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Marginal accuracy of Cad/Cam occlusal veneers fabricated from glass and hybrid ceramics with two preparation designs: An *in vitro* study

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Abstract
Statement of the problem: Treatment of posterior teeth with occlusal wear is complex. Treatment involving more tooth reduction in these cases may be inappropriate. Occlusal veneers are less invasive approach. However, there is insufficient information available regarding the impact of the design of preparation and the type of ceramic material on the marginal adaptation of such occlusal veneers.
Aim: This study aimed to examine marginal accuracy of occlusal veneers fabricated from two ceramic materials (Glass and Hybrid) with two designs of preparation (Planar and chamfer).
Materials and Methods: Two mandibular first molar typodont teeth were prepared to receive 24 occlusal veneers. They were split into 2 equal groups (n=12) based on the material (Group (I): Lithium disilicate (Rosetta SM) occlusal veneers and Group (II): Hybrid ceramics (VITA ENAMIC) occlusal veneers). According to the preparatory design, each group then split into 2 subgroups (n=6)) (planar and finish line). Preparations were scanned, occlusal veneers were designed, milled and checked for seating under magnification. The vertical gaps between the cervical margin of the occlusal veneers and the outermost part of the finish line were measured using an optical microscope and image analysis software (20 readings per specimen). The mean vertical gap for each occlusal veneer was then calculated.
Results: The Rosetta group showed a statistically non-significant higher gap mean value (26.32±3.61µm) than the Enamic group (23.15±5.15 µm) in the planar preparation design based on the results of student t-test (P=0. 2446 > 0.05). While for finish line preparation design, the Rosetta group recorded higher gap mean value (27.38±3.42 µm) than Enamic group (19.71±3.73 µm) and the difference was statistically significant confirmed by Student's t test (P = 0.004 < 0.05).
Conclusion: Lithium disilicate ceramic and hybrid ceramic materials can be used to fabricate occlusal veneers. Superior vertical marginal fit was demonstrated using hybrid ceramic. More important than the preparation design is the veneer's material in terms of marginal accuracy.

Keywords: Marginal accuracy, occlusal veneers, CAD/CAM, glass ceramics, hybrid ceramics, finish line preparation, planar preparation

Introduction

Tooth wear results in the loss of a significant portion of coronal tooth structure due to erosion, abrasion, or attrition. As a result, strategies to restore the missing tooth structure while keeping as much of the remaining structure as possible were applied. The traditional circumferential crown preparation procedure has been replaced by occlusal veneers [1].

Minimally invasive dentistry tries to retain as much healthy tooth structure as possible, which is important for the success and longevity of restorations. Occlusal veneers can be used to successfully apply this principle. These extra coronal minimally invasive restorations need less preparation depending on interocclusal space and guided by teeth morphology [2].

The design of preparation is a significant aspect that has the potential to affect the marginal adaptation of ceramic restorations. The preparation surface of a tooth having a ceramic restoration should ideally be free of sharp angles and smooth to the greatest extent possible [3].

Planar preparation design of occlusal veneers have gained popularity as a conservative strategy in worn dentition situations over the years. Modifications to this design through cuspal coverage aim at improving the performance of veneers [1].

Occlusal veneers can be constructed from variety of bondable ceramics. Among these materials, lithium disilicate ceramics demonstrate excellent mechanical features. Their microstructure, which consists of interconnecting needlelike crystals encased in a matrix of glass, could explain this [4].
Hybrid ceramics, made up of a polymer-infiltrated ceramic network, were introduced as a way to improve mechanical properties. The rationale for the combination of resin and ceramic materials is to benefit from these materials' elastic deformation properties, thereby increasing their resistance to loading forces [5].
From both a biological and mechanical standpoint, marginal accuracy is a critical criterion for the restoration's long-term success. Inadequate marginal accuracy or an excessively large opening will weaken the restoration, shorten its lifespan, and increase the risk of recurrent caries and periodontal disease [6].
The goal of this study was to examine the marginal accuracy of occlusal veneers made up of two different ceramic materials with two designs of preparation.
The null hypothesis was that there would be no difference in the marginal accuracy of occlusal veneers fabricated from lithium disilicate glass ceramic and hybrid ceramic materials with two preparation designs (planar and finish line).

