FRACTURE RESISTANCE OF OCCLUSAL VENEER ON PREMOLAR TEETH USING TWO DIFFERENT PREPARATION DESIGNS

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ABSTRACT

Aim: The purpose of this study was to investigate the fracture resistance and marginal gap of two different designs of occlusal veneers made of two different ceramic materials. **Materials and Methods**: In this study, sixty recently extracted maxillary premolars were utilized. Two groups of teeth were randomly selected based on the type of occlusal veneer material. (n =30 each). The teeth in the first group were fixed using occlusal veneers made of advanced Lithium Disilicate, (CEREC Tessera™, Dentsply Sirona, Germany)(T), whereas the polymer-infiltrated hybrid ceramic was used for the occlusal veneer in the second group. (Vita Enamic, Vita Zahnfabrik, Germany) (E). Each group was further subdivided into 2 subgroups (n =15 each) according to the preparation design. Traditional occlusal reduction was used to prepare the teeth in the first subgroup. (planner preparation)(P). In the second subgroup, the reduction of teeth included the occlusal surface and 1 mm axial reduction with rounded shoulder finish line (modified = M). The veneers were designed and manufactured using CAD/CAM technology. A universal testing machine was used to measure the fracture resistance. A single static compressive load was applied to each restoration along the tooth's long axis until fracture occurred. A single static compressive load was applied to each restoration along the tooth's long axis until fracture occurred.

Results: The findings demonstrated that there was a statistically significant difference in the fracture resistance of the two preparation designs of the two materials. ($P \leq 0.05$), the subgroups of **CEREC Tessera™**, recorded, higher significant difference than Enamic in the two preparations. The results of the statistical tests demonstrated that the relationship between the preparation designs and materials, found to have a substantial impact on the fracture resistance difference. **Conclusions:** Selecting a particular preparation design should be linked to a thorough understanding of the occlusal veneers' material properties. Both substances could be applied to restorations involving occlusal veneers.. CEREC Tessera had a fracture resistance that gave better values, qualitatively and quantitatively.

INTRODUCTION

Avoiding tooth weakening by using a conservative minimal invasive esthetic treatments is usually preferred as it avoids excessive destruction of dental structures by tooth preparation.[1] Nowadays Ceramic veneers' excellent aesthetic qualities and translucency have led to an evolution in their use..[2] Ceramic veneers also considered a successful option for esthetic restorations.[3] Ceramic Veneers are indicated in different cases such as internal dental discoloration, multiple tooth wear, broken teeth , or malformations of the anterior and premolars.[4] The demand to esthetic excellence by patients and dentists, led to extending that treatment technique to posterior teeth.[5] Some studies showed that durability of ceramic veneers is more than 90% after five years[6]and 93.5% after ten years[7]. The precision of the dental preparation and choice of an suitable restorative material are important factors to achieve long-term success rates.[4] Studies reported that preparations that included exposure of dentine in cervical areas provided better success rates [7-9].On the other side, According to a recent clinical assessment, ceramic veneers that are bonded to enamel have a high success rate.; when dentin was exposed, failure rates increased significantly, Ceramic fracture or debonding was the main cause of failure. [8].Other studies stated that ceramic veneers made without any dental preparation offered low success rates when compared to ceramic veneers bonded to prepared teeth [10]. An esthetic restorative technique with ceramic veneers should preserve dental structures. There are clinical studies about minimal invasive preparations from 0.3 to 0.5 mm depth in buccal area of anterior teeth and 1mm to 2mm in posterior teeth to be veneering, [11,12] The primary cause of failure was ceramic debonding or fracture. [13]. A minimal invasive dental preparation is required as deep dental preparations, >0.5 mm, may expose dentin in the cervical area of the buccal surface [14,15]. The improvement of dental ceramic materials associated with a highly skilled technician in dental prosthesis allow the fabrication of high-strength ceramic veneers even at a very thin thickness [16]. The introduction of computerized technologies in restorative dentistry has led to significant progress for dental protheses. Dental clinics, laboratories, and production centers can now produce indirect restorations [17]. CAD/CAM systems were introduced to the market in the 1980s.. These systems are used to the create dental prostheses, offering improved results compared to other traditional methods [17-19]. Making use of digitally produced data sets, CAD/CAM design, and researchers can precisely manipulate silicate and oxide ceramics thanks to Numerical Control (NC) technology. This allows researchers to work with new, pre-made materials that have better qualities [18]. According to some reports, lithium disilicate glass-ceramic veneers can be made so thinly that they require little to no preparation or even minimal invasiveness. [16-18]. Numerous The literature suggests various dental reduction techniques for veneers based on occlusal and incisal features. [5,16,19,20]. da Costa et al.[19] found that a butt joint incisal reduction (without palatal chamfer) is correlated with greater fracture resistance in veneered tooth than tooth with an incisal preparation with palatal chamfer. Albanesi et al.,[21] in their meta-analysis, presented those veneers with occlusal involvement had a success rate of 88% against 91% of those without occlusal involvement.

