

In Vitro Evaluation of the Effect of Core Thickness and Fabrication Stages on the Marginal Accuracy of an All-Ceramic System

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Abstract

Objective: To evaluate the influence of core thickness and fabrication stages on the marginal accuracy of IPS e.max Press crowns.

Materials and Methods: Twenty IPS e.max Press crowns, 1.5mm thick, were fabricated on metal dies. The crowns had two different core thicknesses, 0.8mm for group A and 1mm for group B, ten for each group. Marginal gap was measured after each stage of core fabrication, veneering and glaze firing. The specimens were not cemented and the measurements were made at four points on metal dies using a stereomicroscope ($\times 120$). Data were analyzed by SPSS software and independent t-test.

Results: Mean marginal gaps measured after each stage for group A were 13.5 (± 1.4) μm , 33.9 (± 2.3) μm and 40.5 (± 1.7) μm , and for group B these figures were 14.9 (± 2.0) μm , 35.5 (± 2.2) μm and 41.3 (± 2.0) μm . There were no statistically significant differences in marginal gap values between the two groups ($p > 0.1$). Significant increase in gap was observed after the veneering stage in both groups ($p < 0.05$). After glazing, no significant increase in gap was detected.

Conclusion: IPS e.max Press crowns have an acceptable marginal fit. Increasing thickness of core does not increase marginal fitness.

Key Words: Marginal Fitness; Marginal Gap; IPS e.max Press

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INTRODUCTION

Marginal integrity is a key factor in the success of restorations. In cemented restorations it means close adaptation of the prosthesis margin to the finishing line of prepared tooth. Gaps in margin render the tooth susceptible to caries, pulpitis and periodontal disease [1-3].

Improving adaptation can increase longevity of treatment and the success rate.

All-ceramic restorations are in fast progression in properties and usage. In situations with high esthetic demands, these materials may be the material of choice. Although adhesive resin cements are recommended for most of all-



Fig1. Left, metal die used for veneering and right, template with certain inner diameter used for core wax-up

ceramics [1], and these luting agents have very low solubility [4], fitness is still important. The incidence of gingival inflammation increases around clinically deficient restorations, particularly those with rough surfaces, subgingival finish lines or poor marginal adaptation [1]. Factors affecting adaptation in all-ceramic restorations may be categorized into those influencing before cementation [5-7] and those influencing after cementation [8-12] and changes in marginal fitness after thermal or mechanical loading in the mouth [13-17]. These factors have influence before cementation: ceramic system (polycrystalline based ceramics, glass-ceramics, glass infiltrated ceramics and feldspathics) [1,18] the manufacturing technique [1,2,6,19] (sintering, slip-casting, heat pressing, casting, CAD/CAM), fabrication stages, [19-21] finish lines [6, 7, 22] core and veneering layer thermal mismatch [23].

In techniques that a strong core is veneered by a layer ceramic, thermal mismatch between

two materials can cause deflections during the fabrication process [23]. In the study of Castellani, thermal distortion of all-ceramic crowns was compared with metal ceramic crowns [24]. The materials exhibited different responses. The metal ceramic crowns stabilized after an initial loss of marginal precision, and the all-ceramic crowns continued to distort with each firing cycle. Balkaya et al. reported that the addition of porcelain to the copings caused a significant change in the marginal fit of the crowns made from conventional In-Ceram, copy-milled In-Ceram and copy-milled feldspathic crowns [19]. Sulaiman et al. compared marginal fit of In-Ceram, Procera, and IPS Empress crowns [20]. No significant differences were detected among the various stages of crown fabrication. Both studies found significantly larger marginal discrepancies in the facial and lingual surfaces than mesial and distal. Greater bulk of porcelain was explained as the probable reason for higher discrepancy in these surfaces [19,20]. Komine et al. reported, ceramic firing did not significantly affect either marginal or internal adaptation of the Cercon, a ZrO_2 ceramic [25]. The difference between studies is possibly a result of the greater strength of ZrO_2 core [25].

