In vitro comparison of microleakage, marginal fit, and cement thickness of conventional and prepless lithium disilicate veneers

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Abstract

**Purpose:** To assess the influence of two preparation techniques on the microleakage, marginal fit, and cement thickness of lithium disilicate veneers. **Materials and Methods:** A total of 24 human maxillary central incisors were divided randomly into two groups according to preparation technique (n = 12): minimally invasive preparation with butt-joint design (0.3-mm depth) and a chamfer finish line (group MP); and no preparation (NP). All teeth were restored with lithium disilicate veneers cemented with photopolymerizable resin cement. Specimens were aged thermally (6,000 cycles of 5°C to 55°C) and mechanically (100,000 cycles at 100 N, 4 Hz). Specimens were immersed in fuchsin for 24 hours employing a standard dye penetration technique, then sectioned and evaluated under a stereomicroscope (x20). Data were analyzed by ANOVA and Kruskal-Wallis tests (P < .05). **Results:** There was significant microleakage (P = .0163) at the cervical area compared to the proximal area. The marginal fit was similar, with no statistical difference (P = .212) between groups MP (153 ± 81 µm) and NP (111 ± 74 µm). Group MP showed a significantly (P = .006) reduced cement thickness at the cervical area (87 ± 27 µm) compared to group NP (210 ± 89 µm). **Conclusion:** Although the preparation technique was shown to influence the cement thickness, it did not show any influence on microleakage or marginal fit. *Int J Prosthodont 2022. doi: 10.11607/ijp.7616*

Introduction

Many factors affect the long-term survival of ceramic veneers. For example, the integrity of marginal seal and resistance to microleakage have been shown to determine the longevity of adhesive restorations, as they prevent the accumulation of bacterial plaque, secondary caries, and other related problems.¹ Studies have
recommended a thin cementing line whenever possible, because it provides greater resistance to the restoration and prevents problems such as cement solubility, fracture, and debonding.\textsuperscript{2,3}

It has been shown that the best maneuver to achieve success in esthetic ceramic restorations is to limit the restoration to tooth enamel.\textsuperscript{4,5} Lithium disilicate makes it possible for the dentists to achieve highly aesthetic results using a minimum thickness of ceramic.\textsuperscript{6} Lately, “prepless” veneers are gaining popularity, and acceptance from as it preserves the tooth structure.\textsuperscript{7–11} However, the over-contoured restoration resulting from placement of ceramic veneers without tooth preparation has drawn criticism, as it could affect the periodontal health and alter the emergence profile.\textsuperscript{12}

Studies have indicated that tooth reduction for ceramic veneers should be around 0.3 to 0.5 mm..\textsuperscript{6,13,14} The finish line of such restorations can have a knife-edge or feather-edge to preserve the enamel, especially in the cervical area.\textsuperscript{6,15} Nevertheless, most previous studies have been shown to focus on comparing termination lines in the incisal third.\textsuperscript{1,16–19} Moreover, studies assessing the cervical margin or comparing the prepless technique with conventional techniques are limited.\textsuperscript{20–22}

Therefore, our study aimed to compare the effect of a conventional and a prepless technique on microleakage, marginal fit, and cement thickness of lithium disilicate veneers. The null hypotheses were: [1] preparation technique does not affect microleakage, [2] preparation technique does not affect marginal fit, and [3] preparation technique does not affect cement thickness of the ceramic veneers.
Materials and Methods

Ethical approval (Nº: xxxxxxxx) was obtained from The Research Ethics Committee of xxxx xxxx xxxx University. Twenty-four freshly extracted human maxillary central incisors were selected according to the following criteria: teeth are free of visible crack, free of caries, and free of developmental enamel defect (enamel hypoplasia). Teeth with similar shape and crown dimensions were chosen, cleaned, and stored in distilled water at 8 °C. Online statistical program “Sealed Envelope Ltd.” ([https://www.sealedenvelope.com](https://www.sealedenvelope.com)) was used to calculate the sample size at 5% significance level (a = 5%) and to achieve 80% statistical power with standard deviation formula based on a previous study.22

Specimen preparation

A single operator distributed the teeth randomly into 2 groups (n = 12) and prepared them with a multiplier contra-angle 1:5 (Sirona, São Paulo, SP, Brazil) under water-cooling as described:

- Group MP: minimally invasive preparation was done with butt joint design (0.3 mm depth) and a chamfer finish-line (figure 1) exclusively in enamel23–25
- Group NP: No teeth preparation was done other than rounding of the incisal edges (figure 2). The retentive areas were removed without forming finish a line26
Teeth were embedded in chemically cured acrylic resin (Jet, Artigos Odontológicos Clássico; SP, Brazil) within plastic tubes, keeping the cervical third of the root exposed 2 mm away from CEJ.

