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FRACTURE RESISTANCE AND COLOR OF ADVANCED LITHIUM DISILICATE (TESSERA) VERSUS LITHIUM DISILICATE (IPS – EMAX CAD) IMPLANT SUPPORTED HYBRID ABUTMENT CROWNS (IN VITRO STUDY)

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ABSTRACT

Aim of the study: To compare the color change (ΔE) and fracture resistance of implant-supported hybrid abutment crowns fabricated from Advanced Lithium Disilicate (CEREC Tessera) versus Lithium Disilicate (IPS e.max CAD).

Materials and methods: A total of 16 (implant with titanium base) samples were fabricated and categorized into two groups according to the hybrid abutment crown material; group 1: Lithium Disilicate (IPS e.max CAD) hybrid abutment crown (L), and group 2: Advanced Lithium Disilicate (CEREC Tessera) hybrid abutment crown (T). All samples were exposed to thermocycling (5000 cycles between 50 and 550). Vita Easy-shade spectrophotometer v was used to determine the Color change(ΔE) between the specimens and the target shade (A2) of the two materials before and after thermocycling. Fracture resistance was tested using a universal testing machine. Data were statistically analyzed.

Results: The IPS e.max Cad hybrid abutment crowns group showed significantly higher (ΔE) color difference than the CEREC Tessera group before thermocycling (7.3 ± 0.74 vs 3.47 ± 0.67) and after thermocycling (7.7 ± 1.11 vs 3.54 ± 0.77) (P-value = 0. 000). Regarding the fracture resistance results, IPS e.max Cad hybrid abutment crowns group showed a significantly higher values than those of Advanced Lithium Disilicate CEREC Tessera hybrid abutment crowns group (787.94 ± 190.96 vs 583.14 ± 104.66) (P=0.02).

Conclusions: HAC material had a significant effect on their color and fracture resistance where Lithium Disilicate (IPS e-max CAD) hybrid abutment crowns showed higher color difference (ΔE) and fracture resistance than Advanced lithium disilicate (CEREC Tessera).

KEYWORDS: Ti- base, thermocycling, vita Easy-shade

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INTRODUCTION

Dental implants had emerged as the most promising and widely accepted prosthetic solution for missing teeth. Innovative technological developments in implant dentistry had improved the effectiveness and longevity of dental implants. The rate of success of implant restorations depends on several variables related to the prosthesis. [1]

Titanium abutments exhibit a much superior fit compared to zirconia abutments, that ceramics can't be milled with the same accuracy as metals. The elevated incidence of fractures is a significant disadvantage of single- piece zirconia abutments, usually occurring at the junction between the implant and abutment, as well as in the transmucosal part of the abutment. These findings have resulted in the creation of hybrid abutments concept that link the titanium insert with the ceramic abutment, secured by resin cement. [2]

Typically, two designs are feasible for Hybrid Abutment Crowns (HACs). A one- piece restoration includes the manufacturing of the abutment and restoration as a single unit, which is fixed to Ti- base and later fixed through a screw to the implant. The alternative involves a two-piece restoration where the abutment is connected to Ti- base prior to its attachment to the implant, subsequently followed by the cementation of ceramic crowns above. One-piece restorations offer a simpler manufacturing process than two-piece restorations, as the crown and abutment are integrated into a single piece. Excess luting agent can be easily eliminated extra-orally for single-piece restorations. That minimizes the probability of biological problems, including as implant failure, bone resorption and peri-implantitis resulting from the excess cement. [3]

The development of 5-axis milling machines with the progression of CAD/CAM technologies enabled precise machining of entire restorations featuring a tailored screw- channel. This benefit expanded the range of CAD/CAM restorative materials applicable for HAC manufacturing to incorporate those provided as blocks or blanks without predetermined screw channels, 3D printed materials and pressable materials derived from milled HAC wax patterns. [4], [5]

The development of computer-aided design and manufacturing (CAD/CAM) technology facilitates the standardized and rapid fabrication of hybrid abutment superstructures with various all-ceramic materials, providing superior aesthetic results. Lithium disilicate (LD), in particular, provides exceptional aesthetics, precise marginal precision, high fracture resistance, biocompatibility, optimal internal fit, and excellent bonding properties, leading to an exceptionally high success rate for posterior implant- supported restorations. [6]

As a consequence, different materials have been manufactured to address the limitations of LD. The producer of CEREC Tessera designates this novel material as 'advanced' LD (ALD) and claims that ALD exhibits enhanced mechanical strength relative to conventional LD while preserving superior aesthetic qualities. Advanced LD comprises a zirconia-enriched glass matrix and lithium aluminium silicate (LAS) crystals known as virgilite, exhibiting a high biaxial strength exceeding 700 MPa.