Methodology

Ethical Approval

This study was granted approval by the Faculty of Dentistry at Cairo University (research ethics committee) with approval number 11-7-20.

Sample size

To apply a 2-sided statistical test to the study hypothesis (null hypothesis), a power analysis was created to have sufficient power. According to the results of a study by (El Guindy *et al*., 2016) in which the (mean±SD) value for both groups were (76.99± 5.04 µm) and (69.51± 7.1 µm) and by adopting beta (β) level of 0.20 (20%), alpha (α) level of 0.05 (5%), i.e. power=80% and an effect size (d) of (1.21); the predicted sample size (n) was found to be a total of (24) samples i.e. (12) for each group, (6) for each subgroup. G*Power (version 3.1.9.4 2) was used to perform sample size calculation.

Samples Grouping

A total of (24) samples i.e. (12) for each group, (6) for each subgroup.

Group (I): Lithium disilicate (Rosetta SM) occlusal veneers

Subgroup (1): Rosetta SM occlusal veneers constructed with planar reduction without finish line.
Subgroup (2): Rosetta SM occlusal veneers constructed with circumferential chamfer finish line.

Group (II): Hybrid ceramics (VITA ENAMIC) occlusal veneers

Subgroup (1): VITA ENAMIC occlusal veneers constructed with planar reduction without finish line.
Subgroup (2): VITA ENAMIC occlusal veneers constructed with circumferential chamfer finish line.

1. Typodont teeth preparation:

Two teeth (mandibular right first molars) of a NISSIN Typodont Dental Model from (Koyoto, Japan) were utilized to make the final preparations; one for each of the two designs of preparation. An addition silicone putty index from (Silagum, DMG, Germany) was taken before the preparation to ensure that the preparation is standardized and the two types of preparations were done by the same operator.
For the planar design the occlusal surface was reduced by 1 mm at the fossa and 1.5 mm at the cusp tip guided by the occlusal anatomy without opening the proximal contact (Figure 1). The finish line preparation was carried out as in the planar design, followed by preparation of circumferential finish line above the height of contour (Figure 2). A graduated periodontal probe was used to confirm the thickness of the finish line and the putty index was used as a guide to confirm the amount of occlusal reduction. For the two designs of preparation, the stones used were tapered stones with round end (Komet Dental, USA) (Coarse grit, REF**:** 6856 314 018) for the purpose of cutting & (Fine grit, REF**:** 8856 314 018) for finishing. Finally, preparations were polished with eve Diacomp plus occluflex from (EVE, Germany) and Sof-Lex polishing spiral wheels from (3M, USA).

Fig 1: Planar preparation design, occlusal view

Fig 2: Finish line preparation design, occlusal view

2. Restoration fabrication

Occlusal veneers were constructed in a complete digital workflow simulating chairside restoration production. Each Prepared tooth was placed in the typodont model and scanned with an intraoral scanner (Primescan, Dentsply Sirona, Germany). Designing of occlusal veneers was done using CEREC software (5.1 version, Sirona Dental System, Bensheim, Germany). Restoration parameters were set such that spacer thickness is 30µm [7] for both types of preparations, and restoration thickness at both cusp tips and central fossa was standardized at 1.5 mm & 1mm respectively. The milling was done using CEREC MC XL 4-axis milling machine from (Dentsply Sirona, Germany). The milling process was totally automated with 2 diamond burs working simultaneously, with abundant water coolant sprayed from both directions.

Crystallization of Rosetta occlusal veneers

Rosetta occlusal veneers were cleaned in ultrasonic cleaner prior to crystallization.

