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Marginal and Internal Assessment of Press and Computer-aided design/Computer-aided manufacturing Lithium Disilicate Veneer Using Conventional and Digital Impressions

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Abstract

Background and objectives: Lithium disilicate veneers are highly valued for their ability to change the size, shape, or color of teeth, as well as for their fitness to the teeth. This study evaluates the marginal and internal fitness of lithium disilicate veneers, fabricated using conventional and computer-aided design and computer-aided manufacturing methods with both conventional and digital impressions.

Methods: This in Vitro-study was done in University of Duhok, college of Dentistry from January 12, 2023, to April 5, 2023. A maxillary central incisor was prepared for veneers. Thirty-two resin die samples were created from digital impressions for veneer cementation. Sixteen pressable lithium disilicate veneers were produced using the conventional lost wax pattern method (Groups A&B): eight from conventional impressions and eight from digital impressions. Sixteen lithium disilicate veneers were made by computer-aided design and computer-aided manufacturing for the two other groups C&D. Lithium disilicate computer-aided design blocks were milled using a five-axis milling machine. Veneers were cemented with 3M ReyX veneer resin cement.

Results: Significant differences in marginal fitness were observed among techniques ($P<0.0001$). Scan-press showed significantly larger marginal gap (147.00μm) compared to scan-computer-aided design and computer-aided manufacturing(97.25μm), conventional-press(112.1μm), and conventional-computer-aided design and computer-aided manufacturing (88.5μm). For internal fitness, conventional-press exhibited larger internal gap (100.58μm) than conventional-computer-aided design and computer-aided manufacturing (87.25μm). ($P<0.001$).

Conclusions: Lithium disilicate veneers fabricated using computer-aided design and computer-aided manufacturing technology with conventional impressions demonstrated superior marginal and internal fitness compared to other groups.

Keywords: Conventional Impressions, Marginal Fitness, Maxillary Central Incisor

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Introduction

Porcelain laminate veneers have gained popularity as a solution for improving the appearance of anterior teeth, particularly those with damage, discoloration, or irregular shapes.[1] They can also be used to address large gaps between teeth and refine the contours of anterior teeth. IPS lithium disilicate CAD ceramic, made of lithium disilicate (LD) material, is designed for use with computer-aided design and manufacturing (CAD/CAM) systems. This material boasts exceptional qualities, including superior transparency compared to other ceramic core options.[2] Currently, there are two main techniques for producing lithium disilicate ceramic veneers. The first method, known as IPS lithium disilicate press technology, involves using heat to press ceramic bars into molds within a porcelain furnace using a pneumatic ram.[3] The second approach employs CAD-CAM technology, which was introduced to dentistry in the 1980s, to design and fabricate veneers.[4] The conventional method of fabricating veneer using a lost-wax pattern is widely employed and regarded as the best. Nonetheless, it is frequently associated with certain drawbacks, such as inefficient use of manufacturing time and inadequate technical expertise.[5] On the other hand, the conventional method of fabricating veneers includes the use of wax and high-temperature baking, which increases the possibility of generating elevated interior porosities.[6] Any ceramic restoration's ability to function depends on a number of variables, including its bonding, optical, and mechanical qualities as well as its marginal and internal fitness.[7,8] For many years, cemented restorations' clinical success has been evaluated using marginal fitness and microleakage.[9,10] Earlier research comparing the marginal fitness of LD veneers produced via CAD-CAM and heat-press techniques yielded conflicting results. Some studies found CAD-CAM LD veneers had inferior marginal fitness compared to heat-pressed restorations. However, more recent investigations suggest CAD-CAM ceramic restorations fitness is better than heat-pressed veneers.[11,12] Papadiochou and Pissiotis, on the other hand, found no evidence supporting CAD-CAM milling's superiority over casting for marginal adaptation.[13] Inconsistencies in previously reported studies have created a dilemma regarding marginal and internal fitness of restorations fabricated by CAD-CAM and conventional techniques. Hence, there is a need to conduct a study on comparative evaluation of fitness of the LD veneers fabricated by conventional and CAD-CAM techniques. This study also helps to support the existing literature. This laboratory study seeks to clarify this dilemma by investigating the marginal and internal fitness of Press and CAD/CAM lithium disilicate (LD) ceramic veneers. These veneers will be made using both heat-Press and CAD/CAM techniques, employing either conventional impression material (PVS) or digital scanning.