Fracture resistance tests are essential for evaluation of dental prosthesis; these tests ensure that the prostheses are able to withstand the forces of chewing and biting in the oral environment to provide long-term function for the patient. [7]

The establishment of instrumental techniques for color assessment was necessary to address the limitations of visual methods and assure the objective evaluation of color. These instruments include digital cameras, colorimeters, intraoral scanners (IOSs), and spectrophotometers. A spectrophotometer determines color by calculating the spectrum reflectance or transmittance of an object, resulting in CIELab values (Commission Internationale de l'Éclairage). [8], [9] A restoration is regarded as acceptable if it can restore both aesthetics and functions while withstanding the demanding oral environment for multiple years without discoloration or fracturing.[10] Therefore, this study aimed to compare the fracture resistance and color change (ΔE) of implant-supported hybrid abutment crowns fabricated from Advanced Lithium Disilicate (CEREC Tessera) versus Lithium Disilicate (IPS e max CAD). The null hypothesis of the study stated that neither advanced lithium disilicate (CEREC Tessera) nor lithium disilicate (IPS e-max CAD) would significantly differ from one another in terms of fracture resistance and color parameter.

MATERIALS AND METHODS

Sample size calculation:

In order to evaluate the difference in fracture resistance between the groups, which represented the primary outcome of the study. A power analysis was conducted to ensure adequate power for a two-sided statistical test of the null hypothesis. Based on the results of a previous study by **Roberts et al.**[11], the calculated sample size (n) was 16 samples, eight per group, this study employed an alpha (α) level of 0.05 (5%), a beta (β) level of 0.20 (20%), which corresponds to a power of 80%, and an effect size (d) of 1.56. Fracture resistance was therefore considered the primary endpoint for the sample size calculations. Color change was assessed as a secondary outcome, and no separate power calculation was performed for this parameter.

Samples' preparation

16 internal connection titanium dummy implants (Dual, Egypt) were used in this study with 3.7 diameter,10mm length and 45^0 conical internal hex connection. Each implant was centrally inserted in an epoxy resin (Kemapoxy 150, CMB, Egypt) block which was produced using a pre-fabricated polyethylene mold(10X20mm) (Ethydco, Alexandria, Egypt) facilitated by a specially designed paralleling device to ensure parallel alignment of the implant to the cylinder outer surface. An epoxy resin material (Kemapoxy 150, CMB, Egypt) was proportioned and mixed per the manufacturer's instructions, subsequently the mixture was injected using a plastic syringe into the polyethylene mold surrounding the implant up to its initial thread (below implant - abutment junction) to simulate the vertical bone loss around the implant **Figure 1(A)**. [12]

The titanium base (Dual, EGYPT) was screwed to the dummy implant using the implant system screw driver **Figure 1(B)**, then it was sprayed with CEREC optispray (Dentsply Sirona, USA) to improve the accuracy of the digital impressions obtained, after which the assembly was positioned on the table of the extraoral laboratory scanner (inEosX5, Dentsply Sirona). STL file of this optical scan was then exported to CAD software (Dental CAD3.0 Galway, Exocad Dental DB software, Germany). Upon evaluating the scan's clarity, the pictures were stored via the software supplied by the manufacturer.

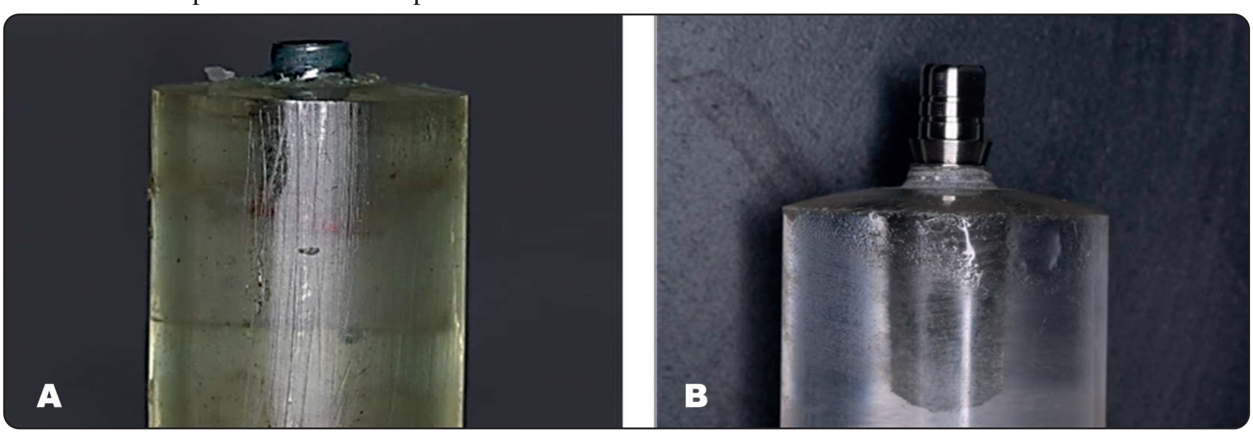

Fig. 1 (A) Dummy implant in epoxy resin block (B) Titanium base screwed to dummy implant