Pre-crystallized Rosetta occlusal veneers were fired using ceramic furnace from (Ivoclar Vivadent AG. Schaan, Liechtenstein). Occlusal veneers were mounted on the crystallization tray using IPS Object Fix Putty (Ivoclar Vivadent AG. Schaan, Liechtenstein). IPS e.max CAD Crystall/Glaze Paste (Ivoclar Vivadent AG. Schaan, Liechtenstein) was thinned with IPS e.max CAD Crystall/Glaze Liquid (Ivoclar Vivadent AG. Schaan, Liechtenstein) and applied on the Rosetta occlusal veneers with a brush then fired following the schedule provided by the manufacturer. After crystallization the veneers were checked on the typodont teeth.

Polishing of Vita Enamic occlusal veneers

The Vita Enamic occlusal veneers were polished using the Vita Enamic polishing kit (Vita Zahnfabrik, Germany) following the polishing protocol provided by the manufacturer.

Pink polishers were used for pre-polishing at 7,000 RPM with light pressure. The polishers were moved on the surfaces without staying in one place too long in order to avoid creating grooves or pits. To achieve high-gloss polish the polishers in grey colour was used at speed 5,500 RPM with light intermittent pressure. After polishing, the veneers were checked on the prepared typodont.

3. Marginal Accuracy measurement

The images were taken digitally by using U500x Digital Microscope from (Guangdong, China) with resolution (3 Mega Pixels) which is placed vertically at a 2.5 cm distance away from the samples, with a right angle between the illumination sources and the axis of the lens. A specially designed and fabricated holding device was used to hold the specimens in place (figure 3). Illumination was provided by eight LED lamps with a colour index of about 95%. The images were taken with a 35X fixed magnification and at maximum resolution (2272 by 1704 pixels), all while being linked to an IBM compatible PC. The images were captured with a resolution of 1280 × 1024 pixels per image.

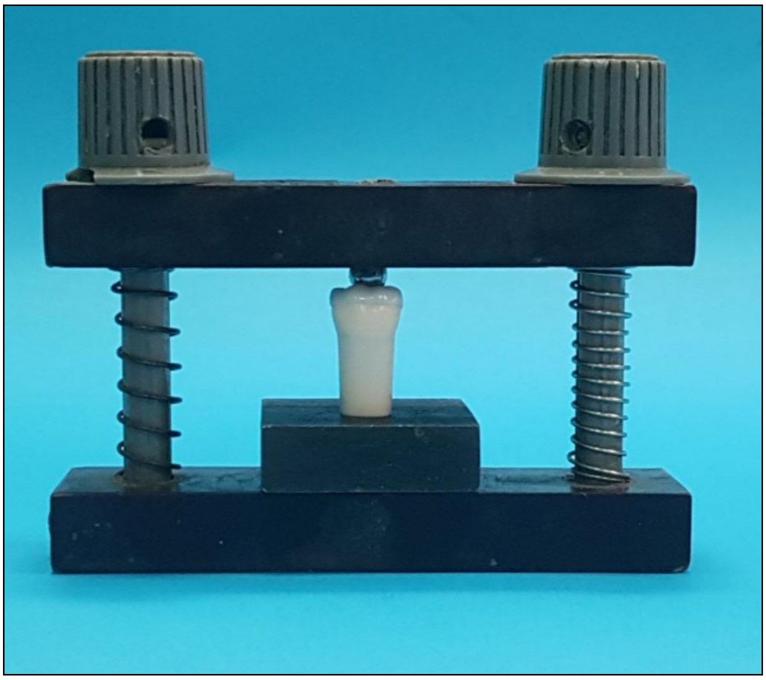

Fig 3: Holding device used to hold the specimens in place

Gap width was measured and evaluated using a computerized image analysis system (Image J 1.43U, National Institute of Health, USA). In this software, all boundaries, frames, sizes and tested parameters are represented in pixels. As a result, the system was calibrated to transform the pixels into precise real units. Comparison of an object of known size, in this case a ruler, with a scale produced by the Image J software served as the basis for calibration. Shots of the margins were captured for each specimen. Then morphometric measurements were done for each shot [5 equidistant landmarks along the circumference for each surface] (figure 4&5). Then the data obtained were gathered, tabulated and then subjected to statistical analysis.

