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Evaluation of Marginal Fit of Lithium Disilicate and Advanced Lithium Disilicate Crowns Using Two Intraoral Scanners: An In Vitro Study

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Abstract

This in vitro study aimed to evaluate and compare the marginal fit, accuracy, and precision of lithium disilicate crowns fabricated using two intraoral scanners—Primescan AC (Dentsply Sirona) and Medit i700 (Medit Corp., South Korea)—and two CAD/CAM ceramic materials (IPS e.max CAD and CEREC Tessera™). A mandibular first premolar was virtually prepared using CAD software and 3D printed to create a master die. Digital impressions were obtained using both scanners, and crowns were fabricated from IPS e.max CAD and CEREC Tessera™ blocks. Marginal fit was evaluated using the Triple Scan Technique, while accuracy (trueness) and precision (repeatability) were analyzed using Geomagic Control X software. Statistical analysis included two-way ANOVA and independent t-tests with significance set at $p<0.05$. No statistically significant differences were found in marginal adaptation between the two ceramic materials ($p=0.880$) or between scanners ($p=0.512$). However, Primescan demonstrated significantly better trueness (15.15±2.52 µm vs. 18.31±2.53 µm, $p=0.012$) and precision (7.73±1.62 µm vs. 10.03±0.72 µm, $p<0.001$) compared to Medit i700. Within the limitations of this in vitro study, Primescan showed superior trueness and precision compared to Medit i700. No significant difference in marginal fit was observed between IPS e.max CAD and CEREC Tessera™ crowns.

Keywords: Lithium disilicate, advanced lithium disilicate, intraoral scanners, marginal fit, CAD/CAM, prosthodontics

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1. Introduction

Ceramic crowns are among the most widely used indirect restorations in fixed prosthodontics due to their superior mechanical properties and excellent esthetics [1]. They are employed to restore both function and appearance in teeth that have been weakened or structurally compromised. Glass ceramics, particularly lithium disilicate, have gained significant popularity in clinical dentistry because of their unique combination of high strength, translucency, and natural esthetics [2]. Lithium disilicate has demonstrated favorable fracture toughness, reliable bonding to tooth structure, and versatility for use in both anterior and posterior restorations [3]. In recent years, new formulations such as advanced lithium disilicate (CEREC Tessera™) have been introduced. These materials are marketed as offering improved strength and faster processing times while maintaining the esthetics of traditional lithium disilicate. The innovation is attributed to the incorporation of virgilite crystal reinforcement within glass-ceramic matrix, which reduces glaze firing time and enhances mechanical performance [4]. Despite these claims, scientific evidence regarding the marginal adaptation and clinical behavior of advanced lithium disilicate remains limited, creating the need for further investigation. Marginal fit is a critical parameter influencing the success and longevity of fixed prostheses. Poor marginal adaptation allows for plaque accumulation, dissolution of luting cement, and microleakage, which may lead to secondary caries, gingival inflammation, periodontal disease, and restoration failure [5].

Although ideal threshold for clinical acceptability remains debated, marginal discrepancies below 100–120 µm are generally considered acceptable for clinical use [6]. Therefore, evaluation of marginal fit is essential when assessing new restorative materials and digital fabrication techniques. The advent of digital dentistry—including intraoral scanners (IOS) and CAD/CAM workflows—has significantly transformed prosthodontics. These systems improve accuracy, reduce chairside time, enhance patient comfort, and facilitate communication with laboratories [7] [8]. However, intraoral scanners may vary in their performance, particularly in terms of trueness (closeness to the reference value) and precision (repeatability). Among the commonly used devices, Primescan (Dentsply Sirona) and Medit i700 (Medit Corp., South Korea) are widely adopted in

clinical practice, but their relative accuracy and influence on marginal adaptation remain an area of active investigation. Based on these considerations, the present in vitro study was designed to evaluate and compare the marginal fit, trueness, and precision of lithium disilicate and advanced lithium disilicate crowns fabricated using Primescan and Medit i700 intraoral scanners. The null hypothesis tested was that neither the type of intraoral scanner nor the ceramic material would significantly affect marginal adaptation, trueness, or precision of the fabricated restorations.

2. Materials and Methods

2.1. Study Design

This was an in vitro experimental study conducted to evaluate the marginal fit, trueness, and precision of lithium disilicate and advanced lithium disilicate crowns fabricated using two intraoral scanners. A total of 56 crowns were fabricated and analyzed.

2.2. Master Die Preparation

A mandibular first premolar was virtually prepared using Exocad CAD software (Exocad GmbH, Darmstadt, Germany), following standardized reduction parameters:

- Occlusal reduction: 1.5 mm
- Axial reduction: 1.0 mm
- Finish line: 1.0 mm shoulder with rounded internal angles
- Total convergence angle: 6–10°

The virtual preparation was exported as an STL file and 3D printed using an Elegoo Mars 4 UV LCD printer (Elegoo Inc., China) with Anycubic methacrylate-based resin to create the master acrylic die. The die was scanned using a reference desktop scanner (inEos X5, Dentsply Sirona, Germany) to generate a high-resolution STL file that served as the baseline for trueness analysis.