Designing of the hybrid abutment crown

A virtual hybrid abutment-crown structure was designed using Exocad software (Dental CAD3.0 Galway, Exocad Dental DB software, Germany) with 7 mm mesio-distal dimension,8.5 mm bucco-lingual dimension and 8mm occluso-cervically from the crest of buccal cusp to cervical margins. The samples were designed to replicate the morphology of maxillary first premolars with 2.5 mm diameter straight screw channel which designed to emerge from the middle of the occlusal surface **Figure (2)**. The cement space had been designed to be 50 µm, as per **Ferrairo et al.** [13]

Milling of the ceramic part of the hybrid abutment crown.

The ceramic part of the hybrid abutment crown (HAC) was milled from Lithium-disilicate glass ceramic (IPS e.max CAD) blocks in shade A2 (MT A2 C 14; Ivoclar Vivadent, Schaan, Liechtenstein) and Advanced lithium disilicate (CEREC Tessera) blocks in shade A2 (MT A2 C 14 Dentsply Sirona, USA) utilizing 5-axis milling machine (Imes. Icore. coritec.350 i.pro, Germany), resulting in the production of 8 HACs for each group that were randomized. Both IPS e.max CAD and CEREC Tessera blocks underwent wet milling following the manufacturer's guidelines. The milling process lasted 15 minutes for each block. Upon completion of the milling procedure, the block of the milled abutment crown was removed from the machine. Then, the connecter area was separated from the abutment by diamond disk (Brasseler, USA). The HACs were then meticulously finished and polished using diamond rubber polishers (OptraFine® F, Ivoclar Vivadent, Schaan, Liechtenstein) to achieve a smooth surface, ensuring that the restoration margins remained untouched to prevent accidental damage that could influence the tested outcomes. All restorations in both groups were thoroughly examined and confirmed to be free of defects, cracks, or marginal chipping. All abutment crowns were cleansed in an ultrasonic water bath (Codyson, Shenzhen, China) following the polishing procedure.

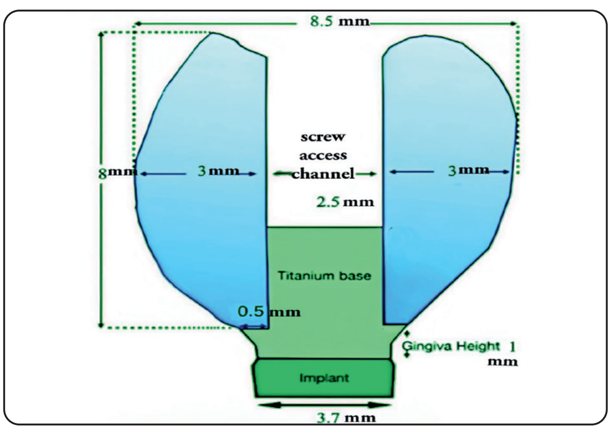

Fig. (2) Schematic diagram for the dimensions of the hybrid abutment crown

Before crystallization, glaze layer (Ips E.max crystal glaze, IvoclarVivadent) was painted on the outer surface of the IPS e-max hybrid abutment crown using a brush to get a consistent thickness, ensuring the attainment of a single layer of coating without any excessive accumulation then, the IPS e-max hybrid abutment crowns had been crystallized in a ceramic furnace (programat P3010, Ivoclar Vivadent) at 850^{o} c for a total firing time of 25 minutes as recommended by the manufacturer, whereas CEREC Tessera restorations were glazed using (Universal glaze, Dentsply Sirona, USA) that was painted on the entire outer surface of the hybrid abutment crown and fired following the recommended firing parameters by the manufactures in traditional porcelain furnace(programat P3010, Ivoclar Vivadent) at 760^{o}c for 12 minutes.

Cementation of the Ceramic part to the titanium base:

Surface treatment of the Titanium base:

Ti-base was subjected to sandblasting using 50 μm aluminium oxide particles (AluSparkle, Xpedent, China) in a sandblaster (Jeep sand-blasting machine, China) at a pressure of 2.0 bar for 20 seconds at a distance of 10 mm. A single layer of Z-primer (Bisco, USA) had been meticulously applied to the Ti-base surface for 20 seconds, followed by a self-reaction time of 60 seconds. [14]

Surface treatment of IPS e.max CAD and Tessera:

A 9.5% hydrofluoric acid etchant (Porcelain etchant, BISCO. USA) was applied for 20 seconds on IPS e.max CAD, while CEREC Tessera was treated for 30 seconds, followed by rinsing with tap water for 20 seconds, and subsequently coated with a silane coupling agent (porcelain primers, BISCO. USA) for 60 seconds.