The aim of this study Premolar fracture resistance and marginal gap would not be impacted by the two preparation designs or the restorative veneers (two types of ceramic), according to the null hypothesis that was tested.

MATERIALS AND METHODS

From the outpatient clinic at South Valley University's Faculty of Oral and Dental Medicine, sixty recently extracted maxillary premolars were gathered. Sixty recently extracted maxillary premolars were collected from the outpatient clinic at the Faculty of Oral and Dental Medicine at South Valley University. The teeth were extracted for periodontal or orthodontic reasons and were free of cavities and fillings. To ensure uniformity, the teeth that would be used in this experiment were measured using a digital caliper and eliminated if they were outside of the following ranges:, 7 ± 1.0 mm; crown bucco-lingual width, 8.8 ± 1.0 mm. Using an electric or ultrasonic scaler to remove calculous deposits and soft tissues, the teeth were then preserved in a 0.1% thymol solution. The teeth were embedded in 15 mm plastic cylinders containing partially- set chemical cured resin so that the cemento-enamel junction was situated 2mm above the resin. The teeth were divided in a random manner into 2 groups according to the material of occlusal veneer (n =30 each). The first group in which the teeth were restored with occlusal veneers made of Advanced Lithium Disilicate (ZLS), (CEREC Tessera™, Dentsply Sirona, Germany) (group T), whereas the polymer-infiltrated hybrid ceramic was used to construct the occlusal veneer material in the second group. (Vita Enamic, Vita Zahnfabrik, Germany) (group E). Each group was further subdivided into 2 subgroups (n =15 each) Conventional occlusal reduction was used to reduce the teeth in the first subgroup. (planar preparation) (subgroup P). In the second subgroup, the preparation of teeth included the occlusal surface and 1 mm axial reduction with rounded shoulder finish line (subgroup M).

Tooth preparation

One operator performed all the preparations. For both subgroups, The manufacturers' instructions regarding the minimum occlusal thickness for the finished restoration were followed when performing the occlusal reduction.. This was applied to the **CEREC Tessera** and the Vita Enamic machinable blocks utilized in this study. In order to verify the extracted tooth structure during preparation, the first and second indexes were divided in buccolingual and mesiodistal directions. In order to verify the amount of reduction in each side that is equal to the thickness of the wax pattern, the third index was utilized as a template for the creation of the wax pattern.. The first subgroup: conventional occlusal reduction (planar preparation). Occlusal preparation: 1mm uniform preparation was performed on the occlusal aspect only following the anatomical landmarks. This uniform preparation was done using short tapered round stone (855D 314 016, Komet, Germany). The third index served as a template for the wax pattern's creation, allowing the amount of reduction in each side to be confirmed to be equal to the pattern's thickness.with depth of 0.8 mm. Then the tooth structure between the groves was prepared using OccluShaper stones (barrel shaped stone) with medium grit (370 Komet). To finish the occlusal preparation, finishers of the same shape were used. (8370, Komet).

