10.21608/ADJC.2023.171938.1194 Advanced Dental Journal
Volume 5 (2023) | Issue 2| Pages 276-285

Original Article

# Evaluation of Marginal Integrity of Lithium Disilicate Vonlays versus Celtra Duo Vonlays Restoring Premolars (In Vitro Study)

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## Abstract

Aim: To compare the marginal accuracy of two types of ceramics; celtra duo and IPS Emax CAD vonlays restoring maxillary premolars. Materials and methods: A natural tooth representing upper first premolar was prepared following ceramic onlay restorations preparation guidelines. After tooth preparation, the tooth was duplicated into twenty epoxy dies using silicone mold. Epoxy dies were randomly divided into two equal groups (n= 10/group). Identical vonlays were constructed from two different materials. For Group I: vonlays were constructed from lithium disilicate blocks (IPS E.max Cad). For Group II: vonlays were constructed from zirconia reinforced lithium silicate blocks (Celtra Duo Cad). All vonlays were cemented to their corresponding epoxy dies using dual cure self adhesive resin cement (breeze). Marginal integrity was evaluated by measuring the marginal opening (MO)at three points on the margin of each surface of the vonlays by using stereomicroscope with magnification of 30X. Results: It was found that Emax CAD vonlays recorded statistically non-significant higher marginal gap mean value (90.64 ±9.64) than Celtra duo vonlays (88.46 ±9.92). All the tested vonlays results were within the range of the clinically accepted value. Conclusion: vonlays fabricated on premolars from Celtra Duo CAD blocks yielded comparable marginal accuracy as that obtained with IPS Emax CAD block which are clinically acceptable.

**Keywords:** Onlay, Veneer, Vonlay, Celtra Duo, Emax Cad, Marginal Integrity, CAD CAM

## *I. INTRODUCTION*

New generations of computer aided design and computer aided manufacturing (CAD/CAM) technology have been created in an effort to improve the optical and mechanical characteristics of glass-ceramic materials(1).

A zirconia-reinforced lithium silicate which is called Celtra Duo was recently introduced for monolithic restorations. There are currently few data on its clinical and laboratory performance(2).

When employed for minimally invasive vonlay restoration, the durability, stability, and behaviour of this new dental material should be studied.

In recent years, the clinical use of bonded ceramic restorations has grown. This expansion has been pushed by an increase in patient demand for aesthetics, as well as the profession's need for conservative treatments.

The type of preparation, such as Ceramic laminate veneers, which can be utilised as a conservative solution to an

aesthetic problem, has an impact on the longevity of the restorations. They are used to treat discoloured teeth, teeth with undesirable shapes or contours, teeth that lack size and/or volume, and diastema. Veneers may also be used to restore tooth structure that has been lost due to disease or trauma[3].

Onlays are a popular treatment option in modern dentistry for restoring badly decayed teeth and replacing old restorations.

New methods of offering minimally invasive dentistry have developed. A combined restoration known as a "vonlay" is one such method that can be used to restore damaged posterior teeth as an alternative to full-coverage crowns[4].

Because of increased cement film exposure, unacceptably or poor marginal fits (wider than 120 m) can worsen the restoration prognosis[5], resulting in several complications; including discoloration, luting agent dissolution, decay,microleakage and plaque accumulation[6] so it is very important to fabricate restorations with optimum marginal fit to enhance restoration longevity.

## *II. MATERIALS AND METHODS*

### A. Tooth preparation

It was decided to use a freshly extracted maxillary premolar that was free of dental cavities or restorations. This tooth was extracted for one of two reasons: periodontal disease or orthodontics. The tooth was then prepared using a tapered flat end diamond bur for non-functional cusp 1.5 mm reduction and functional cusp 2 mm reduction following ceramic MOD inlay restoration preparation.

Using a conical flat end diamond bur [III], the occlusal box was extended by 2 mm from the cusp tip to the pulpal floor and 1 mm from the pulpal floor to the gingival seat with a 120-divergence angle. The isthmus part measured one third of the bucco-lingual width.

The labial surface was included in the preparation, which was finished with a 0.5 mm chamfer finish line using a tapered round end diamond bur. All of the edges and angles of the lines were finished and rounded.