Cementation of the ceramic part of the hybrid abutment crown to Ti base:

The screw of the Titanium base was retightened to 25 Ncm to avoid loosening and reduce the settling effect. The screw hole had been subsequently sealed with Teflon (ABRO INDUSTRIES, INC, USA). A thin coating of opaque dual-cured adhesive resin cement (Breeze, Pentron, USA) had been applied to the fitting surface of the hybrid abutment crown and the titanium base. After applying finger pressure to secure the ceramic part of the hybrid abutment crown to the titanium base, it was placed in a custom-made cementing device and subjected to 5 kg axial load. Excess cement had been eliminated using a micro-brush (Cotisen, China) and dental explorer. Following this, the screw channel had been sealed using a light- cured resin-based composite (Tetric Evo ceram, Ivoclar). The cement joint was then light-cured for 20 seconds on each side using an LED curing unit (Woodpecker i-led plus curing light).

All samples were subsequently kept at 100% humidity at 37°C for 24 hours prior to thermal cycling. Samples underwent thermal cycling for 5000 cycles in a thermocycling machine (SD Mechatronic thermocycler, Germany) between 5°C and 55 °C, with a dwell time of 25 seconds, simulating a clinical duration of 6 months. In each water bath, there is an interval of 10 seconds. The minimum temperature threshold was 5°C simulated the cold beverages (e.g., energy drinks). The maximum temperature was 55 °C represented hot beverages such as coffee [15]. It should be noted that this protocol reproduced only thermal aging without additional mechanical fatigue loading.

Color measurements:

All samples were measured for color change before and after thermocycling using a vita Easy- shade (vita Zahnfabrik, Germany) spectrophotometer v. One blinded assessor made all measurements under daylight, between12and1pm.[16]

Color change (ΔE) from shade A2:

To make sure every measurement was accurate, the spectrophotometer was calibrated in the calibration slot as directed by the manufacturer. Prior to taking measures of the restoration, the device had been switched to restoration mode and the shade A2 was selected for examination. On the hybrid abutment crown restoration, the aperture was positioned in the middle of the buccal surface. The average value was recorded after measuring each specimen three times. [17] **Figure (3)**

Fig. (3) Measuring color of hybrid abutment crown before and after thermocycling

Fracture resistance test

A computer-controlled materials testing machines (Model 3345; Instron Industrial Products, Norwood, MA, USA) was used to place the samples individually on a 5 kN load cell and gather data. The testing machine's bottom fixed chamber was secured with screws, which held the samples in place. A metallic rod with a round tip (3.8 mm diameter) had been used for fracture testing. The rod had been attached to the upper movable compartment of the testing machine and moved at a cross-head speed of 1mm/min. A tin foil sheet had been placed in between the rod and the machine to ensure uniform stress distribution and to minimize the transmission of local force peaks. The results can be seen in a loud crack and a sharp decline in the load- deflection curve recorded by computer software (Instron® Bluehill Lite Software) both pointed to the load at failure. A force in Newtons was used to estimate the necessary load for fracture. **Figure (4)**

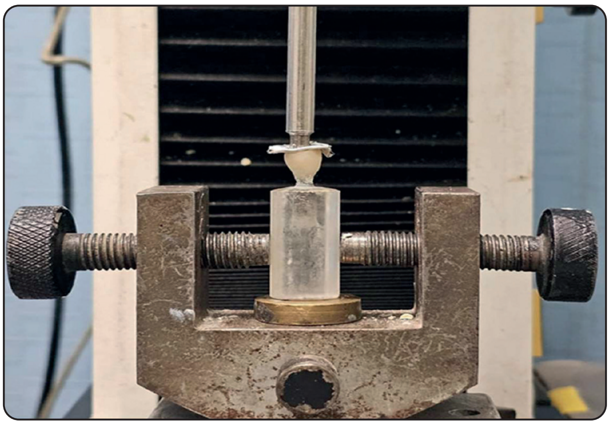

Fig. (4) Hybrid abutment crown on universal testing machine

Failure mode analysis:

Each fractured sample was checked using USB Digital microscope (U500x Digital Microscope, Guangdong, China) with a built-in camera at fixed magnification of 25X. Failure mode was analyzed and categorized according to **Schubert et.al** [18] who consider the Potential complications with CAD-CAM fabricated hybrid abutment single implant restorations made of monolithic lithium disilicate ceramics as technical complications:

