



ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2020; 6(3): 734-741
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www.oraljournal.com
Received: 06-07-2020
Accepted: 13-08-2020

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Fracture resistance of Vita suprinity versus IPS e.max CAD vonlays restoring premolars (An *in vitro* study)

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DOI: <https://doi.org/10.22271/oral.2020.v6.i3k.1029>

Abstract

IPS e.max CAD has been considered one of the strongest glass-ceramics which provides higher mechanical properties than other types of glass based ceramic material but still limits its use in thin sections in posterior area. The aim of this study was to compare the fracture resistance of IPS e.max versus VITA suprinity CAD vonlays restoring premolars. First maxillary premolar was prepared according to all ceramic vonlay preparation guidelines, duplicated into twenty epoxy resin dies, the samples were divided into two equal groups, group (I) IPS e.max CAD and group (V) VITA suprinity CAD, then scanned by 3 shape D500 extra oral scanner and milled by Sirona MCX5 milling machine. Vonlays were subjected to thermomechanical fatigue load, by using universal testing machine load to fracture was tested. A statistically significant difference was found between IPS e.max and VITA suprinity where the highest mean value was recorded in VITA suprinity group.

Keywords: Vonlay, onlay, veneer, fracture strength, IPS e.max and vita suprinity

1. Introduction

The trend in recent years has been “minimally invasive dentistry”, to preserve as much tooth structure as possible whenever feasible. This inherently signifies moving away from procedures, such as full coverage restorations that require destruction of sound enamel and dentin to a less invasive options which are now available because of the adhesive approach and the introduction of high strength ceramic materials thus making it equally effective as full coverage restoration. One of the newly introduced approach is the Vonlay that are considered a conservative combination approach combining the veneer and the onlay restorations and can be used as an alternative to full coverage restoration in the posterior region. With the increasing demands for esthetic dentistry, it is now preferable to use ceramic restorations as an alternative to metallic ones. Ceramic restorations have the advantage of being highly esthetic material considering translucency and fluorescence and also having the advantage of being a highly biocompatible material^[1].

According to the way of construction, ceramics are available in two types either bilayered or monolithic. In bilayered ceramics there are differences in stress distribution and coefficient of thermal expansion between layers causing the weak bond between the veneer and the framework, so they are associated with a high incidence of chipping and veneer delamination from the inner core.

To overcome this problem Monolithic ceramic restorations have been introduced to simplify the fabrication process and eliminate residual stresses formed in between the veneer and the core. Lithium disilicate ceramic (IPS e.max CAD) is one of the monolithic CAD-CAM materials developed to provide outstanding esthetics without requiring veneering porcelain^[2]. One of its derivatives is Zirconia-reinforced lithium Silicate ceramic (VITA suprinity) containing 10% Zirconia by weight has been recently launched into the market in an attempt to combine the positive material properties of both lithium silicate and Zirconia ceramic thus achieving both higher flexural strength and esthetic properties. *In vitro* testing of dental materials requires simulation of the oral conditions and thermomechanical fatigue has been found to reproduce a close simulation of the oral environment^[3].

Thus, thermomechanical fatigue has been done to all samples before fracture. The aim of the present invitro study was to compare the fracture resistance of two types of ceramics; Vita suprinity and IPS e.max CAD vonlays restoring maxillary premolars. The null hypothesis was that there will be no difference in the fracture resistance of Vita suprinity and IPS e.max CAD vonlays restoring premolars.

2. Materials and methods

2.1 Tooth selection and preparation

Freshly Extracted maxillary premolar was selected and approved by the Research Ethics Committee to be used as a human biological sample where the remaining soft tissue was removed by ultrasonic scaler and the tooth was disinfected. This tooth was selected according to the following inclusion criteria: no caries, fractures, restoration or crack and to be extracted due to orthodontic purposes. The tooth was inspected for any defect under high light condition with magnifying lens (3.5X). The selected tooth was disinfected by immersion in 5% sodium hypochlorite solution for 15 minutes at room temperature followed by cleaning using an ultrasonic scaler at low power and under copious amount of water coolant to avoid the formation of any micro-cracks. The tooth was then kept hydrated in room temperature in saline solution prior to the study [4]. To assess the amount of occlusal reduction a silicon index (Speedex, coltene company, C-silicone, Switzerland) was fabricated on the natural tooth

before preparation. The index was then splitted into 2 halves using lancet blade no.15 (Sterile single use, carbon steel blade, China). For checking of the MOD inlay dimensions for the vonlay preparation a wax block (Model casting wax, Renfert, Germany) was carved following standardized inlay preparation dimensions then casted into a metal inlay for internal preparation checking [5]. Then the tooth was prepared following ceramic MOD inlay restoration preparation using a tapered flat end diamond bur (ISO 171/016, TF-21, Mani, Germany) where preparation was done with 1.5 mm occlusal reduction of non-functional cusp and 2 mm occlusal reduction of the functional cusp. Occlusal box was extended by 2 mm depth from cusp tip to the pulpal floor, 1 mm depth from the pulpal floor to the gingival seat with 12° divergence angle with conical flat end diamond bur (ISO 170/016, TF-31, Mani, Germany) ending with an isthmus portion measuring one third of the bucco-lingual width. The preparation was extended to the labial surface ending with a chamfer finish line of 0.5 mm by using tapered round end diamond bur (ISO 199/016, TR-12, Mani, Germany) (Figure 1). All of the line angles and the margins were rounded and finished. For occlusal preparation standardization, the occlusal clearance was checked by the silicon index fabricated before preparation along with a periodontal probe. While for the MOD inlay preparation checking, the metal block was inserted into the preparation till complete seating.