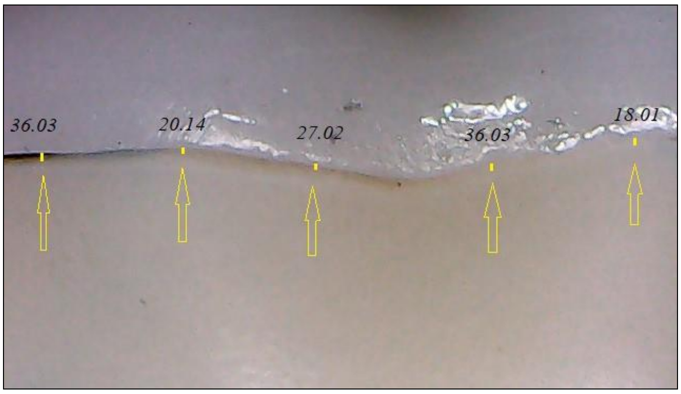

Fig 4: 5 equidistant landmarks along buccal surface of Rosetta occlusal veneer

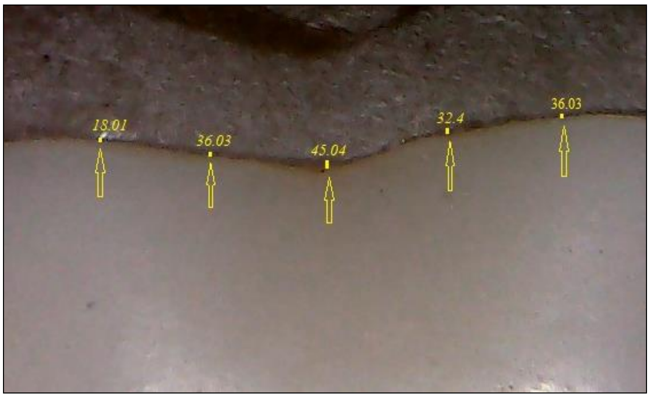

Fig 5: 5 equidistant landmarks along buccal surface of Vita Enamic occlusal veneer

4. Statistical Analysis

Standard deviation and mean were used to express the data. Student t-tests were conducted for compared pairs after the homogeneity of variance and normal distribution of errors had been established. One-way analysis of variance was carried out between all subgroups followed by Tukey's post-hoc test if showed significance. Two-way ANOVA performed for each variable (material & design). Sample size (n=12/group) was sufficient to detect large effect sizes for main effects and pair-wise comparisons. The satisfactory level of power was set at 80% and confidence level was set at 95%. Windows software (Graph Pad, Inc.) was used to analyze results. P value $\leq$ 0.05 was considered statistically significant.

5. Results

5.1 Marginal gap results between preparation designs in each group

Rosetta group: Finish Line subgroup recorded higher gap mean value (27.38 µm) than Planar subgroup (26.32 µm) which was non-statistically significant as confirmed by one-way ANOVA (P=0.6129 > 0.05) as demonstrated in (table 1).

Vita Enamic group: Planar subgroup showed higher gap mean value (23.15 µm) than Finish Line subgroup (19.71 µm) which was non-statistically significant as indicated by one-way ANOVA (P=0.2151 > 0.05) as demonstrated in (table 1).

Table 1: Comparison of the preparation designs' gap outcomes (Mean values and SDs) for the two groups

Variables		Mean	± SD	95% CI		Statistics
				Low	High	P value
Gr R	Subg_P	26.32	3.61	23.43	29.21	0.6129
	Subg_FL	27.38	3.42	24.64	30.12	
Gr V	Subg_P	23.15	5.15	19.03	27.26	0.2151
	Subg_FL	19.71	3.73	16.73	22.69	

Gr R; Rosetta group Gr_V; Vita Enamic group
Subg_P; Planar subgroup Subg_FL; Finish Line subgroup

5.2 Marginal gap results between 2 groups as a function of preparation design

With planar preparation design, the Rosetta group had higher gap mean value (26.32 µm) than Enamic group (23.15 µm) which was statistically non-significant confirmed by one-way ANOVA (P=0. 2446 > 0.05) as demonstrated in (table 2).