1. Fracture of ceramic
2. Screw loosening
3. Screw fracture
4. Loss of retention between crown and titanium base CAD-CAM abutment
5. Loss of sealing composite resin of the screw access opening
6. Implant fracture

Statistical analysis

SPSS 16 ® (Statistical Package for the Social Sciences) was employed to conduct the statistical analysis. The minimum, maximum, median, mean, and standard deviation of fracture resistance were reported. The normality of the data had been evaluated using the Shapiro-Wilk and Kolmogorov-Smirnov tests, which verified that all data were derived from a normally distributed distribution. As a result, an independent t-test was implemented to compare various groups. The significance level was determined to be $P \leq 0.05$.

RESULTS

Color Change (ΔE) from shade A2 Results:

The descriptive results regarding the impact of HAC material on color change (ΔE) relative to shade A2, as well as the effect of thermal aging on the color stability of two materials, are summarized in **Table 1**, including mean values and their standard deviations (SD). The analysis of color change (ΔE) in relation to shade A2 revealed a statistically significant difference. The results demonstrated that the IPS e-max Cad hybrid abutment crowns group had a significantly higher color difference (ΔE) relative to shade A2 than the CEREC Tessera group of hybrid abutment crowns(ΔE) both before and after thermocycling. With a P-value of 0.000. Regarding the impact of thermal aging on the color stability of two materials, A paired t-test revealed no statistically significant difference between the IPS-e.max CAD group pre- and post-thermal aging ($P = 0.19$) and the CEREC Tessera group pre- and post-thermal ageing ($p=0.83$). **Figure (5)**

Fracture Resistance Results:

The descriptive results of fracture resistance for both groups are shown in **Table (2)** and **Figure (6)**. An independent t-test was conducted for group comparison, revealing that the IPS e-max Cad group (787.94 ± 190.96) exhibited a significantly higher fracture resistance than the CEREC Tessera group (583.14 ± 104.66), with a difference of 204.8 ± 76.99, and $P=0.02$.

TABLE (1) Descriptive results of the effect of (HAC) material on color change (ΔE) in relation to shade A2 and the effect of thermal aging

		IPS E-max CAD group Mean (SD)	Cerec Tessera group Mean (SD)	t-value	df	P-value
ΔE compared to A2	Before thermocycling	7.3 (0.74)	3.47 (0.67)	10.8	14	0.000
	After thermocycling	7.7 (1.11)	3.54 (0.77)	8.7	14	0.000
t-value		-1.43	-0.22			
(df)		7	7			
P-value		0.19	0.83			

**P-value is significant at 0.05 level or less*

TABLE (2) Descriptive results of the effect of (HAC) material on their Fracture resistance

	IPS E-max CAD	Cerec Tessera	Independent t test: Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper	T	Df	P value
Minimum	589.12	489.86							
Maximum	1028.60	756.36							
Median	777.47	519.00	204.80	76.99	35.07	374.53	2.66	10.86	0.02*
Mean	787.94	583.14							
Standard Deviation	190.96	104.66							

Significant difference as P≤0.05.

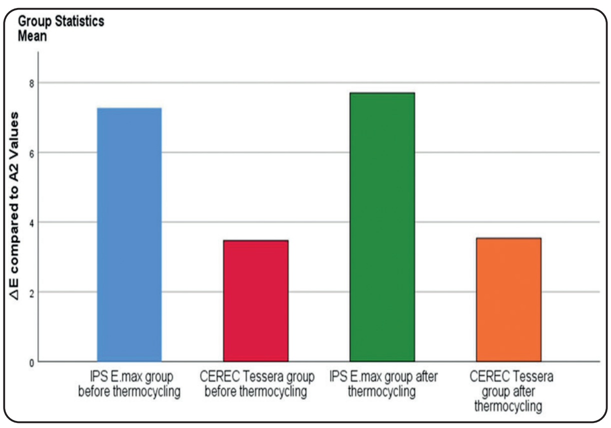

Fig. (5) Bar chart representing the ΔE compared to A2 mean values of the study groups

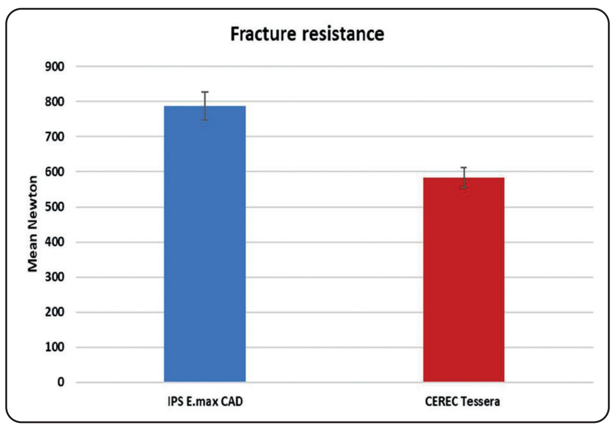

Fig. (6) Bar chart representing fracture resistance of both groups.