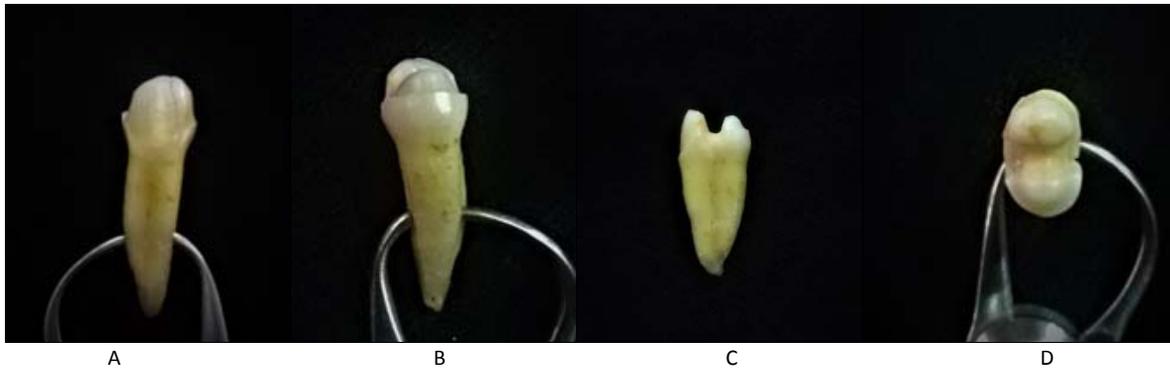


Fig 1: Natural tooth preparation (A) Buccal view (B) palatal view (C) Proximal view (D) Occlusal view of preparation

2.2 Duplication of the prepared acrylic tooth

Duplicating addition silicon material was used to produce a silicon mold for the construction of epoxy resin dies. The natural tooth was placed in a plastic cylindrical container 20mm in diameter. Equal amounts of the duplicating material base and catalyst were mixed according to the manufacturer recommendations for 5 minutes then it was poured into the plastic container under vibration to eliminate any entrapped air. Silicon mold was allowed to set for 30 minutes according to the manufacturer instructions then the natural tooth was removed. For construction of the epoxy dies, base and catalyst of the epoxy resin material (Solvent free transparent epoxy resin. CMB Intl, Egypt) were mixed according to the manufacturer instructions in the rate of 200r/min and then was poured into the silicon mold under vibration to eliminate any air entrapment, then was allowed to set completely for 24 hours, this procedure was repeated 20 times to produce 20 epoxy resin dies replicating the prepared natural tooth. Checking of any surface defects, irregularities or change in the dimensions was done carefully to ensure accuracy of duplication by using magnifying loupes with 3.5X magnification power. (Dental Binocular Loupes with

Headband & LED Light 3.5X, China). Epoxy resin mold was constructed to hold each die during cementation and supporting it during cyclic loading and fracture resistance test. To construct the epoxy resin mold, a plastic mold was used to hold epoxy resin material with the epoxy die till complete setting inside of the mold that takes about 24 hours as shown in Figure 2



Fig 2: Duplicated epoxy resin dies

2.3 Optical impression of the epoxy resin dies

Each die was digitalized by optical scanning using 3 shape D500 extra oral scanners; die was sprayed with Cerec Optispray for optical

impression (Sirona dental systems GmbH, Germany) to enhance the precision of the impression by removing optical highlights and obtaining a uniformly reflective surface as shown in Figure 3.

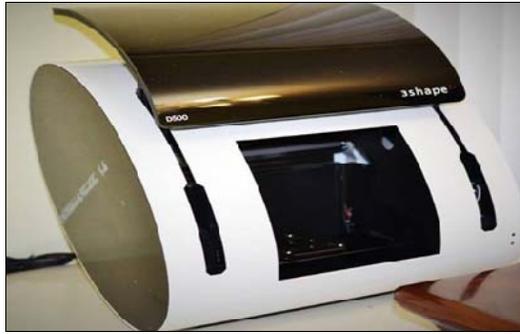


Fig 3A: Lab scanner 3shape D500

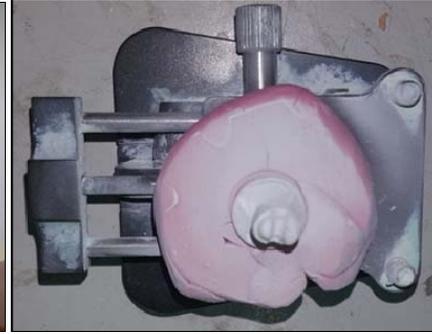
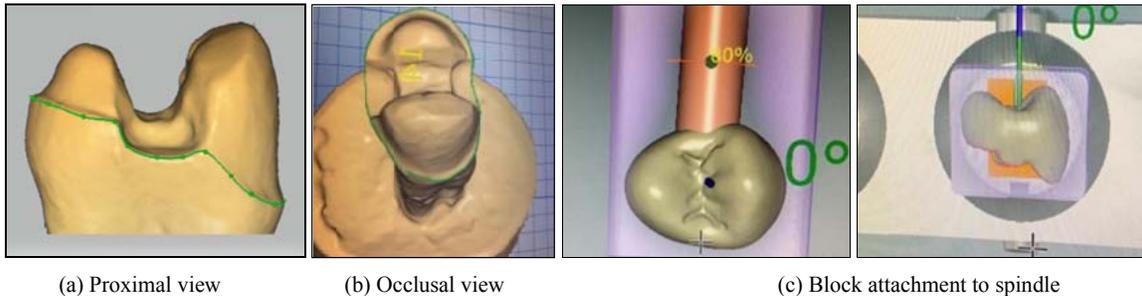


