm) movements for a total of 1,200,000 cycles. During the test, the specimens were subjected to 39,000 thermal cycles between +5°C and +55°C by filling the chambers with water of the appropriate temperature for 30 s.[23] The TML was checked every 10,000 cycles by monitoring the mechanical action and water temperature within the chewing chambers.

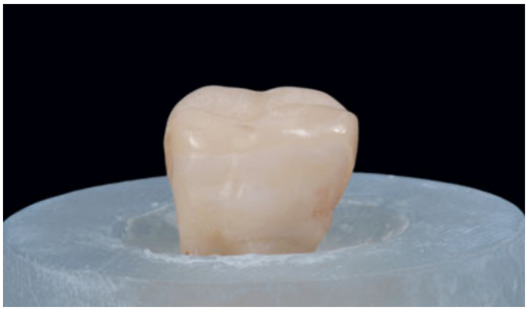


Fig 12 Butt Joint PIAR after adhesive cementation and before testing. Any marginal adaptation was performed before cementation.

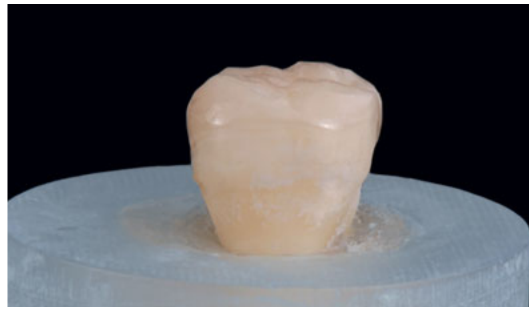


Fig 13 Full Bevel PIAR after adhesive cementation and before testing. Any marginal adaptation was performed before cementation.

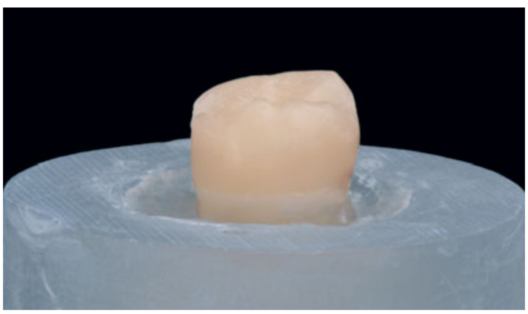


Fig 14 Shoulder PIAR after adhesive cementation and before testing. Any marginal adaptation was performed before cementation.

Fig 15 Full Crown Modified Chamfer PIAR after adhesive cementation and before testing. Any marginal adaptation was performed before cementation.

Analysis of marginal quality

Following completion of the TML, impressions were obtained for each restoration and replicas were produced. Gold sputtered epoxy replicas mounted on aluminum stubs were examined with a SEM (Quanta 250; FEI) under 50× magnification.

A single SEM operator examined each margin quantitatively in a single-blind manner. Each margin was classified as either a 'continuous margin,' a 'gap/irregularity' or a 'not judgable/artifact,' following a well-established protocol and consistent with previous studies.[24,25] The percentage of continuous margins relative to the individual judgable margins was calculated as the marginal integrity.

Statistical analysis

The influence of the preparation on the variable marginal adaptation was assessed by means of univariable and multivariable logistic regression analyses using SPSS Statistics 24 (IBM SPSS Statistics) software. The level of significance was pre-set at $\alpha = 0.05$. Adjusted odds ratios, ie, the effect of a factor independent of the others, were obtained using the multivariable logistic regression mode.

Results

All the specimens survived the TML (simulating approximately 5 years of clinical use) in the chewing machine without loss

