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Original Article

Assessment of Trueness and Internal Fit of Glass Ceramic Crowns Constructed by Four and Five-Axis Milling Machines (An In Vitro Study)

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Abstract

Aim: This in-vitro study was conducted to assess the trueness and internal fit of glass ceramic crowns (Lithium disilicate: IPS e.max CAD) constructed by four and five-axis milling machines.
Methodology: A typodont model of mandibular 1st molar was prepared for full coverage crowns. With the intraoral scanner (primescan), the prepared model was digitally scanned and designed by CEREC software to fabricate 14 glass ceramic crowns (IPS e.max CAD).Group I: 4-axis (MX CL), and group II: 5-axis(MC X5) milling machines (n =7). The milled restorations were scanned then internal and external occlusal surfaces were superimposed onto the reference CAD model using software for difference analysis (Geomagic Control X, 3D systems, USA) to assess. A silicone replica technique was utilized to evaluate the internal gap. After testing for normality, Numerical data were presented as mean and standard deviation values. Data were statistically analyzed at a level of significance ($P \leq 0.05$).
Results: Crowns produced by the MC X5 machine exhibited higher trueness than those produced by the MC XL machine ($p < 0.05$). There were significant differences in trueness values between different crown areas ($p < 0.001$, 44.07±9.78 in the in-lab MC X5), ($p < 0.001$, 71.99±31.22 in the MC XL group). When comparing both groups regarding internal fit, the MC XL group had a significantly higher internal gap than the MC X5 group ($p < 0.05$) for overall measurements and axial 2 which is the region between the axio-occlusal and the axial 1. Meanwhile, for the other measurements, there was no statistically significant difference ($p > 0.05$).
Conclusions: The five-axis milling machine yielded higher trueness than the four-axis. Also, crowns produced by the four-axis milling machine had a significantly higher internal gap compared to those produced by the five-axis milling machine.

Keywords: Accuracy. (CAD/CAM).Fit. Milling. Trueness. Internal fit. Glass ceramic.4-axis .5-axis.

Introduction

Dental ceramics have long been recognized as the most favored material for esthetic restorations because of their proven acceptable durability (Jalalian et al., 2015). Variations in the fit accuracy of different all-ceramic restorations might be attributed to the manufacturing process (Jalalian et al., 2015).

Computer-aided design and computer-aided manufacturing (CAD/CAM) technology are used in the production of ceramic restoration through three phases: scanning, designing and machining (Al Hamad et al., 2020). Every phase of the fabrication process must be accurate enough to produce restorations of adequate quality (Al Hamad et al., 2020).

Poor marginal and internal fit exposes the cement content to the oral environment leading to cement dissolution, stimulating caries initiation, and causing damage to essential pulp and paradental structures resulting (AL-Zomur et al., 2021).

Precision and trueness are two ways to define accuracy (Al Hamad et al., 2020). Trueness is the degree to which a measured item or data set deviates from the reference item or reference data set, while precision refers to the repeatability of measurements. 3-D inspection software is used for superimposition analysis of the measured data and the reference data to assess the trueness (Al Hamad et al., 2020).

Since most restorations using CAD/CAM are machined from a material block, precise milling is also necessary since it influences the marginal gap size and internal fit (Goujat et al., 2018). Gingival tissue inflammation may result from imperfections at the margins (Goujat et al., 2018). The number of axes of the milling machine has a major effect on the accuracy of the milling process; currently, there are three, four and five-axis milling machines available (Goujat et al., 2018). For long-term clinical uses, dental prosthesis manufacturing accuracy is crucial (Goujat et al., 2018).

The 4-axis milling machines involve an additional axis to the three spatial axes and it can allow the block to rotate around the X-axis (Alageel et al., 2019). The fourth axis is defined as tension bridge A which can turned infinitely variably (Alageel et al., 2019). This is useful for milling large blocks for long-span frameworks to adjust the bridge with a large vertical height displacement into the usual mold dimensions and thus save material and milling time (Alageel et al., 2019). In the 5-axis milling machines, the tension bridge B is referred to as the fifth axis (Alageel et al., 2019). This makes it possible to grind intricate shapes and subtly curved surfaces (Alageel et al., 2019).