Fig 3B: Die after spraying before scanning

2.4 Computer aided restoration designing

Margins of the digital die were identified and drawn using Sirona in Lab CAD Software. Path of insertion was identified to start designing the restoration, then milled materials were selected from the library of the software that were Vita suprinity and IPS e.max CAD blocks. Cement space was

adjusted to 60 micrometer and dimensions of the restoration were drawn on design window to adjust fissure depth, cusp heights, buccolingual, mesiodistal dimensions and thickness of the restoration, central groove was adjusted to 1.41mm width, 3.69mm length and 0.97 depth, forming a bio generic copy for all the samples as shown in Figure 4.



(a) Proximal view

(b) Occlusal view

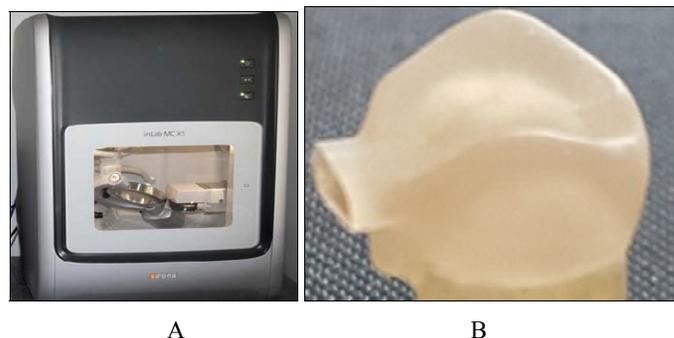
(c) Block attachment to spindle

Fig 4: Steps of restoration digital restoration production and dimensions adjustment

2.5 Computer aided milling of the restorations

Milling was accomplished using Sirona MCX5 milling machine (In Lab MC X5, Sirona, Germany) using IPS e.max CAD blocks and Vita suprinity® CAD blocks: 10 IPS e.max CAD blocks with block size C14 and 10 Vita suprinity® CAD blocks with block size PC14 were used. Each block was inserted into the work piece spindle and tightened, with the block holder. Milling was done according to manufacturer instructions under wet conditions that took approximately 15 min per cycle. After milling process was accomplished, each vonlay was separated from the blocks carefully then fitted on the dies to check marginal accuracy and exclude any discrepancy by using sharp probe and magnifying loupes with

3.5 X magnification power as shown in Figure 5. The lug was removed with a fine-grit diamond abrasive stone (ISO 173/016, TF-12F, Mani, Germany) and also used for contouring and finishing of the restoration. Then finishing was accomplished with a rubber silicon bur and finally the restoration contours are checked on the die. Thickness of the restoration was then checked using conventional caliper (Gdc Castroviejo Caliper # Straight (17Cm) Clc40L, GDC) to ensure that the preset thickness was maintained. All restorations were cleaned carefully in ultrasonic bath cleaner (Digital ultrasonic cleaner CD-4820 (Power supply: 60W-AC 100°120V, 50/60Hz)/USA) with 98% alcohol to remove any milling remnants



A

B

Fig 5: (A) MCX5 milling machine, (B) Restorations after milling and separation from universal holder

2.6 Crystallization & Glazing phase

After milling, the IPS e.max CAD and the vita suprinity ceramic vonlays are in their pre-crystallized form, where they have a bluish-gray color and transparent honey color, respectively. To reach their final strength and esthetic properties, they were placed in a ceramic furnace (Vaccumat 6000 MP furnace, Vita Zahnfabrik, Germany) for crystallization. Vonlays were supported by an object fix material and firing pins then fired on the supplying firing tray according to the manufacturer's instructions. For the vita suprinity samples; the vonlays were first pre-dried at 400°C for 4 minutes and the heating temperature was then increased at a rate of 55°C/min until reached 840°C and held for 8 minutes. For the IPS e.max CAD vonlays; the vonlays were first pre-dried at 403°C for 6 minutes and the heating temperature was then increased at a rate of 90°C/min until reached 820°C and held for 10 minutes, then the temperature

was then increased at a rate of 30°C/min until reached 840°C and held for 7 minutes. After firing, the samples were left to cool at room temperature. Then the surface of the restoration was processed with a fine diamond (ISO 173/016, TF-12F, Mani, Germany). Then grinding particles must be carefully removed from the restoration. The cleaned restoration was coated with a fine layer of glazing material by smooth brush. Then vonlay samples were inserted into the furnace for glazing phase as shown in Table 1 and Figure 6.

