Research article

Internal fit evaluation of indirect restorations fabricated from CAD/CAM composite blocks versus ceramic blocks in badly broken teeth using cone beam CT (CBCT): double-blinded randomized clinical trial

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ABSTRACT

Objective: The restoration durability is essentially governed by optimum marginal integrity of an indirect restoration that is obtained and maintained by essential factors. This study aimed to evaluate the internal gap of indirect restorations fabricated from CAD/CAM composite blocks versus ceramic blocks in badly broken teeth using cone beam CT (CBCT) to determine their internal fit accuracy over the cast.

Materials and methods: Fifty-four participants were allocated into two groups: composite blocks or ceramic blocks. The trial participants and assessors were blinded to the material assignment, whereas the operator was not. Cavity preparation was performed followed by cavity optimization and impression taking. The produced master cast was scanned, restoration was designed using Exocad 2019 software and the final restoration was milled. The restoration was doubled-checked on the cast for internal fit using cone beam computed tomography (CBCT), and intraorally for interproximal contact and marginal adaptation before final cementation. CBCT measurements were collected and statistically analyzed. Restoration was cemented with resin cement and was immediately assessed clinically, then after one year and two years of follow-up periods.

Results: Results of an independent t-test revealed Composite blocks samples (0.25mm ± 0.03) to have a significantly better adaptation than ceramic blocks samples (0.29 mm ± 0.04) (p = 0.008).

Conclusions: Both materials have acceptable internal adaptation with a noticed difference reflected in their clinical performance.

Clinical relevance: Both indirect esthetic CAD/CAM restorations exhibit acceptable internal and marginal adaptation in posterior teeth however, composite blocks have a better adaptation than ceramic blocks.

Trial registration: This trial was registered in clinicaltrials.gov (NCT04784676).

1. Introduction

The restoration of the biomechanical and esthetic properties of badly broken vital posterior teeth is a great challenge for dental clinicians. This makes the choice of direct composite restoration inconstant as the remaining structure of the weakened tooth and the cavity size exceeded the conventional stress response of directly placed resin composite restoration. This condition dictates the shift to indirect esthetic restoration that combines both esthetic and strength properties and wear resistance [1]. Ceramic restorations are considered to be an excellent and reliable line of treatment for such clinical situations.

The evolution of digital dentistry has extremely changed dental practice. With the introduction of computer added design/computer

added manufacturer (CAD/CAM) technology to the field of dentistry, which is considered as one of the evolutions of digital dentistry, posterior restorations can be prepared chairside with one single appointment. Different sorts of materials are now offered to the dentist: ceramic blocks, ceramic/glass-polymer blocks (hybrid ceramic), and resin composite blocks [2]. The main advantage of CAD/CAM resin composite blocks over the conventional resin composite material is that they are prepolymerized blocks that provide restoration with enhanced curing and mechanical properties [3, 4, 5, 6, 7].

Both CAD/CAM ceramic materials and resin composite blocks revealed acceptable clinical performances even when facing tough oral environmental factors such as the flow rate and buffering capacity of saliva, cyclical loading, thermal changes, and pH-cycling. However, resin

composite blocks are predicted to have more fracture resistance compared with glass ceramics especially in restorations with limited thickness [8]. Along with better fatigue resistance and flexure strength [7, 9, 10]. In addition to this, they have promising repair potentiality that would increases their serviceability in the oral cavity [11].

The restoration durability is essentially ruled by optimum marginal integrity of an indirect restoration that is obtained and maintained by essential rules. Several studies displayed clinically acceptable accuracy of fit with maximum marginal openings at a maximum accepted range of 40–90 μm for CAD/CAM restorations however, this may differs according to the type and location of restoration [12, 13, 14, 15, 16, 17]. Furthermore, several other factors might have an impact on the fit accuracy of indirect restorations such as the scanning, designing, and milling procedures [18, 19, 20, 21, 22, 23]. It is crucial to assess the internal fit and gap distance. There is several 3D imaging techniques that could help the clinician in the evaluation of the accuracy of the internal fit of the restorations. These 3D imaging techniques either using optical scanners such as triple-scan technique, or using x-rays, such as in case of micro-CT and cone beam computed tomography (CBCT). At the present, the cone beam computed tomography (CBCT), considered as an evolution of digital dentistry, is a non-invasive diagnostic system that permits quantitative analysis of the internal gap of all ceramic restorations [23, 24, 25, 26, 27, 28]. As per available resources in the country, CBCT was the chosen method of measurement.