Internal fit is a clinical criterion that adds to the fracture resistance and increases the clinical success rate of the final restoration (Al Maaz et al., 2019; Okamoto et al., 2022). It is defined as "the perpendicular measurement from the internal surface of the restoration to the axial wall of the preparation" (Holmes et al., 1989).

Several non-destructive approaches have been used to measure the marginal and internal gaps like the silicone replica technique (SRT) and 3-D inspection software (Al-Atyaa & Majeed, 2018).

The accuracy of restoration may be impacted by the type of milling bur and the size of its particles (Goujat et al., 2018). Additional factors could potentially affect the outcomes, such as how the software configures the virtual cement spacer parameter, the inherent characteristics of the CAD-CAM system, the selection of rotary instrument and its speed in the milling machine (Goujat et al., 2018).

Subjects and Methods

Sample size calculation was performed using G-power software ver-3.1.9.7 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) with 0.05 alpha and 80% power, rendering 7 samples in each group.

Preparation of Typodont tooth

A mandibular first molar of a Typodont model (NISSIN Dental Model, Kyoto Japan) was selected and prepared to receive an all-ceramic crown following the principles of all-ceramic crown preparation. with 1.5 mm axial reduction, 1 mm deep chamfer finish line, occlusal reduction of 2 mm, and 6 degrees of convergence(Figure 1**).** The preparation was carried out by the researcher and was checked using a silicone index which was taken before the preparation to ensure the achievement of the required reduction.

Depending on the milling machine that was utilized IPS e.max CAD crowns (IPS e. max CAD block, IvoclarVivadent, Schaan Liechtenstein) were divided into two groups of seven samples each, group (I): crowns constructed by (MCXL) 4-axis milling machine, group (II): crowns constructed by (MCX5) 5-axis milling machine (Sirona Dental System, Bensheim, Germany).

Fabrication of the crowns:

All crowns were fabricated using CEREC AC CAD/CAM system, a bio-generic individual design was selected to allow designing the crown from the software database. Prepared teeth were scanned using the CEREC Prime Scan^{Tm} scanner (Sirona Dental System, Bensheim, Germany) and design was carried out using CEREC 5.2 software. Fourteen crowns were divided into two groups of lithium disilicate blocks and milled using 4-axis (MCXL)and 5-axis (MCX5) wet milling machines. Normal milling protocol was selected in each machine to standardize the milling process. After completion of the milling process in the MCXL milling machine, the crowns were separated from the block holder in the milling chamber. The attachment point to the block (sprue) was smoothed out on the crown using recommended grinding tools (EVE Diapol, EVE Ernst Vetter GmbH, Pforzheim, Germany). All crowns were checked over the prepared typodont tooth for proper seating after removing

Figure 1: Prepared tooth in the model.

the sprue. On the other hand, a diamond disc (EVE Diapol, EVE Ernst Vetter GmbH, Pforzheim, Germany) was used to separate the crowns milled by the MCX5 milling machine from the blocks and a suitable grinding tool was used to finish the sprue attachment points. The IPS e.max CAD crowns were crystallized in a programmat furnace after the milling processes. (Programmat P510, Ivoclar, Vivadent, Schann, Lieichtein) at 850ºC for thirty minutes. All crowns were checked over the prepared typodont tooth for proper seating (Figure 2).

Figure 2: Fit of the crown checked on the master typodont tooth before and after crystallization.

Trueness assessment

Trueness measurement was done by scanning the intaglio and the outer surfaces (whole crown) of all e.max crowns with an intraoral scanner (i700; Medit, Seoul, Korea), and was exported as high-resolution Standard Tessellation Language (STL) files with the reference designs to a 3D assessment program (Geomagic Control X;3D system, Geomagic Inc, Morrisville, NC, USA). Subsequently, the scanned data was superimposed onto the reference CAD data, which was utilized for crown construction.