Patients and methods

Thirty-two resin die samples were created for this study. These 32 samples were divided into 4 groups, according to the fabrication and impression methods. Group A consist of 8 samples made from Scan-press method, Group B consist of 8 samples made from Scan-CAD/CAM method, Group C consist of 8 samples made from Conventional-press method while Group D consist of 8 samples made from Conventional-CAD/CAM method. An Ivorine typodont maxillary right central incisor was used for the veneer preparation. The standard veneer preparation was done using a Ceramic Veneer System (CVS) preparation bur set from Komet, Germany. Depth orientation grooves were made on the facial surface of the tooth by a 3-wheel diamond bur followed by markings the depths to make the preparation for the veneers by diamond tapered burs and

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finishing stones. 0.4 mm was removed cervically with a chamfer finish line. The middle and incisal thirds of the tooth were reduced by 0.6 mm. To ensure proper fitness of the veneer, a butt joint design was created at the incisal edge. While the preparation extended between the teeth, care was taken to preserve the existing contact points with adjacent teeth. Then sixteen impressions of the prepared tooth were created using a one-step impression technique with A-silicone impression material (3M ESPE Express, Germany), applying moderate pressure with plastic perforated impression trays. These impressions were then filled with a type IV dental stone (Jade Stone; Whip Mix Corp, Louisville, KY, USA) to create replicas of the prepared tooth. Eight of these replicas were then scanned with a laboratory scanner (AutoScan-DS-EX Pro, SHINING 3D, Hangzhou, China) to create digital models for the computer-aided design and manufacturing (CAD-CAM) process of creating the dental restorations. The remaining eight stone casts were used for the traditional lost wax pattern method of LD fabrication. A skilled laboratory technician will begin by trimming each stone cast and exposing the margins, then applying a die spacer to allow room for cement. Next, the technician will build up wax on the cast and attach a sprue. The wax pattern will be secured at a 15° angle to the investment wax in the center of the casting ring, then completely removed through a burn-out process. Ceramic ingots (Ivoclar IPS lithium disilicate Press LT pressed all ceramic, LT BL1) will be inserted into the casting ring and heat-pressed for 25 minutes in a furnace (Ivoclar Vivadent Programat EP 3010, Germany). Subsequently, the casting ring will be trimmed using a diamond disc, followed by sandblasting. The sprue will be removed, and the ceramic veneer will be finished and polished. Sixteen digital scans of the prepared upper central incisor will be made using the TRIOS 4 / 3Shape scanner (Copenhagen, Denmark). The scan data will then be sent to design software (Exocad, Darmstadt, Germany) to design the veneers. Blocks of IPS lithium disilicate CAD material (Ivoclar Vivadent, Schaan, Liechtenstein) in shade BL1 will be milled for 8 of the veneers using a five-axis milling machine (IMES-ICORE, Coritec 150i series, Germany). The other 8 veneers will be fabricated using a conventional heat press technique, with the models first 3D printed in resin using a Form3 printer (Formlabs Dental, Somerville, Massachusetts, USA). A digital intraoral scan of the prepared upper central incisor will be used to create 32 resin models using a 3D printer (Form3, Formlabs Dental, Somerville, Massachusetts, USA). These models will serve as the base for veneer cementation. To attain micro-retention, the inside surface of every veneer was subjected to a 9% hydrofluoric acid solution for a duration of 20 seconds. After that, there was a 10-second water washing, a 10-second air-drying period, and a moist microbrush cleaning. The binding between the veneer and the tooth was then strengthened with a silane coupling agent (Bisco Inc., Schaumburg, IL, USA), which was then allowed to dry for a minute. After 20 seconds of etching with 37% phosphoric acid (Bisco Inc., Schaumburg, IL, USA), the resin replicas of the prepared teeth were rinsed for ten seconds and allowed to air dry for ten seconds. In order to get the resin replicas ready for bonding, a universal adhesive (Scotchbond, 3M ESPE, Dental Products, MN, USA) was finally applied and allowed to air dry for five seconds. The inside surface of the veneer was coated with Rely X Veneer (3M Espe AG, Espe Platz Seefeld, Germany), a light-activated resin cement. Next, in order to replicate the conventional clinical procedure, the veneer was placed onto its matching duplicate using finger pressure. To help with the removal of superfluous cement, the first hardening of the cement was accomplished using a curing light (Woodpecker LEDB curing light, Guilin Woodpecker Medical Instrument Co. LTD) with a wavelength of 420 nm to 480 nm and a light intensity of 1000 mW/cm² to 1200 mW/cm². Next, the front and rear sides of the veneer were fully cured by shining a light on them for 40 seconds. The assessment for fitness of the veneers was directly measured using a vertical sectioning technique. This method is highly effective in minimizing software and repositioning errors. To prevent disintegration during sectioning, the specimens were embedded in acrylic resin.[14,15,16] Samples were placed in the sectioning machine (Microtome, MT-4 Diamond cut-off saw, Cleveland, USA) in a single position to guarantee a standardized cutting. A 0.3 mm thick cutting blade was utilized. Using a scanning electron microscope (SEM) (Quanta 450 FEG, FEI) with a ×230 magnification, the vertical distance between the veneer and the tooth was measured at predetermined positions in the internal and marginal regions. The internal and marginal gaps were precisely measured and captured using Image J software and a mean of three readings was taken for each sample. All studies were carried out in a controlled setting with a room temperature of 25 °C and a relative humidity of 40% in order to reduce any potential bias. An experienced dentist evaluated the veneers' internal and marginal fitness while remaining blind to the research groups and materials. Ethical approval is given by Kurdistan Higher Council of Medical Specialties.

