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# MARGINAL ADAPTATION AND INTERNAL FIT OF ADVANCED LITHIUM DISILICATE (TESSERA) VERSUS LITHIUM DISILICATE (IPS-EMAX CAD) IMPLANT-SUPPORTED HYBRID ABUTMENT CROWNS (AN INVITRO STUDY)

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## *ABSTRACT*

**Aim:** This study aimed to assess the marginal gap and internal fit of implant-supported hybrid abutment crowns (HACs) fabricated from advanced lithium disilicate (CEREC Tessera) and lithium disilicate (IPS e.max CAD).

**Materials and Methods:** A total of twenty-four HACs were fabricated using a digital workflow from CEREC Tessera and IPS e.max CAD (n=12 per group). Marginal adaptation was evaluated using a stereomicroscope, while internal fit was assessed using the replica technique. The collected data (mean and standard deviation) were statistically analyzed.

**Results:** A statistically significant difference was observed between the two groups in terms of marginal adaptation (P=0.001), with CEREC Tessera exhibiting a lower marginal gap. However, no statistically significant difference was found between the two tested groups concerning internal fit (P=0.056).

**Conclusion:** Both CEREC Tessera and IPS e.max CAD hybrid abutment crowns demonstrated clinically acceptable marginal adaptation and internal fit within the established clinical values. These findings support their compatibility for implant-supported restorations.

**KEYWORDS :** CAD/CAM, Ti-base, Stereomicroscope, Replica technique.

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## INTRODUCTION

Dental implants have played a fundamental role in modern dentistry, often serving as the foremost treatment option for restoring function and aesthetics in cases of tooth loss[1]. Implants-supported restorations in aesthetic zone are challenging due to potential discoloration of the soft tissue from titanium abutments. To enhance mucogingival aesthetics, all-ceramic abutments have been introduced [2]. One-piece all-ceramic abutments have numerous shortcomings, including poor fit and a high risk of fracture. To overcome these limitations, hybrid abutments were developed[3].

A hybrid abutment is a two-piece dental component that consists of a titanium base and a ceramic abutment, often made of ceramic materials like zirconia or lithium disilicate. In contrast, a hybrid abutment crown is a complete restoration that combines both the hybrid abutment and the crown in one integrated unit [4]. Screw-retained hybrid abutment crowns (HACs) simplify manufacturing process by combining the ceramic abutment and crown into a single unit. Additionally, they eliminate subgingival cement, minimize soft tissue manipulation, and allow for a customized emergence profile. Moreover, they provide easy screw access in case of loosening and are ideal for limited vertical space where cemented restorations may lack retention [5].

A hybrid abutment is a two-piece implant-supported restoration consisting of a titanium base and a separate ceramic abutment and crown, usually made of materials like lithium disilicate glass ceramics or zirconia. In contrast, a hybrid abutment crown (HAC) is a complete implant-supported restoration that combines both the hybrid abutment and crown in on integrated unit [4]. Screw-retained HACs reduce the complexity of the manufacturing process, eliminate subgingival cement, minimize manipulation of soft tissue and allow for customization of the emergence profile. They also provide easy screw access in case of loosening. Moreover, they are ideal for situations with limited vertical space, where cemented restorations may lack retention [5].

In the digital workflow, HACs are commonly manufactured using CAD/CAM meso-blocks with prefabricated screw channels, but their storage requirements and limited availability restrict material selection. A more adaptable, versatile and cost-effective alternative is the use of solid blocks. With Advancements in CAD/CAM technology and 5-axis milling, custom screw channels can now be precisely fabricated, overcoming previous limitations and expanding material choices [6].

Advancements in CAD/CAM technology have led to a considerable expansion in the range of available restorative materials, enabling combination that were previously unavailable in conventional restoration manufacturing, including zirconia, glass ceramics and hybrid materials [7]. Lithium disilicate glass ceramic is commonly used in restorative dentistry due to its high strength, wear resistance, aesthetic translucency, and strong adhesive bonding, ensuring durability and longevity. IPS e.max CAD, was introduced in 2006, reduces chairside time and enhances treatment predictability. The system offers high aesthetics, translucency options, and strength [8]. In 2021, Dentsply Sirona launched CEREC Tessera, an advanced lithium disilicate (ALD) material enhanced with virgilite crystals for CAD/CAM restorations. It features a biaxial strength exceeding 700 MPa, improved aesthetics, and a rapid sintering time of 4.5 minutes in the CEREC SpeedFire furnace [9].