The CAD file was assigned as reference data, and the scanned crown was assigned as measured data. At first, the reference model was segmented into many parts according to its surfaces: occlusal, buccal, lingual, mesial, distal, internal and finish line area. Alignment mode was selected to start aligning data sets.

A color map was used to show the difference between the aligned target and reference data. Only the area of interest was compared in three dimensions. The color map displays + 0.8 mm maximum deviation range and – 0.8 mm minimum deviation. A tailored acceptable tolerance of 0.01 mm was used. A positive divergence from the nominal CAD was indicated by the red color (under-milled areas). On the other hand, a negative divergence was demonstrated by the blue color (over-milled area). Matching surfaces were displayed in green color (± 0.01 mm).

The highest reading for both the positive and negative divergences was 200µm. A larger crown fabrication was indicated by positive deviations, whilst a smaller crown fabrication was indicated by negative deviations. Areas of crown surfaces measuring zero or close to zero mm deviation indicated perfect matching or superimposition and thus higher crown fabrication accuracy. Clinically, the negative deviations cannot be altered; however, the positive deviations can be reduced (Figures 3 and 4).

The color-difference map provides a qualitative representation of the deviation between the tested scan and reference CAD design. However, Root Mean Square (RMS) was utilized to analyze the variation between scans statistically and quantitatively.

An automatic report was generated that provided numerical values of low, high, average, positive average, negative average, variation, and RMS for each crown area.

The software calculated the square of the phase difference between several points in 3D space (x-, y-, and z-axis) after superimposition of the two data sets. Then the sum of these squares was divided by the number of points. The following calculation uses the RMS to express the mean of positive and negative values

$$RMS = \frac{\sqrt{\sum_{i=1}^{n} (X1, i - X2, i)^2}}{\sqrt{n}}$$

coexisting:

where X2, i is the measurement point of the prosthetic crown scan data following milling, X1,i is the measuring point of the reference CAD data and n is the total number of measuring points. Trueness was expressed by the RMS mean's standard deviation. RMS, positive, and negative average means are displayed for each crown area's descriptive statistics.

RMS data was recorded in 7 areas for each scan (one result for each crown) with a total number of samples (n=98).

Internal fit assessment

The silicone replica technique was used for internal fit measurement. A thin layer of light-body addition silicon (Vinylpolysiloxane; Panasil®, Germany) was applied to the fitting surfaces of the e.max crown that was then placed on the prepared typodont tooth and kept under a load of 50 N using a specially designed and fabricated holding device. After five minutes (setting time of the light-body material), the e.max crown was removed from the typodont tooth leaving an adherent layer of light body on the outer surface of the tooth. A plastic container with heavy-body additional silicone inside was then used as a tray to keep the light body stable, where the typodont tooth was placed inside the container until the material set. The thin layer of light body replica remained attached to the heavy body imprint substance when the tooth was removed from the container.

A sharp surgical blade no. 15 (HuaiAn TianDa Medical Instruments Co, Ltd, China) was then used to cut each replica into four slices, designated MB, ML, DB, and DL, starting from the center and going in both mesio-distal and bucco-lingual directions. Two opposing sections from each of the four sections obtained from the replica were utilized to calculate the internal fit, with six regions measured for each section (margin, axio-margin, axial1, axial 2, axio-occlusal and mid-occlusal), equipping 12 internal measurements for each crown by 6 points from each section, (Figure 5). Using a digital microscopy at ×35 magnification (U500x Digital Microscope, Guangdong, China), the light-body silicone thickness for all replicas, which was measured represents the distance between the external surface of the preparation and the internal surface of the crown. A digital image analysis system (Image J 1.43U, National Institute of Health, USA) was used to measure and qualitatively evaluate the gap width.

Statistical analysis:

Numerical data were presented as mean and standard deviation values. They were tested for normality using Shapiro-Wilk's test. Trueness data were normally distributed and were analyzed using an independent t-test. While internal fit data were non-parametric and were analyzed using Mann-Whitney U test. The significance level was set at $p<0.05$ within all tests. Statistical analysis will be performed with IBM® SPSS® Statistics Version 26 for Windows (IBM Corporation, NY, USA.).