Therefore, the present study aimed to evaluate the internal gap of indirect restorations fabricated from CAD/CAM composite blocks versus ceramic blocks in badly broken teeth using cone beam CT (CBCT) to determine their internal fit accuracy over the cast. The null hypothesis tested in this study reveals that there is no difference in the accuracy of internal fit among the restorations used.

2. Materials and methods

2.1. Setting and design

This study was conducted at the clinic of the Conservative Dentistry Department, Faculty of Dentistry, Cairo University, and was registered in clinicaltrials.gov (NCT04784676) after approval of the Research Ethics Committee (No.8-3-19). The study started in March 2019 and the last follow-up was in March 2021, i.e., 24 months of clinical follow-up. The method of sampling was an appropriate and sequential method in which each participant who fulfilled the inclusion criteria was chosen; until the required sample was attained. The selection criteria for recruitment of the participants were young adult male or female patients (with the age between 20-50 years) who presented to the clinic with badly broken vital teeth, good oral hygiene measures who expressed to be compliant, and approved to participate in the trial; however, patients having a compromised medical history, severe or active periodontal disease, or lack of compliance were excluded. The included teeth should have extensive class II cavitated lesions in permanent molars on visual and periapical digital radiographic examination (reaching $\geq\frac{1}{2}$ of the dentin thickness) with at least two missing walls and with the absence of spontaneous pain, negative sensitivity, and periapical lesions. Besides, the excluded teeth were endodontically treated teeth, shallow or enamel caries or periodontally affected. All participants who fulfilled the inclusion criteria were recruited from the outpatient clinic of the Conservative Dentistry Department, Faculty of Dentistry, Cairo University. The patients were subjected to full examination and diagnosis using dental charts that included full medical and dental records. The study timeline from recruitment to follow-up and analysis is demonstrated in CONSORT Flow Diagram (Diagram 1).

2.2. Sample size calculation

In order to assess the clinical relevance of this trial, power analysis used marginal adaptation criteria of modified clinical evaluation criteria as an outcome. The effect size w1= (0.514) and w2= (0.828) were calculated based upon the results of Fasbinder et al (2005) [29]. Using alpha (α) level of 5% and Beta (β) level of (20%) i.e. power = 80%; the minimum estimated sample size was a total of 42 restorations. the sample size was increased to a total of 54 restorations (27 restorations per group) after compensation for a dropout rate of 30%. Sample size calculation was performed using G*power version 3.1.9.2.

2.3. Sequence generation and randomization

Randomization was carried out using computerized sequence generation (https://www.randomizer.org/). Participants were assigned into two groups (A and B) according to the type of restorative material received. Each participant received an opaque sealed envelope with a randomized number. Group A received CAD/CAM lithium disilicateceramic blocks (IPS E.max CAD, Ivoclar Vivadent, Lieschtenstein, Germany) restorations and group B received CAD/CAM nanohybridcomposite blocks (Grandio, VOCO, GmgH, Cuxhaven, Germany) restorations.

2.4. Allocation concealments

A number was given to each member in each group. This number was written by indispensable pen on a large white paper sheet that was pleated several times and saved inside an opaque, well-sealed envelope.

2.5. Implementation

The candidates under supervision were responsible for providing allocation generation and dividing patients into two groups. They had to save it in envelopes in a secured place till the date the procedure was performed. Eligible patients received treatment until the withdrawal of consent or until unacceptable safety or toxicity were identified.

2.6. Blinding

The trial participants and assessors were blinded to the material assignment, whereas the operator was not; this was because of the difference in the treatment protocol of both blocks (double-blind).

2.7. Assignment of intervention

Patients' demographic data, tooth number, and the number of surfaces were recorded in the diagnostic chart. The operator and the assessors were qualified well experienced staff members. The clinical procedural steps were explained to eligible participants and they signed written informed consent. The participants were then scheduled for scaling and polishing and preparations were made. Local anesthesia was administered, followed by tooth isolation by rubber dam, thus improving cavity visualization through the whole procedures and facilitating cleaning and cavity disinfection before adhesion procedures. Cavity preparation was performed according to the common principles for indirect restoration using #245 diamond stone (Komet, USA) and straight fissure carbide bur #57 size 010 (Komet, USA) rotating at high speed with an air/water-cooled hand piece. A new bur was used for every six preparations [30].Any remaining carious dentin was excavated by hand excavator according to caries removal clinical recommendations [31].Cusp tipping was performed for the weak cusp not less than 2 mm clearance by wheel stone leaving a thickness not less than 1.5 mm. The finishing of cavity walls was then performed by an extra-fine grit tapered with round end diamond stone to obtain internal divergence at 12–15°.