The long-term success and durability of implant superstructures depends not only on material selection but also on achieving precise marginal adaptation and internal fit [10]. Multiple approaches have been suggested for measuring marginal discrepancy, each with its own strengths and limitations. However, a single standardized method has yet to be established. In 1990, Sorensen [11] classified marginal adaptation evaluation methods into four main categories: direct observation, clinical assessment with a dental probe, cross sectional analysis, and impression replica technique. The silicone replica technique is a widely used as it is a non-destructive method that can be applied clinically and in vitro for assessing marginal and internal adaptation [12].

Although monolithic hybrid abutment crowns made from lithium disilicate have demonstrated high clinical success rates with minimal chipping and fractures over three-year follow-up period [13], minimal researches exist on the fit between HACs with custom-milled screw channels and Ti-bases. Therefore, this study aimed to compare advanced lithium disilicate (CEREC Tessera) and lithium disilicate (IPS e.max CAD) implant-supported hybrid abutment crown in terms of marginal adaptation and internal fit to Ti-base. The null hypotheses were that there would be no significant difference regarding the marginal adaptation of hybrid abutment crowns fabricated from Advanced lithium disilicate (CEREC Tessera) and lithium disilicate (IPS E-max CAD). Furthermore, there would be no difference in terms of internal fit of HACs between these two materials.

## MATERIALS AND METHODS

### Sample size calculation:

A power analysis was conducted to ensure sufficient statistical power for a two-sided test of the null hypothesis, assessing differences in marginal adaptation between groups. Based on a previous study of Alves, et al. [14], with an alpha (α) level of 0.05 (5%), a beta (β) level of 0.20 (20%)—equivalent to a power of 80%—and an effect size (d) of 1.22, the required sample size was calculated to be 24 samples (12 per group).

### Specimens' preparation

Endosseous dummy implant (3.7mm diameter x 10mm length) (Dual, Egypt) was inserted in an epoxy resin ( Kemapoxy 150, CMB, Egypt ) block fabricated in a ready-made polyethylene mold (Ethydco, Alexandria, Egypt) The implant was inserted in the mold with a specially constructed paralleling device to adjust the implant in a parallel position to the external side of the mold. The proper epoxy resin liquids A and B were proportioned and mixed according to manufacturer instructions and injected into polyethylene mold till the first thread of the implant. The ti-base was fixed to the implant then its screw was tightened by the aid of the corresponding screw driver and torque wrench (Dual, Egypt) at 25 Ncm as recommended by the manufacturer.

The titanium base was sprayed with CEREC optispray (Dentsply Sirona, Charlotte, North Carolina, United States) to enhance the accuracy of the optical impressions. Laboratory scanning was performed using extra-oral lab scanner (InEos X5, Dentsply Sirona, Germany). STL file of this optical scan was then exported to CAD software (Dental CAD 3.0 Galway, Exocad Dental DB software, Germany). After checking the scan's clarity, the data were saved using the computer software provided by the manufacturer.

On the computer screen, a three-dimensional model was generated and the design was done using exocad software. The margins and finish line of the titanium base were detected and the path of insertion was identified. The generic outline of all samples in both groups was standardized. The cement gap was set to be (50 $\mu$m) [15]. The buccolingual, mesiodistal dimensions, and cusp height of the HACs were adjusted on design window. The samples were designed to replicate the morphology of maxillary first premolars **Figure (1).**

The HACs dimensions were set to be 8 mm occluso-cervically from the crest of buccal cusp to cervical margins, 7 mm mesio-distally and 8.5mm bucco-lingually [16]. A straight screw channel measuring 2.5mm in diameter was designed to emerge from the middle of the occlusal surface **Figure (2)**. The completed model was subsequently exported to STL file.