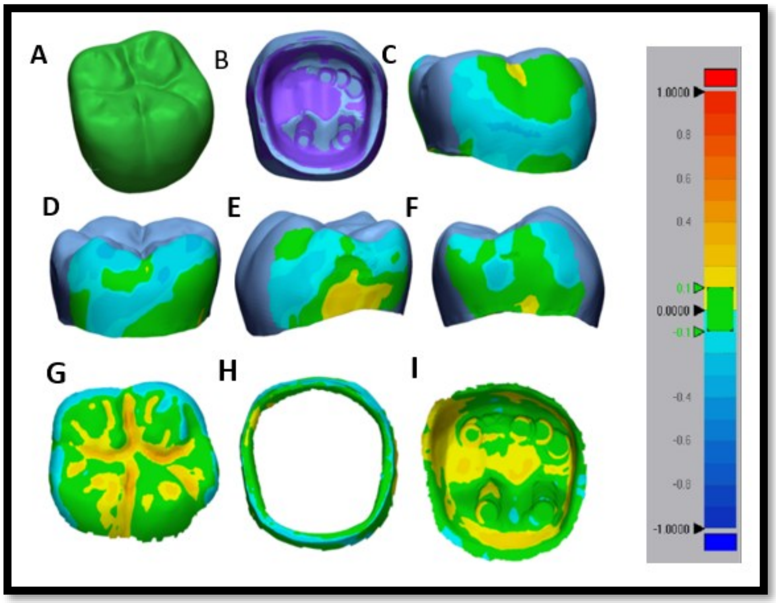

Figure 3: Color difference map trueness analysis for 4-axis glass ceramic crown areas. A, Reference design. B, Best-fitting alignment between reference design and ceramic crown specimen. C, External area, buccal area. D, lingual, E and F, Mesial and distal areas, G, Occlusal area, H, Marginal area, I, Internal area.

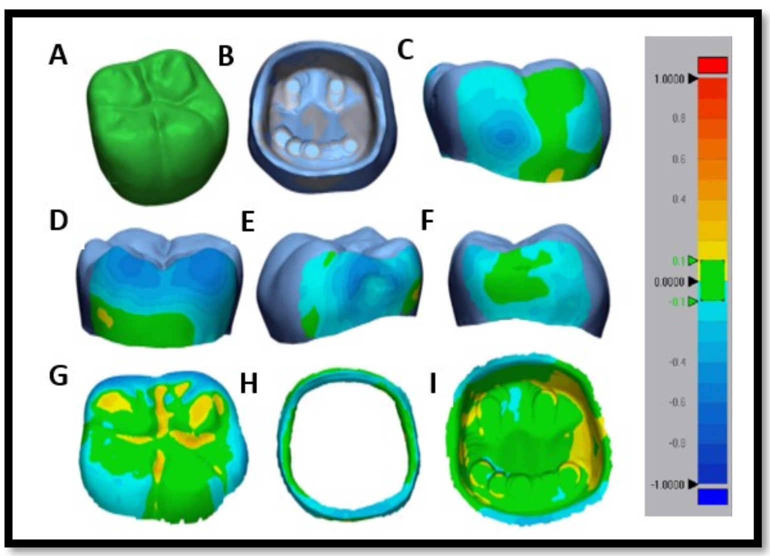

Figure 4: Color difference map trueness analysis for 5-axis glass ceramic crown areas. A, Reference design. B, Best-fitting alignment between reference design and ceramic crown specimen. C, External area, buccal area. D, lingual, E and F, Mesial and distal areas, G, Occlusal area, H, Marginal area, I, Internal area.