*Measurement of remaining enamel thickness*

This remaining enamel thickness was measured to assure that all restorations were limited to enamel. Cone-beam computed tomography was taken for all teeth (i-CAT Next Generation, Imaging Science International, Hatfield, PA, USA) using the following protocol: 0.25 mm voxel, 8.0 x 4.0 FOV cm, 37.07 mAs, and 120 KvP in 26.9 s. The images were taken before cementation of the ceramic veneers to measure the thickness of remaining facial enamel in the cervical, middle, and incisal thirds using a software (OnDemand3D, Cybermed, Seoul, South Korea).

*Restoration fabrication*

Two-step impressions were taken for all teeth with polyvinylsiloxane addition silicone (Virtual - Ivoclar Vivadent Ltda, Barueri, SP, Brazil). Impressions were then poured with special type IV plaster (Durone - Dentsply, York, Pennsylvania, USA) to make working casts. A desktop scanner (Swing - DOF, Seoul, South Korea) captured the data from each cast to develop CAD (Computer Aided Design) models using EXOCAD software (CAD Design for Labs - Darmstadt - Germany). The software designed the veneers and then they were milled in resin. The lithium disilicate
veneers were fabricated using the lost wax technique, with finishing thickness of 0.4 to 0.6 mm.

Cementation procedures

The veneers were initially placed on their respective teeth to visually check their fit prior to definitive cementation. The internal surface of the veneers were then treated according to the manufacturers’ instructions: 5% hydrofluoric acid (Dentsply, York, Pennsylvania, EUA) for 20 s, then washed and dried for 30 s. This was followed by application of silane with micro brush (Monobond N – Ivoclar Vivadent Ltda, Barueri, SP, Brazil) for 5 s, which was disperse with a stream of air after 1 min. The surface treatment of the teeth was then carried out according to the following protocol: 35% phosphoric acid (Dentsply, York, Pensilvânia, EUA) for 30 s, washing and drying for 20 s; application of the adhesive (N-Bond Universal – Ivoclar Vivadent Ltda, Barueri, SP, Brazil) for 10 s and drying for 5 s. Each veneer was cemented with transparent light cured Variolink Esthetic LC resin cement (Ivoclar Vivadent Ltda, Barueri, SP, Brazil).

A single operator cemented all specimens with finger pressure for 10 s. An initial polymerization was carried out for 2 s on the facial surface with LED curing light (Valo, Ultradent, Indaiatuba, Brazil) with an energy intensity of at least 600 mW/cm² which was measured on a radiometer. The excesses cement were then removed with a periodontal instrument followed by light curing for 30 s at the facial surface and 30 s at the incisal area. Glycerin gel (Liquid stripX, Ivoclar Vivadent Ltda, Barueri, SP, Brazil) was then applied over the margins and further light curing was performed to
complete the polymerization process of these areas. All specimens were finished and polished with burs 3203 FF (KG Sorensen, Barueri, SP, Brazil) and disks (Ceramic Basic Kit, American Burrs, Palhoça, SC) at the margins.

Aging cycles

The specimens were subjected to thermocycling between 5 - 55 ºC in distilled water with dwell time of 30 s for 6.000 cycles (Biopdi Termocycler – Biopdi, São Carlos, SP, Brazil). The specimens were then subjected to mechanical-cycling (ER-11000Plus – São Paulo, SP, Brazil): 100 N for 100.000 cycles at 4 Hz. The load was applied in an oblique direction (45 º) on the palatal surface at the junction of the middle and incisal third.

Specimen analyses

The entire surface of the specimens, except the restoration margins was covered with two layers of nail polish to prevent leakage. They were then expose to a standard dye technique for 24h by immersing in basic fenicated fuchsin by Gram and Ziehl-Neelsen (Qeel Química Especializada Erich Ltda, São Paulo, SP, Brazil). The specimens were washed in running water and dried to be ready for horizontal and vertical sectioning using a precision cutter (ISOMET, Buehler, Lake Bluff, IL, USA). In the vertical cut, the marginal fit and microleakage were evaluated at the cervical margin. Besides that, the cement thickness was assessed at three points (cervical,
middle, and incisal third). The horizontal cut at the root was made to remove the tooth from the plastic tube, and the horizontal cut of the middle third to evaluate the microleakage at proximal margin.

