EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 71, 1605:1613, APRIL, 2025
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 10-02-2025 • Accept Date : 25-03-2025 • Available online: 20-04-2025 • DOI : 10.21608/edj.2025.359552.3379

EVALUATION OF MARGINAL GAP OF OCCLUSAL VENEERS CONSTRUCTED FROM TWO DIFFERENT CERAMIC MATERIALS

Mostafa Mahmoud Hussein*

ABSTRACT

Aim: Examining the marginal fit of two occlusal veneer designs constructed of various ceramic materials, both before and after going through an aging process.

Material and methods: Twenty recently-extracted mandibular second molars were used in this investigation, and two groups (n = 10 each) were randomly assigned to the occlusal veneer material. First group received occlusal veneers named Celtra Duo (Dentsply Sirona, Germany) composed of reinforced lithium silicate (ZLS), while second group received Vita Enamic (Vita Zahnfabrik, Germany) occlusal veneers made of hybrid ceramic infiltrated with polymers. Based upon the preparation design, each group was further subdivided into two subgroups (n = 5 each). Conventional occlusal reduction was used in the first grouping, and occlusal surface reduction + 1 mm of axial reduction with a rounded shoulder finish line was used in the second. CAD/CAM technology was used in the design and milling of the occlusal veneers. Before and after the cemented teeth-veneer assemblies were submerged in food- and oral-simulation liquids and thermocycling, the marginal gap was assessed with a stereomicroscope.In order to evaluate the interaction between various factors, the data from the marginal gap measurements were gathered, collated, and statistically evaluated using independent t-tests and a three-way ANOVA. At $p<0.05$, the results were deemed significant.

Results: The results showed that the marginal gap between the two preparation designs of the two materials before aging did not differ statistically significantly ($p<0.05$). After aging, there was no significant difference between the two designs as the Celtra subgroups showed marginal gaps of 91±14 µm and 89±12 µm for the traditional and rounded shoulder designs, respectively. Conversely, the Vita Enamic subgroups demonstrated marginal gaps with a very significant difference ($p<0.003$**) of 114±8 µm for the traditional shoulder design and 106±9 µm for the rounded shoulder design. The marginal gap discrepancy was shown to be significantly influenced by the interaction between the materials, preparation designs, and aging techniques, as indicated by the results of the ANOVA test.

Conclusion: For occlusal veneer restorations, Vita Enamic and Celtra Duo are both suitable as occlusal veneer materials. Celtra Duo demonstrated better marginal adaptability, both in terms of quality and quantity, even following the aging process used in this investigation.

KEYWARD: Marginal elevation, occlusal, veneers

* Lecturer, Fixed Prosthesis Faculty of Dentistry Beni -Suef University

INTRODUCTION

Tooth wear can result in attrition, abrasion, and erosion of the tooth structure owing to a variety of variables, including eating habits, medical conditions, and oral habits[1]. Preserving as much good tooth structure as possible is the primary goal of restorative dentistry [5]. To maintain the pulp's vitality and to prevent post- and core treatments, root canal therapy, and other intrusive techniques that may eventually deteriorate the repaired teeth's appearance and functionality. Studies have indicated that the amount of tooth structure removed for partial coverage preparations, including dental onlays and partial coverage ceramic crowns, is 40% less than for full coverage crowns [6]. Preserving tooth structure is essential to preserving the finely balanced interplay of mechanical, biological, and aesthetic elements[7]. Occlusal veneers are extra-coronal restorations requiring the least amount of preparation. When the occlusal enamel is thin and the underlying dentin is visible, they are advised. The repair of worn-down teeth with limited space has been transformed by the combination of improved bonding techniques and CAD/CAM technology [8].

Various ceramic materials can be used to create occlusal veneers. Because of its interconnecting, needle-like crystal microstructure imbedded in a glassy matrix, lithium disilicate ceramics have demonstrated the best mechanical capabilities of all the glass ceramic materials now on the market [11]. As an alternative, a polymer-infused ceramic network structure has been created to incorporate the advantages of both materials. Because of their strong fatigue resistance and enhanced mechanical and physical characteristics, these machinable polymer restorative materials can replace glass ceramics in thin restorations that are exposed to high occlusal stresses [13].