2.3. Grouping of Samples

Fifty-six crowns were divided into two main groups according to the intraoral scanner used (n=28 each):

Group P: Primescan AC intraoral scanner (Dentsply Sirona, Germany)

Group M: Medit i700 intraoral scanner (Medit Corp., Seoul, South Korea)

Each group was further subdivided based on the ceramic material used for crown fabrication (n=14 each):

Subgroup E: Lithium disilicate (IPS e.max CAD, Ivoclar Vivadent, Liechtenstein)

Subgroup T: Advanced lithium disilicate (CEREC Tessera™, Dentsply Sirona, Germany)

Each subgroup (n=14) was then equally divided for evaluation of marginal fit (n=7) and accuracy/trueness and precision (n=7).

2.4. Crown Fabrication

All digital impressions (STL files) were imported into Exocad software for crown design, maintaining standardized parameters across all groups. The crowns were milled using a CEREC inLab MC XL milling machine (Dentsply Sirona). Lithium disilicate crowns: fabricated from IPS e.max CAD blocks, crystallized according to manufacturer instructions at 840°C for 25 minutes in a Programat P310 furnace (Ivoclar Vivadent). Advanced lithium disilicate crowns: fabricated from CEREC Tessera™ blocks, fired according to manufacturer-specific protocols with shortened glaze firing cycles due to virgilite reinforcement.

2.5. Marginal Fit Evaluation

The Triple Scan Technique [9] was employed to evaluate marginal adaptation:

1. Scanning the prepared acrylic die alone.
2. Scanning the intaglio surface of each crown.
3. Scanning the crown seated on the die without cementation.

Scans were aligned and analyzed using Geomagic Control X software (3D Systems, USA). Vertical marginal gaps were measured at four standardized locations: mid-buccal, mid-lingual, mesial, and distal. The mean marginal gap (µm) was recorded for each crown.

2.6. Accuracy and Precision Evaluation

Trueness: Each intraoral scan was superimposed on the reference STL file (inEos X5 scan) using best-fit alignment. Root Mean Square (RMS) deviations were calculated to quantify trueness.

Precision (Repeatability): Deviations between repeated scans within each group were analyzed to assess reproducibility.

2.7. Statistical Analysis

Data were analyzed using R statistical software (v4.5.1, Windows). Normality and variance homogeneity were assessed using the Shapiro–Wilk and Levene tests. Trueness and precision values analyzed with independent t-tests. Marginal fit was analyzed using two-way ANOVA (scanner × material). Post-hoc comparisons were performed using the Wald test with Sidak correction for multiple comparisons. Effect sizes were calculated using Partial Eta Squared (PES) and Cohen's d, interpreted according to Cohen (1988). The level of significance was set at $p < 0.05$.

3. Results and discussion

3.1. Results

Table 1 shows the effect of ceramic material, scanner type, and their interaction on marginal adaptation. The analysis revealed no statistically significant differences among the tested variables ($p > 0.05$). This indicates that neither the choice of restorative material (IPS e.max CAD vs. CEREC Tessera™) nor the scanner system (Primescan vs. Medit i700) significantly influenced the marginal fit of the fabricated crowns. The very low Partial Eta Squared (PES) values suggest that these factors contributed minimally to the overall variance in marginal gap measurements. Table 2 presents the comparison of marginal adaptation between the two ceramic materials. The mean marginal gaps were 312.79 ± 63.83 µm for the IPS e.max CAD and 309.73 ± 61.03 µm for CEREC Tessera™, with no statistically significant difference ($p = 0.880$). This finding suggests that both traditional and advanced lithium disilicate ceramics demonstrated comparable marginal adaptation when fabricated under similar CAD/CAM conditions. Table 3 compares marginal adaptation across the two scanners. The mean marginal gap was 317.94 ± 58.04 µm for the Primescan and 304.58 ± 65.89 µm for Medit i700, with no significant difference ($p = 0.512$). These results indicate that both scanners provided similar levels of accuracy in terms of the marginal fit, reinforcing that scanner selection did not markedly influence this specific outcome.

Table 1. Effect of variables on marginal adaptation RMS (µm)

Source	Sum of Squares	Df	Mean Square	F-value	p-value	PES
Material	94.06	1	94.06	0.02	0.880	0.00
Scanner	1782.83	1	1782.83	0.44	0.512	0.01
Material × Scanner	1.52	1	1.52	0.00	0.985	0.00

df: degree of freedom; PES: Partial Eta Squared; ns: not significant.

Table 2. Marginal adaptation RMS (µm) for different materials

Material	Mean ± SD (µm)	p-value	PES
IPS e.max	312.79 ± 63.83	0.880	0.00
Tessera	309.73 ± 61.03		

PES: Partial Eta Squared; ns: not significant.