Fig. (1) The first subgroup finished preparation.

The second subgroup: The occlusal reduction was done as described in the first subgroup. A wider round-ended cylindrical diamond stone (836 KR 314 018, Komet) was used to reduce the axial walls creating a rounded shoulder finish line, which was then finished using a fine-grit bur (88836 KR 314 018, Komet). Figure 2

Fig. (2) The second subgroup finished preparation.

Design and construction of restorations

An intraoral scanner was then used to scan each preparation. (CEREC Omnicam, Dentsply Sirona, Germany). Then using the in-lab software (CEREC SW 4.4.4., Sirona Dental Systems GmbH, Bensheim, Germany). Every occlusal veneer was created to restore the matching tooth.. For uniformity, an internal relief spacer of 40 microns was utilized in every design. The design data was sent in the form of STL file to the milling machine (inLab MCXL, Dentsply Sirona, Bensheim, Germany). After that, milling blocks were used to mill the occlusal veneers. After being milled, the veneers were separated from the sprues. The seating of the veneers on the matching tooth was then examined.

Occlusal veneer cementation

For five minutes, all of the occlusal veneers were cleaned in an ultrasonic cleaner with 99% isopropanol. Fluoride-free pumice was used to remove preparation debris from the prepared teeth. (Proxyt RDA 36, medium, Ivoclar Vivadent, AG, Schaan, Liechtenstein) for 15 seconds. They were then given a thorough 15-second water rinse.

9.5% hydrofluoric acid was used to etch the fitting surface of the occlusal veneers made of both materials. (**BISCO PORCELAIN ETCHANT**) for 30 seconds in the **CEREC Tessera** group and for 60 seconds for the Vita Enamic group. After that, the etched sample was thoroughly cleaned with water spray and dried with compressed air that was free of oil. One coat of silane coupling agent (**BISCO's porcelain primer**) was applied to the veneers' interior surface and allowed to dry for a minute. To get rid of the remaining primer, a dry air steam is applied..

37% phosphoric acid was used to etch the prepared teeth. (Total Etch, Ivoclar Vivadent) for 30 seconds, followed by a 20-second thorough water spray rinse. and dried using oil-free air. Immediately, a tooth primer (**Bisco** All **bond** universal) is pplied to all the preparation surfaces, thinned with gentle steam of dry air, leaving the surface appearing glossy. Dual-polymerizing composite resin cement (**TotalCem** self etching self adhesive) was injected into the veneers' fitting surface, and each veneer was seated using finger pressure on its matching preparation.. Seating pressure of 49 (equivalent to 5 kg force) w was applied for five minutes to the veneers using a universal testing machine. Lastly, each surface received 20 seconds of light curing..

Evaluation of the marginal gap

A stereo microscope was used to take pictures of each specimen. (Lecia,205MC, USA) connected via a magnifying device to a computer monitor screen of 7.5 up to 160X. A digital image analysis system (Image J 1.43U, National Institute of Health, USA) was employed to gauge and assess the gap's width. Each specimen's margins were photographed; the scale bar was 2mm. Each shot was then subjected to morphometric measurements. For every surface of the specimen, there are ten equally spaced landmarks along the cervical circumference. (Mesial, labial, distal, and palatal, a total of 40 points for each sample). Five times, the measurement was made at each location. Figure 3. After that, the information was gathered, tabulated, and statistically examined.