Maintaining a healthy periodontium and preventing cement dissolving need for a marginal fit. The literature provides a clinically acceptable marginal gap range of 100-120 microns, although with the developments in CAD/CAM technology, the reported marginal gap of the prosthesis is often within 100 microns [14].

The FDA recommends using food/oral mimicking liquids to examine bonding, elution, chemical affinity, wear of the material, and emulation of the oral environment. These liquids mimic a number of oral circumstances, such as viscosity, pH, and constituents. It is possible to simulate the effects of saliva, water, lipids, acids, and alcoholic beverages using various mimicking fluids. Their application facilitates expedited material wear testing and aids in the assessment of mechanical and physical attributes impacted by these fluids [14, 15].

This study aims to examine the marginal fit of two occlusal veneer designs, each manufactured of a different ceramic material, both prior to and subsequent to aging.

Null hypothesis: The preparation design or ceramic material will not change the initial marginal gap measurements. Aging will not have an impact on the initial marginal gap measurements.

MATERIALS AND METHODS

A power analysis was designed to have adequate power to apply a two-sided statistical test of the null hypothesis that there is no difference would be found between different tested groups regarding marginal gap . By adopting alpha (α) and beta (β) levels of (0.05) (i.e., power=95%) and effect size (d) of (2.72) calculated based on the results of a previous study(Martinez-Rus F et al., 2013); the total required sample size (n) was found to be (20) samples (i.e., 5 samples per group). Sample size calculation was performed using R statistical analysis software version 4.4.0 for Windows.(Team, 2024)

Twenty recently extracted lower first molars were taken from the University beni suef Faculty of

Dentistry out patient clinic. The patient gave their informed consent before having their teeth used for study. The tooth is being pulled for periodontal reasons and is devoid of cavities and fillings. In order to ensure uniformity, the teeth that were a part of this study were measured using a digital caliper and were excluded if their measurements went over the specified ranges: mesiodistal crown width, 11 mm, and bucco-lingual crown width, 9 mm. the teeth were free of calculus and soft tissue buildup before being preserved in a 0.1% thymol solution.. Based on the occlusal material, the teeth were randomly divided into two groups, with ten teeth in each group. In the first group, lithium silicate (ZLS) were used to reconstruct the teeth (Celtra Duo, Dentsply Sirona, Germany); in the second group, occlusal veneer materials were made, using hybrid ceramics laced with polymers (Vita Enamic, Vita Zahnfabrik, Germany). The preparation process was then followed to each group into two smaller groups (each group having n = 5).

Preparation of teeth

The same operator handled every preparation. Occlusal reduction was carried out for both subgroups in accordance with the manufacturer's guidelines about the minimal occlusal thickness required for full recovery. The amount of occlusal reduction 2mm. This was used on the Vita Enamic and Celtra Duo machining blocks that were employed in this investigation. Before reduction silicone indices were applied to every tooth. Figure 1

The first subgroup:

The short tapered round stone (number 13, Komet, Germany) was used for this consistent reduction. Black laser markings appear on the stone in millimeters from the tool's tip. The stone was positioned vertically on the occlusal surface, and one millimeter-deep guide grooves were made.. The occlusal preparation was carried out with a finishing device (yellow color stone, Komet). figure 2

The second subgroup: The first subgroup's description of the occlusal reduction procedure was followed. The axial walls were reduced with a tapered stone -round end (number 13, Komet) to create a rounded shoulder finish line figure 3. The amount of axial reduction 0.5mm, finish line thickness 0.3mm and amount of occlusal reduction 2mm.