Specimens were placed under 20 x magnification using a stereomicroscope (Discovery V20, Zeiss; Gottingen, Germany) and a measuring software (Axio Vision LE 4.8, Carl Zeiss Microscopy GmbH, Jena, Germany) was used for the analyses following calibration. Microleakage in the cervical and proximal margins was evaluated by measuring the maximum penetration of the fuchsin dye. For group MP, the marginal fit was measured as the distance from the inner margin of the laminate veneer to the margin of the finish line. For group NP, the measurements were done from the inner margin of the veneer to the dental enamel. The cement thickness was measured from the facial surface of the tooth to the internal wall of the restoration at the cervical, middle, and incisal third of the tooth. Figure 3 presents a schematic drawing with stereomicroscopic images describing how the cuts and measurements were made.

Statistical analyses

Descriptive statistics was used to analyze the results with calculations of mean and standard deviation. Inferential statistics were performed using the Kolmogorov-Smirnov test to check the normal distribution. Two-way ANOVA test was performed to assess the interaction between the preparation technique and the regions (cervical and proximal) on the microleakage. Kruskal-Wallis inferential test was performed to assess the influence of the type of preparation on cement thickness and One-way
ANOVA was performed to analyze marginal fit. The tests were performed using the Statistica software (StaSoft, Tulsa, OK, USA) with a significance level of 5%.

**Results**

The means and standard deviations of enamel thickness, microleakage, marginal fit, and cement thickness are presented in figures 4, 5, 6 and 7.

*Enamel thickness*

As expected, the thickness of the remaining enamel was highest in group NP in the evaluated areas, with the highest value at the incisal third.

*Microleakage*

Microleakage was higher in group MP. However, there was no interaction between the preparation technique and the regions analyzed (p = 0.431 > 0.05). In contrast, there was significant difference in the microleakage between the cervical and proximal areas (p = 0.0163 < 0.05). Microleakage at the cervical area was greater than that at the proximal area. The results are shown in table 1.

*Marginal Fit*
The marginal fit values were highest in group MP. However, the difference was not statistically significant \( p = 0.212 > 0.05 \). The results are shown in table 2.

**Cement Thickness**

The group NP showed the highest cement thickness values. However, the difference between the groups was statistically significant only at the cervical third \( 0.006 < 0.05 \), as shown in figure 8.

**Discussion**

Our results indicate that even though the type of preparation had no effect on the microleakage and marginal fit of lithium disilicate veneers, there was significant effect on the cement thickness. Group MP showed lower cement thickness than group NP at the cervical area. Therefore, the first and second null hypothesis were accepted, and the third could be rejected.

The thickness of the remaining enamel in our study showed that all restorations were limited to the enamel. It has been shown that, bonding in enamel is stable and highly efficient, because of its high mineral content, structural homogeneity, and low moisture. Whereas dentin, even with the newer adhesive agents in the market, the bond has been shown to be affected due to its water content and presence of organic components.\textsuperscript{3,4} In our study, the depth of preparation in group MP was 0.3 mm, which was guided by three orientation grooves; this is following the criteria of minimal invasive preparations as described in the literature.\textsuperscript{23–25} The use of the depth
orientation grooves technique decreases the risk of unnecessarily removing intact tooth structure that could possibly lead to dentin exposure. Enamel thickness in the facial surface of the anterior teeth varies from 0.3 to 0.5 mm in the cervical third, 0.6 to 1 mm in the middle third, and 1 to 2.1 mm in the incisal third. These values are similar to the measurements obtained in this study using computed tomography.

The microleakage in our samples is seen to have occurred at the interface between the ceramic veneer and the composite resin cement. This could be due to the location of the restoration margin being placed in the enamel. These results corroborate with previous studies, which suggest that preservation of the tooth structure and bonding to enamel leads to better marginal integrity. Moreover, a recent study has shown that the risk of ceramic veneers fracture increased when they are bonded to a large amount of exposed dentin.

Although the microleakage was not significantly different between the groups, group NP showed lower microleakage values. This could be due the smaller marginal gap in unprepared teeth. In addition, since the very thin margins of this type of veneers resemble the margins of teeth restored with the knife-edge finish-line. Thus, leading to lower tension, in consequence, less marginal degradation and less microleakage. The results of the present study corroborate the findings of a previous clinical study that reported the marginal gap for ceramic veneers with no-preparation was 100 μm and for those with minimal preparation was 140 μm. In contrast, another clinical study suggested ceramic veneers with minimal preparation have better internal adaptation compared to prepless ceramic veneers.