### B. Epoxy models fabrication

A silicon mold was used to create the epoxy resin dies, which was made utilizing duplicating addition silicon material. The natural tooth was enclosed inside a plastic cylindrical container with a 20 mm diameter. According to the manufacturer's directions, equivalent amounts of the duplicating material base and catalyst were blended for five minutes, then poured into the plastic container while vibrating to release any trapped air. The natural tooth was removed after the silicone mold had been permitted to harden for 30 minutes as directed by the manufacturer[8].

For the construction of the epoxy dies, the epoxy resin material's base and catalyst were mixed at a rate of 200r/min according to the manufacturer's instructions, then poured into the silicon mould while being shaken to prevent air from being trapped, and then left 24 hours to solidify completely. 20 times of this process were performed to create 20 epoxy resin dies that resembled the prepared natural tooth.

### C. Scanning of epoxy resin models

The epoxy resin dies were scanned optically with 3 shape D500 extra oral scanner, Cerec Optispray [I] was sprayed onto each die. which removes optical highlights and obtains a uniformly reflective surface to enhance the precision of the impression.

### D. Construction of CAD/CAM milled vonlays

Milling was accomplished by Sirona MCX5 milling machineII with C14 block size of IPS e.max CAD and Celtra® Duo CAD blocks:

- 10 IPS E.max CAD blocks were used.

- 10 Celtra Duo CAD blocks were used.

**E. Crystallization& Glazing phase**

After milling, the IPS e.max CAD ceramic vonlays are in their pre-crystallized form, where they have a bluish-gray color. They were heated in a ceramic furnace for crystallization to achieve their final aesthetic qualities and strength.

Celtra duo is a fully crystalized material, so it was subjected to firing according to the manufacturer instructions for glazing only.

**F. Cementation**

According to the manufacturer instructions, each vonlay's fitting surface was treated with hydrofluoric acid 9.5% for 20 seconds before being thoroughly washed with vigorous water spray. After that, rinse under running water for 20 seconds. After that, an oil-free air spray was used to dry the interior surface for 30 seconds. The fitting surface was then covered with a single coating of silane coupling agent using small brushes, which was then allowed to react for 60 seconds before being air dried with oil-free air spray. The vonlays were attached to the dies using Breeze, a dual cure self-adhesive resin cement (Pentron, USA). A cementing device was utilised to standardize.

**G. Marginal Integrity**

Marginal accuracy was assessed by measuring the marginal opening (MO)which is the gap between the crown margin and the external surface of the preparation by using stereomicroscope "Leica microsystems" with magnification of 30X.

Measurements of the marginal accuracy were made at three points on the margin of the mesial, distal, buccal and palatal surfaces of the tooth.

## *III. RESULTS*

Celtra duo vonlay group was recorded to be associated with vertical marginal gap values of M=88.46µm (SD=9.92). By comparison, E-max vonlay group was associated with numerically larger recorded values with M=90.64µm (SD=9.64).

To test the hypothesis that Celtra duo group and E-max were associated with statistically significant difference of their means, an independent t-test was performed. Independent t-test revealed no statistically significant difference between Celtra duo group and E-max group with recorded P-value=0.6. A graphical presentation of the means difference was shown in figure (1).

**Table (1): Illustrating the descriptive analysis of the study groups**

Group Statistics

| | Study groups | N | Mean (µm) | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Marginal gap | Celtra | 10 | 88.4570 | 9.91856 | 3.13652 |
| | E-max | 10 | 90.6439 | 9.64267 | 3.04928 |