Immediate dentin sealing protocol was performed using (prime &bond Active Universal, Dentsply) in accordance with the manufacturer's instruction by applying a single coat of the adhesive with active rubbing for 20 s. It was then blown with a gentle air stream for another 20

s to evaporate the solvent, and light-cured for 20 s (Elipar S10, 3M ESPE) at 1200mw/cm^2 intensity.

The cavity was optimized using bulk-fill flowable resin (SDR, Dentsply Sirona) followed by light curing for 20 s. Post curing through clear glycerin gel was performed for an additional 20 s to minimize the formation of an oxygen inhibited layer. Impression was obtained and poured to produce a master cast with a type IV dental stone (GC Fugi Rock) that was scanned by an extraoral scanner (Medit 500 lab scanner, Medit, Korea) and the design of the restoration was achieved using Exocad 2019 software. The final restoration was milled using a 5-axis milling machine (Arum 400 milling machine, Arum GmbH, Germany) from prefabricated blocks.

2.8. Restoration verification for internal adaptation

Restoration was doubled checked on a cast for internal fit using cone beam computed tomography (CBCT), and intraorally for interproximal contact, marginal adaptation, and occlusal contact before final cementation.

2.9. Settings of cone beam computed tomography (CBCT)

All samples were subjected to CBCT evaluation. CBCT images were acquired using a next generation i-CAT scanner (Hatfield, USA). A scout view was obtained and adjustments were made to ensure that all samples were correctly aligned in the scanner according to the adjustment light beam before the acquisition (Figure 1). The machine is supplied with an amorphous silicon flat panel sensor with cesium iodide (CsI) scintillator, 0.5 mm focal spot size, 14-bit gray scale resolution, and is operated following the same protocol for all the scanned samples of this trial:

Tube voltage 120 kVp.
Milliampere 37.07 mAs
Voxel size 0.125 mm.
Scanning time 26.9 s.
Field of view 4 cm height * 16 cm diameter.