Failure Mode Analysis Results:

All samples of both groups showed catastrophic vertical fracture of the ceramic crown, splitting the superstructure mesio-distally into buccal and palatal parts. Usually, one part remained attached to Ti base. **Figure (7)** is showing representative sample of each group.

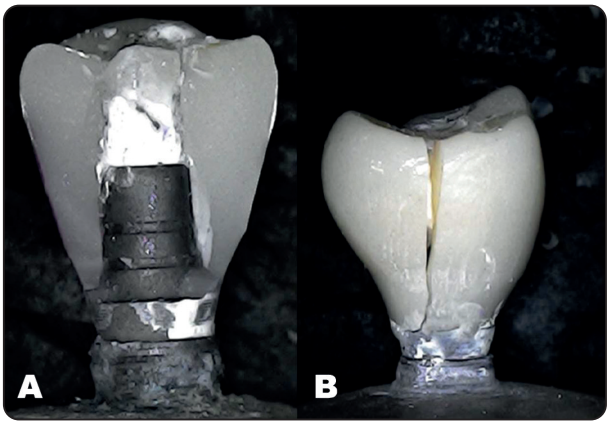

Fig. (7) Vertical fracture of hybrid abutment crown; (A): IPS e-max, (B): CEREC Tessera

DISCUSSION

Implant-supported single restorations have emerged as a favored treatment modality for replacing missing teeth, demonstrating similar efficacy and rate of survival to traditional fixed dental restorations. The efficacy of implant-supported restorations relies on mechanical qualities, biocompatibility, aesthetic results, osseointegration, and functioning. [19]

Hybrid abutment crowns include a titanium base attached to a ceramic meso-block via resin cement, thereby combining the benefits of both ceramic and titanium abutments, such as enhanced aesthetics, ideal biological response, and enhanced mechanical properties, without negatively impacting the implant-abutment interface. Titanium bases appeared to be a suitable choice for preserving the most susceptible metallic implant surface and material integrity, as titanium interfaces with titanium at the implant-abutment interface (IAI), providing superior stability. A hybrid retention mechanism (cemented and screwed), This technique provides benefits such as customization of the emergence profile, increased time efficiency with cost savings, improved light curing of the restoration margins prior to screwing and allows for the removal of excess cement. [2, 20, 4]

This investigation evaluated superstructures for restoring maxillary first premolars, due to their frequent loss of these teeth and high esthetic importance. Due to the frequently limited sagittal space for missing teeth in this region, where the implant diameter typically exceeds 3.8 mm, a premolar was chosen in agreement with previous studies conducted by **Nouh et.al** [21], **and Graf et.al** [22]. Moreover, this region is frequently characterized by strong forces and extra-axial group functions. For the purpose of HAC construction, both materials that were tested had an A2 shade, which corresponds to one of the most frequently encountered shades in clinical practice. [4] However, the study design was limited to this single crown type and shade, which restricts the generalizability of the findings. Result may differ in molars, which experience higher occlusal loads and stress concentrations, or in anterior teeth, which are subjected to shear forces and increased esthetic demands. Future studies should therefore investigate various crown designs and tooth location to enhance clinical relevance.

The specimens were machined using 5-axis milling machine, owing to its high precision and accuracy in processing complex shapes of dental restorations and in correctly machining the screw channels in both groups. [21]

The color stability of dental ceramics is crucial for the sustained aesthetic success of restorative dentistry. The visual perception of color changes in ceramics may lead to patient dissatisfaction and the need for restoration replacement or repair. [23]

Colorimetric and spectrophotometric analysis had been established as an effective method for objectively assessing color in dentistry, exceeding the accuracy of shade matching with the human eye. Spectrophotometry has demonstrated ability to identify minor color changes, and its repeatability in color evaluation exceeds that of alternative methods. [24]

The Vita Easy-shade spectrophotometer is frequently employed in dental research to obtain CIELAB coordinates. Color coordinates within the color space are represented by the CIE L*a*b* parameters. The L* coordinate denotes lightness, the a* coordinate denotes the green–red range, and the b* coordinates the blue-yellow spectrum. The quantification of the perceptible color difference between the hybrid abutment crown and the shade tab is provided by the CIELAB measurements. Total color differences were calculated between the Vitapan Classical shade guide (tab A2) and each group, as determined by CIELAB coordinate values. In comparison to human visual observations or conventional techniques, spectrophotometers have been demonstrated to provide a 33% increase in precision and a more objective color match in 93.3% of cases. Furthermore, spectrophotometers are not influenced by object metamerism and have more lifetimes than colorimeters [17] Consequently, the ΔE values for the (HAC) were determined using vita Easy-shade in our study.

