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ORIGINAL ARTICLES

MARGINAL ADAPTATION OF CERAMIC INLAYS—AN IN VITRO STUDY

Sabina Keremedchieva[1], Stefan Peev[1], Ivaylo Parushev[2]

[1]Department of Periodontology and Dental Implantology, Faculty of Dental Medicine, Medical University of Varna, Bulgaria
[2]Department of Clinical Medical Sciences, Faculty of Dental Medicine, Medical University of Varna, Bulgaria

ABSTRACT

INTRODUCTION: Class II approximal defects are very common in the clinical practice, in many cases extending subgingivally and beyond the cementoenamel junction (CEJ). For large defects in the posterior region, indirect ceramic restorations provide a better solution than direct composite restorations.

AIM: The aim of this experimental in vitro study is to compare the marginal adaptation of hybrid ceramic and lithium disilicate inlays, fabricated using classic and hybrid technique and cemented with two different types of dental cements.

MATERIALS AND METHODS: Forty extracted human molars and premolars were randomly divided into 8 groups and class II cavities (medio-oclusal or disto-oclusal) with the same dimensions were prepared. Hybrid ceramic and lithium disilicate inlays were fabricated according to the manufacturer's instructions. The marginal gap after cementation was measured using a microscope at 40x magnification.

RESULTS: The lowest cement thickness was registered for Group 4—lithium disilicate inlays, classic technique, cemented with composite cement, closely followed by Group 3—hybrid ceramic inlays, classic technique, cemented with composite cement. The highest mean cement thickness values were registered for Group 1—hybrid ceramic inlays, classic technique, cemented with glass ionomer cement, followed by Group 5—hybrid ceramic inlays, hybrid technique, cemented with glass ionomer cement.

CONCLUSION: Under the limitations of this experimental in vitro study, we can conclude the following: lithium disilicate and hybrid ceramic inlays cemented with composite cement have better marginal adaptation than the ones cemented with glass ionomer cement. Lithium disilicate restorations and inlays without cervical margin relocation (classic technique) have a slightly better marginal fit than hybrid ceramic inlays and restorations with hybrid technique. For a more detailed insight, microleakage evaluation should also be carried out.

Keywords: *hybrid ceramic, lithium disilicate, ceramic inlays, marginal fit, marginal adaptation*

Address for correspondence:
Sabina Keremedchieva
Faculty of Dental Medicine
Medical University of Varna
84 Tzar Osvoboditel Blvd
9002 Varna, Bulgaria
e-mail: sabina.keremedchieva@gmail.com

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INTRODUCTION

Class II proximal defects are very common in the clinical practice, in many cases extending subgingivally and beyond the cementoenamel junction (CEJ). Indirect ceramic restorations provide a better solution than direct composite restorations for large defects in the posterior region (1–3). Ceramic inlays allow an exquisite tooth-colored aesthetic outcome, durability, and wear resistance (4), while being minimally invasive compared to crowns (5). Lithium disilicate is categorized as a particle-filled glass-ceramic material (6). It was first fabricated using the heat-pressing technique, but later a milled version was also introduced (7). Hybrid ceramics is a mixed structure between composite and ceramics, which intends to reduce the rigidity and fragility of the material, while having high optical properties and easy milling in a short period of time (8).

Cementation of the indirect restorations is a very important step of the treatment process, because it can increase marginal discrepancies (9). Proper isolation and correct choice of a dental cement are crucial for the final outcome. In some clinical cases, involving subgingival margins of the preparation, correct impression taking and isolation are difficult to achieve. Deep cervical margins of the proximal box can be relocated supragingivally using the deep margin elevation method (10), also called hybrid technique or cervical margin relocation (11). A variety of materials can be used to execute the deep margin elevation technique (12). Composite is usually the material of choice. Bulk fill or highly filled flowable composite can be applied, as well as traditional viscous resin composite or a combination between them (13–17).

AIM

The aim of this experimental in vitro study is to compare the marginal fit of hybrid ceramic and lithium disilicate inlays. The indirect ceramic restorations were fabricated using classic or hybrid technique and cemented with glass ionomer or composite cement.