The purpose of the present study was to investigate the influence of core and veneer thickness on marginal adaptation of IPS e.max Press (Ivoclar Vivadent, Schaan, Liechtenstein) crowns, during different stages of core fabrication, veneering and glazing. IPS e.max Press is a heat pressed lithium disilicate glass-ceramic, which is veneered by IPS e.max Ceram, a nano-fluorapatite glass-ceramic. This material is the last generation of pressed ceramics from Ivoclar Vivadent Company, with improved strength and optical properties. Its flexural strength is 400MPa (50MPa greater than IPS Eris). It is indicated for anterior and posterior single crowns, for bridges anterior to second premolars and implant superstructures. The null hypothesis was that increasing the

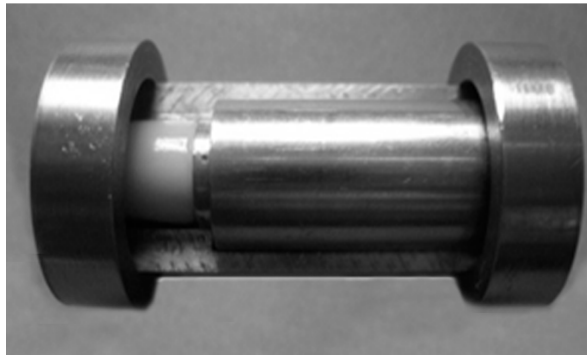


Fig 2. A crown and related die in the holding device

core thickness has no effect on marginal accuracy of this ceramic.

MATERIALS AND METHODS

Three stainless steel dies were machined simulating a premolar, prepared for full coverage, with 7.5 mm height, 7mm diameter, and 6° convergence angle (Fig 1). Finish line was rounded shoulder, with different width for each die. The minimum framework thickness recommended by Ivoclar Vivadent was 0.8mm and the maximum thickness for the veneering layer was 0.7mm. So cores were fabricated on 0.8mm (group A) and 1mm shoulder dies (group B), ten specimens for each group. The 1.5mm shoulder die was used for veneering cores to final crowns. Special metal templates were machined to insure similar thickness for cores in each group and final crowns (Fig 1). A groove, 4mm long and 0.5mm deep was inserted on dies for repeatable seating of samples and preventing their rotation. Depressions were made on four sides of dies 0.5mm below margins, pointing identical positions for measurements. Die spacer was not used.

To fabricate cores, templates were placed on related dies and wax was injected in between. During removing wax patterns from metal dies, any incomplete one, due to attaching to metal was remade. Wax patterns were removed, sprued and invested in IPS PressVest speed investment material (Ivoclar Vivadent,

Schaan, Liechtenstein). Preheating of investment rings was done at 800°C . Then rings were transferred to Ivoclar EP600 press furnace (Ivoclar Vivadent, Schaan, Liechtenstein) and press filled with IPS e.max Press, [K20768 (Ivoclar Vivadent, Schaan, Liechtenstein)] HO ingots at 920°C . Then the cores were divested, sandblasted with glass polishing beads at 2 bar (30 psi) pressure and cleaned by Invex (Ivoclar Vivadent, Schaan, Liechtenstein) in ultrasonic bath to remove the reaction layer formed on them. Any incomplete cast core was discarded. Each core was seated on the main die (1.5 shoulder) and the assembly was placed in a device designed to keep them together and prevent their movement (Fig 2). One end of the device was not fixed and could apply pressure on the core, to insure close adaptation of core to die. Marginal fit was examined at $\times 120$ magnification by a stereomicroscope (SZX12 Olympus, Japan) at four predetermined points. According to Holmes definition for marginal gap [26], the distance between crown margin and the edge of die was measured. After this stage, all cores were reinserted on the 1.5mm shoulder die and IPS e.max Ceram [K3116 powder, K43221 liquid (Ivoclar Vivadent, Schaan, Liechtenstein)] as the veneering layer was applied on them using a template to insure uniform thickness. The marginal 0.5mm of cores was not veneered. Each veneered crown was inserted on the main die and again the assembly was placed in the device and the fitness was examined under the stereomicroscope. The process was repeated after glazing [H29987]. All laboratory procedures were done by one technician and all examinations were done by one of the investigators. Data were analyzed by SPSS software and independent t-test.