To obtain the ceramic part of the hybrid abutment crowns, IPS e-max CAD (Ivoclar Vivadent, Schaan, Liechtenstein) and CEREC Tessera (Dentsply Sirona, Charlotte, North Carolina, United States) blocks were selected in shade A2 (medium translucency). Each block was inserted and fixed into 5-axis milling machine (CORiTEC 350i X PR, IMES-ICORE GMBH, Hessen, Germany). Both of IPS e.max CAD and CEREC Tessera blocks were wet milled following the manufacturer's instructions. The time of the milling procedure was 15 mins/block.

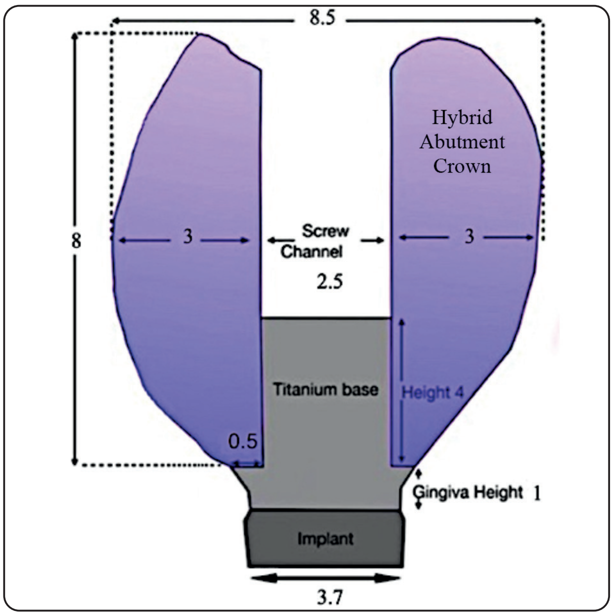


Fig. (1) Schematic diagram for the dimensions of the hybrid abutment crown

Following the end of 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 (Brasselar, 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 under a magnifying lens and confirmed to be free of defects, cracks, or marginal chipping. They were then cleaned using an ultrasonic cleaner (CODYSON, Shenzhen, China).

Following the manufacturers' instructions, IPS e.max CAD restorations were crystallized according to manufacturer parameters (Programat EP3010 furnace, Ivoclar Vivadent, Schaan, Liechtenstein), whereas CEREC Tessera restorations were glazed. Finally, each hybrid abutment crown was individually assessed on its respective Ti-base to verify seating, marginal and internal fit **Figure (3)**. Each specimen was given a distinct number to ensure accurate identification and prevent any potential mix-ups in the future.

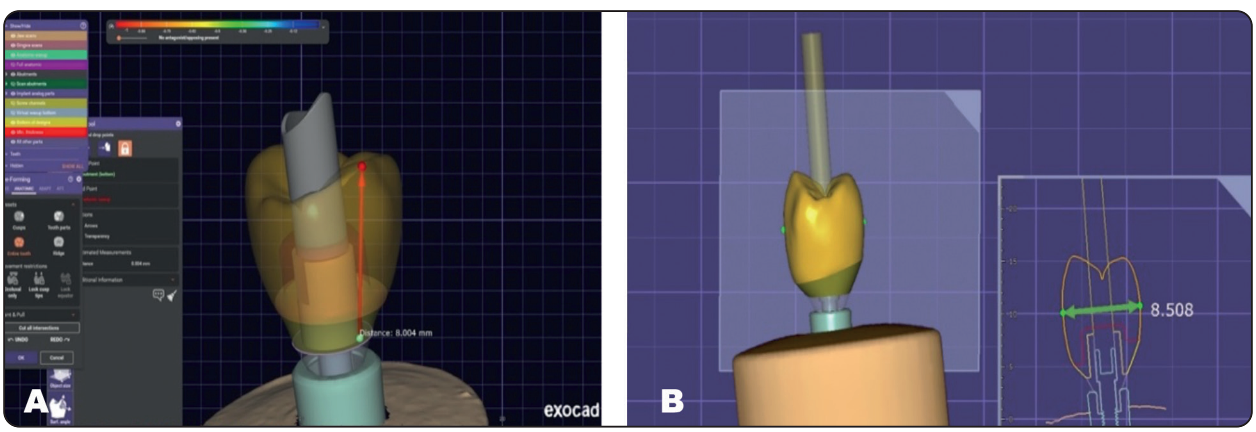


Fig. (2) Opening the screw channel in the implant direction after adjusting the proposed design (A) Occluso-cervically, (B) Bucco-lingually