Microleakage is the penetration of fluids, molecules, and bacteria from the oral cavity into restorative materials, leading to several problems such as caries, hypersensitivity, pulp inflammation, color changes below the restorations, and even
might break.\textsuperscript{32,33} Whereas, the perpendicular distance from the internal surface of restoration to the finish line of the preparation is defined as a gap. It has been suggested that there is a significant discrepancy between the acceptable marginal gap and the clinical reality. Even though most of the literature states that the acceptable marginal gap is less than 120 \(\mu m\)\textsuperscript{34}, a clear consensus is lacking on the exact value. This becomes even more relevant, as a bacterium of \textit{Streptococcus mutans} is only approximately 0.75 \(\mu m\). Moreover, a large marginal gap can expose the cementation material to oral fluids, leading to restoration failures.\textsuperscript{35}

The differences in values between the cervical and proximal regions in our samples can be explained as a result of the degradation in the cervical area with mechanical cycles since excessive loads generate tension concentration in this region of the restoration.\textsuperscript{36} This finding is in agreement with a finite element analyses\textsuperscript{37}, which concluded that the cervical region has the highest probability of restoration failure as it presented high shear stress, regardless of the preparation design. Since microleakage is an important factor for restoration longevity, the finish line should be viewed with caution.

Among our study samples the group NP showed a higher value of cement thickness, which could be attributed to the presence of greater retentive areas in the preparation. Moreover, during the designing of the veneers in the CAD software, the program itself did an internal relief based on the retentive areas of the preparation. We observed that in the group NP, the software always indicated a larger internal relief area to facilitate the insertion of ceramic veneers. However, both groups showed an even film thickness of the cement, which indicates better stress distribution in the interface of ceramic veneers. This could be related to the fabrication technique used in our study (pressable ceramic). These findings are in agreement with another study.
in which ceramic veneers fabricated by the pressable technique showed uniform film thickness. This in vitro study found direct relationships between the preparation technique and a factor that is linked to the longevity of the restoration.

Limitations of our study include the low number of groups evaluated, involvement of only a single operator, and the non-blinded nature of evaluation of the results. Further research, especially in vivo studies will provide a better understanding of findings in the long-term.

**Conclusion**

Based on the findings of our in vitro study, we draw the following conclusions:

- Type of preparation did not influence the microleakage, but it was significantly higher at the cervical area than at the proximal in both groups studied.
- Type of preparation did not influence the marginal fit of lithium disilicate veneers.
- ‘Prepless’ technique led to significantly higher cement thickness at the cervical one third when compared to the minimally invasive technique.

**Conflict of Interest:** The authors have no conflicts of interest to declare that are relevant to the content of this article.

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Ethical approval: This research was approved by the Human Research Ethics Committee of the XXX of the xxx xxx xxx University (n\textsuperscript{o}:xxxxxxxxx).

Informed consent: For this type of study, formal consent is not required.

References


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2-factor ANOVA test.
Table 2 - Influence of the preparation on marginal fit

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1-factor ANOVA test.

Fig 1 a) Before preparation  b) Depth orientation grooves in incisal, middle, and cervical third with bur 4141 (KG Sorensen, Barueri, SP, Brazil)  c) Groove marking d) Preparation of intact tooth structures between the grooves in incisal, middle, and cervical third 3145FF KG Sorensen  e) immediately after preparation  f) Defining and smoothening of finish line with bur 3203FF KG Sorensen  g) Finished tooth
Fig 2 a) Intact tooth b) Incisal edge rounding with bur 3145FF KG Sorensen c) Retentive areas rounding with bur 3145FF KG Sorensen d) Finished tooth. It is possible to notice that even with the rounding, the dental anatomy remained the same, characterizing the group as “Prepless”.

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Fig 3 Schematic drawing: the dashed lines show the cut locations; the red dots are the microleakage analysis regions and the green dots are the cement thickness analysis regions. The black arrow shows the marginal fit analyze region. The four images taken by the stereomicroscope illustrate the exact area of each region and the red lines simulate how the measurements were made.

![Bar graph showing mean and standard deviation results of enamel thickness](image)

Fig 4 Bar graph showing mean and standard deviation results of enamel thickness
Fig 5 Bar graph showing mean and standard deviation results of microleakage

Fig 6 Bar graph showing mean and standard deviation results of marginal fit
Fig 7 Bar graph showing mean and standard deviation results of cement thickness

Fig 8 Kruskal-Wallis inferential test. *Statistically significant difference between groups in the cervical region