RESULTS

The randomization list was followed in the collection and tabulation of data. Following data normality testing, a one-way ANOVA test is used to compare the four groups. (30 for each group). Data followed a normally distribution. Variations in the obtained results that are statistically significant. Range (minimum and maximum), mean, standard deviation, and median were used to characterize quantitative data. Post-hoc Hoc Tests were used to compare the groups (Tukey HSD). The findings demonstrated that mean fracture resistance was statistically significantly impacted by the ceramic type, the occlusal veneer design, and the interaction between these factors. The variables are dependent on one another since there is a statistically significant interaction between them. The impact of various designs and groups on the marginal gap, or µm, between various groups and subgroups. correction Significant level was set at $p \leq 0.05$ ($\alpha \leq 0.05$). The study's findings showed that, following aging, enamic samples had the highest recorded values of the marginal gap. (83.30 ± 4.24 µm for ME and 85.73 ± 5.34 µm for PE), with the two subgroups not significantly different from one another (ME and MP) ($p \leq 0.005$), while the two subgroups of CEREC Tessera (MT and MP) had recorded significant difference figure 4. Subgroups of CEREC Tessera showed notable differences in the preparation designs under study. Table 1 and Figure 3 presented the results both graphically and numerically. Following data normality testing, four groups (30 for each group) were compared using a one-way ANOVA test. The data was distributed normally.

Tests		Mean ± SD	Min.	Max.
Fracture resistance	MT	1186.27± 28.66	1139	1235
	PT	1172.50 ± 21.87	1150	1225
	ME	1158.17 ± 9.861	1133	1180
	PE	1156.87 ± 13.48	1137	1189
Marginal gaps	MT	76.90 ± 2.62	70	82
	PT	79.73 ± 2.42	76	84
	ME	83.30 ± 4.24	77	90
	PE	85.73 ± 5.34	76	93

Table 1 Mean and standard deviations of the Fracture resistance and Marginal gaps for all groups.

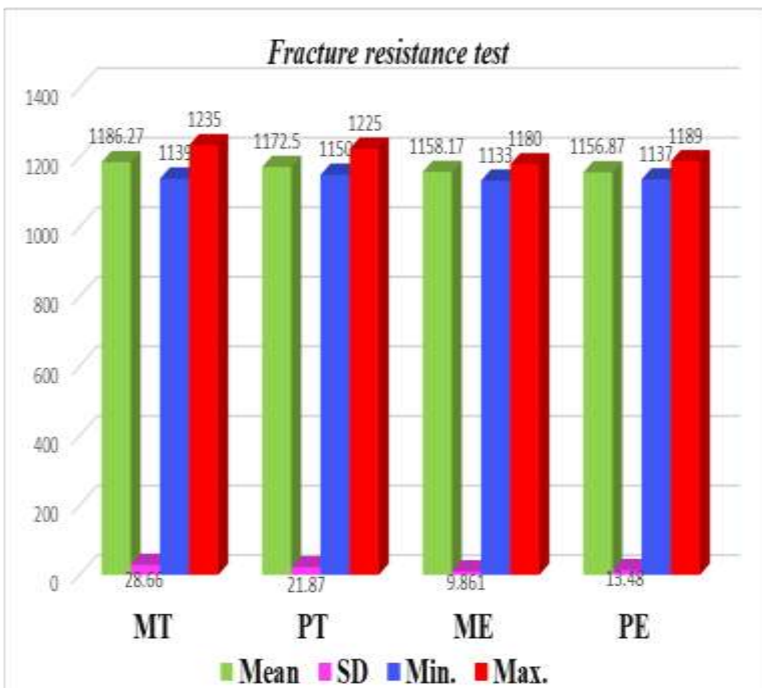

Fig 3: Mean and standard deviations of the Fracture resistance for all groups.