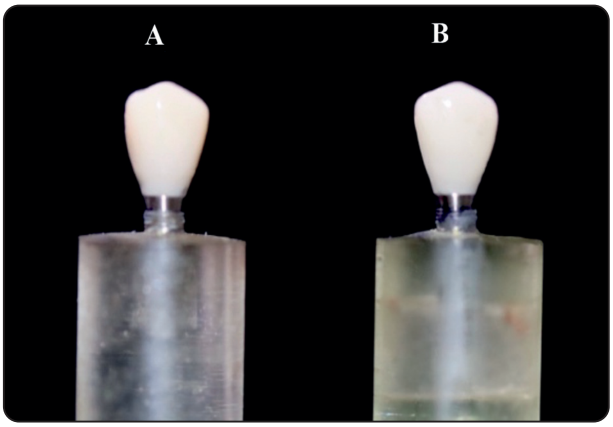


Fig. (3) Final hybrid abutment crowns: (A) IPS e.max CAD, (B) CEREC Tessera

### Assessment of marginal adaptation

A specially designed holding device was utilized to secure the hybrid abutment during the measurement recording process [17]. All Samples were positioned onto a stereomicroscope (Leica MZ6 Stereo-microscope, Wetzlar, Germany) at magnification X50 [18]. A fixed starting point was marked on the titanium base using a permanent indelible marker to ensure consistency during the measurement of each sample. The marginal gap measurements were performed by one calibrated investigator starting form this point at 8 points around the hybrid abutment crown (mid-buccal, mid-lingual, mid-distal, mid-mesial, mesio-buccal, mesio-lingual, disto-buccal, and disto-lingual) [19].

### Assessment of internal fit

The silicone replica technique was utilized to assess the internal fit of each hybrid abutment crown in both tested groups. Polytetrafluoroethylene tape was used to seal the Ti-base screw channel, preventing impression material from entering and ensuring that the light-body silicone impression material was confined to the cement space between the Ti-base and the HAC. In contrast, the HAC screw channel was left unsealed to facilitate the escape of excess material. The samples were filled with auto-mixed light-body addition silicone material (Elite, Zermack SPA, Germany) and seated on the titanium base with finger pressure till complete setting of the material following the manufacturer recommendations. After complete setting of the light-body material, the hybrid abutment crown was carefully removed from the titanium base leaving the light-body addition silicone attached to the titanium base. Then, a heavy-body silicone (Elite, Zermack SPA, Germany) with different color was used to stabilize the light-body silicone and prevents its distortion upon removal by using a metal box [20].

After complete setting of the heavy-body addition silicon, the silicon replica was obtained and removed from the titanium base and sectioned into four equal segments bucco-lingually and mesio-distally. To assess the internal fit, three equidistant points were measured (P1: cervical, P2: middle, and P3: occlusal) for each surface (buccal, palatal, mesial, and distal), yielding 12 internal measurements for each sample [14]. **Figure (4)**. The thickness of light-body addition silicone material of each section was assessed under the same stereomicroscope at magnification of X24 representing the discrepancy between the abutment crown and the titanium base.

### Statistical analysis

Initially, the quantitative data was collected using SPSS 25® software (Statistical Package for Social Science, IBM, USA). Kolmogorov– Smirnov test and Shapiro Wilk's test were used for checking the normality of the data. Data were presented as mean and standard deviation (SD). P-value ≤ 0.05 was considered statistically significant in all tests.