Restorations design and manufacturing

After that, an intraoral scanner medit korea was used to scan each preparation. Then, exocad a laboratory program was utilized. Every The milling machine (inLab mseicore) received the design data in the form of STL files. For lithium di slicate occlusal surfaces, they recieved a crystallization and glazing cycle. Each veneer is then checked to see if it sits on the corresponding tooth. The Vita Enamic

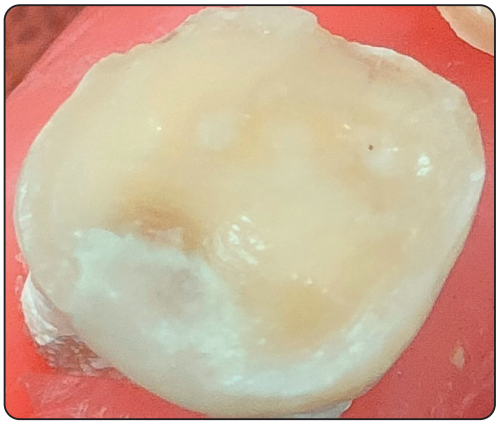


Fig. (1)

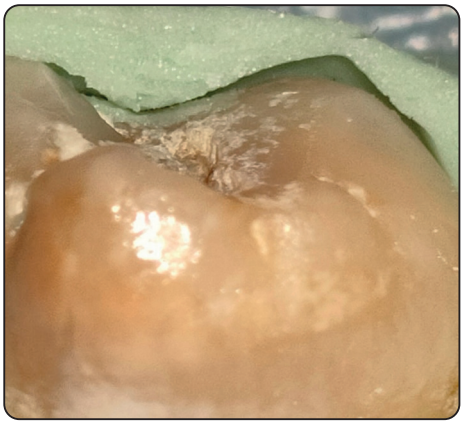


Fig. (2)

occlusal surface has been finished and polished (VITA Enamic Set polishing technique) according to the manufacturer's recommendations.

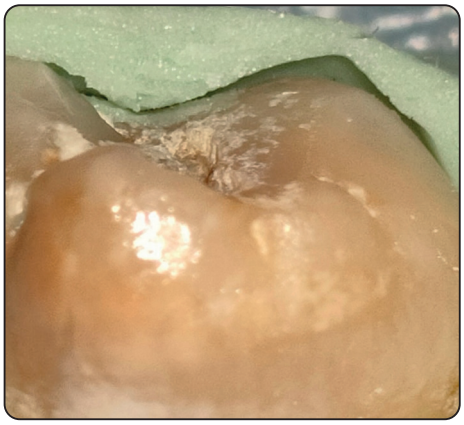


Fig. (3)

Cementation of the occlusal veneers

99% isopropanol was used to clean every occlusal surface for five minutes in an ultrasonic cleaner. After that, they were given a complete 15-second water rinse. For 30 seconds for the Celtra Duo group and 60 seconds for the Vita Enamic group, the occlusal surfaces of both materials were etched with 9.5% hydrofluoric acid (Porcelain etch,vivadent). After giving the etched sample a thorough cleaning with a water jet, oil-free compressed air was used to dry it. The inside surface of the veneer was coated with a coating of silane bonding agent (Silane,vivadent) and given a minute to cure. The teeth were etched with 37% phosphoric acid (Total Etch, Ivoclar Vivadent) for 15 seconds and allowed to dry in an oil-free environment. The prepared surfaces were immediately covered with a layer of dental primer (Ivoclar Vivadent), which was blended for ten seconds and then thinned with a small amount of dry air vapor, leaving a shining face. Dual cure composite resin cement (Rely x) was applied using hand pressure to the veneer for a duration of 5 minutes. Using a pad of gauze , extra cement was scraped off, and air inhibitor gel was applied to the edges. Finally, each surface receives a 20-second light treatment.

Immersion in food simulating liquids

Each sample was immersed separately for 2weeks at room temperature in glass containers that were tightly sealed. The food simulation liquid contains distilled water, a 75% ethanol solution, heptane, and 0.02NC15 of citric acid.

Thermocycling

The samples were subjected to 10,000 thermal cycles, with each cycle consisting of an immersion for 30 seconds in the hot lane at 55 + 1 °C, and an equal amount of time in the cool route at 5 + 1 °C, separated by a 5-second wait in the midst of a hot aisle. and chilly highways. For every face, the vertical boundary space is measured again at the same predefined locations.