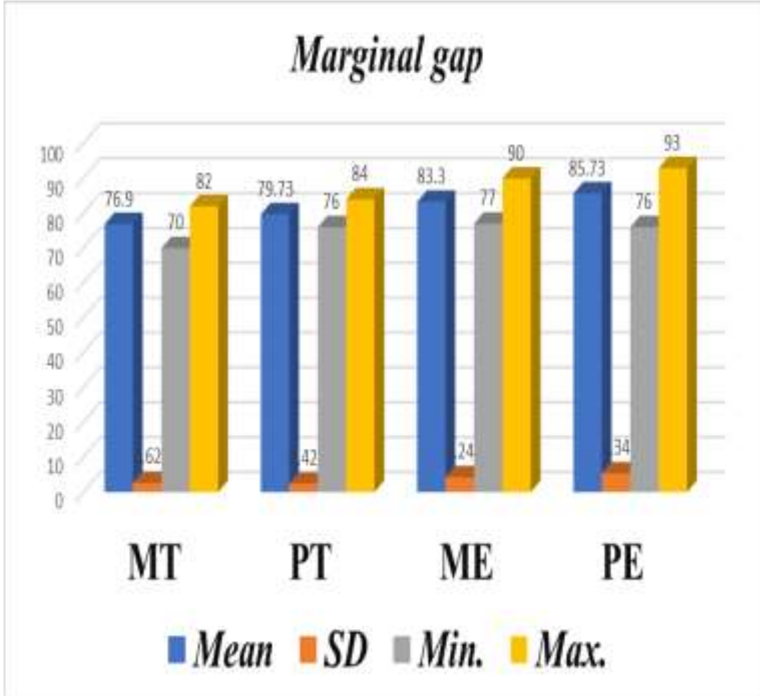

Fig 4: Mean and standard deviations of Marginal gaps for all groups.

Tests		Mean	SD	S. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Fracture resistance	MT	1186.27	28.66	5.23	1175.57	1196.97
	PT	1172.50	21.87	3.99	1164.33	1180.67
	ME	1158.17	9.861	1.80	1154.48	1161.85
	PE	1156.87	13.48	2.46	1151.83	1161.90
Marginal gaps	MT	76.90	2.62	2.10	1164.29	1172.61
	PT	79.73	2.42	0.48	75.92	77.88
	ME	83.30	4.24	0.44	78.83	80.64
	PE	85.73	5.34	0.77	81.72	84.88

Table 2: 95% Confidence Interval for Mean of Fracture resistance and Marginal gaps for all groups.

Tests	Sum of Squares	Df	Mean Square	F	P Value
Fracture resistance	17212.70	3	5737.57	14.54	0.001
Marginal gaps	1362.43	3	454.14	30.65	0.001

Table 3: ANOVA test for Fracture resistance and Marginal gaps between Groups

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J) *	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Fracture resistance	MT	PT	13.77	0.04	.40	27.14
		ME	28.10	0.01	14.73	41.47
		PE	29.40	0.01	16.03	42.77
	PT	MT	-13.77	0.04	-27.14	-.40
		ME	14.33	0.03	.96	27.70
		PE	15.63	0.02	2.26	29.00
	ME	MT	-28.10	0.01	-41.47	-14.73
		PT	-14.33	0.030	-27.70	-.96
		PE	1.30	0.990	-12.07	14.67
	PE	MT	-29.40	0.01	-42.77	-16.03
		PT	-15.63	0.02	-29.00	-2.26
		ME	-1.30	0.99	-14.67	12.07
Marginal gaps	MT	PT	-2.83	0.03	-5.42	-.24
		ME	-6.40	0.01	-8.99	-3.81
		PE	-8.83	0.01	-11.42	-6.24
	PT	MT	2.83	0.03	.24	5.42
		ME	-3.57	0.01	-6.16	-.98
		PE	-6.00	0.01	-8.59	-3.41
	ME	MT	6.40	0.01	3.81	8.99
		PT	3.57	0.01	.98	6.16
		PE	-2.43	0.07	-5.02	.16
	PE	MT	8.83	0.01	6.24	11.42
		PT	6.00	0.01	3.41	8.59
		ME	2.43	0.07	-.16	5.02

*. The mean difference is significant at the 0.05 level.

Table 4: Post Hoc Tests (Tukey HSD) between each two groups.