Table 1: glazing phase

Predry. °C	→ min.	↗ min.	↗ °C/min.	T °C	→ min.	VAC min.
400	4.00	5.00	80	800	1.00	-

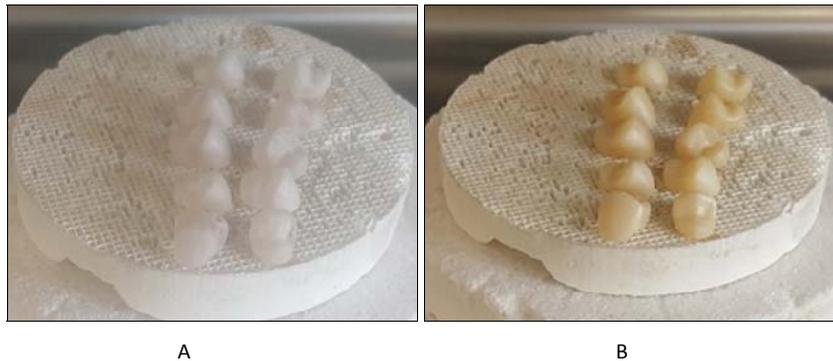


Fig 6: Vita Suprinity samples (A) samples Before crystallization, (B) samples After crystallization

2.7 Surface treatment of the intaglio of all vonlays

Hydrofluoric acid etching 9.5% was applied to the fitting surface of each vonlay for 20 seconds then rinsed with forceful water spray. Then rinsing for 20 seconds under running water. After that internal surface was dried with oil free air spray for 30 seconds. Then a single layer of silane coupling agent was applied to the fitting surface using fine brushes and allowed to react for 60 seconds then air dried with oil free air spray. Dual cure self-adhesive resin cement Clearfil (Clearfil SA luting/CL/0005AA/ Kuraray, medical Tokyo, Japan) was used to cement the vonlays to the dies. Cement material was dispensed into the intaglio surface of each vonlay using an auto-mixing tip along the axial walls. Then each vonlay was held by finger pressure on its corresponding die. For standardization a cementing device was used which consists of: Rectangular metal base, Rectangular upper horizontal plate, Two vertical supporting arms attached to the base and upper horizontal plate, T-shaped metallic part that is formed of a sliding vertical bar that passes through the center of the upper horizontal plate ending with a teflon base and has an upper disc shaped portion onto which the load was applied. A load of 2Kg was placed over a disc of the T shaped portion and a base at which the sample is placed. Then each sample was fixed to the lower compartment of the cementation device, and vertical bar slid in a downward direction till it touched the restoration and a 2Kg static load was applied on the upper disc shaped portion of the device during the cementation procedure [6]. Tack curing was done for 2 seconds and excess cement was removed by a sharp scaler as resin cement reached the gel stage, then air inhibiting gel (Liquid Strip; Ivoclar Vivadent AG, FL-9494 Schaan/Liechtenstein) was placed on the margins of the

restoration to ensure removal of oxygen inhibited layer left by the adhesive cement, after that the restorations were light polymerized from a distance of 5 mm by using a halogen light unit (Elipar 2500; 3M ESPE, USA) with a peak power output of 450 mW/cm² from the mesial, distal, buccal, lingual, and occlusal directions for 20 seconds each [7].

2.8 Thermo-mechanical fatigue

Mechanical aging via cyclic loading was performed using a programmable logic-controlled equipment; the newly developed four stations multimodal ROBOTA chewing simulator (ROBOTA chewing simulator integrated with thermo-cyclic protocol operated on servo-motor (Model ACH-09075DC-T, AD-TECH TECHNOLOGY CO., LTD., GERMANY) integrated with thermo-cyclic protocol operated on servo-motor with special parameters. ROBOTA chewing simulator has four chambers simulating the vertical and horizontal movements simultaneously in the thermodynamic condition. Each of the chambers consists of an upper Jacob's chuck as hardened steel stylus antagonist holder that can be tightened with a screw and the lower part was Teflon housing as sample holder. A weight of 5Kg which was comparable to 49 N of chewing force was exerted with thermal aging between 5° C and 55° C. Samples were exposed to thermo-mechanical aging that was repeated for 75,000 cycles which simulate 6 months inside oral environment [3].

2.9 Fracture resistance testing procedure

All samples were individually mounted on a computer-controlled materials universal testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a loadcell of 5 KN and data were recorded using computer

software (Instron® Bluehill Lite Software). Samples were secured to the lower fixed compartment of testing machine by tightening screws. Fracture test was done by compressive mode of load applied occlusally using a metallic rod with a spherical tip (5 mm diameter) that contacted the occlusal surface of the restorations at their cuspal inclinations. It is attached to the upper movable compartment of testing machine and traveling at cross-head speed of 1mm/min. A tin foil sheet was placed in-between the occlusal surface and the

metallic rod to achieve homogenous stress distribution and minimize the transmission of local force peaks. (8) The load at which the material failure occurred was manifested by an audible crack followed by sudden drop in the load resistance reading recorded by the software. The load required to fracture was recorded in Newton. Following the fracture testing the mode of failure was visually examined and classified according to Burke’s classification (1995) into:

Table 2: Burke’s classification

Mode of fracture	Description of each class
Class I	Minimal fracture or crack in crown
Class II	Less than half of crown is lost
Class III	Crown fracture through the midline, half of crown was displaced or lost
Class IV	More than half of crown was lost
Class V	Severe fracture of tooth and or crown

2.10 Scanning electron microscope (SEM)

Surface images of nanoparticles were recorded using Quanta FEG 250 scanning electron microscope (FEI Company, USA) available at EDRC, DRC, Cairo. Samples were mounted onto SEM stubs. Applied SEM conditions were: a 10.1 mm working distance, with in-lens detector with an excitation voltage of 10 kV and 1000x magnification and failure modes were classified into: Adhesive, cohesive and mixed adhesive-cohesive failure mode (9).