Results

For each experimental group, marginal and internal gaps were measured across 32 samples. The minimum, maximum, mean, and standard deviations of these gap values were calculated and are presented in Table (1) and Table (2). A Pairwise comparison between the study groups is shown in Table (3). The study in table 1 showed that the marginal fitness is significantly different among study techniques (P<0.0001). The marginal gap of Scan-press was significantly larger that Scan-CAD-CAM and Conventional-press and Conventional-CAD-CAM, P<0.001; Table (1).

Table (1): Comparisons of the marginal fitness among study groups

	Marginal fitness			
Groups	Number	Mean ± Std Dev	Std Err Mean	P
Scan-press	8	147.00 ±16.60	5.87	<0.0001
Scan-CAD/CAM	8	97.25 ±10.47	3.70	
Conventional-press	8	112.13 ±14.23	5.03	
Conventional-CAD/CAM	8	88.5 ±8.62	3.05	

ANOVA was one-way and was performed for statistical analyses.

The study in Table (2) showed that the internal fitness was significantly different among study techniques. The internal gap of Scan-press was larger than Scan-CAD/CAM and Conventional-CAD/CAM (P<0.001). Also, internal gap of Conventional-press was larger than Conventional-CAD/CAM, P<0.01; Table (2).

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Table (2): Comparisons of the internal fitness among study groups

	Internal fitness			
Groups	Number	Mean ± Std Dev	Std Err Mean	P
Scan-press	8	115.42 ± 7.32	2.59	<0.0001
Scan-CAD/CAM	8	93.58 ±3.83	1.36	
Conventional-press	8	100.58 ± 3.86	1.37	
Conventional-CAD/CAM	8	87.25 ±2.76	0.98	

A one-way ANOVA was performed for statistical analysis.

The pairwise comparison in Table (3) showed marginal and internal gaps of Scan-press > Scan-CAD-CAM and Conventional-press and Conventional-CAD-CAM (P<0.001).