With finish line preparation design, the Rosetta group had higher gap mean value (27.38 µm) than Enamic group (19.71 µm) which was statistically significant confirmed by one-way ANOVA (P=0.004 > 0.05) as demonstrated in (table 2).

Table 2: Gap results (Mean values and SDs) between the two groups as a function of preparation design are compared.

Variables		Mean	± SD	95% CI		Statistics
				Low	High	P value
Subg P	Gr_R	26.32	3.61	23.43	29.21	0.2446ns
	Gr_V	23.146	5.15	19.03	27.26	
Subg FL	Gr_R	27.38	3.42	24.64	30.12	0.004*
	Gr_V	19.71	3.73	16.73	22.69	

5.3 Marginal gap results between preparation designs in both groups

It was found that Rosetta group with finish line preparation recorded statistically significant highest gap mean value (27.38 µm) followed by Rosetta group with planar preparation gap mean value (26.32 µm) then Vita Enamic group with planar preparation (23.15 µm) while the lowest statistically significant gap mean value recorded with Vita Enamic group with finish line preparation (19.71 µm) confirmed by one-way ANOVA (P=0.0156< 0.05). Pair-wise Tukey's post-hoc test showed non-significant (p>0.05) difference between both Rosetta group and Vita Enamic group with planar preparation subgroups, also between both Rosetta group subgroups as shown in (figure 6).

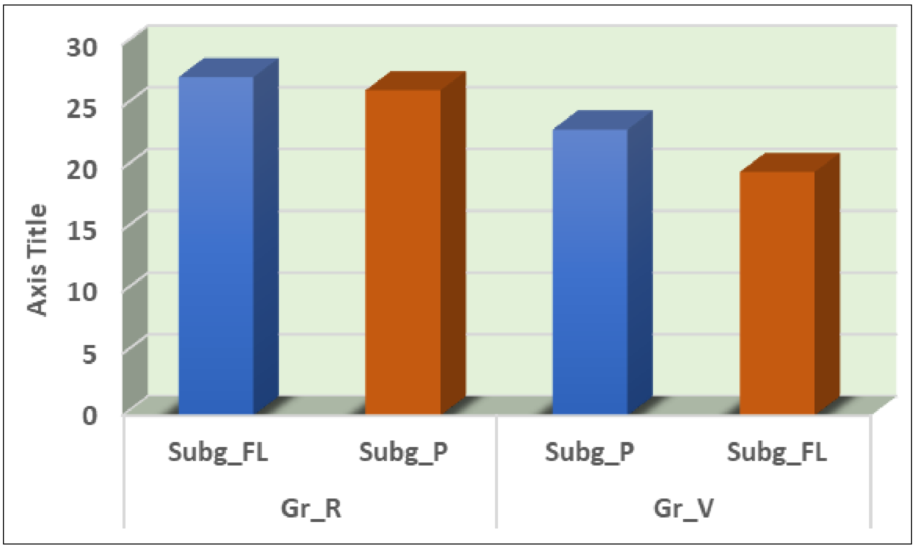

Fig 6: A column chart that compares mean values between preparation designs with the two material groups ranked from higher to lower

5.4 Total effect of material on marginal gap of occlusal veneers

Regardless of preparation design, totally there was significant difference between both groups confirmed by two-way ANOVA test (p=0.0031 < 0.05) where Rosetta group recorded higher gap (26.85 ± 3.52) than Vita Enamic group (21.43 ± 4.44) (table 3) (figure 7).