3. Results

3.1 Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Fracture resistance data showed normal (parametric) distribution. Data were presented as mean, standard deviation (SD) and 95% Confidence

Interval (95% CI) for the mean values. Student’s t-test was used to compare between the two groups. Failure mode (Qualitative) were presented as frequencies and percentages. Fisher’s Exact test was used to compare between the two groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

3.1.1 Statistical analysis of fracture resistance tests of vonlay samples restored with IPS e.max CAD and vita suprinity blocks

The mean \pm SD values of fracture resistance were recorded for vita suprinity and IPS e.max CAD groups (704.3 \pm 139.3 N) and (582.3 \pm 119.6 N) respectively. It was found that VITA Suprinity group showed statistically significant higher mean fracture resistance than IPS e.max CAD group (P-value = 0.050, Effect size = 0.940) as shown in Table 3 and Figure 7.

Table 3: Descriptive statistics and results of Student’s t-test for comparison between fracture resistance (N) of the two groups (IPS e.max and vita suprinity)

	IPS E.max CAD	VITA suprinity
Mean	582.3	704.3
Standard deviation	\pm 119.6	\pm 139.3
P-value	0.050*	
Effect size	0.940	

*: Significant at $P \leq 0.05$.

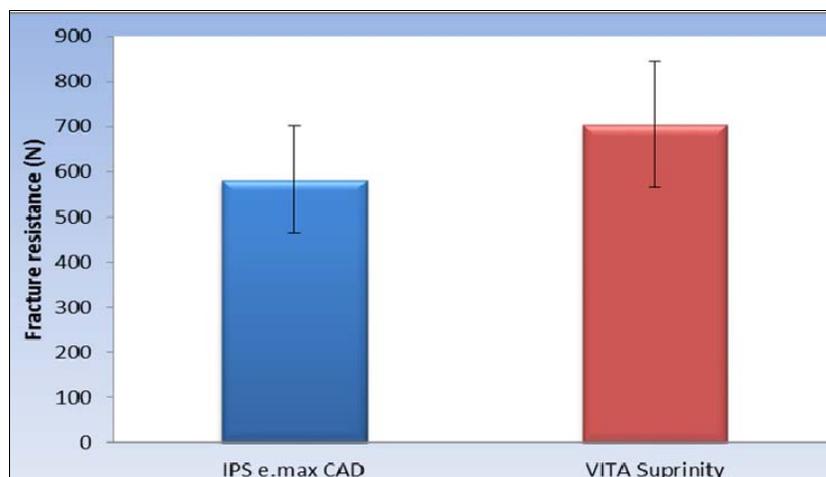


Fig 7: Bar chart representing mean and standard deviation values for fracture resistance of the two groups (IPS e.max CAD and VITA Suprinity)

3.2 Failure mode

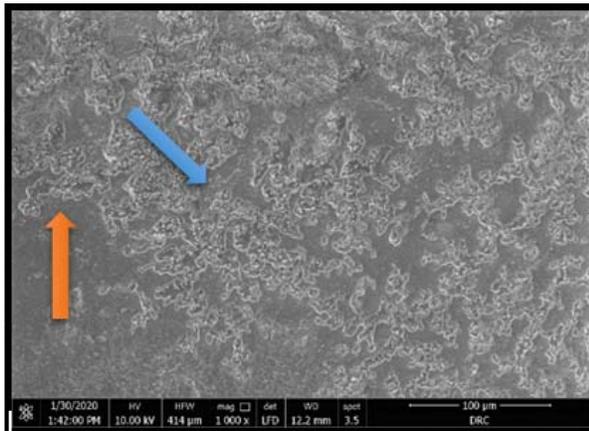
3.2.1 Visual examination

3.2.1.1 Group I: failed IPS e.max CAD vonlays showed that: Two samples showed Class V in the form of fracture of the lingual cusp of the epoxy die while the restoration was totally displaced and fractured into 4 parts. Three samples showed Class IV where a proximal Part of the restoration remained attached to the die and the other part was scattered into 2 parts. Five samples showed Class IV where the whole restoration was displaced and fractured into 2 parts and 4 tiny fragments.

3.2.1.2 Group V: failed VITA suprinity vonlays showed that: Eight samples showed Class II where less than half of the restoration was fractured while the remaining part still attached to its corresponding epoxy die. One sample showed Class IV where the whole restoration was displaced from the die and fractured into 4 fragments. The last sample showed Class V where the whole restoration was displaced and fractured into small fragments while the die was vertically splitted into two segments.

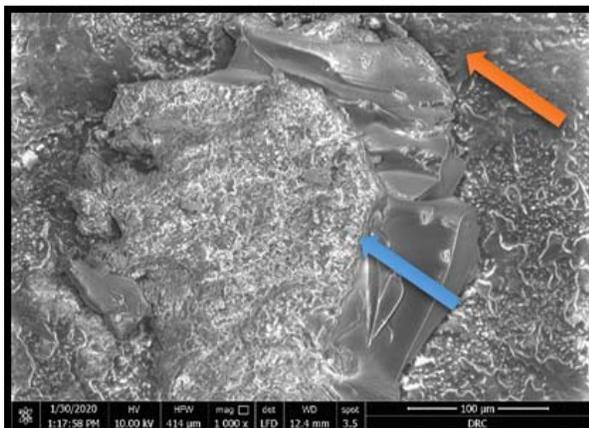
3.2.2 Scanning electron microscopic examination

Group I and V showed mixed adhesive cohesive failure mode.