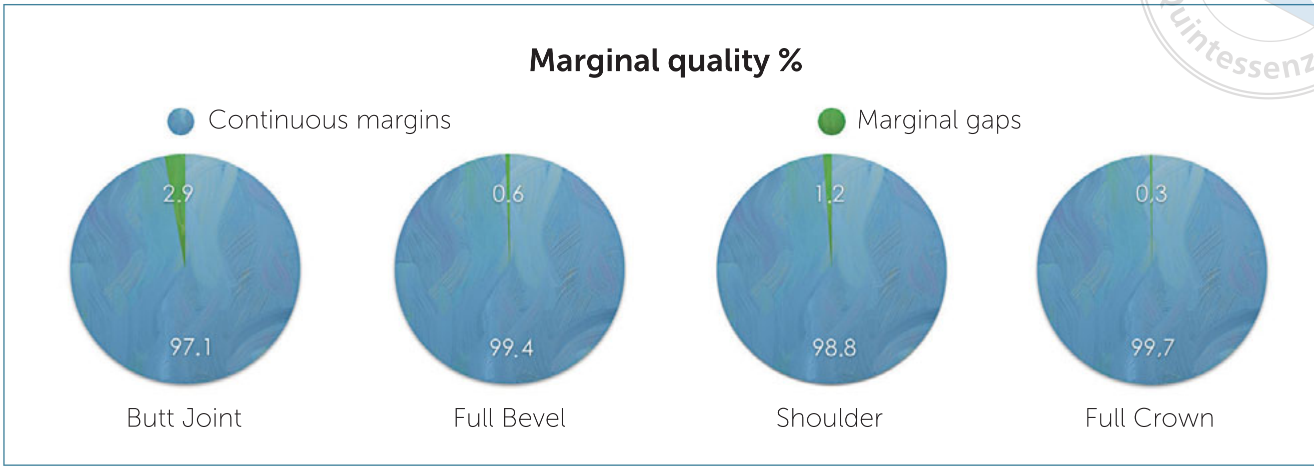


Fig 16 Pie charts depicting the marginal quality of the tested specimens by different preparations with SEM analysis. Percentage of continuous margin at the tooth–restoration interface after TML.

of retention or fracture and could be analyzed for marginal adaptation using the SEM. Table 1 and Fig 16 show the marginal quality data. The Butt Joint group showed a significant difference in marginal quality compared with the other groups ($P < 0.05$). No statistically significant differences were found among the Full Bevel, Shoulder, and Full Crown groups ($P > 0.05$). Considering the marginal adaptation, the total mean percentage after TML was 98.7%. The SEM analyses showed the thickness of the resin cement to be similar (50 µm).

Discussion

The hypothesis that preparation can influence the marginal quality of different restorations was accepted. Marginal adaptation, defined as the distance between the finish line and the restoration margin, is considered one of the major criteria affecting the long-term prognosis of ceramic restorations.[26]

In this investigation, a TML device was used that allowed the simultaneous application of dynamic load and thermal stress in

Table 1 Results of marginal quality of the tested specimens by different preparations with SEM analysis. Same superscript letters indicate no significant difference between groups. (P>0.05).

Marginal quality	Butt Joint	Full Bevel	Shoulder	Full Crown	Total
Continuous	1360	1392	1384	1396	5532
Gap/irregularity	40	8	16	4	68
Non-judgable artifact	0	0	0	0	0
Total	1400	1400	1400	1400	5600
Percentage of continuous margin*	97.1[b]	99.4[a]	98.8[a]	99.7[a]	98.7

* Percentage of continuous margin at the tooth–restoration interface after TML.

order to simulate clinical conditions within the limitations of the protocol used.[27] The specific focus in the present study was marginal quality in vitro as an indispensable prerequisite for clinical success.[28] In an in vitro study on marginal adaptation of adhesive ceramic inlays, Krejci et al[29] showed that the marginal integrity in enamel and dentin begins to deteriorate after 120,000 thermomechanical cycles.

PIAR requires substrates favorable for adhesive cementation. Considering the IDS and buildup are already done on dentin, the usual two available substrates for adhesion are enamel and resin composite (buildup), and they can have a good bond strength over time, especially the natural enamel. In this study, to better standardize the preparations, all groups of preparations (Butt Joint, Full Bevel, Shoulder, and Full Crown) led to the exposure of some areas of dentin on the teeth, and in this case the buildup was not performed, and only IDS was carried out. Apart from the Full Bevel group, the preparation designs in all the other groups arrived close to the CEJ in the proximal area. Moreover, the Full Crown group also arrived close to the CEJ in the buccal and palatal aspects.