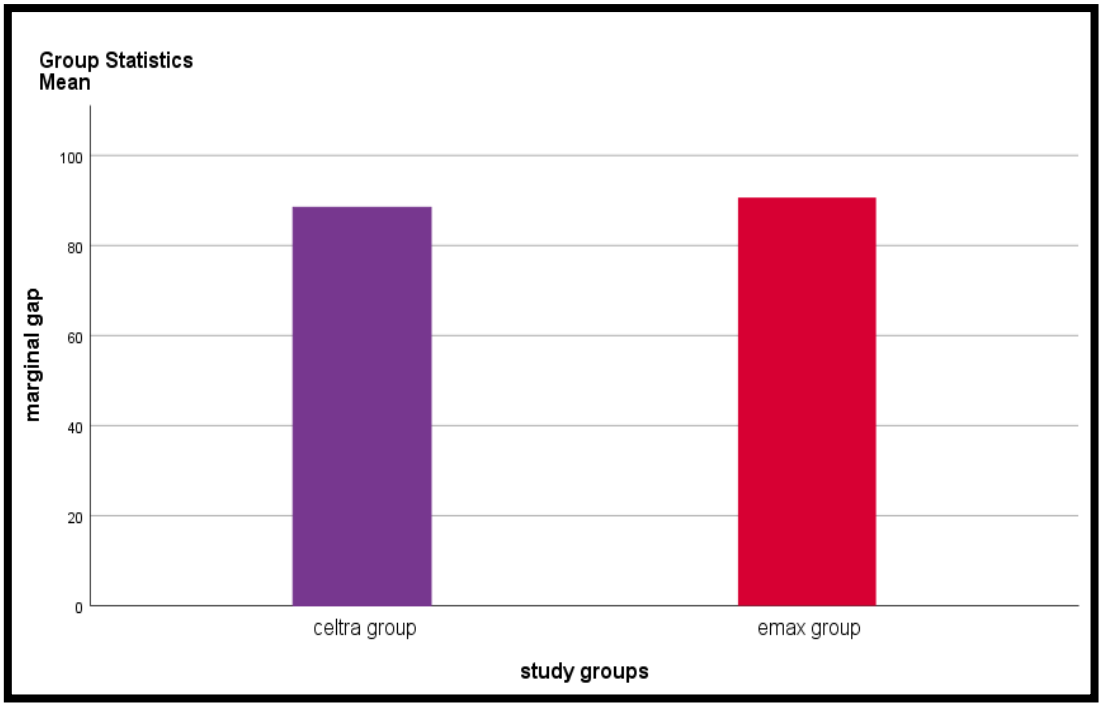


**Figure (1): Column chart representing the mean marginal gap differences between Celtra group and E-max group in µm.**

## *IV. Discussion*

CAD/CAM have recently expanded the use of advanced ceramics and enabled the creation of recent treatment modalities. With CAD/CAM technology, milled restorations have a more homogeneous structure, higher accuracy, and shorter production times[7].

Resulting from their improved translucency, ceramic restorations are nowadays commonly used. They also resemble natural teeth as they have beneficial qualities, like their mechanical and physical characteristics; great periodontal tissues biocompatibility; lowered plaque formation when compared to metal ceramics[8].

Typically, if a posterior tooth required a restoration, the ideal plan of treatment was thought to be a full coverage crown. Although, the issue with full coverage restorations, which involves a greater amount of sound tooth structure reduction, which can result in pulp involvement in some cases, has caused a shift toward the newly adopted minimally invasive dentistry, this means that the patient's tooth is restored with the least amount of tooth reduction possible.

As a result, partial coverage restoration has been adopted into the dental field in order to fulfil the concept of conservative reduction, which involves minimal tooth reduction in order to improve mechanical resistance and retention forms.

A combined restoration known as "vonlay" is a recently introduced approach. It is a monolithic ceramic restoration that combines a complete onlay with an additional buccal veneer surface.

The adhesive concept has been used for indirect restorative procedures as partial coverage indirect restorations have a reduced surface area of bonding. It ensures a strong and long-lasting adhesion between the restoration and the dental structure, while also improving marginal integrity and restoration strength[9].

The in-vitro test was used in this study because it eliminates many of the limitations of clinical investigations, like individual

variability, by establishing a completely controlled workplace[10] and allowing stereomicroscope use for marginal assessment.

CAD/CAM technology was used in this study to promote the idea of standardization in the manufacturing of all samples, as it simplifies the design of fabricated restorations and milling procedures.