Red arrow: restoration's fitting surface
Blue arrow: cement

Fig 8: SEM image showing mixed adhesive-cohesive failure mode within 2 samples of IPS e.max CAD vonlays



Red arrow: restoration's fitting surface
Blue arrow: cement

Fig 9: SEM image showing mixed adhesive-cohesive failure mode within samples of VITA suprinity vonlays

4. Discussion

Traditionally, if a patient requires restoration in the posterior region, full coverage restoration was thought to be the ideal treatment option, however the problem encountered with the full coverage restoration which includes increasing the amount of tooth reduction which may lead in some cases to pulp involvement resulted in a shift to recently introduced minimally invasive dentistry which aims to preserve as much tooth structure as possible whenever feasible. So, Partial coverage restorations have been introduced in the dental field trying to fulfill the idea of conservative preparation where minimal preparation of the teeth is done, thus enhancing mechanical resistance and retention forms [10]. With the increasing demands for esthetic dentistry, it is now preferable to use ceramic restorations as an alternative to metallic ones. Ceramic restorations have the advantage of being highly esthetic material considering translucency and fluorescence and also having the advantage of being a highly biocompatible material. Ceramics can be available as a bilayered or a monolithic restoration. In bilayered ceramics there are differences in stress distribution and coefficient of thermal expansion between layers causing the weak bond between the veneer and the framework, so they are associated with a high incidence of chipping and veneer delamination from the inner core. To overcome this problem Monolithic ceramic restorations have been introduced to simplify the fabrication process and eliminate residual stresses formed in between the veneer and the core. Lithium disilicate ceramic (IPS e.max CAD) is one of the monolithic CAD-CAM materials developed to provide outstanding esthetics without requiring veneering porcelain [2]. IPS E.max CAD block was chosen in this study owing to its long-term success and stability. Pressure-casting procedure is utilized in the manufacture of these blocks optimizing the processing parameters to avoid the formation of defects such as pores and pigments accumulation in the body of the block. Partial crystallization ensures easy processing in an intermediate crystalline phase, enabling rapid machining with CAD/CAM systems. The partial crystallization process leads to the formation of lithium metasilicate crystals, which are responsible for the material's favorable processing properties, comparatively high strength and high edge stability. Following the milling procedure, the restorations are tempered to reach the final state. In the course of this process, lithium disilicate crystals are formed providing the ceramic object with its final shade and desired high strength. Also, it has superior bonding characteristics since it is an etchable ceramic owing to its composition, which consists of crystals dispersed in a glassy matrix that is partially dissolved during etching process creating surface irregularities which in turn enhances the bonding [11]. Continuous with the aid of the evolution in the computerized systems for the production of dental restorations associated with the development of novel microstructures for ceramic material. A new glass-ceramics were introduced (VITA Suprinity®) to contain lithium silicate as the main crystalline phase in a vitreous matrix reinforced with zirconium dioxide crystals (~10%). Zirconia particles are incorporated to reinforce the ceramic structure where they act as nucleating agents dissolved in the glassy matrix that causes crack interruption [12].

VITA Suprinity® in its partially crystallized form is a newly introduced material to the dental market so it is mandatory to study its mechanical properties to see if this material would replace the gold standard monolithic IPS e.max CAD ceramic material in restoring posterior dentition, since this region

exhibit occlusal forces beyond IPS e.max CAD strength^[13]. Thus, the aim of the present in-vitro study was to measure the fracture resistance of IPS e-max CAD versus vita suprinity vonlays restoring premolars. Natural teeth exhibit wide variety of dimensions which might affect the restoration dimensions fabricated and thus any test performed wouldn't have relevant results so only one tooth (maxillary premolar) was selected as a master die based on the inclusion criteria and prepared following ceramic onlay restoration preparation guidelines. Duplicating silicon mold for prepared natural tooth was done using REPLISIL 22 N (Denteccon, Germany) as it has a low viscosity to record fine details, best mechanical characteristics with high ultimate tensile strength and offers an extremely high dimensional accuracy of the duplicating form^[14].