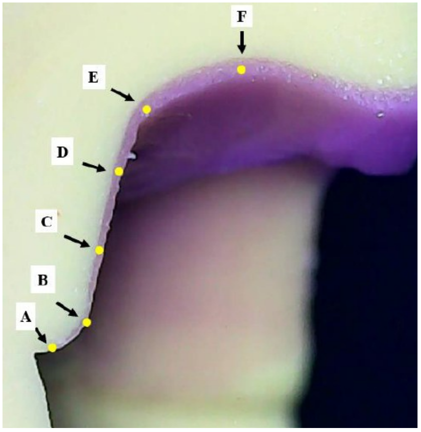

Figure 5: Replica of e.max crown, A: marginal, B: axio-marginal, C: axial 1, D: axial 2, E: axio-occlusal, F: mid-occlusal

The MC XL group had a significantly higher positive deviation value than the MC X5 (p<0.001) Table (1). For marginal, occlusal, mesial and distal measurements, the MC X5 group had significantly higher values (p<0.05). On the other hand, there was no statistically significant difference (p>0.05) for the buccal & lingual and total measurements.

The negative deviation for the internal and buccal & lingual measurements, the difference between the two groups was not significant (p>0.05) Table (1).However, for other points and overall, higher significant deviations were recorded in the MC XL group than in the MC X5 group (p<0.05).

Results

Results of trueness

In the results of trueness the intergroup comparisons as well as mean and standard deviation (SD) values of RMS (µm) are presented in Table (1) and Figure (6), The internal surface, there was no significant difference between both groups (p=0.109). However, for other points and overall, the MC XL group had significantly higher RMS values than the MC X5 (p<0.05).

Results of internal fit

The mean and standard deviation (SD) values of the internal fit (µm) resulting from intergroup comparisons are displayed in Table (2)and Figure (7), for axial 2 and overall measurements, the MC XL group had a significantly higher internal gap than MC X5 group (p<0.05). There was no statistically significant difference (p>0.05) for the other measures.

Table 1: Intergroup comparisons, mean and standard deviation (SD) values of RMS (µm) of trueness.

CROWN AREA	RMS (µM) (MEAN±SD)		P-VALUE	POSITIVE DEVIATION (µM) (MEAN±SD)		P-VALUE	NEGATIVE DEVIATION (µM) (MEAN±SD)		P-VALUE
	4-axis milling(MCXL)	5-axis milling(MCX5)		4-axis milling(MCXL)	5-axis milling(MCX5)		4-axis milling(MCXL)	5-axis milling(MCX5)	
INTERNAL	36.50±3.56	32.85±3.64	0.109ns	34.33±3.53	26.47±1.04	<0.001*	-17.93±2.64	-23.83±6.35	**0.062ns**
MARGINAL	71.87±7.13	44.53±11.56	<0.001*	12.50±3.73	18.22±2.64	0.012*	-65.85±6.58	-41.03±8.73	**<0.001***
OCCLUSAL	65.87±11.06	55.30±3.00	0.047*	38.75±0.72	46.55±3.41	<0.001*	-51.03±11.27	-35.27±4.23	**0.009***
MESIAL	103.52±26.65	42.38±1.49	<0.001*	13.47±5.59	22.93±5.74	0.016*	-90.61±21.70	-40.48±0.98	**<0.001***
DISTAL	53.83±11.07	36.23±3.31	0.004*	7.20±7.66	15.27±3.39	0.040*	-46.08±11.39	-34.93±2.79	**0.042***
BUCCAL AND LINGUAL	100.37±41.17	53.13±4.71	0.019*	12.25±2.57	15.82±3.75	0.084ns	-74.42±32.23	-46.67±4.55	**0.063ns**
OVERALL	71.99±31.22	44.07±9.78	<0.001*	19.75±12.98	24.21±11.39	0.126ns	-57.65±28.40	-37.04±8.67	**<0.001***