In the present study, the setting approximated 5 years of clinical use. Subsequent to tooth preparations, IDS was applied using a three-step, etch-and-rinse dentin adhesive (Optibond FL). Freshly prepared dentin is more permeable compared with old prepared dentin and is thus more susceptible to bacterial contamination. The application of a dentin adhesive to freshly prepared dentin might seal and protect dentin against bacterial leakage. In general, the bond strength of an indirect restoration is increased by IDS.[30,31] After etching, chlorhexidine digluconate 2% was used as a conditioner for 30 s.

Optibond FL is considered to be one of the gold standard reference materials among three-step, etch-and-rinse adhesives, with several studies validating its bonding ability; it is characterized by non-solvated hydrophobic bonding applied on primed dentin.[32,33] Bond longevity and stability of the adhesive–dentin interface are adversely affected by physical and chemical factors.[34] Even when the coronal seal is effective, degradation of the composite–dentin interface may occur through activation of endogenous dentin matrix metalloproteinases (MMPs).[35] Chlorhexidine has been reported to inhibit MMP activity within the hybrid layer, thereby contributing to the preservation of bond strength over time when applied on acid-etched dentin.[36] Gresnigt et al[22] showed that when ceramic veneers are bonded to a large surface of exposed dentin, the application of an IDS improves the adhesion and thereby the fracture strength of veneers. For this reason, the IDS and buildup of the dentin cavities is the first choice in the adhesthetics protocols because, after the curing of the bonding, one or more layers of resin-based composite materials further protect and stabilize the IDS layer. No cavities were seen in the present study; therefore, the IDS remained an adhesive layer without any buildup performed.

The clinical success of ceramic restorations depends on the cementation procedure and condition of the ceramic. The technique for bonding to disilicate ceramic takes advantage of the formation of chemical bonds and micromechanical interlocking at the resin–ceramic surface. Etching with HF is used to create a rough surface on the bonding area of the ceramic material in order to enhance bonding between the ceramic and the resin cement. HF removes the glass matrix and the second crystalline phase, thus creating irregularities within the lithium disilicate crystal for bonding.[37] Another treatment recommended for ceramic surfaces involves airborne particle abrasion with 50 µm aluminum oxide (Al_2O_3) particles to aid in mechanical retention.[38] In the present study, the ceramic restorations were etched with 5% HF for 20 s. Some authors have advocated the use of 5% HF acid to reduce the risk of defect formation on the ceramic surface and their propagation in the bulk structure of the disilicate restoration.[39]