Then the tooth was prepared following ceramic MOD inlay restoration preparation using a tapered flat end diamond bur (ISO 171/016, TF-21, Mani, Germany). For occlusal preparation standardization, the occlusal clearance was checked by the silicon index fabricated before preparation along with a periodontal probe. While for the MOD inlay preparation checking, the metal block was inserted into the preparation till complete seating. Milling of restorations were performed with Sirona MCX5 milling machine (Sirona, Germany) which provides the highest accuracy. This was confirmed by a study done by (Goujat *et al.*, 2018),^[15] who stated that a 5-axis milling machine provides a better occlusal marginal gap and better axial internal gap than a 3-axis milling machine. Cementation was done using dual cure self-adhesive resin cement (clearfil), which provides a simple bonding procedure and saves time compared to the application of multi-steps adhesive materials^[16]. To complete the standardized cementation protocol each sample was fixed to a specially constructed loading device with 20 N weight for static load application till the setting of resin cement was completed^[6]. Since it was reported that adhesive resin cements leave behind an oxygen-inhibited layer at the uppermost surface when polymerized in air which may adversely affect the cementation process; so, air inhibiting gel was placed on the margins of the restorations before completing the curing process to ensure complete polymerizations^[7]. ROBOTA chewing simulator has four chambers simulating the vertical and horizontal movements simultaneously in the thermodynamic condition. Each of the chambers consists of an upper Jacob's chuck as hardened steel stylus antagonist holder that can be tightened with a screw and the lower part was Teflon housing as sample holder. A weight of 5Kg which was comparable to 49 N of chewing force was exerted with thermal aging between 5° C and 55° C. Samples were exposed to thermo-mechanical aging that was repeated for 75,000 cycles which simulate 6 months inside oral environment^[3]. Fracture resistance is a mechanical property of a brittle material to resist stress concentration until fracture if this stress exceeds the yield strength of this material that is completely different than ductile material that is relieved by plastic deformation under stress^[17]. The null hypothesis was that there would be no significant difference between partially crystallized IPS e.max CAD and vita suprinity vonlays in terms of fracture resistance. The results in this study showed that there was statistically significant difference between the two tested groups, where the highest mean value was recorded in group V (VITA suprinity) (704.278±139.297N), while the lowest mean value was recorded in group I (IPS e.max CAD) (582.308±113.443 N). Hence the null hypothesis was

rejected. Results of the present study were in agreement with Elsaka and elnaghy (2015)^[18] who reported that Vita Suprinity had significantly higher fracture resistance, higher fracture toughness, elastic modulus, and hardness than the IPS e.max CAD and they attributed that to the homogeneous fine crystalline structure of VITA suprinity in comparison with fine-grained needle shaped crystals embedded in a glassy matrix in IPS e.max CAD. In addition, the increased fracture toughness of VITA suprinity compared with IPS e.max CAD glass-ceramic could be also attributed to the incorporation of zirconia filler to the composition of VITA suprinity. The glass matrix is reinforced, without getting clouded by the dissolved zirconia particles, which gives it higher fracture toughness^[19]. This was also in accordance with (Hamza & Sherif, 2017)^[20], who reported that Vita Suprinity crowns had higher fracture resistance than the IPS e.max CAD, and also related this to the material micro structure. The strong bonding between glass ceramics and resin cement can be owed to: The dominant mechanism is that silane molecules can react with water to form three silanol groups (-Si-OH) from the corresponding methoxy groups (-Si-O-CH₃). The silanol groups then continuously react with the glass ceramic surface to form a siloxane network (-Si-O-Si-O-). Additional silane pretreatment contributes to form a uniform and functional layer that is beneficial for adhesion of resin to glass substrate. Then, the monomeric ends of silane can react with methacrylate groups of composite resins through free-radical polymerization, mainly because silane monomers contain C=C bonds. Therefore, silane creates a bridge between glass substrate and composite resin cements. Through the polymerization between silane and methacrylate monomer and between methacrylate monomer and another methacrylate monomer, a strong bond between glass substrate and resin is formed.⁽²¹⁾ Finally, the component of resin cement used is one of the most important factors that affects bonding strength to ceramic restorations which also affects the material fracture strength. In this study (Clearfil SA) resin cement was used, which contains MDP (10-methacryloyloxy-decyl dihydrogen phosphate). The adhesive potential of MDP to zirconia depends on the presence of a passive coating of zirconium oxide on the ceramic surface. Chemical reactions involving the hydroxyl groups of the layer and the phosphate ester monomers of the MDP may occur at the interfacial level^[22]. This was confirmed with the visual assessment of the failed restoration parts along with the scanning electron microscope images that showed: In case of group I (IPS e.max CAD), 2 samples exhibit class V, 8 samples exhibit class IV fracture mode and in case of group V (vita suprinity CAD), 8 samples exhibit class II, 1 sample exhibit class IV and the last sample exhibit class V fracture mode. Where class II fracture means: failure of small part of the crown while the other remains attached to tooth and in this study 80% of VITA suprinity vonlays showed class II failure mode according to Burke's classification that means stronger bond was created between VITA suprinity vonlay samples more than IPS e.max CAD samples. This was also confirmed by SEM images that showed: In case of group I (IPS e.max CAD), samples failed adhesive-cohesively, where there were small patches of cement on the surface of the failed restoration. While in case of group V (vita suprinity CAD), samples failed adhesive-cohesively where thick cement patches were adherent to the whole surface of the VITA suprinity fractured parts. Therefore, the results in this study were relevant and favors the use of the new material (vita suprinity), that can replace IPS e.max CAD ceramic material in partial coverage

restorations in the posterior premolar region.

BUT; the limitation of this study includes the fact that *in vitro* studies cannot completely simulate the oral environment but they are considered a reliable testing method of comparison among tested groups and give an indication about the behavior of the material under different testing conditions. Another limitation was that all testing was performed on epoxy resin dies, not on natural teeth which might have lacked the simulation of the clinical situation.

5. Conclusion

Within the limitations of the present study, the following conclusions were drawn:

- Vonlays fabricated from vita suprinity CAD blocks yielded promising fracture resistance compared to IPS e.max CAD blocks.
- Both VITA suprinity and IPS e.max CAD ceramic restorations have fracture resistance values that are clinically acceptable and can be safely used for premolar area.
- Vonlay preparation is considered a reliable and conservative partial coverage restoration that could be used in the premolar region.