A chamfer finish line design was selected as the chamfer marginal design creates a round angle between the gingival and axial seats, the crown can be seated more accurately than with a 90° shoulder finish line. Shoulder marginal design results in an incomplete crown seat and a larger vertical marginal gap. Also, as noted by ZAK Al-Zubaidi and AMW Al-Shamma, it could be owing to the precision of digital scanner detection being affected by variances in preparation depth, which could be easily observed in deep chamfer marginal design[11].

Recent ceramic materials are being developed in association with new processing techniques such as CAD/CAM technology. Monolithic glass-ceramic materials have been introduced in recent years to offer good aesthetics instead of the need for a ceramic veneer.

Because of its long-term success and stability, the IPS Emax CAD block was chosen for this study. The manufacturing of these blocks is done using a pressure-casting technology that optimizes the processing parameters to eliminate flaws like porosity and pigment accumulation in the block's body. Partial crystallization enables quick machining with CAD/CAM systems by allowing easy processing in an intermediate crystalline phase. Lithium metasilicate crystals are created by the partial crystallisation process, and these are what give the material its excellent processing capabilities, high strength, and edge stability. The restoration is tempered after the milling technique obtains its final state. During this process, lithium disilicate crystals are formed, giving the ceramic product its desired high strength and final shade. Furthermore, because it is an etchable ceramic, it has excellent bonding qualities due to its composition that contains scattered crystals in a glassy matrix that during the etching process is partially dissolved, resulting in a surface roughness that improve bonding[12].

Continually aided by advancements in automated technologies for the fabrication of dental prosthetics, as well as the creation of innovative ceramic materials microstructures. Lithium silicate was used as the main crystalline phase in a vitreous matrix that was reinforced with 10% zirconium dioxide crystals in a vitreous matrix to create a new glass-ceramic material. Zirconia particles are used to support the structure of the ceramic by acting as nucleating agents, which prevents cracks from developing[13].

Celtra Duo presented to the dental field recently in its fully crystallized form, so it is necessary to research its characteristics. Despite that in-vitro research results cannot be correlated to the clinical prognosis of the material directly, they provide valuable information about the clinical behaviour of the material[14]. Thus the aim of this in vitro study is comparing marginal integrity of celtra due vonlays with Emax CAD vonlays

Natural teeth have a wide range of dimensions that could affect the restoration dimensions fabricated. Therefore, based on the inclusion criterion, The maxillary premolar was chosen as the single master die and prepared according to guidelines for ceramic onlay preparation, with a functional cusp occlusal reduction of 2 mm and a non-functional cusp occlusal reduction of 1.5 mm, while keeping the inclination of the cusps to preserve the prepared tooth's occlusal morphology, which is essential for resistance form.

The depth of the occlusal box was 2.0 mm, and a divergence angle of 12° was formed in direction of the occlusal surface to create

diverging walls toward the occlusal surface, which aids in the creation of the restoration path of insertion[14].

Proximal boxes were prepared with a third of the buccolingual width isthmus and 1.0 mm in depth from the gingival margin., where these boxes improve the restoration resistance form[15].

Then, as a veneer preparation, the labial surface was also included in the preparation with a chamfer finish line "0.5 mm". Finally, the margins and line angles were polished and rounded to eliminate any stress concentration areas under the restoration.

REPLISIL 22 N was used to duplicate each master die because its low viscosity allows it to capture fine detailsIt gives the highest level of accuracy in dimension and design of the duplicating form and has the best mechanical properties, including high tensile strength, it has the highest tear resistance, it is very flexible and easy to deflask, and it has a 100% recovery after deflasking. (according to manufacturer instructions)[16]. In this study, shrink-free epoxy resin material was utilised to make epoxy resin dies, which were then used as a substitute for natural teeth to allow for the construction of identical restorations, which is critical for a realistic comparison of different groups[17].

Epoxy resin dies were employed in this investigation because they had greater dimensional accuracy, surface detail reproduction, transverse strength, and abrasion resistance than other materials. (18) The modulus of elasticity of epoxy resin is similar to that of dentin (12.9 GPa). There's also the ability to bond with luting agents similar to dentin[18].

Scanning of the manufactured epoxy was performed with a 3 shape D500 lab scanner, after spraying the teeth with Sironaoptispray to obtain an evenly reflecting surface, increasing the precision of the scan.