Table 3: Total gap results (Mean values and SDs) as a function of material group are compared

Variables		Mean	± SD	95% CI		Statistics
				Low	High	P value
Material group	Gr_R	26.85	3.52	24.04	29.67	0.0031*
	Gr_V	21.43	4.44	17.88	24.98	

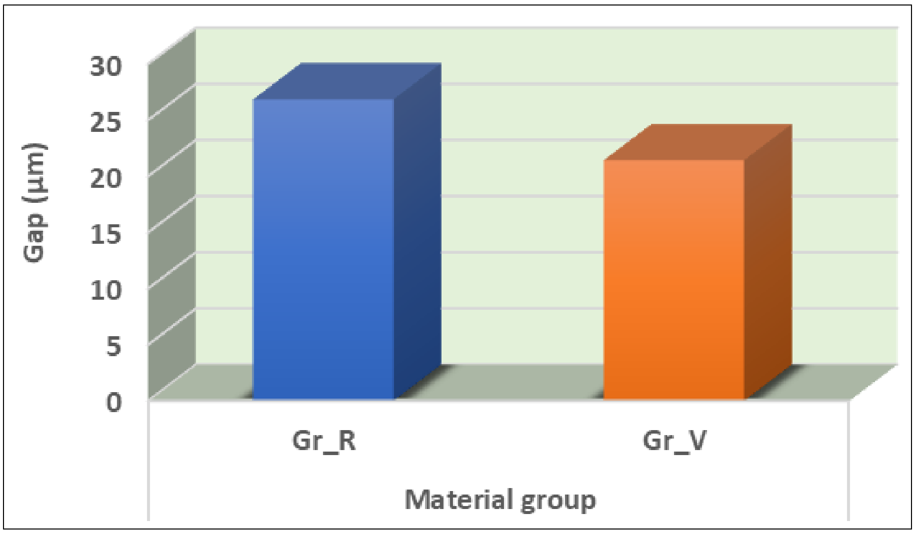

Fig 7: A column chart that compares total gap mean values between the two material groups

5.5 Total effect of preparation design on marginal gap of occlusal veneers: Regardless of material group, totally there was non-significant difference between both preparation designs confirmed by Two-Way ANOVA test (p=0.4736 > 0.05) where (Planar subgroup ≥ Finish Line subgroup) as demonstrated in (table 4) & (figure 8).

Table 4: Comparison of total gap results (Mean values ±SDs) as function of preparation design

Variables		Mean	± SD	95% CI		Statistics
				Low	High	P value
Preparation design	Subg_P	24.735	4.38	21.23	28.235	0.4736
	Subg_FL	23.545	3.575	20.685	26.405	

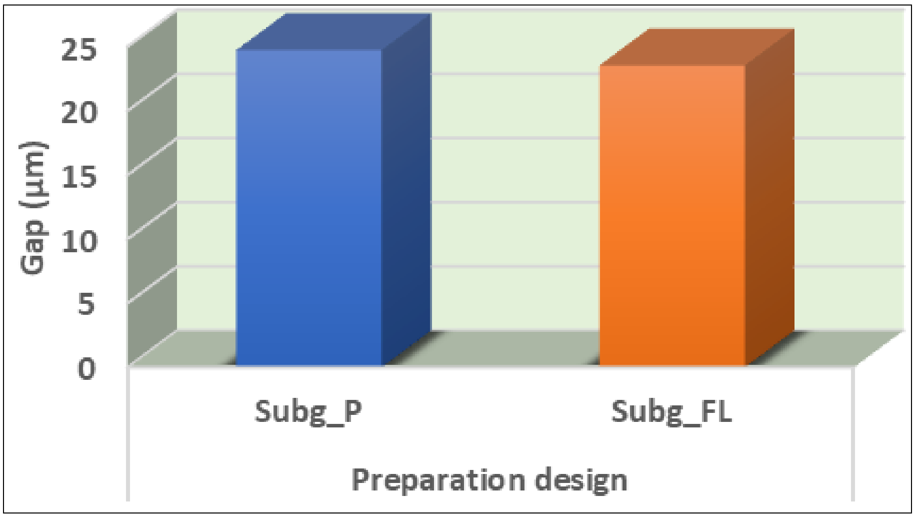

Fig 8: A column chart that compares total gap mean values between the two preparation designs

6. Discussion

Fixed prosthodontists have been pushed into more conservative treatment methods by recent advancements in restorative materials, construction technology and adhesive techniques. Occlusal veneers are thought to be the most recent therapeutic option for conservatively treating the problem of advanced erosive lesions [8].