Thermal cycling was conducted to replicate the restoration aging process before the fracture resistance testing. In this study 5000 thermal cycles between 5°C and 55 °C, with a dwell time of 25 seconds were performed, corresponding to approximately 6 months of clinical service, following the protocol of **Donmez et al.** [15] However, no mechanical fatigue loading was applied. This constitutes a limitation, as intraoral conditions usually involve the combined effect of thermal and mechanical stresses. Nevertheless, thermal aging had been widely proposed to simulate the extreme temperature variations commonly encountered in the oral environment. such thermal fluctuations may induce degradation of resin cement at the titanium base insert and the ceramic interface, potentially compromising the efficiency of load transfer across the interface. [25]

Regarding comparison of the color difference ΔE between shade A2 tab and IPS e.max Cad hybrid abutment crowns group and CEREC Tessera hybrid abutment crowns group, the null hypothesis was rejected, As the results showed that the color difference ΔE of IPS e.max Cad hybrid abutment crown group compared to shade A2 was statistical significantly higher than ΔE of CEREC Tessera hybrid abutment crown group before and after thermocycling.

The difference in ΔE between IPS e-max CAD and CEREC Tessera may result from variations in chemical composition, crystalline structure, and firing settings. [25]. In accordance with our study findings, **Elbieh et al.** [27] found that IPS e.max had a significantly higher color change (ΔE) than the other ceramic material group when comparing two implant-supported (CAD/CAM) monolithic crown models fabricated from lithium disilicate glass ceramic (IPS e-max CAD) and an alternative ceramic material using a spectrophotometer (VITA Easy Shade).

Also, our results were in agreement with those of **Hesham et.al** [14] who compared color reproduction of two lithium disilicate ceramic crowns of IPS e.max CAD and CEREC Tessera (shade A2) and measured the color change before and after thermocycling and found that the IPS e-max CAD had higher values of color change (ΔE) (6.76±1.77) than CEREC Tessera (3.19±1.00).

Our study used a threshold of perceptibility of (ΔE = 2.6) and a threshold of acceptability of (ΔE = 5.5) as reported by **Douglas et.al** [28] and **Siwachakeeyawat et.al** [29]**.** The (ΔE) values of IPS e.max CAD study group was above the selected perceptibility threshold (PT) and acceptability threshold (AT)**,** With a mean value of (7.3), indicating color changes that may be clinically unacceptable. In contrast, the CEREC Tessera hybrid abutment crown group showed (ΔE) values above the reported clinically perceptible level (ΔE = 2.6) but below acceptability threshold (ΔE= 5.5) with a mean value of (3.47) before thermocycling, suggesting that color changes would be noticeable but remain within clinically acceptable limits. The results were aligned with the study conducted by **Della Bona et al** [30], which showed that none of the CAD/CAM ceramic systems could accurately match their respective shades, with a high ΔE value observed in IPS e-max CAD (LT) for the Vita Classical shade guide VC(A1) shade. Additionally, **Al Hamad et al.** [16] examined the impact of the background color on shade reproduction employing CAD/CAM zirconia and lithium disilicate ceramics, revealing that the (ΔE) values of each group exceeded both the acceptability threshold (AT) and the perceptibility threshold (PT).

Color stability testing can be done by simulating the effect of oral environment daily use on the materials through a thermocycling process to evaluate changes in the structure and color of the material by using the microscopic and spectrophotometry analysis. [31]

There was no statistically significant difference between the pre- and post-thermocycling values of the CEREC Tessera and IPS e.max CAD groups when examining the effect of thermal aging on the color stability of the two materials. This may be explained as both undergo a glazing process. Rough surfaces can elevate the potential of water penetration, which may subsequently dissolve the silica component in lithium disilicate, leading to reduced crystallinity and raised adsorption of color pigments. [26], [31]

The fracture resistance was chosen as a test property in this study because it is a mechanical property of brittle materials that withstands concentrations of stress until fracture if the stress exceeded the yield strength of the material. [32]

The null hypothesis was rejected based on fracture resistance data, indicating that the IPS e-max CAD hybrid abutment crowns group (787.94±190.96) exhibited considerably greater strength than the CEREC Tessera hybrid abutment crowns group (583.14±104.66). The findings of **Rauch A et al.**[33] aligned with our investigation, which assessed implant- supported crowns fabricated with conventional IPS e.max CAD and the novel lithium disilicate including virgilite CEREC Tessera. This study examined screw-retained implant crowns, evaluating the latest ceramic both with and without a coupling agent. The findings revealed that the latest CEREC Tessera had lower fracture load values relative to the conventional IPS e.max CAD.