Marginal gap evaluation

A stereomicroscope (Lecia, 205MC, USA) with magnifications ranging from 7.5 to 160X was used to take pictures of each specimen. The National Institutes of Health, USA's Digital Image Analysis System (Image J 1.43U) is used to quantify and assess space width. For every sample, a margin shot is taken; the scale is 2 mm. totaling 20 points placed throughout the cervical circumference (proximal, labial, distal, and palatal,). Five repetitions of each measurement were made at each stage (Figure 4). Following that, the data were gathered, collated, and statistically examined.

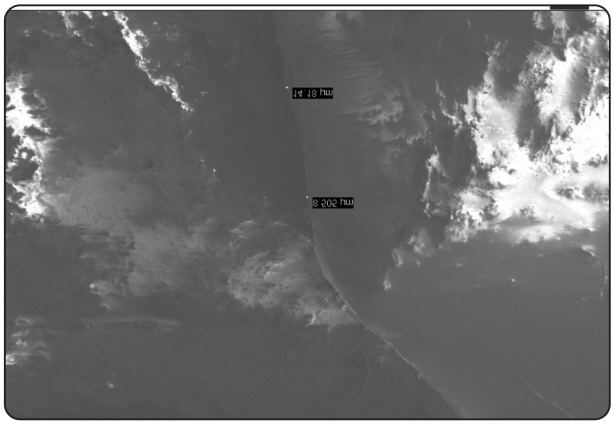


Fig. (4)

RESULTS

Statistical Analyses

Data analysis was performed by student t-tests to detect significance between groups. One way analysis of variance ANOVA test followed by pair-wise Newman-Keuls was used to detect significance between sites. Statistical analysis was performed using Graph pad Prism-4 statistics software for Windows. P values <0.05 are considered to be statistically significant in all tests.

Marginal accuracy

Marginal gap results measured in micron (μm) for both designs at different sites Table 1

Design of preparation	Celtra groups. mean ± SD		Enamic groups, mean±SD	
	Control	Aged	Control	Aged
Conventional	81±8	90±10	75±11	114±12
P-value	0.064		0.001	
Rounded shoulder	78±8	89±9	72±10	107±8
P-value NS	0.0682		0.001	

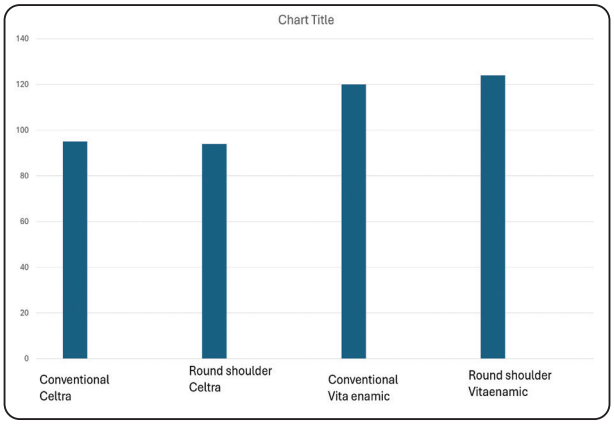
Table (2) illustrates that while the marginal deviation values rose with age, no statistically significant differences were found between the two preparation models in the Celtra subgroups; however, the Vita Enamic subgroups showed significant outcomes with age.

	Mean	P value
Celtra_after ageing	Conventional 90±10	< 0.06
	Rounded shoulder 89±9	
Vita enamic	Conventional 114±12	< 0.003
	Rounded shoulder 107±8	

This results show that:

1. No statistically significant differences were found between the two preparation models in the Celtra subgroups; however, the Vita Enamic subgroups showed significant outcomes with age.
2. No statistically significant differences were found between Celtra Duo and vita enamic regarding marginal adaptation
3. Vita Enamic subgroups showed significant outcomes with age

Bar charts to describe the results bar (1)



Bar (1) illustrates that while the marginal deviation values rose with age, no statistically significant differences were found between the two preparation models in the Celtra subgroups; however, the Vita Enamic subgroups showed significant outcomes with age

DISCUSSION

Dental professionals, prosthodontists, and patients have strived to create restorations that are optimal in terms of both appearance and functionality throughout the history of dentistry. A dental restoration's ability to withstand fracture, esthetic, and be somewhat adaptive are only a few of the variables that affect its effectiveness. Inadequate fit can cause plaque accumulation, which raises the possibility of problems including cavities, discoloration, and microleakage. Holmes et al.

presented in 1989 includes the terms internal gap, marginal gap, overextended margin, underextended margin, vertical marginal discrepancy, horizontal marginal discrepancy, absolute marginal discrepancy, and seating difference.