According to previous studies, planar occlusal veneer preparation design has earned a reputation as a very conservative treatment option for severely worn teeth [9, 10]. On the other hand, finish lines are thought to provide positive seating and offer greater support than vague finish lines offered by the planar design.

In our study typodont teeth were used instead of natural teeth, as natural teeth represent great variations among each extracted tooth due to difference in age, anatomy and storage time after extraction so that standardization is difficult [11].

CAD/CAM technology was selected in order to minimize technical laboratory variables and achieve the highest level of standardisation of the construction process for all veneers in terms of thickness, anatomical features and internal fit [12].

Intraoral scanner (Primescan, Dentsply Sirona, Germany) was used, to simulate a completely clinically digital workflow for acquisition. It showed the highest trueness and precision when compared to other intraoral scanners and conventional impression technique [13].

Cerec software closed system was used for designing and milling the occlusal veneers to avoid any discrepancies that may show up by open system. According to (Ben-Izhack *et al*., 2021) there were significant differences in favour of zirconia-reinforced lithium silicate crowns produced by closed systems compared to open systems when the absolute marginal discrepancy parameter was evaluated [14].

Lithium disilicate glass ceramic material (Rosetta SM blocks) and hybrid ceramic material (VITA ENAMIC® Blocks) were the materials chosen to conduct this study. (Von Maltzahn *et al*., 2018) reported that lithium disilicate can be a very convenient material for fabrication of occlusal veneers in cases with severe worn out dentition or when occlusion needs heavy correction, as it offers high resistance to fracture allowing restoration fabrication with minimum thickness (1–1.5 mm), high wear resistance, high bond strength and excellent biocompatibility [15]. Hybrid ceramic material (VITA ENAMIC® Blocks) exhibits great strength, high edge stability. It also allows for minimal tooth reduction which supports its use where there is limited space available or when posterior occlusal veneers are needed [16].

Vertical marginal gap distance was measured in this study using direct viewing method which has the advantages of not being invasive, being less time consuming, and being the most often used for reliable results [17].

Measurement of the marginal gap vertically was chosen as it is most commonly utilised to assess the precision of fit of the restorations since this disparity is the least likely to be corrected following restoration manufacturing. The vertical marginal gap can only be corrected with luting cement, which cannot resist dissolution for long period of time, in contrast to the horizontal disparities, such as overhangs, which can be corrected intraorally to some extent. As a result, measurement of the gap width vertically has the highest clinical significance and should be considered the most important parameter in margin evaluation [18].

The null hypothesis of this study was accepted for the planar preparation design and rejected for the design with finish line.

All the tested occlusal veneers marginal gap results were within the range of the clinically accepted value below 50 µm [19]. The Rosetta group had higher gap mean value (26.32 µm) than Enamic group (23.15 µm) which was statistically non-significant confirmed by one-way ANOVA (P=0. 2446 > 0.05) with the planar preparation design. With the finish line preparation design, the Rosetta group had higher gap mean value (27.38 µm) than Enamic group (19.71 µm) which was statistically significant confirmed by one-way ANOVA (P=0.004 > 0.05).

This was in accordance with (El-Malah *et al*., 2019) who evaluated marginal accuracy of lithium disilicate laminate veneer (IPS e.max CAD) compared to hybrid ceramic veneer (VITA ENAMIC). Lithium disilicate laminate veneer showed statistically significant higher mean marginal gap value (67.81±14.22) than hybrid ceramic veneer (38.07±6.16) [20].