RESULT

Mean marginal gaps measured after core fabrication, veneer firing and glaze were $13.5 (\pm 1.4) \mu\text{m}$, $33.9 (\pm 2.3) \mu\text{m}$ and $40.5 (\pm 1.7)$

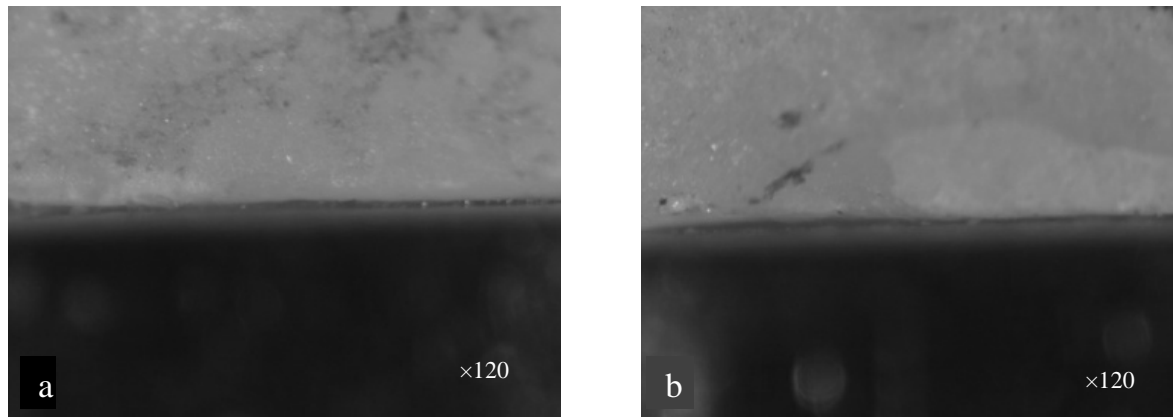


Fig 3. Stereomicroscopic view of marginal gap at core stage, (a) group A, (b) group B

μm , respectively for group A and $14.9 (\pm 2.0) \mu\text{m}$, $35.5 (\pm 2.2) \mu\text{m}$ and $41.3 (\pm 2.0) \mu\text{m}$, respectively for group B. There were no significant differences in marginal gap values between the two groups ($p > 0.1$). Significant increase in gap was observed after veneering stage in both groups ($p < 0.05$), but no significant increase was detected after glazing in either of the two groups. The results are shown in figure 4.

DISCUSSION

This study was designed to evaluate the influence of core and veneer thicknesses on marginal adaptation of IPS e.max Press crowns during different stages of fabrication. The results showed 0.2 mm increase in core thickness had no effect on the marginal accuracy of crowns and the null hypothesis was confirmed. Addition of the veneering layer significantly decreased marginal adaptation of the crowns ($p < 0.05$).

In this study, metal dies were used to prevent wear of dies during fabrication processes and measurements [19]. Finish line was rounded shoulder that is suggested for all-ceramic full coverage crowns [27].

Core thicknesses were 0.8 and 1mm, because the least thickness recommended by the manufacturer was 0.8 mm. Die spacer was not used because crowns were not cemented; further

more, die spacer application might complicate uniform thickness of the samples [24] and may affect crown fitness [19]. The marginal 0.5mm of cores was not veneered, because veneer material on the margin could lead to misleading results [25].

The methods used for measurement of the marginal fit include: 1) direct view of the crown on a die, 2) cross-sectional view, 3) impression replica technique, and 4) clinical examination [19]. The last three methods are suitable for measuring gaps after cementation and after loading in the mouth. In this study, uncemented, nonsectioned specimens were examined by direct view under the stereomicroscope. To reposition them repeatedly, a groove was inserted on dies. Grooves and depressions helped all examinations to be done in identical points. Because of symmetrical contour in the specimens, only four measurement points per specimen were considered. The sample size of ten for each test group was for compensating minor variations in the fabrication process.

In the present study, the mean marginal gap of IPS e.max Press crowns was $41 \mu\text{m}$. Stappert et al. studied marginal adaptation of different types of all-ceramic partial coverage restorations after exposure to an artificial mouth. The result of the present study is in agreement with values reported for four cusps reduced group