***; significant ($p \leq 0.05$) ns; non-significant (p>0.05)**

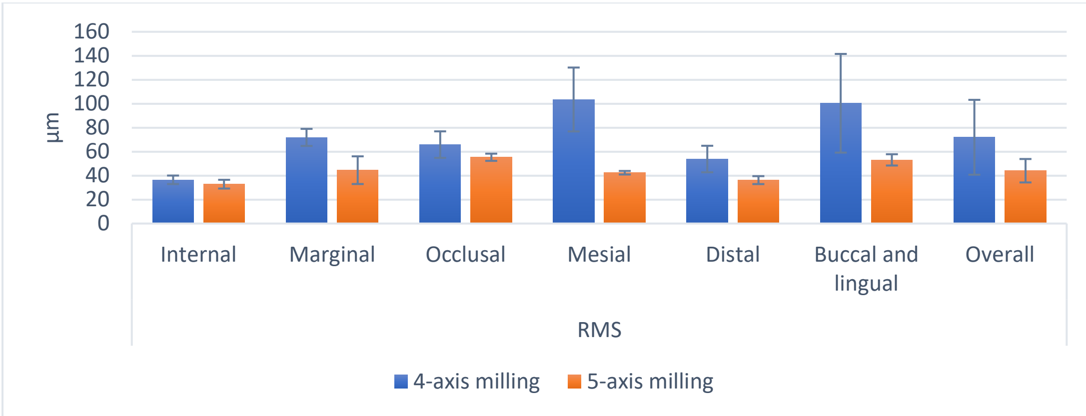

Figure 6: Bar chart showing mean and standard deviation (SD) RMS (µm) of the two groups of trueness.

Table 2: Intergroup comparisons, mean and standard deviation (SD) values of internal gap (µm).

Crown area	Internal fit (µm) (mean±SD)		p-value
	4-axis milling (MCXL)	5-axis milling (MCX5)	
Margin	69.85±62.09	38.75±13.45	0.345ns
Axio-margin	68.42±53.62	36.59±9.38	0.089ns
Axial 1	69.29±40.22	43.83±14.40	0.271ns
Axial 2	71.65±36.90	40.63±16.61	0.019*
Occluso-axial	105.55±53.76	72.08±26.94	0.162ns
Mid-occlusal	140.92±38.52	109.20±38.35	0.104ns
Overall	87.61±53.86	56.85±33.94	<0.001*

***; significant ($p \leq 0.05$) ns; non-significant (p>0.05)**

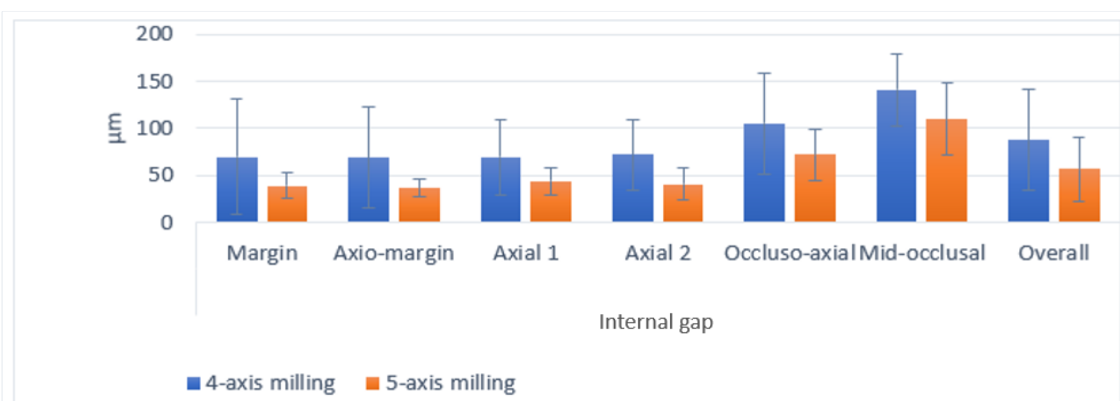

Figure 7: Bar chart showing the mean and standard deviation (SD) internal gap (µm) of the two groups.

Discussion

Clinical dentistry is moving toward a digital workflow with computer-aided design/computer-aided manufacturing (CAD/CAM) systems (Hassan & Goo, 2021). Dentists are beginning to accept CAD/CAM technology, especially for single-visit workflow in a faster and easier protocol (Hassan & Goo, 2021).

The adaptation of the restoration to the abutment tooth is one of the most important factors that affect restoration prognosis (Hasanzade et al., 2021). The accuracy of the scanner which captures the data and the precise milling machine which grinds the blocks are responsible for marginal and internal adaptations of CAD/CAM restorations (Hasanzade et al., 2021). The geometry of the preparation could affect data capture (Hasanzade et al., 2021).