MATERIALS AND METHODS

This experimental study includes 40 recently extracted human molars and premolars. The teeth were carefully selected according to the following criteria: intact crown, finished root development, without endodontic treatment. Immediately after extraction, the teeth were thoroughly cleaned and investigated under a microscope for cracks. Afterwards, they were stored in 4% formaldehyde solution. Every tooth underwent class II cavity preparation (medio-oclusal or disto-oclusal) with the same dimensions. The teeth were divided into eight groups:

- **Group 1:** teeth with hybrid ceramic restorations, classic technique, cemented with glass ionomer cement;
- **Group 2:** teeth with lithium disilicate restorations, classic technique, cemented with glass ionomer cement;
- **Group 3:** teeth with hybrid ceramic restorations, classic technique, cemented with composite cement;
- **Group 4:** teeth with lithium disilicate restorations, classic technique, cemented with composite cement;
- **Group 5:** teeth with hybrid ceramic restorations, hybrid technique, cemented with glass ionomer cement;
- **Group 6:** teeth with lithium disilicate restorations, hybrid technique, cemented with glass ionomer cement;
- **Group 7:** teeth with hybrid ceramic restorations, hybrid technique, cemented with composite cement;
- **Group 8:** teeth with lithium disilicate restorations, hybrid technique, cemented with composite cement.

Cavity Preparation

Every sample tooth was first fixed in a polymethyl methacrylat polymethyl methacrylat (PMMA) tube, using a thin layer of casting wax in the area of the apex. Then the tube was filled with epoxy resin (EpoThin, Buehler), covering the root section of the tooth up to 3 mm before the CEJ. This way sufficient stability was achieved, allowing comfortable workflow **(Fig. 1a)** Medio-occlusal or disto-occlusal cavity preparations for indirect restorations were prepared using Expert set 4562 for ceramic inlays and partial crowns (Komet Dental), **(Fig. 1b)**. The cavity wall inclination was 6–10°, the minimal depth of the preparation from the bottom of the fissure was 1.5 mm, the minimal width of the isthmus was 2.5 mm, the minimum medio-distal size of the proximal box was 1.5 mm, with proximal box extending 1 mm below the CEJ, horizontal pulpal floor, and rounded inner angles. A UNC 15 periodontal probe was used to ensure the proper measurements **(Fig. 1c)**. Hybrid technique including cervical margin relocation with composite was used in groups 5,

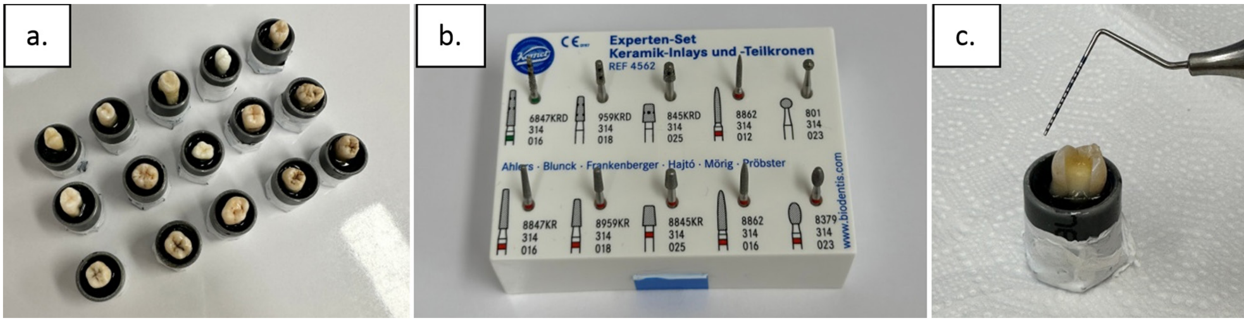

Fig. 1. ***a.*** *a fraction of the samples before preparation;* ***b.*** *Expert set 4562 for ceramic inlays and partial crowns (Komet Dental);* ***c.*** *tooth sample after preparation, UNC 15 periodontal probe.*

6, 7, and 8. The composite material of choice was Estelite Bulk Fill Flow (Tokuyama Dental). A 4652-204 polishing kit for composite (Komet Dental) was used for final polishing.