Marginal fit is often measured using the absolute marginal disparity or the marginal gap. In the general population, severe tooth wear or loss of coronal tooth structure are prevalent. Dental wear is caused by a variety of factors, such as age, nutrition, health issues, and oral habits. These factors can erode, abrade, and wear down the enamel and dentin of teeth. It might be difficult to treat individuals who have significant tooth wear or erosion. The field of minimally invasive dentistry, which aims to preserve as much of the natural tooth structure as possible while maintaining biocompatibility and longer durability, has seen a rise in attention recently[14].

Occlusal veneers and other restorations that need less preparation based on interocclusal space can benefit from this method and teeth anatomy. The occlusal surface anatomy served as the basis for the initial design,conventional, and more conservative preparation. In order to give enough thickness for the occlusal veneer repair, it included utilizing a depth groove stone for standard preparation with 1 mm of cusp reduction and 1 mm of depth in the central fossa. The second design finished with a rounded shoulder finish line and shared the same occlusal reduction characteristics, but it extended 1 mm onto the tooth's axial surfaces.

The occlusal veneers were made of two types of ceramic materials: polymer-infiltrated ceramic network (PICN) and zirconia-reinforced lithium silicate (ZLS). ZLS has outstanding optical qualities, translucency, better polishing ability, strong cementation quality, and fatigue resistance equivalent to lithium disilicate. The second material, called PICN (Vita Enamic), is a CAD/CAM material made of an organic polymer (14 wt%) infiltrated into a porous, pre-sintered feldspar ceramic network matrix (86 wt%). This combination yields a feldspathic ceramic that resembles enamel and characteristics that mimic the dentin's modulus of elasticity[18].

The high Weibull modulus of the ZLS materials utilized in this investigation suggests that the material's quality remains constant. Lithium meta silicate and lithium disilicate crystals, with an average size of 0.5–0.7 μm, make up these minerals. The zirconia contributes to the homogeneous texture, which has an average grit size of around 0.5 to 0.7μm. Because of their tiny microstructure, the ceramics offer a substantial number of glassy matrices and high flexural strength. Both high optical qualities and efficient cementation are facilitated by these structural compositions[18,19].

Occlusal veneers were built on natural molars rather than using die materials to replicate real-world circumstances. The restorations were subjected to cyclic temperature variations in the laboratory to evaluate bond strength, tracer penetration, marginal leakage, and marginal gap-all frequent factors in the oral environment. In clinical practice, thermal cycling is frequently employed to mimic the aging process that biomaterials go through. With the exception of a constant temperature range of 5-55°C, there are no set methods for thermocycling, and there is considerable variation in the number of cycles and dwell duration. Thermocycling was done in this study for 5000 cycles at 5-55°C with a 30-second dwell period[12].

To mimic exposure to food and liquid solutions, the specimens underwent heat cycling in addition to immersion. Each material first showed good marginal match, according to a comparison of the vertical marginal gaps between the two materials. Nonetheless, the marginal discrepancy between Vita Enamic and Celtra Duo was somewhat reduced, while not statistically significant. Studies have contrasted several finish line designs, including chamfer and

rounded shoulder. Straight shoulders typically did not produce the same effects as chamfer finish lines. Regarding marginal gap, rounded shoulder finish lines were determined to be similar to other designs. Wider marginal gaps were produced by thin finish lines as opposed to rounded shoulders.