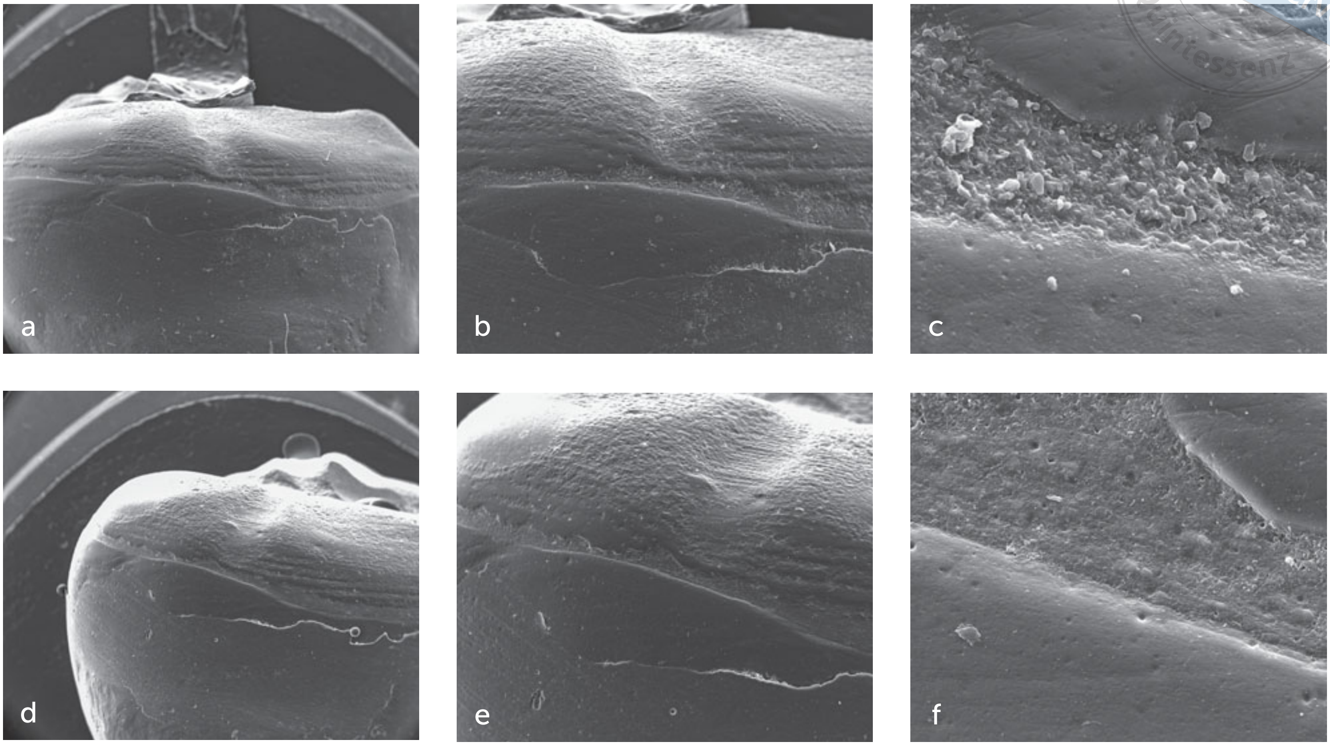
Generally, an adhesive resin cement is recommended for luting a ceramic restoration, particularly due to the excellent esthetic and mechanical properties (flexural strength, compressive strength) of adhesive resin, which is also directly dependent on the degree of conversion in the polymerization reaction.[40] The amount of light actually penetrating through the ceramic influences not only the bond strength of the bonding systems, but also the conversion rate and therefore the degree of crosslinking of the luting composite.[41] In the present study, an etch-and-rinse system with a dual-cure resin cement was used to standardize the protocol for adhesive cementation for both overlay and full-crown–type PIAR. The adhesthetics protocol for the PIAR onlay (and overlay) type is recommended as the first choice for luting with a highly filled, packable resin composite after a preheating for 5 min at 55°C to 62°C in a heating device.

Several studies show that this heating strategy reduces composite resin viscosity, which could benefit the luting procedure,[42] and that even thick restorations demonstrate appropriate mechanical performance when delivered with a solely light-polymerized composite resin.[43,44] It has been reported that heating is a way to achieve a higher degree of conversion for light-curing composite resins similar to dual-cure resin cements.[45] Composite resins may perform better than resin cements on restoration margins in the long term due to more inorganic load filling. This higher filler content gives better mechanical properties to this composite resin material.[46] Moreover, composite resin does not contain chemical activators, which are related to long-term color instability.[47]