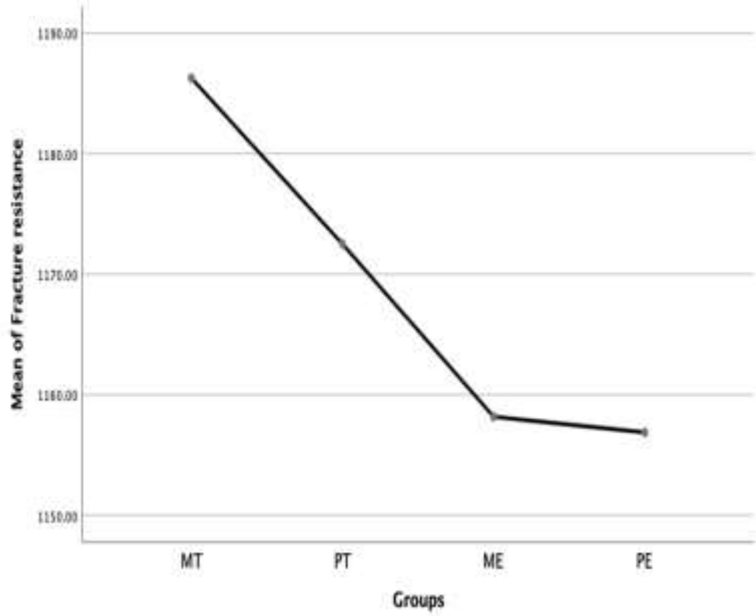

Fig 5: Means Plots of Fracture resistance.

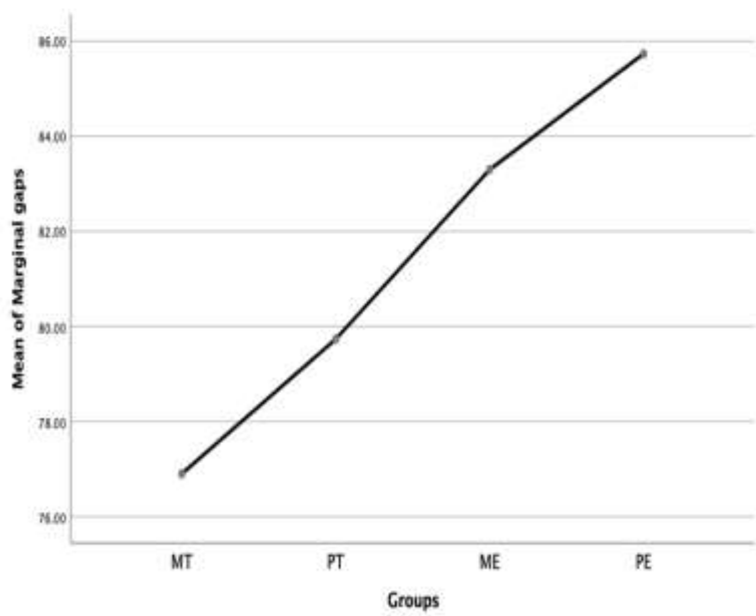

Fig 6: Means Plots of Marginal gaps

Effect of different interactions

a) A comparison of the two kinds of ceramic**;** The two ceramic types differed in a highly statistically significant way. There was a highly statistically significant difference between the two ceramic types. (T)

	new group N= 60	Mean	SD	T-test	P value
Marginal gaps	**T**	78.32	2.88	-8.401	0.001
	E	84.52	4.94		
Fracture resistance	**T**	1179.38	26.21	5.966	0.001
	E	1157.18	12:00		

Table 5 : Differences between T and E group by independent t test.

b) A comparison of the two designsCompared to modified design (M), conventional design (P) demonstrated statistically significant lower mean fracture resistance. When compared to the conventional design (P), the modified design (M) showed statistically significant higher values in the marginal gap. table (6)

	Group	Mean	SD	T	P value
Marginal gaps	**M**	80.10	4.76	-2.923	0.004
	P	82.73	5.12		
Fracture resistance	**M**	1172.22	25.547	1.881	0.062
	P	1164.35	19.94		

Table 6: Differences between M and P group by independent t test.