The restoration of posterior teeth that have been eroded and worn down can now be achieved using non-retentive full-coverage occlusal veneers, which are a widely used treatment option. When a large amount of dental tissue has already been removed, minimally invasive designs or the "no-preparation" technique are preferred. But in contrast to undefined finish lines in traditional designs, shoulder finish lines could offer additional support. A traditional planar design would not be able to meet the minimum circular edge thickness of 0.3 mm needed for the milling process in CAD/CAM systems, which could result in marginal gap values that are somewhat higher[19].

Between Vita Enamic and Celtra Duo, there was a notable difference in marginal adaptability following the aging process. When compared to Celtra Duo, Vita Enamic showed a higher violation of marginal adaption and wider marginal gap values. Celtra Duo appeared to be less negatively impacted by the aging treatment. The impact of preparation designs on the marginal adaption and failure load of occlusal veneers was assessed in a prior study, and the findings indicated that thermocycling had no discernible effect on the marginal seal or fracture load of lithium disilicate glass-ceramic veneers.

Temperature gradients, internal and external bonding, hydrolytic aging, and immersion in food and liquid solutions are some of the elements that contribute to the degradation processes of ceramic materials, such as ZLS and polymer infiltrated ceramic networks (PICN), such Vita Enamic. Water can function as a plasticizer in a polymer matrix composite structure, causing the material to flex. Ester bonds in the polymer network may break down due to chemical substances in aqueous solutions. Low pH settings can lead to the disintegration of matrix components and the fallout of inorganic fillers, weakening the material and creating fissures. Additionally, materials based on bisGMA may degrade due to the solubility impact of ethanol solutions.

According to the study's findings, design (2) with rounded shoulders and a 1 mm axial wall extension recorded a better fit with reduced marginal space after ageing. It is nonetheless evident that this design offers greater bonded surface area in addition to the strong internal support of the rounded shoulder finish, even though the differences in outcomes between the two designs are not statistically significant. Even after ageing, the two materials under study showed marginal deflection values that fell within the clinically approved ranges for the round-shouldered and regular-shouldered Celtra groupings, respectively. Vita Enamic documented subgroups at the Regular and round shoulder models, respectively, measuring within accepted range.

According to McLean and Von Fraunhauf 120 μm is the upper limit that can be tolerated. Based on the reported values of numerous studies, the present study's marginal deviation values were deemed clinically appropriate. A examination of the retrieved data on marginal deviation revealed that measured values less than in the literature were in literature less than or equal to 120 mm.

As such, when choosing a material for a specific clinical scenario that calls for a particular preparation design, doctors should proceed with caution. Because a decent marginal seal's durability can be in doubt. We might conclude that the null hypothesis of the current investigation has been rejected based on the prior findings and debate. The durability and fracture resistance of various materials and alternative preparation schemes should be the subject of further research on these conservation restorations.

Null hypothesis was rejected

CONCLUSIONS

The selection of certain preparation patterns must be combined with careful knowledge of the material properties of the occlusal surface.

Both materials can be used in occlusal restorations.

Celtra Duo had marginal adaptation that existed with better qualitative and quantitative values even after applying the aging procedure in this study.