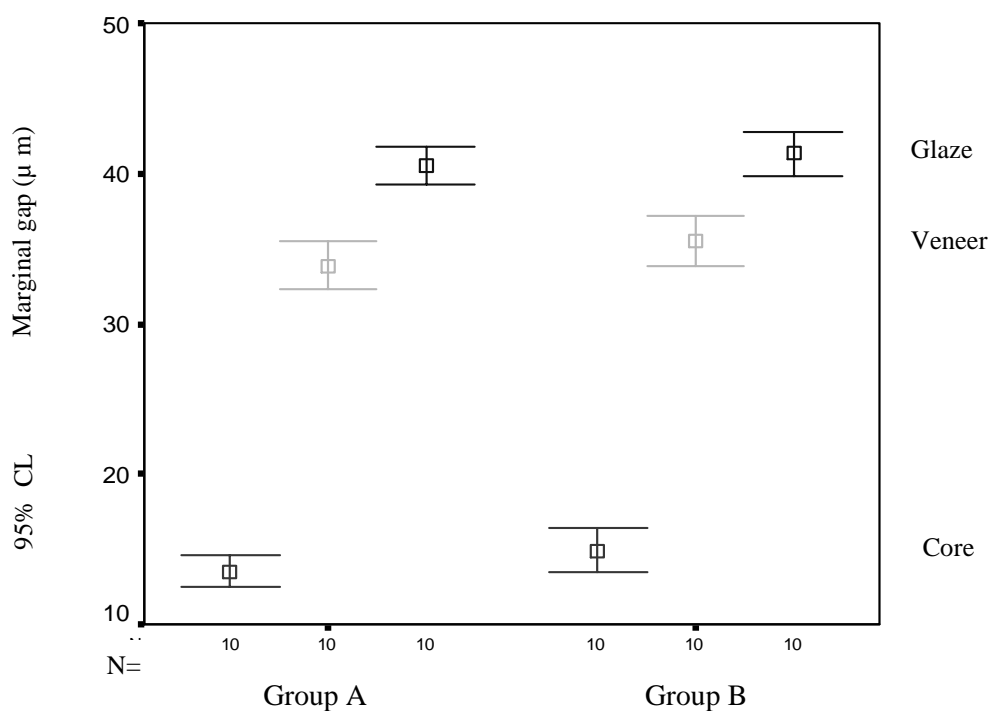


Fig 4. Comparison of Marginal Gaps between Two Groups According to Fabrication Stages

(50µm) before cementation [14]. Conrad et al. reviewed current literature for in vivo and in vitro marginal discrepancy evaluations. The value reported for IPS Empress 2 was 44 µm [1]. Balkaya et al. reported that the labial and palatal surfaces of the conventional and copy milled In-Ceram crowns exhibited significantly larger marginal discrepancies than the other surfaces [19]. The results are consistent with the findings of Sulaiman et al. for Procera, IPS Empress and In-Ceram [20]. They explained the result by shrinkage of porcelain toward the greatest mass. Their specimens were made on dies simulating prepared maxillary central incisor, with a wider shoulder and as a result, a greater mass of porcelain at the labial and palatal surfaces compared to the mesial and distal [19, 20].

In the present study, there was no variation in shoulder width and veneer thickness inside one group. This may explain the difference of

results between the studies. Changing core and veneering layer thickness in different groups did not influence the fitness either.

In this study, the marginal gap increased in every stage of fabrication. Significant increase ($p < 0.05$) was observed after firing veneering layer. This result agrees with what Balkaya et al. found in their study. They indicated that addition of porcelain to the copings caused a significant change in the marginal fit of the crowns [19], but Sulaiman et al. found no significant differences among the various stages of crown fabrication [20].

Low shrinkage of heat pressed cores may explain the difference. For heat pressed ceramics that use lost wax technique, 0.4% shrinkage of wax pattern and 0.2% shrinkage of ceramic coping can be compensated by 0.3% setting and 0.2% thermal expansion of investment material [20]. Because of inherent properties, large gaps are not expected in pressed copings

[28]. In the present study, the mean marginal gap of copings was 14.2 μ m. After veneer firing there was a significant increase in gap. This is different from what Komine et al. found in their study [25].

Their comparison between ZrO₂ copings and crowns demonstrated that ceramic firing did not significantly affect marginal adaptation. They explained that the strength of ZrO₂ copings prevent them from being affected by porcelain firing procedure. Lithium disilicate glass-ceramics are not as strong as ZrO₂ copings (400MPa compared with 900MPa). Increase in marginal discrepancy after veneer firing is a probability.

Glaze had no significant effect on gap, similar to what Balkaya [19] et al. reported. The values for marginal gaps in both groups were in a clinically accepted range proposed by Christensen [29], McLean and Fraunhofer [30].

CONCLUSION

IPS e.max Press crowns have an acceptable marginal fit.

The comparison between the present study and previous studies indicate that variation in veneer thickness of one crown is more influential on marginal accuracy than uniform change in veneer or core thickness.

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