Table (3): A Pairwise comparison of the marginal and internal fitness among study groups

	Internal fit			
Groups	Number	Mean ± Std Dev	Std Err Mean	P
Scan-press	8	115.42 ± 7.32[a]	2.59	<0.0001
Scan-CAD/CAM	8	93.58 ±3.83[bc]	1.36	
Conventional-press	8	100.58 ± 3.86[abcd]	1.37	
Conventional-CAD/CAM	8	87.25 ±2.76[acd]	0.98	
	Marginal fit			
Groups	Number	Mean ± Std Dev	Std Err Mean	P
scan-press	8	147.00 ±16.60[abcd]	5.87	<0.0001
scan-CAD/CAM	8	97.25 ±10.47[ab]	3.70	
conventional-press	8	112.13 ±14.23[acd]	5.03	
conventional-CAD/CAM	8	88.5 ±8.62[acd]	3.05	

Nonparametric Comparisons for all Pairs using Dunn Method for Joint Ranking were performed for pairwise comparisons.

Discussion

Lithium disilicate veneers are highly valued for their ability to change the size, shape, or color of front teeth. Achieving precise fitness at the margins and internally between the tooth and the veneer is crucial. The reason for using LD veneers among other materials available, is their translucency and aesthetic appearance. This makes them the most favorable material for all ceramic restorations. [17] Previously there were inconsistencies in reported studies that have created a dilemma regarding fitness of restorations fabricated by CAD-CAM and conventional techniques. Hence, the rationale behind this study was that there is a need to

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conduct a study on comparative evaluation of fitness of the LD veneers fabricated by heat-press and CAD-CAM techniques with conventional and digital impressions. This study also helps to support the existing literature. In this study, the assessment for the marginal and internal fitness of the veneers were compared between the fabrication methods and conventional and digital impressions. Group D, which consists of conventional impression technique with the CAD-CAM systems showed that the marginal (88.5 ±8.62µm) and internal (87.25 ±2.76µm) fitness were superior than the other study groups. Group B followed after with the best results for fitness, marginal (97.25 ±10.47µm) and internal (93.58 ±3.83 µm). With also using CAD-CAM systems (Group B) for manufacturing but different impression technique, digital scanning impression. Regardless of the impression methods, the CAD-CAM technique showed better results in marginal and internal fitness compared to the conventional heat-pressed technique. This may be because of the higher precision and milling capability of the CAD-CAM systems. Fitness measurements at the marginal and internal region were taken by averaging three readings per sample at specific points, using image processing software. A clinically acceptable maximum fitness/gap is generally considered to be 100–150 µm.[18] Our results were close to the results reported in previous studies. Previous studies found that CAD-CAM veneers had inferior marginal fitness compared to heat-pressed restorations. However, more recent investigations suggest CAD-CAM ceramic restorations fitness is better than heat-pressed veneers.[19,20] Papadiochou and Pissiotis, on the other hand, found no evidence supporting CAD-CAM milling's superiority over casting for marginal adaptation.[13] When comparing our results with Neves et al., it showed that the marginal fitness of CAD-CAM restorations was superior to the conventional technique.[21] This finding supports the results of our studies. Another similar outcome was showed in a study made by Alqahtani in which the fitness of restorations prepared by CAD-CAM systems showed better overall fitness compared to conventional procedures.[22] The main limitation of this study was the use of resin models outside the oral cavity, which might result in slightly different outcomes compared to other methods for assessing marginal and internal fitness, such as direct measurement, profilometry, micro-CT technology, and the silicone replica technique. Extracted teeth and resin or metal dies have been used in previous studies for assessment of fit.[23] However, extracted teeth are widely variable because of their different dimensions, storage time, age, and medium after extractions. While, resin dies have homogenous structure and uniform dimensions, which offers a reproducible medium for bonding.[24]

Conclusion

It was found that lithium disilicate veneers created using CAD-CAM technology and conventional impressions exhibited smaller marginal and internal gaps, resulting in a better overall fitness compared to other study groups. Therefore, CAD-CAM technology with conventional impressions can be considered superior and a viable alternative to other methods examined.

Conflict of interest

The authors declare no conflicts of interest.

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