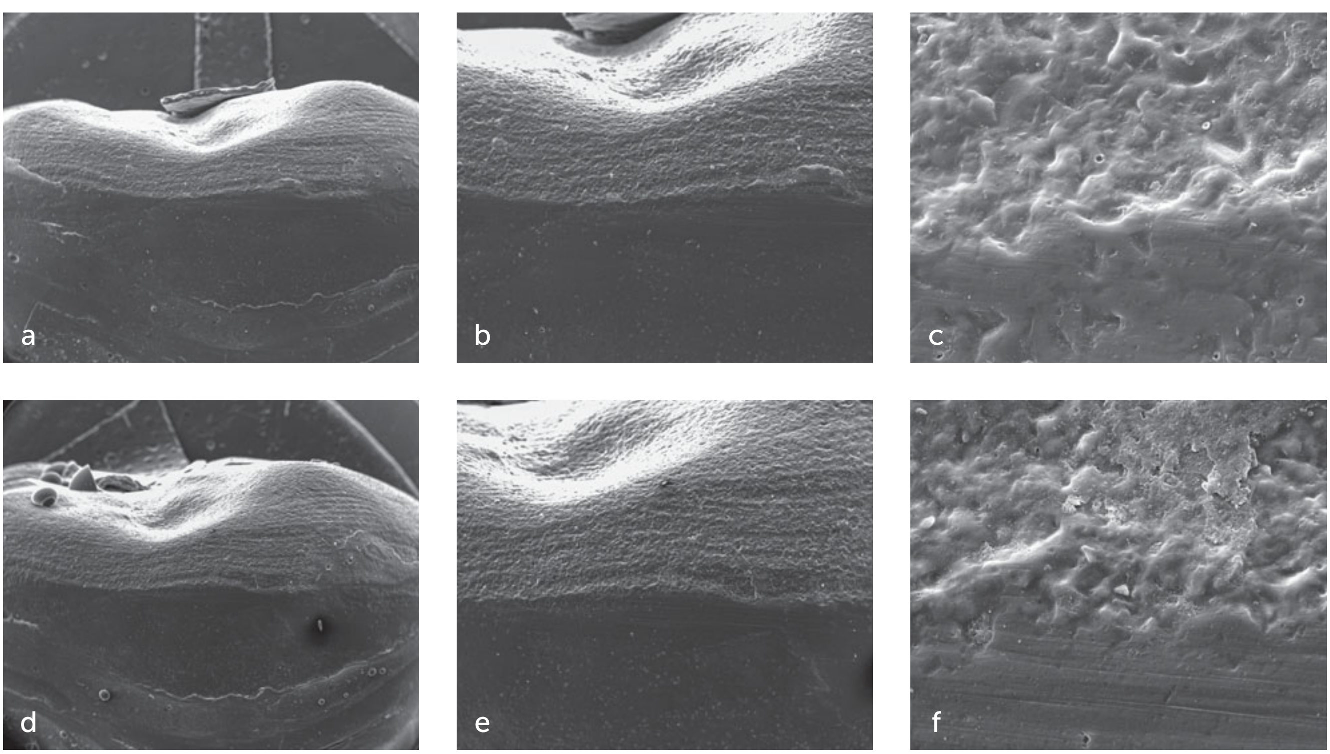
Different methods have been used to measure marginal discrepancies between preparations and restorations. The direct view and cross-sectioning methods can acquire data directly, whereas the silicone replicas and microcomputed tomography (MCT) methods measure discrepancies indirectly.[48] Although the direct view and cross-sectioning methods have been widely used because they are straightforward, the latter method requires destruction of the specimens.[49] The MCT method has also been used, but it is complex and requires expensive equipment.[50] The silicone replica method using light-body polyvinyl siloxane (PVS) impression material to replicate the specimens has been popular because it avoids these disadvantages and it is reliable.[51]

In the present study, there was a high prevalence of continuous margins for PIAR, from 97.1% (Butt Joint group) to 99.4% (Full Bevel group). The clinical prevalence of unacceptable marginal integrity occurred in 0% to 17.8% of the onlays.[1] If a significant marginal gap is present between the tooth and the restoration, luting material will be exposed to the oral environment, resulting in its dissolution and consequent microleakage. The unacceptable marginal integrity for all PIAR groups in the present study was very low, only 0.3% for Full Crown, 0.6% for Full Bevel, 2.2% for Shoulder, and 2.9% for Butt Joint (Figs 17 to 20). Only one optical impression was performed for the indirect onlay restorations. Although none of the CAD/CAM restorations were rectified under stereomicroscopy to improve adaptation, the marginal quality of all groups was 98.7% after TML that approximated 5 years of clinical use.