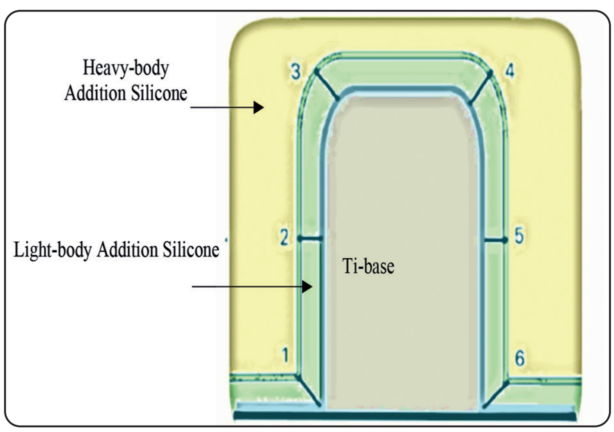


Fig. (4) Diagram representing points of internal fit measurements

## RESULTS

The mean marginal and internal gap values, along with their standard deviations (SD), are presented in **Table (1).** Regarding the marginal gap, the results showed a statistically significant difference (P = 0.001). For the internal gap, A t-test showed no statistically significant difference between the IPS e.max CAD and CEREC Tessera groups (P = 0.056).

TABLE (1) Results of marginal adaptation and internal fit.

| Marginal adaptation values ($\mu$m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Study Groups | Mean | SD | Mean±SD | Min. | Max. | 95%CI | | P-value |
| | | | | | | Lower | Upper | |
| IPS e.max CAD | 18.26 | 2.006 | 18.26±2.006 | 13.43 | 21.00 | 16.9936 | 19.5431 | 0.001 |
| CEREC Tessera | 16.78 | 24.33 | 16.78±24.33 | 8.20 | 94.00 | 1.3211 | 32.2456 | |
| **Internal fit values ($\mu$m)** | | | | | | | | |
| Study Groups | Mean | SD | Mean±SD | Min. | Max. | 95⁰/0 CI | | P-value |
| | | | | | | Lower | Upper | |
| IPS e.max CAD | 73.2100 | 3.13283 | 73.2100±3.133 | 68.98 | 77.85 | -8.15 | 0.121 | 0.056 |
| CEREC Tessera | 77.2238 | 4.46328 | 77 .2238±4.463 | 71.02 | 84.34 | -8.19 | 0.166 | |

## DISCUSSION

Dental implants have been established as an effective treatment option for restoring oral function and aesthetics in cases of tooth loss due to their high clinical survival rates. Prefabricated titanium abutments remain the most commonly used type because of their straightforward application and cost-efficiency [21]. However, the use of these abutments is typically restricted to cases with optimal implant positioning, and cases where the depth, diameter and, emergence profile align ideally with the restored edentulous area [22].

The choice of the hybrid abutment crown (HAC) system in this study aligns with the recommendations of Joda & Brägger [23] who advocated for its use to streamline laboratory procedures and lower overall treatment costs. Moreover, this approach is further supported by Edelhoff et al. [5], who highlighted several advantages of the HAC, including a simplified manufacturing process, the prevention of residual subgingival cement, and reduced manipulation of peri-implant soft tissue, all while enabling the emergence profile customization. Moreover, in cases of screw loosening, the crown's screw access channel allows for easy screw removal, further enhancing its practicality [24].

The CAD/CAM technology has significantly improved the manufacturing of implant-supported restorations by enhancing accuracy, precision, efficiency, and standardization while eliminating manual errors in laboratory procedures. This technology enables the fabrication of highly precise restorations with better marginal and internal adaptation [25]. Given these advantages, the CAD/CAM fabrication technique was selected for this study. In the present study, lithium disilicate (LDS) blocks were selected as a comparator material for hybrid abutment crowns (HACs) because of their superior esthetics, proper marginal adaptation, and strong bonding capabilities [8].

The clinical outcomes of CAD/CAM monolithic implant-supported HACs in the posterior region remains not yet adequately supported by scientific evidence, particularly regarding their internal fit and marginal adaptation to the titanium base. To address this gap, the present study assessed the fit of HACs fabricated from lithium disilicate (LDS) (IPS e.max CAD) and advanced lithium disilicate (ALD) (CEREC Tessera). The findings aim to help clinicians identify materials that offer superior internal fit and marginal adaptation for implant-supported restorations.

The present study tested a recently introduced advanced lithium disilicate (ALD) ceramic material (CEREC Tessera) which incorporates virgilite crystals. It was chosen because it represents a relatively innovative CAD/CAM material on the market, offering both aesthetic appeal and high strength. Moreover, limited researches exist regarding CEREC Tessera marginal accuracy. This study was an in vitro study, serving as a valuable alternative to in vivo research, allowing for the assessment of material properties and their potential clinical applications in a time-efficient and cost-effective manner (26).