2.10. Measuring the internal gaps

Composite and ceramic samples were scanned separately over corresponding dies. After acquisition, the data of each material were exported and transferred in DICOM format and downloaded by using a compact disk (CD) to a personal computer supported with a calibrated medical monitor for analysis, where On-Demand 3D dental software (Cybermed, South Korea) was used for linear measurement. In the fusion module, datasets from composite and ceramic scans were registered using the same dies. To obtain the exact cuts for both materials over the dyes, they were aligned in accordance with the orthogonal plane, to intersect the true mesio-distal and bucco-lingual planes with coronal and sagittal planes. Before taking the reading, both scans were adjusted for the wind width and window level to minimize the noise effect. Then three consecutive cuts were selected at the middle of each restoration at both directions (mesio-distal and bucco-lingual), and linear measurement was taken between the restoration and the dye at certain line angles. The same procedure was followed for both composite and ceramic
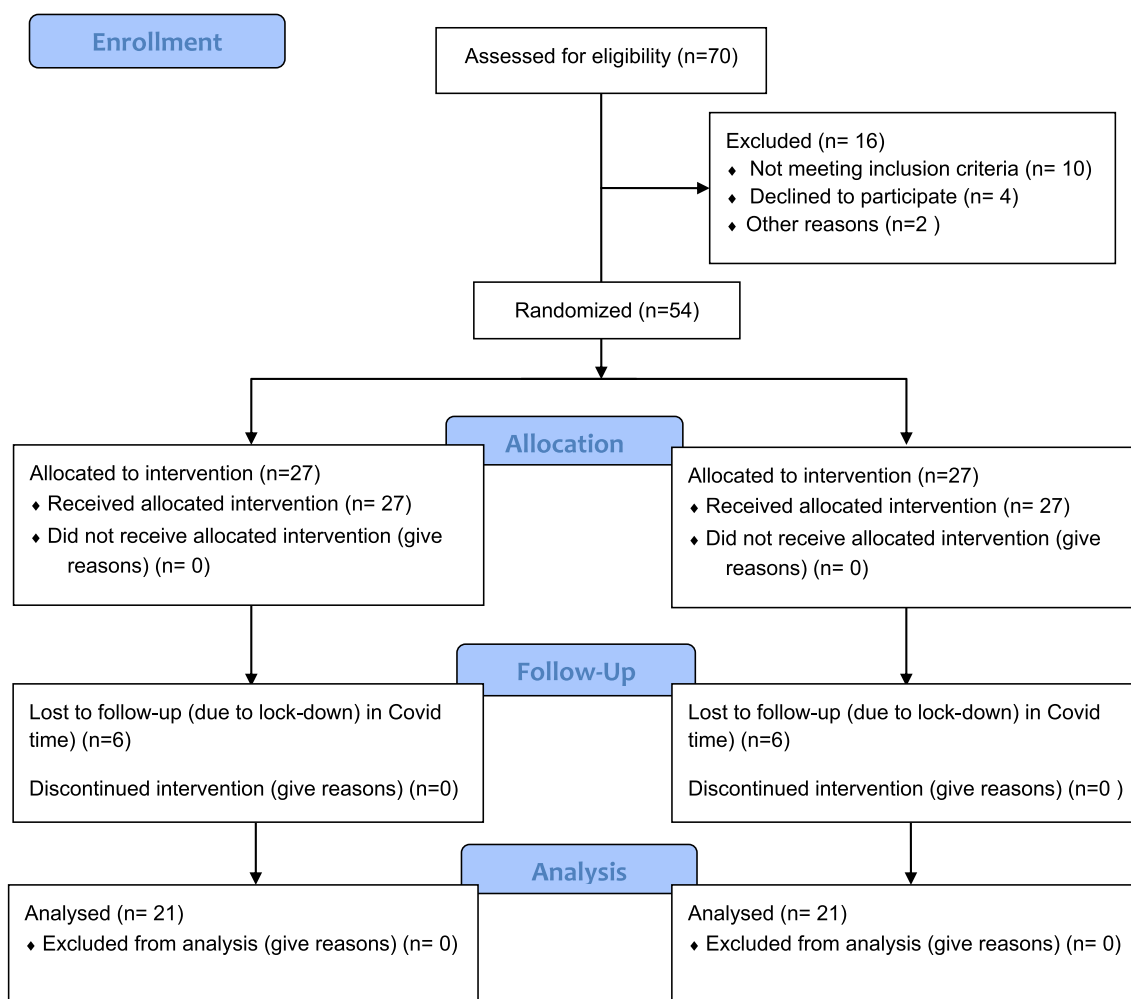

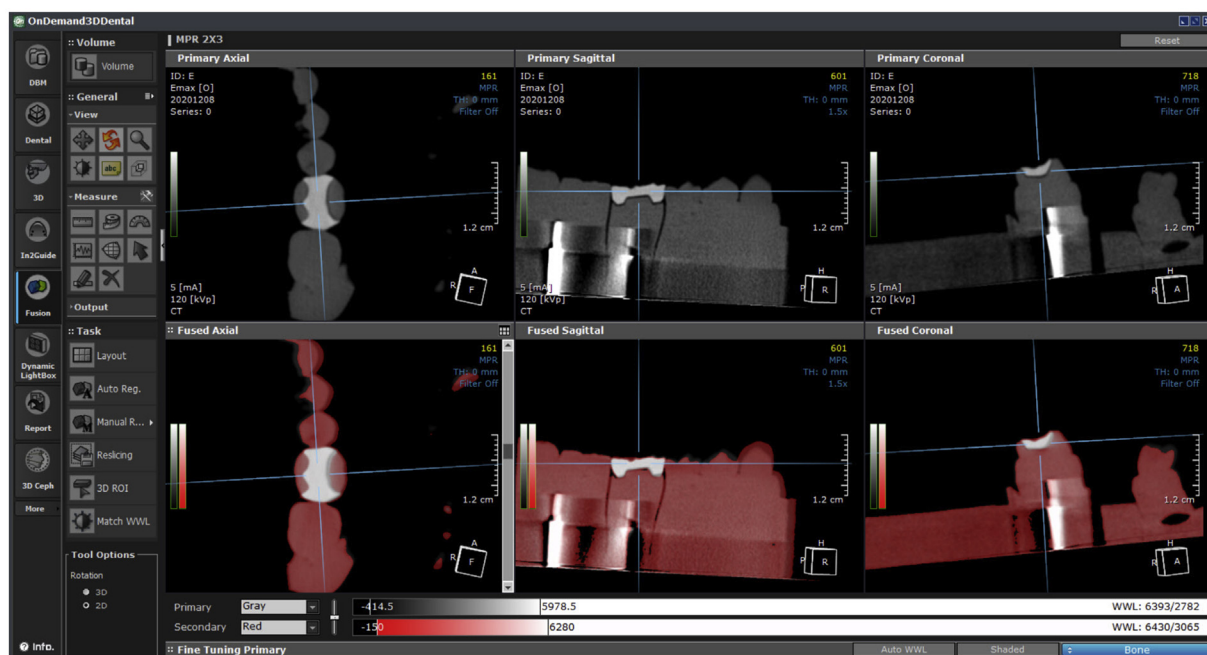**Diagram 1.** CONSORT 2010 flow diagram.