Table 3. Marginal adaptation RMS (µm) for different scanners

Scanner	Mean ± SD (µm)	p-value	PES
Primescan	317.94 ± 58.04	0.512	0.01
Medit i700	304.58 ± 65.89		

Table 4. Marginal adaptation RMS (µm) for different scanner-material combinations

Scanner	Material	Mean ± SD (µm)	p-value	PES
Primescan	Emax	319.27 ± 65.60	0.926	0.00
	Tessera	316.60 ± 52.96		
Medit i700	Emax	306.31 ± 64.85	0.904	0.00
	Tessera	302.86 ± 70.39		

ES: Partial Eta Squared; ns: not significant.

Table 5. Trueness RMS (µm) for different scanners

	Scanner	Mean ± SD (µm)	p-value	Cohen's d
Trueness RMS (µm)	Primescan	15.15 ± 2.52	0.012	-1.25
	Medit i700	18.31 ± 2.53		
Precision RMS (µm)	Primescan	7.73 ± 1.62	<0.001	-1.84
	Medit i700	10.03 ± 0.72		

Table 4 illustrates the combined effect of scanner type and material on marginal adaptation. The mean values ranged from 302.86 µm (Medit–Tessera) to 319.27 µm (Primescan–Emax). None of the subgroup comparisons reached statistical significance ($p > 0.05$), confirming that neither scanner-material interaction nor subgroup variations affected the marginal gap. This reinforces the consistency of results observed in Tables 2 and 3. Table 5 summarizes trueness and precision outcomes for both scanners. A significant difference was detected ($p = 0.012$), with Primescan demonstrating lower RMS deviation (15.15 ± 2.52 µm) compared to Medit i700 (18.31 ± 2.53 µm). This suggests that Primescan more accurately reproduced the reference geometry, highlighting its superior optical and processing technology. The large effect size (Cohen's d = –1.25) further emphasizes the clinical relevance of this difference, also a highly significant difference was found ($p < 0.001$), with Primescan showing better repeatability (7.73 ± 1.62 µm) than Medit i700 (10.03 ± 0.72 µm). The large effect size (Cohen's d = –1.84) indicates that this difference is not only statistically significant but also practically meaningful. This finding highlights Primescan's enhanced ability to produce consistent scan data across repeated measurements.

3.2. Discussion

Marginal fit is a critical determinant of the clinical success of indirect restorations. Well-fitting restorations reduce the risk of microleakage, plaque accumulation, caries, periodontal inflammation, and endodontic lesions, thereby improving the longevity of single-crown rehabilitations [10-11] With the transition to digital dentistry, intraoral scanners (IOS) have become widely accepted, offering simplified workflows and three-dimensional imaging for precise impressions [12] Nevertheless, scanner performance varies, and accuracy remains a concern. In this study, fifty-six lithium disilicate crowns were fabricated and assessed for marginal fit and precision using two IOS systems: Primescan and Medit i700. Crowns fabricated from IPS e.max CAD and CEREC Tessera™ blocks. Results indicated that Primescan achieved superior marginal fit, with a higher percentage of crowns exhibiting adaptation values below gold-standard thresholds (75 µm and 30 µm). This finding can be explained by scanner's advanced optical system, blue light technology,

and high-speed Smart Pixel Sensor, which consolidates more than 50,000 images per scan and captures up to one million 3D points per second [13-14]. These results align with Zimmermann et al. and Adam Brian, who reported higher accuracy of Primescan compared with other scanners [15].

Although Medit i700 employs advanced full-color streaming imaging and demonstrated acceptable accuracy, its performance in trueness and precision was lower than that of Primescan in this study. Some studies have reported similar outcomes for conventional and digital workflows [16] while others found superior accuracy with extraoral scanners [17]. These findings support the conclusion that IOS technologies differ in performance, and new technologies tend to present superior outcomes [18]. For standardization, epoxy resin dies were used due to their dimensional stability and elastic modulus similar to dentin [19]. No significant differences were found between CEREC Tessera™ and IPS e.max CAD crowns in terms of marginal adaptation. The mean marginal gaps were 309.73 ± 61.03 µm for Tessera and 312.79 ± 63.83 µm for e.max, with no statistically significant difference. These results are consistent with Perez et al. [20] and Demirel et al.[21], who also found similar adaptation values b/w two materials after crystallization. Accordingly, null hypothesis regarding material type was accepted, indicating that both Tessera and e.max CAD provide comparable adaptation and internal fit [22]. This study, however, has limitations inherent to in vitro designs. Variables such as saliva, subgingival margins, patient movement, and light reflection, which affect outcomes in vivo, were not simulated here. Thus, while controlled laboratory conditions ensured reproducibility, further clinical studies required to validate these findings.

4. Conclusion

1. No statistically significant difference in marginal fit was observed between IPS e.max CAD and CEREC Tessera™ crowns. Primescan demonstrated significantly superior trueness and precision compared to Medit i700, suggesting it is a more reliable scanner for clinical applications requiring high accuracy.

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