Impression Technique

The impression technique used in this experimental study was digital impression taking using a dental laboratory scanner True Color Texture Scan UP3D UP560.

Indirect Restoration Manufacturing

Teeth in groups 1, 3, 5, and 7 were restored with hybrid ceramic inlays (Vita), whereas in groups 2, 4, 6, and 8 milled lithium disilicate inlays (Ivoclar Vivadent) were used. After the digital impression was obtained **(Fig. 2a,b)**, a design of the restoration was created in Exocad **(Fig. 2c,d.)**. Hybrid ceramic and lithium disilicate inlays were fabricated according to the manufacturer's instructions.

Cementation

The restorations in groups 1, 2, 5, and 6 were cemented using resin-modified glass ionomer cement (Fuji Plus, GC), **(Fig. 3a)** according to the following protocol: Fuji Plus Conditioner was applied for 20 seconds and then rinsed with water and air-dried without desiccating the cavity surfaces. Fuji Plus is a resin-modified glass ionomer cement, which has powder and liquid components. They were mixed together in a 1:1 ratio and a thin layer of cement was

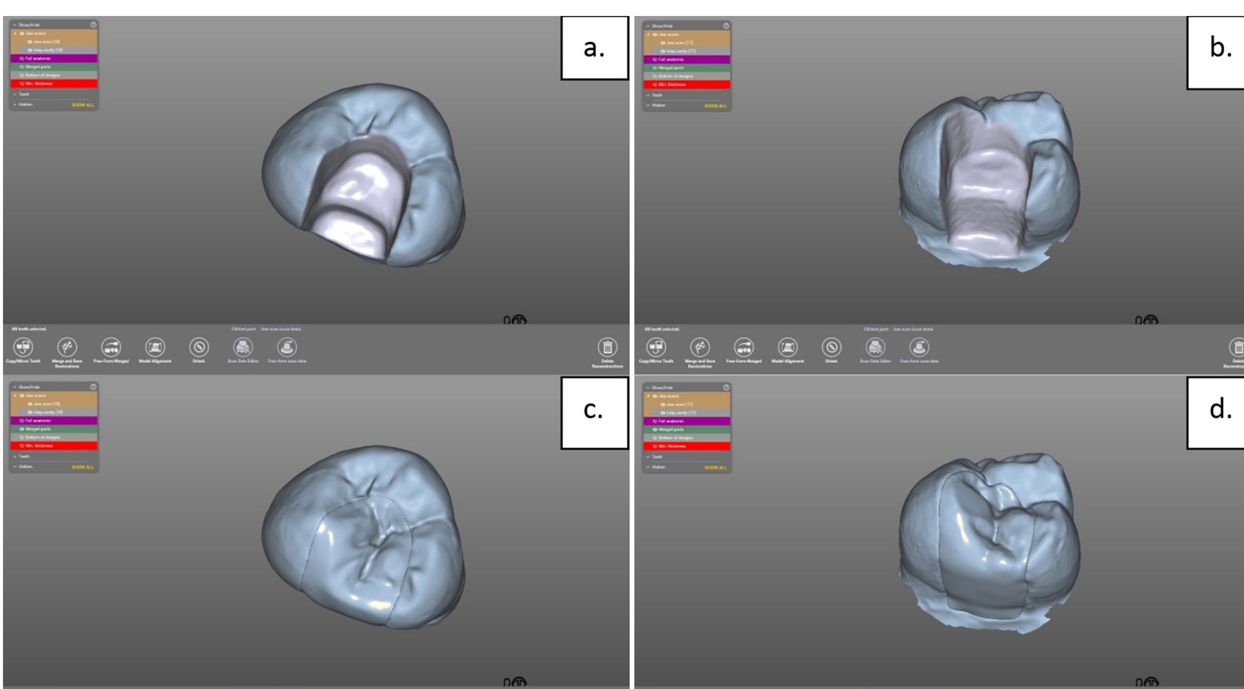

Fig. 2. ***a,b.*** *digital impression;* ***c,d.*** *restoration design in Exocad.*