In the present study, a fully digital workflow was implemented as it offers greater accuracy, efficiency, and time savings compared to conventional methods, while enhancing the overall fit of the restoration (12, 27). The cement space was adjusted to 50 µm, aligning with the methodologies from previous studies, including those by Ferrairo et al; Pachiou et al (15, 28). All HACs were CAD/CAM manufactured from solid blocks, featuring custom screw channels. The study by Yıldız et al. (29) revealed that HACs with custom screw channels demonstrated superior performance in minimizing vertical marginal discrepancies compared to cement-retained restorations. A 5-axis milling machine was employed to ensure accurate milling, allowing for the accurate fabrication of the HACs with custom made screw-channels in both research groups(4). The main parameter evaluated in this study was the marginal adaptation since it plays a critical role in prostheses success. The internal fit was also evaluated to provide a more comprehensive understanding of how the superstructure adapted to the abutment.

The marginal fit of implant-supported restorations is critical as it significantly affects their long-term success (30). The selection of measurement points for evaluating marginal adaptation is an essential factor to consider. In this study, eight points were assessed around each HAC, consistent with the methodology employed in previous study by Elrashid et al (19). This approach maintains consistency with established research protocols while providing a comprehensive assessment of the marginal adaptation.

In the present study, the replica technique was employed as it is a non-destructive approach that enables the quantitative assessment of internal adaptation. This technique preserves the integrity of the restoration, allowing for repeated and reproducible measurements at various time intervals(12). According to Di Fiore et al.(31), the number of measurement points affects the reliability of internal fit assessment and enhances the consistency of the results. In this study, all replicas were precisely sectioned into four equal parts along the buccolingual and mesiodistal directions. Following the methodology established by Alves et al (14) and to ensure a comprehensive assessment, measurement points were selected from three distinct regions within each section - occlusal, middle, and cervical- resulting in a total of 12 measurement points per sample.

Regarding the marginal gap results, the null hypothesis was rejected, indicating a statistically significant difference between the two tested groups (P=0.001). The CEREC Tessera HACs demonstrated a lower mean marginal gap (16.26µm ±24.33) compared to IPS e.max CAD (18.26µm ±2.006) **Table (1).** Despite this difference, both materials remained within the clinically acceptable values of 120µm(32). Variations in marginal gap values between the tested groups can be primarily attributed to differences in their material composition, including crystal structure, chemical formulation, and firing parameters. One significant factor contributing to the higher marginal discrepancy observed in IPS e.max CAD HACs is ceramic shrinkage during the crystallization firing process. As the material transitions from a partially sintered to a fully crystallized state, densification occurs, leading to slight dimensional changes at the margins. Gold, et al.[33] reported that the crystallization of lithium disilicate restorations results in a shrinkage of 0.2%–0.3%, which can increase the marginal gap. These alterations can affect the overall restoration fit, which is critical for its long-term clinical success. A key distinction between the two ceramic materials lies in their post-milling firing process. IPS e.max CAD requires an additional crystallization step at 850°C, with a total firing time of 25 minutes, to achieve superior esthetic and mechanical properties. In contrast, CEREC Tessera undergoes only a glaze firing at 760°C for a significantly shorter duration of 4.5 to 12 minutes, optimizing its strength [34]. These findings highlight the role of material processing in determining the final fit of restorations and may clarify the discrepancies in marginal adaptation observed between the two research groups.

The findings of the present study are consistent with those of Perez Canals [35] who investigated the marginal fit of CAD/CAM crowns fabricated from Lithium Disilicate (IPS e.max CAD) and Advanced Lithium Disilicate (CEREC Tessera). The study found that while both materials showed clinically acceptable marginal gap values, CEREC Tessera exhibited slightly better adaptation, with an average marginal gap of 69.4 µm compared to 71.1 µm for IPS e.max CAD. The results of the present study differ from those of Kojima, et al. [36], who evaluated the marginal adaptation of crowns fabricated from three lithium disilicate glass-ceramic blocks: GC Initial® LiSi Block, IPS e.max CAD, and CEREC Tessera. Their findings indicated that the CEREC Tessera group had the largest marginal gap. This variations in results may be associated to differences in study design, as their research evaluated the marginal gap between a prepared tooth and its corresponding crown, whereas the present study focused on the adaptation between the titanium base and the hybrid abutment crown.