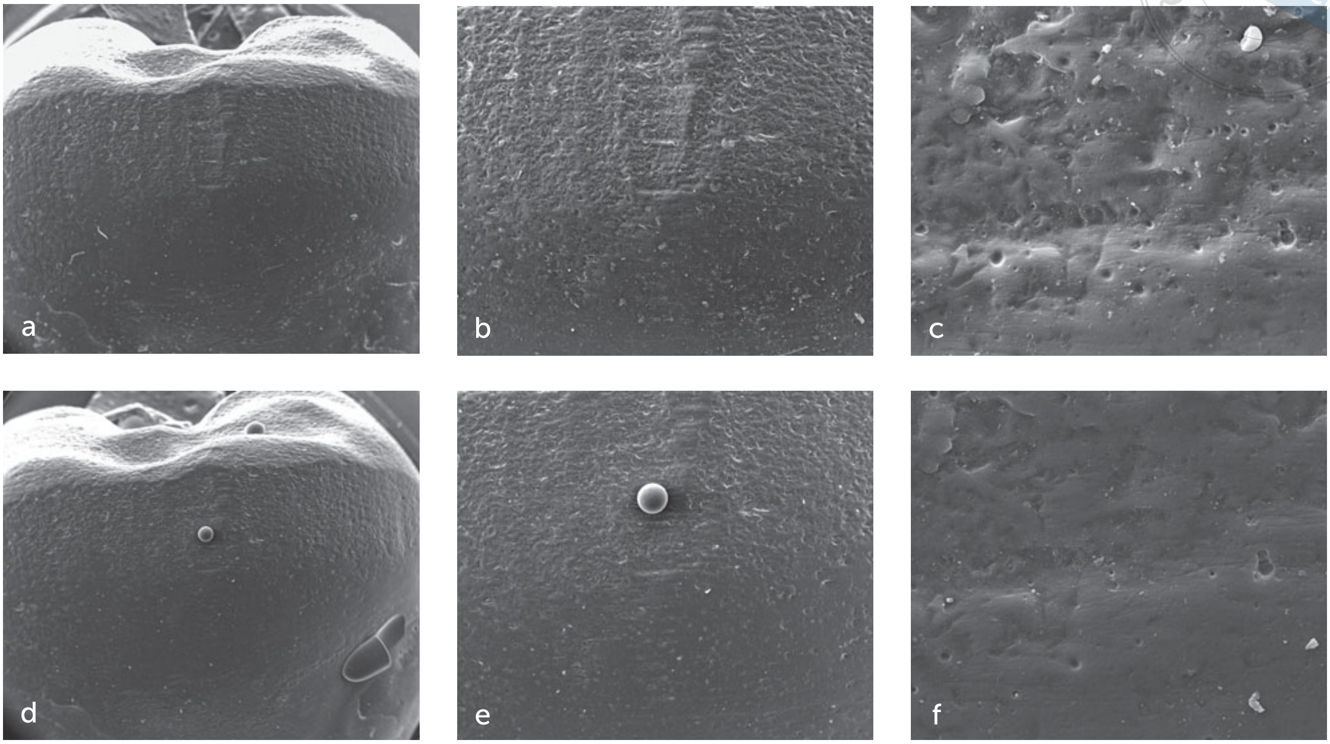
Under normal circumstances, a patient with adhesive restorations will undergo annual checkups. It is also important to assess



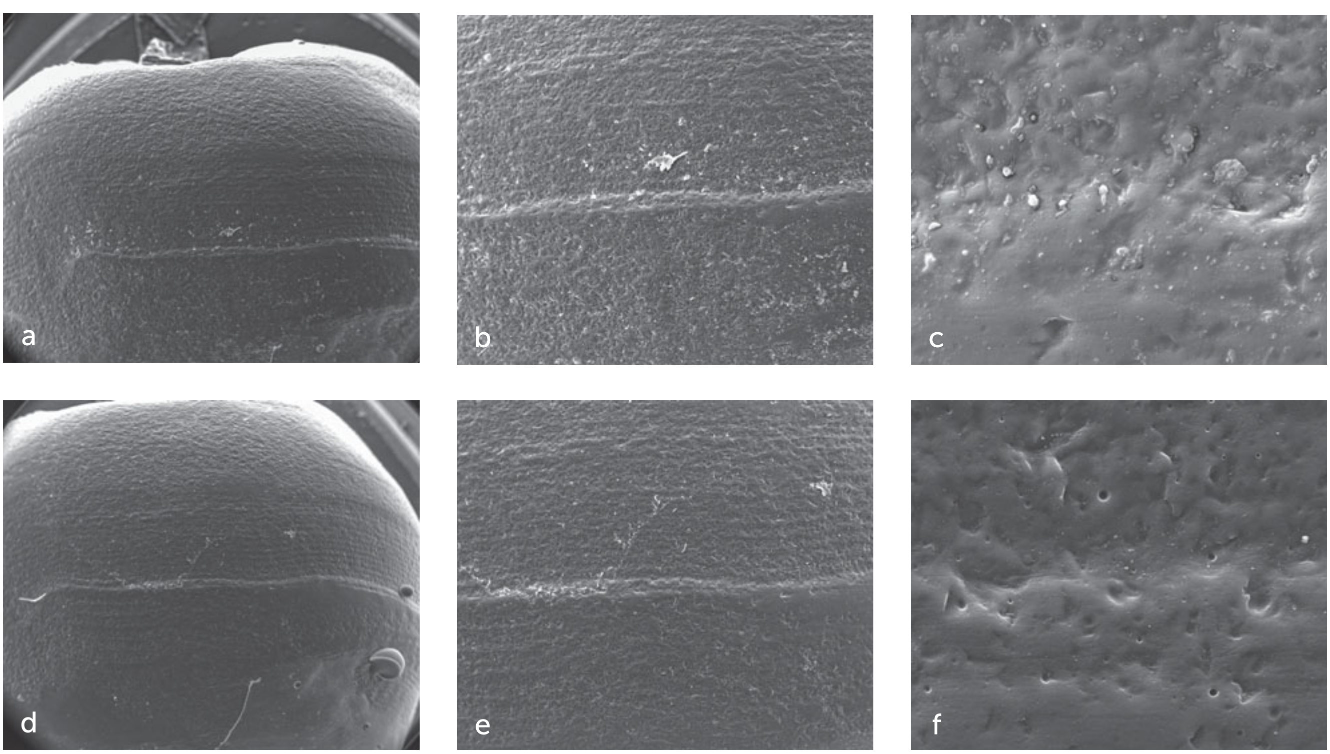
Figs 17a to f Butt Joint PIAR margins after cementation (a to c) and after TML of 1,200,000 cycles and 3,900 thermal cycles between +5°C and +55°C, for an approximate equivalent of 5 years in the mouth (d to f). The SEM images are at 25×, 50×, and 500× magnification.