Trueness and internal fit of restorations are integral to the success of the prosthodontic treatment. These properties are readily affected by the milling process. Manufacturers strive to produce better machines with higher accuracy and efficiency. There's insufficient scientific literature comparing the trueness and internal fit of restorations produced using the most recently developed 4- and 5-axis machines.

Trueness evaluation is crucial because a number of issues, including dental preparation and the preparation's scan, can impact the marginal and internal adaptation of a prosthesis, including an inaccurate inner surface (Kirsch et al., 2017). A restoration with a high degree of trueness can shorten chairside visits (Kirsch et al., 2017).

This study aimed to assess the trueness and internal fit of CAD/CAM lithium disilicate glass-ceramic crowns (IPS e. max CAD) which were milled by four and five-axis milling machines.

In the present study, a typodont resin tooth was used for crown preparation to overcome the variations that may show in natural teeth, which was confirmed by Nawafleh et al. (2016) who confirmed that the use of (die) materials such as epoxy resin or acrylic resin, are easier to standardize and produce, on the other hand, natural teeth are variable in size, form and quality, making it difficult to standardize in tooth preparation. The mandibular lower 1st molar was selected in this study because it is the most commonly restored with a crown.

Ceramic material (IPS e.max CAD) was selected in this study because of its high flexural strength reaching 440 MPa, favorable esthetic appearance and translucency, in addition to being widely used in the construction of restorations (Fu et al., 2020).

Lithium disilicate is a glass ceramic that is machinable, etchable and stronger than conventional feldspathic porcelain with proper mechanical characteristics and high bond strength to tooth structure due to its silica component (Zarone et al., 2019). A crystallization phase in a ceramic oven is required for the restorations. It has been suggested that this crystallization stage is one of the causes of the differences in internal and marginal adaptation (Zarone et al., 2019).

Throughout this study, CEREC Primescan intraoral scanner was used, which is one of the most accurate scanners in the market in terms of trueness and precision. It produces precise 3D models in natural color-enhancing digital workflow efficiently on both chair-side and lab-side. Moreover, Primescan's connection to CEREC Software enables the quick and precise design of customized restorations (Passos et al., 2019; Schmidt et al., 2020).

The database for the 5.2 Cerec software occlusal anatomy biogeneric individual mode was used to standardize the crowns in the current investigation. This process confirmed that the crowns were uniform in all study groups.

CEREC scanners, software and milling machines were chosen in this study because they are designed and manufactured from the same system of Sirona, so it is easy to operate, integrate and transfer data among them without the need to use other systems and save time. CEREC software is particularly good for single restorations because a single tooth can be scanned within a matter of seconds.

Two milling machines were used in our study, the crowns were constructed with a 4-axis milling machine (CEREC MCXL) that milled the restoration from both sides (Kirsch et al., 2017), and the (CEREC MCX5) 5-axis milling machine, which uses one motor spindle with many instruments of varying geometries (Al Hamad et al., 2020).

To standardize production options, both machines were set to normal milling mode (Hany & Taymour, 2019).

The 5-axis milling machine (MCX5) is the lab-side milling unit of the Cerec system. The fifth axis allows the production of more sophisticated and difficult anatomies and undercuts. Additionally, wet processing was used to mill e.max CAD glass-ceramic blocks and optimal machining was conducted with a single motor spindle and instruments with varying geometries (Kirsch et al., 2017).

For trueness, the inner and outer surfaces of the crowns were scanned by using an intraoral scanner and exported as high-resolution STL files to a 3D evaluation software (Geomagic Control X, 3D systems, USA), along with the reference designs (Al Hamad et al., 2020).

The Medit i700 Intraoral Scanner was used for trueness measurements, STL file from each group was superimposed by Geomagic Control X software on the reference CAD file obtained from the primescan scanner one by one. Medit i700 is characterized by fast, accurate scanning and high trueness. It's artificial intelligent built-in software enables the capture of anatomically accurate scans with high precision (Mahdy et al., 2022; Demirel et al., 2023).