(El Mekkawi, 2020) evaluated marginal accuracy of CAD/CAM crowns fabricated from hybrid ceramic (VITA Enamic), lithium disilicate (E.max CAD) and zirconia lithium silicate ceramic materials (Celtra-Duo and VITA Suprinity). Marginal discrepancy was tested for all samples. He found that the group with the greatest marginal gap mean value was the E-max CAD group, followed by Celtra-Duo group, then VITA Suprinity group and VITA Enamic group showed the lowest mean value. The samples of VITA Enamic showed the lowest marginal gap values (29.5 µm ± 1.5). While, the samples of E-max CAD showed the highest marginal gap values (33.8 µm ± 0.75) [21].

For the hybrid ceramic material (VITA Enamic), occlusal veneers with finish line preparation design showed lower vertical marginal gap mean value (19.71µm ± 3.73) than the planar preparation design (23.15 µm ± 5.15) which was not statistically significant. This is in agreement with (Abo-Eittah and Shalaby, 2020), who investigated the marginal adaptation of occlusal veneers constructed from different ceramic materials with two preparation designs before and after aging. They found that VITA Enamic occlusal veneers with finish line preparation design had lower vertical marginal gap mean value (71 µm ± 12.33) than conventional planar design (75 µm ±10.43) before aging [4].

For the lithium disilicate occlusal veneers (Rosetta), occlusal veneers with conventional planar preparation design showed lower vertical marginal gap mean value (26.32 µm ±3.61) than finish line preparation design (27.38 µm ± 3.42) and the difference was not statistically significant. This is in agreement with (Angerame *et al*., 2019) who evaluated the fracture resistance, marginal seal and and cement thickness of lithium disilicate glass-ceramic occlusal veneers with two designs of preparation (planar and marginal chamfer) and found no statistically significant difference in the marginal adaptation with the two preparation designs [3].

Regardless of preparation design, hybrid ceramic (Vita Enamic) occlusal veneers showed lower vertical marginal gap mean value (21.43 µm ± 4.44) than Lithium disilicate (Rosetta) occlusal veneers (26.85 µm ± 3.52) and the difference was statistically significant.

Hybrid ceramic material (Vita Enamic) exhibits high edge stability after milling (up to 0.3 mm) which ensures precision fit and excellent marginal seal [16]. Also, Lithium disilicate glass ceramic material undergoes shrinkage of approximately 0.2–0.3% upon crystallization process**.** This crystallization shrinkage has significant effect on the increase of the marginal gap [22]. These are factors that may explain why the hybrid ceramic material has a better marginal seal than the lithium disilicate glass ceramic material.

Regardless of material, finish line preparation design showed lower vertical marginal gap mean value (23.54 µm ± 3.57) than conventional planar preparation design (24.73 µm ± 4.38) and the difference was not statistically significant.

The margin of the occlusal veneer in case of planar preparation design might have thin areas which increase the risk of chipping during production. For precise milling, the milling burs used in the CAD CAM milling machines need at least 0.3 mm margin thickness, which is sometimes difficult to obtain in the planar preparation design [4]. This might account for the greater vertical marginal gap mean value of the conventional planar design.

Finally, occlusal veneers proved their reliability in the restoration of worn out dentition. Care must be given when selecting the material of construction of veneers. Hybrid ceramics proved superior marginal adaptation when compared to glass ceramic materials.

Conclusions

Within the limitations of this study, the following could be concluded

- Occlusal veneers can successfully be fabricated from lithium disilicate glass ceramic and Hybrid ceramic materials.
- Hybrid ceramic showed better vertical marginal fit compared to lithium disilicate ceramic.
- The material of the occlusal veneer is more critical in the marginal accuracy than the preparation design.

Recommendations

- Fracture resistance after cyclic loading should be evaluated.
- Clinical investigations to compare the behavior of the two tested materials with the two designs of preparation should be conducted.
- An investigation to test the retention of the circumferential finish line and planar occlusal veneer preparation designs should be put in consideration.

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Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this paper.

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