DISCUSSION

The current study's null hypothesis, which states that there will not be any variation in the two designs' or the ceramic materials' tested fracture resistance, was disregarded in light of the data's statistical analysis, which demonstrated that the two tested occlusal veneer designs' fracture resistance differed significantly, Additionally, of the two ceramic materials that were tested, According to Abrahamsen and Spijker et al., pathologic loss of coronal tooth structure or severe tooth wear such as abrasion and erosion is not unusual in the general population. (38) Even skilled medical professionals find it difficult to diagnose in its early stages (Bartlett). (39) Therefore, many researchers have been interested in and concerned about the significance of re-establishing optimal functional equilibrium parameters. (1,6,8, and 15) Modern adhesive technologies, restorative material advancements, and construction technology have pushed fixed prosthodontists toward more conservative treatment regimens. (7-9, 40). Occlusal veneers are thought to be the most recent conservative treatment option for advanced erosive lesions.. (7,41,42) However, Schlichting et al, (8) stated that it is still unknown what the best restorative material is. They believed that the biomimetic principles of conservation and aesthetics could only be addressed by bonded ceramics. Thus, the primary goal of the current in vitro study was to specifically suggest a new occlusal veneer design that would maximize the mechanical benefits of the recently released advanced lithium silicate ceramic (Tessersa). (T) and a nano-hybrid ceramic (E) in terms of marginal gap and fracture resistance. Premolars were prepared using both the modified (M) and conventional (P) occlusal veneer designs for the sake of uniformity in this study. A total of sixty upper premolars were prepared, 30 in each group. The most crucial element influencing the clinical longevity of all-ceramic restorations was thought to be fracture resistance.. (48 According to Yucel et al. (49), the modulus of elasticity of the selected abutment material determines the fracture resistance of all-ceramic restorations.Wood et al, (50) Yucel et al. (49) state that the fracture resistance of all-ceramic restorations is determined by the modulus of elasticity of the chosen abutment material., Consequently, it was selected for the current study. Waltimo and Kononen, (52) Using a new bite force recorder, we discovered that young women's and men's biting forces in the premolar region varied from 597 N to 847 N, respectively. Gibbs et al, (53) Lundgren and Laurell, (54) reported that normal masticatory forces ranged between 37% to 40% of the biting force. The two occlusal veneer designs and the two ceramic materials used in this study had mean fracture loads that were higher than the range of realistic occlusal forces in the posterior region. (Table 2). All of the tested specimens are therefore presumed to be able to tolerate the highest intraoral posterior masticatory forces. In relation to the impact of the occlusal veneer designs, Table 4 and Figures 3 and 4 demonstrate that the modified design (M) had a statistically significant higher mean fracture resistance value than the conventional design (P). Table 4 and Figures 3 and 4 show that the modified design (M) had a statistically significant higher mean fracture resistance value than the conventional design (P) in relation to the impact of the occlusal veneer designs.Regarding the influence of the occlusal veneer designs, Table 4 and Figures 3 and 4 demonstrate that the modified design (M) had a statistically significant higher mean fracture resistance value than the conventional design (P).Regarding the CEREC Tessera (T) and the nano-hybrid ceramic (vita Enamic) (E), the two occlusal veneer materials that were tested for fracture resistance, the statistical analysis of the obtained data (Table 2 and Fig 3,4) revealed that the CEREC Tessera (T) mean values were higher significantly than those of Enamic (E). These results contradict those of Schlichting et al. (8), Johnson et al. (26) Magne et al. (42) and Egbert et al. (55) who reported that, when subjected to vertical loading, occlusal veneers composed of resin nano-ceramic composite material or comparable hybrid ceramics exhibited the highest fracture strength among the ceramic materials tested. In contrast to these findings, Schlichting et al. (8), Johnson et al. (26) Magne et al. (42) and Egbert et al. (55) found that occlusal veneers made of resin nano-ceramic composite material or similar hybrid ceramics showed the highest fracture strength among the ceramic materials tested when exposed to vertical loading. Additionally, according to the manufacturer (3M ESPE), the interstitial spaces between the