The software was used to design the vonlay restoration, which resulted in restorations with dimensions that mimicked those of a natural premolar tooth, with a material occlusal thickness of 2.mm, ensuring the highest material strength according to manufacturer instructions[19].

Cement space parameters were found to have a statistically significant impact on the marginal fit of CAD-CAM restorations[20]. The die spacer parameter was set to 60 microns in this study.

The Sirona MCX5 milling machine (Sirona, Germany), which provides a high level of accuracy, was used to mill the restorations. A study by (Goujat et al., 2019)[21] confirmed this, claiming that a 5-axis milling machine produces a better axial internal and marginal fit than a 3-axis milling machine.

Direct view technique, through a high powerful microscope was the most commonly used method to detect marginal discrepancy. This study utilized the stereomicroscope to observe marginal discrepancy, which is a good instrument that can accurately record the amount of discrepancy at various levels. Groten et al. stated that there is no significant difference between the accuracy of the use of scaning electron microscope and light microscope for marginal accuracy assessment[22].

The marginal opening, defined as the distance between the most external point on the restoration margin and the most external point on the preparation margin[23], was used to determine marginal accuracy. In most research evaluating the crown's marginal accuracy, the term "marginal opening" has been employed as a generic term[24].

The null hypothesis is accepted as it was found that there is no statistically significant difference between the marginal gap mean values of celtra duo vonlays and Emax vonlays.

This result is in agreement with (Taha et al., 2018)[25] who found that The difference between marginal gap values of the tested materials which included lithium disilicate and zirconia reinforced lithium silicate endocrown restorations was statistically insignificant.

All the tested vonlays results were within the range of the clinically accepted value according to (McLean and von Fraunhofer, 1971)[26] who concluded that a marginal discrepancy of 120 µm should be the limit of clinical acceptability.

It was found that Emax CAD vonlays recorded marginal gap mean value (90.64µm ±9.64) which is within the clinically acceptable range. This reslut is in agreement with (Riccitiello et al., 2018)[27] who found that the marginal gap values of lithium disilicate single crowns were within the clinically acceptable range and in agreement with (Azarbal et al., 2018)[28] who evaluated the marginal gap of precrystalized and crystallized lithium disilicate copings and results were within the clinically accepted values. This could be due to the developments in dental CAD-CAM technologies which improved the performances of such systems in the manufacturing of glass-based materials like Emax CAD.

While Celtra duo vonlays recorded marginal gap mean value (88.46µm ±9.92) which is clinically acceptable. These results were in agreement with (Zimmermann et al., 2018)[29] who evaluated the marginal fit of celtra duo endocrowns using 3D digital measurement technique and the results were clinically acceptable. This could be explained by the fact that the celtra duo material milled in its final state as it is a fully crystallized material, with no dimensional changes occurring during any subsequent processing steps. Furthermore, the manufacturer stated that the microstructure of materials like ZLS ceramics has the benefit of excellent edge stability; enabling milling of the restorations with satisfactory margins[25].

However, this study's drawback is that in vitro testing did not entirely resemble the clinical situation, yet they are regarded as a trustworthy testing approach for comparing groups and giving an indication of the material's behavior at various conditions. Additional drawback was the lack of clinical situation simulation because all of the testing was carried out on epoxy resin dies rather than natural teeth.

## *V. CONCLUSIONS*

The following conclusions were reached within the limitations of this study:

- Celtra Duo CAD vonlays produced comparable marginal accuracy as that obtained with IPS Emax CAD vonlays.
- Celtra duo and Emax CAD restorations have clinically acceptable marginal accuracy values and can be securely used for premolars.
- Vonlay preparation provides a trustworthy and conservative partial coverage restoration in the premolar region.

## *VI. RECOMMENDATIONS*

Based on the results of this study,

- More research into the material's other mechanical and aesthetic features is needed.
- In vitro experiments using various marginal investigative techniques on natural teeth before and after ageing are also recommended.
- Controlled trials under oral simulation and follow-up observation periods are advised.
- Clinical trials should also be carried out to determine the material's longevity and durability in the oral environment.

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