REFERENCES

- Abrahamsen TC. The worn dentition- pathognomonic patterns of abrasion anderosion. Int Dent J 2005; 55:268-76.
- Turner KA, Missirlian DM. Restoration of the extremely worn dentition. J Prosthet Dent 1984; 52:467- 74.
- Al-Omiri MK, Lamey PJ, Clifford T. Impact of tooth wear on daily living. Int J Prosthodont 2006; 19:601- 5.
- Moslehifard E, Nikzad S, Geraminpanah F, et al . Full-mouth rehabilitation of a patient with severely worn dentition and uneven occlusal plane: a clinical report. J Prosthodont 2012; 21:56- 64.
- Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for posterior teeth. Int J Periodontics Restorative Dent 2002; 22:241-9.
- Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for anterior teeth. J Prosthet Dent 2002; 87:503-9.
- Magne P, Belser U. Bonded porcelain restorations in the anterior dentition: a biomimetic approach. Chicago: Quintessence; 2002. p. 23-55.
- Torbjomer A, Fransson B . Biomechanical aspects of prosthetic treatment of structurally compromised teeth. Int J Prosthodont 2004; 17: 13 5-41.
- Magne P, Schlichting LH, Maia HP, B aratielfi LN. In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. J Prosthet Dent 2010; l 04.: 149-57.
- Oh, S .C ., Dong, J .K., Luthy, H., Scharer, P. Strength and microstructure of IPS Empress 2 glass-ceramic after different treatments. Int. J. Prosthodont. 2000; 13, 468-472.
- Elsaka, Shaymaa E., and Amr M. Elnaghy. Mechanical properties of zirconia reinforced lithium silicate glassceramic. Dent. Mater.2016; 32: 908-14.
- Coldea, A., Swain, M.V., Thiel, N. Mechanical properties of polymer-infiltrated ceramic-network materials. Dent. Mater. 2013; 29, 419-26.
- Vouvoudi EC, Sideridou ID. Effect of food/oral-simulating liquids on dynamic mechanical thermal properties of dental nano hybrid light-cured resin composites. Dent Mater.; 2013 Aug; 29(8):842-50.
- Martinez-Rus F, Ferreiroa A, Ozcan M, Pradies G. Marginal discrepancy of monolithic and veneered all-ceramic crowns on titanium and zirconia implant abutments before and after adhesive cementation: a scanning electron microscopy analysis. Int J Oral Maxillofac Implants 2013;28:480-7.
- Pelekanos S, Koumanou M, Koutayas SO, Zinelis S, Eliades G. Micro-CT evaluation of the marginal fit of cliff erent In-Ceram alumina copings. Eur J Esthet Dent 2009; 4:278-92.
- Jonathon S. Egberta, Andrew C. Johnsonb, Daranee Tantbirojnc, Antheunis Versluisd : Fracture strength of ultrathin occlusal veneer restorations made from CAD/CAM composite or hybrid ceramic materials . Oral Science International 2015;12:53-58.
- Sorrentino R, Nagasawa Y, Infelise M, et al. In vitro analysis of the fracture resistance of CAD-CAM monolithic lithium disilicate molar crowns with different occlusal thickness. J Osseointegr. 2018;10: 24
- Sven R, Matthias Ro., Dirk Zi. , and Anne-Kathrin Sc.: Fabrication of Zirconia-Reinforced Lithium Silicate Ceramic Restorations Using a Complete Digital Workflow; Case Reports in Dentistry Volume 2015, 2015: 162178
- Denry and J. R. Kelly, "Emerging ceramic-based materials for dentistry," Journal of Dental Research, vol. 93, no. 12, pp. 1235-1242, 2014.
- Andrade JP, Stona D, Bittencourt HR, Borges GA, Burnett LH Junior, Spohr AM. Effect of different computer-aided design/computer-aided manufacturing (CAD/CAM) materials and thicknesses on the fracture resistance of occlusal veneers. Oper Dent. 2018;43:539-548.

- Anna LuciaMorresia, MaurizioD'Amarioa, n, Mario Capogrecoa, Roberto Gattob, Giuseppe Marzob, CamilloD' Arcangeloc AnnalisaMonaco. Thermal cycling for restorative materials: Does a standardized protocol exist in laboratory testing? A literature review Journal of the mechanical behaviior of biomedical materials 29(2014) 295- 308.
- Ural C, Burgaz Y, Sarac D. In vitro evaluation of marginal adaptation in five ceramic restoration fabricating techniques. Quintessence Int 2010; 41:585-90.
- Tao J, Han D. The effect of finish line curvature on marginal fit of all-ceramic CAD/CAM crowns and metal-ceramic crowns. Quintessence Int 2009;40:745-52. 33. Fahmy NZ. Influence of veneering materials on the marginal fit and fracture resistance of an alumina core system. J Prosthodont 2011 ;20:45-51.
- D' Arey BL, Omer OE, Byrne DA, Quinn F.The reproduciibility and accuracy ,of internal fit of Cerec 3D CAD/CAM all ceramic crowns. Eur J Prosthodont Restor Dent 2009; 17:73-76