This method was used as it enables assessment of the discrepancy between the scanned crowns and the CAD design in relevant areas using several points (Mahdy et al., 2022). The superimposition software (Geomagic Control X) provided a color map for qualitative analysis of the deviation, which was also numerically analyzed using the Root Mean Square equation (Mahdy et al., 2022).

Our results concluded that the second group (MCX5) (The 5-axis milling machine) had higher trueness (32.85± 3.46 µm) for the internal surface compared to (36.5± 3.56 µm) the first group (MCXL) (The 4-axis milling machine), however, the difference was non-significant (P = 0.109), which goes in accordance with Tapie et al. (2015) who concluded that a commonly used chair-side milling device achieved a trueness value of (61 ± 22 µm) for the inner surfaces, while the trueness of the five-axis device was (41 ±15 µm).

The higher trueness of crowns produced by the MC X5 machine in all areas of the e.max crowns compared to the MC XL machine led to the rejection of the study's first null hypothesis that there would be no difference in trueness of crowns produced by milling machines with a different number of axes.

It is worth mentioning that 5-axis milling units are slower than 4-axis milling machines. The faster milling of the 4-axis units might result in lesser accuracy of the restoration, more marginal chipping and thus reduced longevity (Bosch et al., 2014).

In MCXL (4-axis milling machine) 2 burs were used to mill the e.max crowns; the outer surface of the restoration was milled by using the cylinder-pointed bur 12S, and step bur 12S for the internal surface. Those burs had tip diameters of 1.8mm and 1.35mm respectively. On the other hand, the MCX5 (5-axis milling machine) uses 3 mill burs of diameters 2.2, 1.4 and 1.2mm which creates fine details.

The internal fit was also one of the tested measurements in the current research. The replica technique (SRT) was employed because it is simple, precise, affordable, and reproducible without loss of accuracy. Additionally, it is a non-destructive method that leaves the restoration and the abutment tooth without damage. However, the drawback of this technique is the potential of the impression materials tearing and distorted, also it is 2- a dimensional-based method (AL-Zomur et al., 2021; Colpani et al., 2013). Oka et al. (2016) discovered that all the areas measured using both methods showed no discernible differences when they compared the silicone copy created by combining silicone and contrast media with the microcomputed tomography method.

Our results showed that glass-ceramic crowns produced by the 4-axis milling machine had higher internal gap than those produced by the 5-axis milling machine which led to the rejection of the study's second null hypothesis that there would be no difference in the internal fit of crowns produced by milling machines with different number of axes.

Regarding the internal fit, this study found that the overall internal fit of the e.max CAD crowns milled by MCXL were higher (87.61±53.86μm) than MCX5 (56.85±33.94) and there was a statistically significant difference between the two groups. This may be a result of removing more of the internal crown material by the milling diamond tool to ensure the complete seating of the crown, often referred to as over-milling (Zimmermann et al., 2019).

It is worth mentioning that a variety of factors can affect the internal fit of the e.max CAD crowns. In the chair-side workflow with MCXL, the operator can choose between normal, fine and extra fine milling options and also between normal and fast milling strategies, all of which affect the accuracy of fit. The need for fast one-visit treatment would enforce the use of the fast-milling protocol at the expense of quality of fit and an increased cement layer thickness. In our study normal milling, one step protocol was adopted for production of the e.max CAD crowns. In contrast to the 5-axis milling machine which uses smaller diameter tools and more flexible milling strategies, it results in a correctly produced crown fitting surface and accurately milled restoration details.

Conclusions

Within the limitations of the present study the following conclusions could be drawn:

1- IPS e.max CAD crowns produced by the 5-axis milling machine showed higher trueness than those produced by the 4-axis machine.
2- Trueness values varied among different crown surfaces of the two tested groups (as affected by the difference in surface sophistication and contours).
3- Significantly higher internal gap values were detected for the e.max crown produced by the 4-axis machine compared to the 5-axis machine.

Conflict of Interest:

The authors declare no conflict of interest.

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