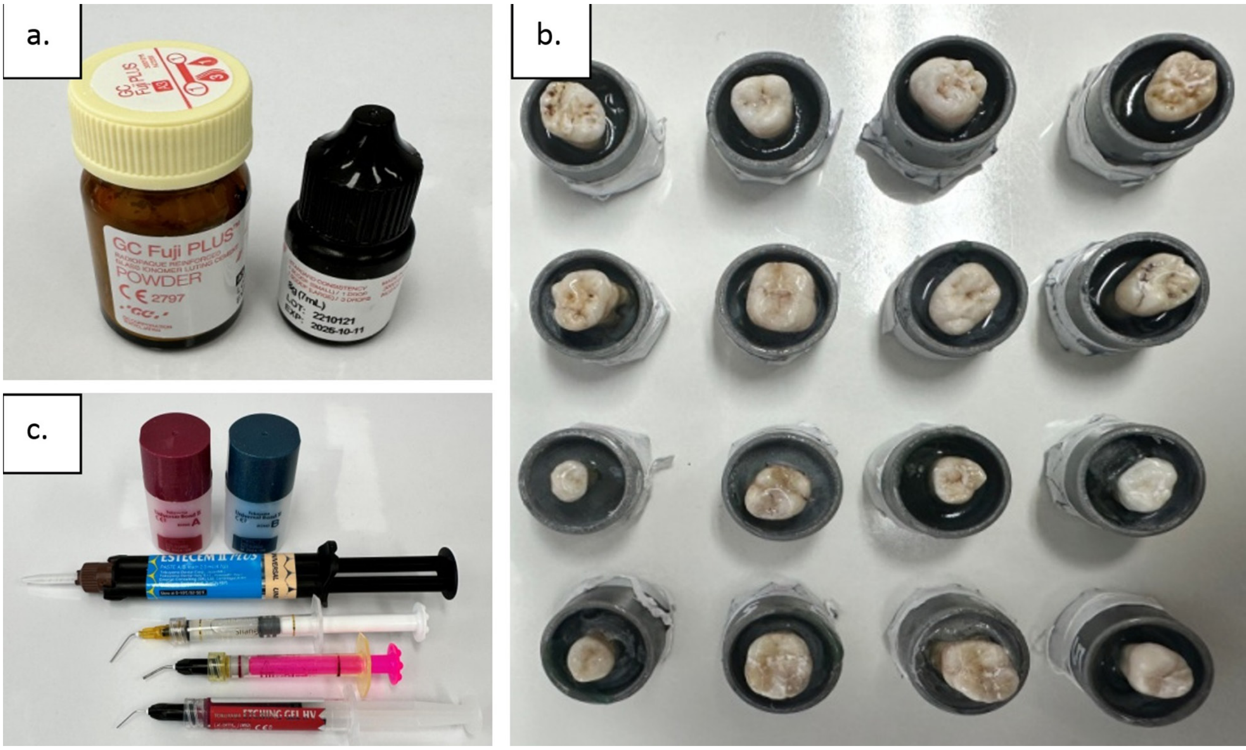

Fig. 3. ***a.*** *resin-modified glass ionomer cement (Fuji Plus, GC);* ***b.*** *sample teeth with cemented restorations*; ***c.*** *composite cement (EsteCem II, Tokuyama Dental).*

applied on the inner surfaces of the inlay, before fitting it into the cavity preparation. Approximately one minute after cementation, the excess cement was gently removed. The working time according to the manufacturer is 2 min 30 sec from the start of mixing at room temperature. Final polishing was done after waiting for at least 4 min 30 sec after cementation **(Fig. 3b)**.