Regarding the internal fit results, the null hypothesis was accepted, indicating no statistically significant difference between the two tested groups. Both groups showed values within the clinically acceptable range of 150 µm, as reported by Al-Thobity, A.M. [27]. The lack of significant difference may be attributed to the use of a cement gap of 50 µm may have contributed to this result, as it has been shown to provide adequate space for cement while minimizing discrepancy [37]. Previous studies have also linked internal fit accuracy of CAD/CAM-milled restorations to the precision of the scanning process and the milling capabilities of the CAD/CAM system. These studies highlight variations in performance among different CAD/CAM systems and emphasize the benefits of advanced 5-axis milling machines, which enhance accuracy and precision [38].

Although the difference was not statistically significant, CEREC Tessera HACs demonstrated a slightly higher mean internal gap (77.22 ± 4.46 µm) compared to IPS e.max CAD HACs (73.21 ± 3.13 µm) **Table (1)**. This minor variation could be attributed to differences in the material composition, which may influence their microstructural properties and overall adaptation. Furthermore, the gradual wear of milling instruments can negatively impact the accuracy and fit of ceramic restorations by increasing surface roughness, reducing marginal precision, and causing deviations in the internal adaptation. Studies have shown that as milling burs degrade, they tend to produce restorations with larger gaps due to reduced cutting efficiency and irregular material removal [39].

The present study findings are consistent with those of Fayed et al.[40], who found no statistically significant difference in marginal adaptation between lithium disilicate (IPS e.max CAD) and advanced lithium disilicate (CEREC Tessera) crowns. However, CEREC Tessera demonstrated a slightly improved fit with lower marginal gap values compared to IPS e.max CAD. This variation may be due to differences in study design, as their study evaluated the fit of single crowns on abutment teeth rather than the fit of HACs on a titanium base. Additionally, a triple-scan protocol was used for fit evaluation, whereas the present study employed a stereomicroscope for measurement.

Another study by Demirel & Donmez [41] corroborates our findings, revealing no statistically significant differences between the tested groups following crystallization. Additionally, their study highlighted a substantial decrease in the internal gap of IPS e.max CAD after the crystallization process, a phenomenon not observed in CEREC Tessera. This distinction may be attributed to the structural and compositional differences between the two materials, particularly in how they respond to the crystallization firing process.

The limitations of the current study include the fact that all crowns were evaluated under in vitro conditions, which may not fully replicate the complexities of the intraoral environment. Factors such as masticatory forces, thermal fluctuations, and oral moisture could influence the fit and adaptation of restorations in clinical settings. Additionally, measurements were conducted prior to cementation, meaning that any potential alterations in the marginal and internal gaps due to the cementation process were not assessed [42]. Furthermore, there remains insufficient evidence to definitively determine which CAD/CAM esthetic material offers the most precise marginal adaptation and internal fit for implant-supported restorations in the posterior region. Variability in study methodologies, material properties, and clinical conditions contributes to the ongoing debate regarding the optimal ceramic material for such restorations.

## CONCLUSIONS

Considering the limitations of the present study, the following could be concluded:

1. The marginal adaptation of CEREC Tessera hybrid abutment crowns was superior to that of IPS.emax CAD.
2. The internal fit of IPS e.max CAD and CEREC Tessera HACs were comparable.
3. Both CEREC Tessera and IPS e.max CAD hybrid abutment crowns demonstrated clinically acceptable marginal adaptation and internal fit within established clinical values. These findings support their suitability for implant-supported restorations.

### Conflict of Interest

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

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This research was not financially sponsored by any public, commercial, or nonprofit funding agencies.

### Ethics Approval

Ethical approval for this study was obtained from the Research Ethics Committee of Faculty of dentistry, Cairo University; Cairo, Egypt (N.91022).

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