6. Acknowledgement

Thanks to ALLAH for providing me with the strength and the ability to complete this thesis.

I would like to express my deepest sense of gratitude to my supervisors Dr. Rana Mahmoud Sherif professor of Fixed Prosthodontics and Dr. Noha El Khodary lecturer of Fixed Prosthodontics, who offered their continuous help, knowledge and advice throughout the journey of this thesis. Great thanks to my family and friends who supported me through the past years.

7. References

1. McLaren EA, Figueira J. Updating Classifications of Ceramic Dental Materials: A Guide to Material Selection. In Compendium of continuing education in dentistry (Jamesburg, N.J. : 1995. 2015; 36:6.
2. Sen N, Us YO. Mechanical and optical properties of monolithic CAD-CAM restorative materials. *Journal of Prosthetic Dentistry*. 2018; 119(4):593-599.
3. Nawafleh N, Hatamleh M, Elshiyab S, Mack F. Lithium Disilicate Restorations Fatigue Testing Parameters: A Systematic Review. *Journal of Prosthodontics*. 2016; 25(2):116-126.
4. Zhu Z, Dong XY, He S, Pan X, Tang L. Effect of Post Placement on the Restoration of Endodontically Treated Teeth: A Systematic Review. *Int. J Prosthodont*. 2015; 28:475-483.
5. Vianna ALS, de V, Prado CJ, do Bicalho AA, Pereira RA, da S *et al.* Effect of cavity preparation design and ceramic type on the stress distribution, strain and fracture resistance of CAD/CAM onlays in molars. *Journal of Applied Oral Science : Revista FOB*, 2018, 26.
6. Pavanelli CA. Cementation of ceramics and indirect composite resin to enamel and dentin using different resin-based cements – Shear bond strength. *RFO, Passo Fundo*. 2012; 17(3):261-267. Set./Dez. 2012, 261-267.
7. Al-Akhali M, Kern M, Elsayed A, Samran A, Chaar MS. Influence of thermomechanical fatigue on the fracture strength of CAD-CAM-fabricated occlusal veneers. *Journal of Prosthetic Dentistry*. 2019; 121(4):644-650.
8. Al shibri S, Elguindy J. Fracture Resistance of Endodontically Treated Teeth Restored with Lithium Disilicate Crowns Retained with Fiber Posts Compared to Lithium Disilicate and Cerasmart Endocrowns: *In vitro* Study. *Dentistry*, 2017; 7(12).
9. Paradella TC, Bottino MA. Scanning Electron Microscopy in modern dentistry research. *Brazilian Dental Science*, 2012, 15(2).
10. Yoshida T, Kurosaki Y, Mine A, Kimura-ono A, Mino T, Osaka S *et al.*, Fifteen-year survival of resin-bonded vs full-coverage fixed dental prostheses. *Journal of Prosthodontic Research*. 2019; 63(3):374-382.
11. Guess PC, Schultheis S, Bonfante EA, Coelho PG, Ferencz JL. All-ceramic systems: laboratory and clinical performance. *Dent Clin North Am*. 2011; 55:333-352.
12. Denry I, Kelly JR. Emerging ceramic-based materials for dentistry. *Journal of Dental Research*. 2014; 93(12):1235–1242.
<https://doi.org/10.1177/0022034514553627>
13. Schwindling FS, Rues S, Schmitter M. Fracture resistance of glazed, full-contour ZLS incisor crowns. *Journal of Prosthodontic Research*. 2017; 61(3):344–349.
14. Journal I, Kumar L, Garg A. In-Vitro Comparative Study of Mechanical Properties Of Type V Die Stone And Epoxy Resins, 2014.
15. Goujat A, Abouelleil H, Colon P, Jeannin C. Marginal and internal fit of CAD-CAM inlay / onlay restorations : A systematic review of *in vitro* studies. *The Journal of Prosthetic Dentistry*, 2018.
16. Rosentritt M. Marginal Integrity of CAD / CAM Fixed Partial Dentures, 2019, 25-30.
17. Bergmann CP, Stumpf A. Dental ceramics: Microstructure, properties and degradation. In *Dental Ceramics: Microstructure, Properties and Degradation*. Springer Berlin Heidelberg, 2013.
18. Elsaka SE, Elnaghy AM. Mechanical properties of zirconia reinforced lithium silicate glass-ceramic. *Dental Materials*. 2016; 32(7):908-914.
19. Preis V, Behr M, Hahnel S, Rosentritt M. Influence of cementation on *in vitro* performance, marginal adaptation and fracture resistance of CAD/CAM-fabricated ZLS molar crowns. *Dental Materials : Official Publication of the Academy of Dental Materials*. 2015; 31(11):1363-1369.
20. Hamza TA, Sherif RM. Fracture Resistance of Monolithic Glass-Ceramics Versus Bilayered Zirconia-Based Restorations. *Journal of Prosthodontics*, 2017, 1-6.
21. Wang Y, Spencer P, Yao X, Ye Q. Effect of cointiator and water on the photoreactivity and photopolymerization of HEMA/camphoquinone-based reactant mixtures. *J Biomed Mater Res A*. 2006; 78:721-728.
22. Kern M, Wegner SM. Bonding to zirconia ceramic: adhesion methods and their durability. *Dent Mater*. 1998; 14(1):64-71.