The restorations in groups 3, 4, 7, and 8 were cemented using composite cement (EsteCem II, Tokuyama Dental) **(Fig. 3c)**. Etching gel containing 9.5% hydrofluoric acid (Yellow Porcelain Etch, Cerkamed) was applied on the inner surfaces of the restoration for 60 sec. Afterwards, it was rinsed with water, air-dried, and a silane application followed. Etching gel containing 39% phosphoric acid (etching gel HV, Tokuyama Dental) was applied on the cavity walls for 10–15 sec, rinsed with water for at least 15 sec, and air-dried. The two components of Universal Bond (Tokuyama Dental) were mixed together and applied on the inner part of the ceramic restoration and on the cavity walls of the sample tooth, then thoroughly air-dried. Composite cement was applied on the inner surfaces of the restoration and it was permanently cemented. Excess cement was removed after a quick 2–4 sec photopolymerization and then the final photopolymerization was 20 sec **(Fig. 3b)**.

Thermocycling

The thermocycling method of choice was the one by Aguir Mabrouk Najet et al. (18). The specimens were subjected to thermocycling with a temperature range from 6°C to 60°C. A daily cycle of 45 min at 6°C **(Fig. 4a)**, followed by 45 min at 60°C **(Fig. 4b)** was executed 4 times in a row for a total of 5 consecutive days.

Fig. 4. ***a.*** *refrigerated samples at 6°C;* ***b.*** *samples at 60°C.*

Sectioning and Polishing

The sample teeth were embedded in epoxy resin (EpoThin, Buehler). They were precisely cut in mediodistal direction through the center of the restoration **(Fig. 5a)** using IsoMet1000 (Buehler), **(Fig. 5b)**. Polishing of the samples was done with semi-automatic grinder polisher EcoMet 30 (Buehler), **(Fig. 5c)**.

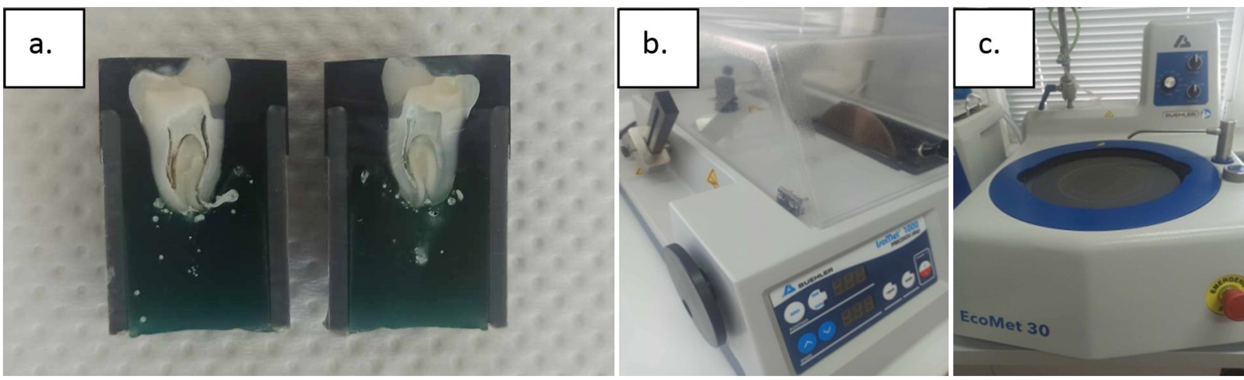

Fig. 5. ***a.*** *separated tooth sample;* ***b.*** *IsoMet1000 (Buehler);* ***c.*** *EcoMet 30 (Buehler).*

Microscopic Evaluation

The marginal adaptation of the hybrid ceramic and lithium disilicate inlays was evaluated by registering the thickness of cement between the restoration and the cavity wall in the area of the proximal box. Each specimen was positioned under a Leika DM 1000 LED stereomicroscope at 40x magnification **(Fig. 6a)**. The images were transferred to a computer and measurements were done using the ruler tool in the Leika Application Suite **(Fig. 6b)**. The cement thickness was recorded in mm in the following three points: T.1, which represents the cement thickness at the outer edge of the proximal box of the restoration, T.2 is the thickness in the middle of the proximal box, and T.3 corresponds to the thickness in the area of the rounded angle of the proximal box. In order to locate point T.2, additional measurements were done, including D.1, which represents the distance between the outer edge of the preparation and the angle of the proximal box, and D.2, which is equal to half of the measurement for D.1. The mean value of cement thickness in the proximal box area was calculated.