Contrary to our results, **Fayed et al.** [7] assessed fracture resistance of crowns composed of advanced (CEREC Tessera) and conventional lithium disilicate materials (IPSe-max CAD). The results indicated no significant difference between the groups, the variation in results may arise from variations in crown design, cement space, and the absence of thermal cycling prior to the fracture resistance test.

Differences in microstructural composition might account for the observed variation in fracture strength among lithium disilicates. Partial crystallization improves its machinability, specifically in the "blue state" just prior to firing. As it crystallizes, the composition transforms from a glassy matrix containing 40% platelet-shaped lithium metasilicate crystals to 70% fine- grained lithium disilicate crystals. The material's interlocking microstructure and higher crystalline concentration (over 60% vol%) are responsible for its remarkable mechanical properties, which include high strength and toughness. By contrast, CEREC Tessera CAD/CAM material has 0.5 μm lithium disilicate crystals incorporated into a glass matrix and 0.2-0.3 μm virgilite, which are platelet-like lithium aluminosilicate crystals ($Li0.5Al0.5Si2.5O6$). [34,7] Virgilite crystals are most effectively formed at temperatures between 800°C and 850°C. Microcracks or residual strains could be created or caused due to the differences in thermal expansion among lithium disilicate crystals along with other elements during cooling, it may also introduce heterogeneity in crystal distribution. In order to enhance the material's strength, CEREC Tessera requires only glaze or matrix fire at 760 °C for 4.5 to 12 minutes. Conversely, IPS e- max CAD necessitates a particular crystallization procedure [7]. These factors may partly explain why, in the present study IPS e.max CAD exhibited higher fracture resistance compared to Tessera, despite manufacturer claims.

The comparison of fracture resistance and color stability highlights distinct performance of the tested materials. IPS e.max CAD exhibited significantly higher fracture resistance, which supports its indication in high stress functional areas. However, its color stability was less favorable, exceeding the acceptability threshold. In contrast, CEREC Tessera demonstrated color stability within clinically acceptable limits, suggesting an esthetic advantage, although with lower fracture resistance. These findings emphasize the necessity of considering both mechanical reliability and esthetic performance when selecting materials for hybrid abutment crowns.

Results showing higher fracture resistance compared to normal masticatory forces applied to premolar teeth (ranging from 200 to 445 N) were obtained with the IPS e-max cad hybrid abutment implant supported crown and the Tessera hybrid abutment implant supported crowns in this study. This proves that the ceramic hybrid abutment crown materials that were examined are suitable for replacing missing premolar teeth. [15]

The mode of failure was classified based on **Schubert et al.** [18], who regard probable challenges related to CAD-CAM produced hybrid abutment single implant restorations composed of monolithic lithium disilicate ceramics as technical issues. All samples exhibited vertical catastrophic fractures of the crown, with no distortion of the implant or screw. All superstructures in this study cracked mesio-distally, fracturing the superstructure into buccal and palatal segments. Typically, a single part left attached to the titanium base.

Based on these findings, the null hypothesis of no difference between the tested materials was rejected for both color change and fracture resistance.

Limitation of this study includes being invitro which doesn't replicate the oral environment. The use of thermal cycling alone without the inclusion of dynamic mechanical loading. While thermal cycling simulates temperature fluctuations in the oral cavity, it doesn't account for the masticatory stresses and fatigue that dental restorations experience during function. The sample size was calculated based on the fracture resistance as the primary outcome; therefore, the results related to color change should be interpreted with caution. Neglecting other components and factors on color perception, such as: translucency which significantly influence the overall aesthetic perception.

CONCLUSIONS

Within the limitations of the present study, the following can be concluded

- The color change (ΔE) values of the CEREC Tessera hybrid abutment crown were lower than those of the IPS e-max CAD hybrid abutment crown when compared to A2.
- Thermal aging did not affect the color stability of the IPS e.max CAD or CEREC Tessera hybrid abutment crown.
- The IPS e-max cad hybrid abutment implant supported crown demonstrated superior fracture resistance compared to the CEREC Tessera hybrid abutment implant supported crown. However, both CEREC Tessera and lithium disilicate hybrid abutment crowns could sustain oral stresses in the premolar area.

Conflict of Interest

The authors declare no conflicts of interest related to this work.

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Ethics Approval

This investigation obtained ethical permission from the Research Ethics Committee of the Faculty of Dentistry, Cairo University, Cairo, Egypt (N.81022).

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