Figs 18a to f Full Bevel PIAR margins after cementation (a to c) and after TML of 1,200,000 cycles and 3,900 thermal cycles between +5°C and +55°C, for an approximate equivalent of 5 years in the mouth (d to f). The SEM images are at 25×, 50×, and 500× magnification.



Figs 19a to f Shoulder PIAR margins after cementation (a to c) and after TML of 1,200,000 cycles and 3,900 thermal cycles between +5°C and +55°C, for an approximate equivalent of 5 years in the mouth (d to f). The SEM images are at 25×, 50×, and 500× magnification.



Figs 20a to f Full Crown Modified Chamfer PIAR margins after cementation (a to c) and after TML of 1,200,000 cycles and 3,900 thermal cycles between +5°C and +55°C, for an approximate equivalent of 5 years in the mouth (d to f). The SEM images are at 25×, 50×, and 500× magnification.

the presence of any recurrent caries and the patient's general periodontal health so as to maintain good esthetic results over time and avoid fracture of the ceramic and unacceptable wear of the composite. In addition, the occlusion must be balanced and checked regularly because it can change.

In the present study, only the Butt Joint group showed results that were statistically significantly lower than the other groups, with a continuous margin of 97.1%, mostly in the interproximal areas. This area is clinically the most difficult part when it comes to luting restorations to avoid overcontouring with composite resin, and it is particularly important to finish very well. In clinical conditions, the removal of excess luting composite is arguably the most critical step of the cementation procedure. The challenging task for the clinician is to avoid overhangs or subcountours resulting from cementation. There is no consensus at present regarding a clinically acceptable marginal value;[52,53] some authors have suggested it to be lower than 100 µm, while others consider a gap lower than 120 µm to be a suitable threshold value.[54,55] Margins providing satisfactory continuity between the restoration and the tooth can be obtained only in perfectly fitting restorations.[56]

Further in vitro research is needed to explore the marginal adaptation of PIAR cemented with composite resin, despite some preliminary findings indicating that PIAR showed good marginal adaptation for all preparations after TML.

Clinical conclusions

Within the limitations of the present study, in terms of marginal quality after TML in molar teeth without endodontic treatments restored with different PIAR monolithic ceramic lithium disilicate, the following conclusions can be drawn:

- All the tested PIAR designs showed very good marginal adaptation (mean 98.7% continuous margins) after TML that simulated approximately 5 years of clinical use.
- The restorations in the Full Crown (99.7%), Full Bevel (99.4%), and Shoulder (98.8%) groups showed better marginal adaptation than those in the Butt Joint (97.1%) group.

Disclaimer

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