particles are filled with more nanomers, resulting in a high ceramic content. Investigations into the recently introduced lithium silicate (LS) ceramics, like Tessera, especially as occlusal veneer restorations, are lacking in the literatureThe majority of the research assessed and contrasted the mechanical characteristics of ZLS in a crown design with lithium disilicate (56), polymer-infiltrated ceramic network (PICN) (Vita Enamic), and (IPS e.max CAD).. (33) Regardless of the material and thickness, they found that masticatory fatigue largely had no effect on the fracture strength of crowns. They came to the conclusion that, in terms of fracture strength, PICN and ZLS ceramic might be a viable substitute for lithium disilicate ceramic. However, Al-Akhali et al. (57) assessed the fracture resistance of four dental CAD/CAM occlusal veneers, including polymer-infiltrated ceramic (Vita Enamic) and lithium disilicate (e.max CAD). According to their findings, occlusal veneers made of resin-containing materials (Vita Enamic) exhibited considerably lower fracture resistance than lithium disilicate (e.max CAD) veneers, which is consistent with this study. Compared to PMMA (Telio CAD) restorations, the lithium disilicate (e.max CAD) demonstrated noticeably greater fracture resistance. This might not be consistent with the current findings, which could be explained by the different materials that were tested. According to Egbert et al., recently introduced lithium disilicate outperformed Vita Enamic in terms of mechanical performance.. (55) Tessera occlusal veneers with the modified design (MT) had the highest fracture resistance (1186.27± 28.66), followed by Tessera occlusal veneers with the conventional design (PT) (1172.50 ± 21.87) and Enamic with the modified design (ME), according to statistical analysis of the various interactions of the variables in the current study (Table 6 and Fig 4). Enamic with the conventional design (PE) had the lowest fracture resistance values (1156.87 ± 13.48) Additionally, Tessera occlusal veneers with the modified design (MT) had the lowest marginal gap (2.62), followed by Tessera occlusal veneers with the conventional design (PT) (79.73 ± 2.42) and Enamic with the modified design (ME) (83.30 ± 4.24), according to statistical analysis of the various interactions of the variables in the current study (Table 1 and Fig 4) Under the conditions of the current study, Tessera veneer with the modified design (MT) should be the first choice in cases with increased occlusal forces, followed by Enamic with the modified design (ME) as a second choice. The highest marginal gap values were found for Enamic with the conventional design (PE) (85.73 ± 5.34) Although the current study has limitations, it did shed some light on innovative thinking regarding this new era of ceramic technology with a wide variety of materials and recommending preparation designs that fit the properties of such materials in order to achieve the most conservative approach possible. New research utilizing novel ceramic materials, such as nano-hybrid ceramics with various occlusal veneer designs on natural teeth to be tested in an artificial chewing simulator, is advisedThe best judgment regarding the longevity and serviceability of these occlusal veneers would then be to evaluate their clinical performance.

CONCLUSIONS

The following conclusions were drawn from the research's findings and limitations:

1. Regarding fracture resistance and marginal gap, the modified occlusal veneer design showed encouraging results. In particular, the Tessera ceramic showed the lowest statistically significant mean values for the marginal gap and the highest statistically significant fracture resistance.

2. In comparison to Enamic with modified or conventional designs, the conventional planar occlusal veneer design demonstrated the lowest statistically significant marginal gap mean values and highly significant fracture resistance, making it superior to Tessera.

3. The mean fracture resistance values of the two tested materials in both conventional and modified occlusal veneer designs were higher than the range of clinical acceptability.

4. Based on their fracture resistance mean values, the tested occlusal veneers were rated as follows: Tessera with the modified design received the highest rating, followed by Tessera with the conventional design, Enamic with the modified design, and finally Enamic with the conventional design.

5. Tessera occlusal veneer with the modified design should be the first option in cases where occlusal stresses are elevated, with Tessera with the conventional design coming in second.

6. The marginal gap and fracture resistance of every occlusal veneer were found to be favorable.

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