RESULTS

The lowest cement thickness was registered for Group 4—lithium disilicate inlays, classic technique, cemented with composite cement (0.17 mm), closely followed by Group 3—hybrid ceramic in-

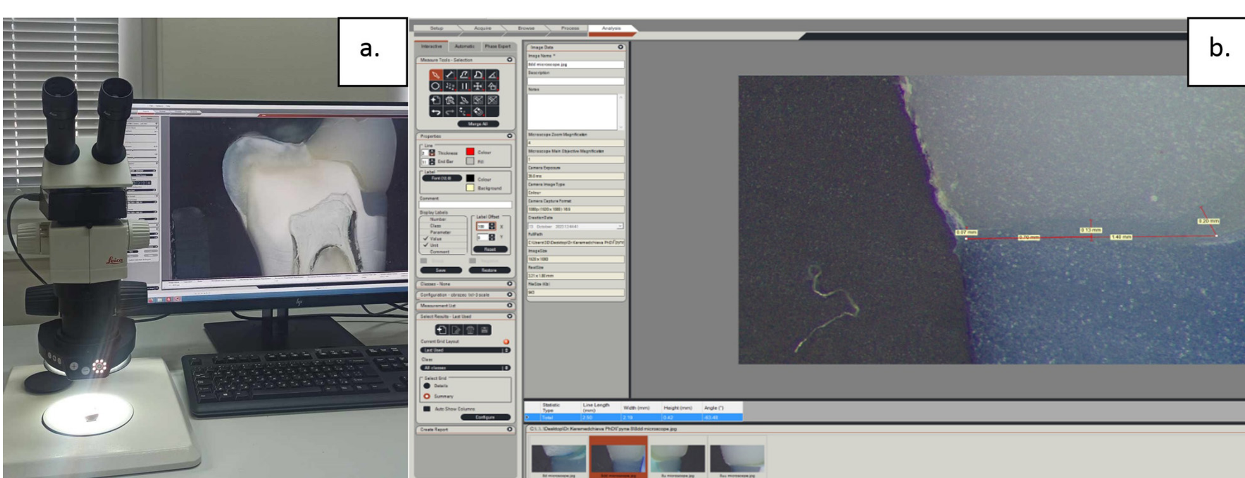

Fig. 6. ***a.*** *Leika DM 1000 LED stereomicroscope*; ***b.*** *Leika Application Suite.*

lays, classic technique, cemented with composite cement (0.18 mm).The highest were the mean cement thickness values for Group 1—hybrid ceramic inlays, classic technique, cemented with glass ionomer cement (0.31 mm), and Group 5—hybrid ceramic inlays, hybrid technique, cemented with glass ionomer cement (0.28 mm).

DISCUSSION

Marginal adaptation of restorations is crucial for the clinical success of the treatment (19). A marginal gap represents the vertical distance from the margins of a restoration to the cavity preparation walls of the tooth (20). In direct composite restorations, the marginal gap is very small; it is only filled with the bonding agent, but there is an additional problem with polymerization shrinkage (21). In indirect restorations, more specifically inlays, which were used in this experimental study, the marginal gap is filled with dental cement. This way the polymerization shrinkage is reduced only to the thin layer of cement, binding the restoration to the tooth surface (22). Groups 5, 6, 7, and 8 in this in vitro study featured cervical margin relocation with the application of composite material, which may lead to marginal opening in this area. In order to gain a more detailed insight, microleakage should also be examined (23).

CONCLUSION

Under the limitations of this experimental in vitro study, the following conclusions can be made: lithium disilicate and hybrid ceramic inlays cemented with composite cement have better marginal adaptation than the ones cemented with glass ionomer cement. Lithium disilicate restorations and inlays without cervical margin relocation (classic technique) have a slightly better marginal fit than hybrid ceramic inlays and restorations with hybrid technique.

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