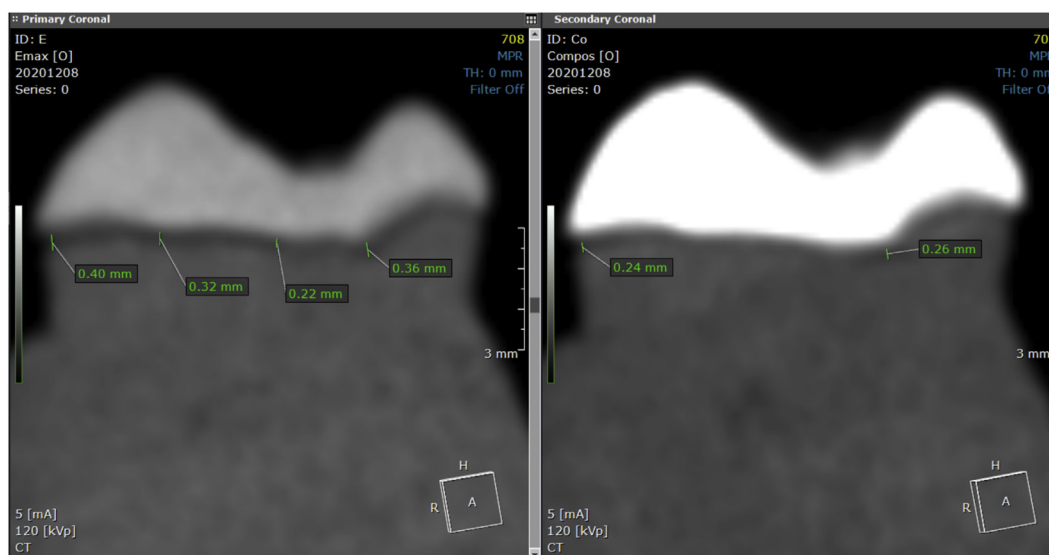**Figure 1.** Alignment in the CBCT scanner according to the adjustment light beam before acquisition.

Figure 2. Internal fit measurement buccolingual section for Emax (left) and composite (right).

scans (Figures 2 and 3). Data was then collected and tabulated for statistical analysis.

2.11. Cementation procedure

After restoration verification, proper isolation of the tooth by a rubber dam was performed. Selective enamel was then carried out using 37% phosphoric acid for 15 s followed by thorough rinsing with water and air drying. A universal adhesive was then applied which was air-thinned and light-cured for 20 s. Conversely, surface treatment of the restoration was performed as follows; application of 9.5% hydrofluoric acid on the fitting surface for 20 s, rinsed out with copious amount of water, and air-dried. This was followed by silane application for 60 s and air-drying. Dual-cured self-adhesive resin cement (BisCem, Bisco, USA) was applied on the fitting surface of the restoration and the cavity followed by gentle placement of the restoration on the tooth with the application of mild finger pressure on the occlusal surface of the restoration. Initial curing for three seconds was performed followed by the removal of excess cement using dental floss and probe. The curing procedure was completed using an LED light cure unit perpendicular to the margins and at each surface of restoration for 40 s. Occlusal contact was checked; high spots were removed using diamond flame finishing stone followed by finishing and polishing of the restoration using rubber cups. Finally, photographs were taken. The restoration was then assessed clinically by two experienced calibrated assessors immediately, after one year and two years follow-up using modified USPH criteria (Figures 4 and 5).

2.12. Statistical analysis

Numerical data were represented as mean and standard deviation (SD) values. Shapiro Wilk's test was used to test for normality. Homogeneity of variances was tested using Levene's test. An independent t-test
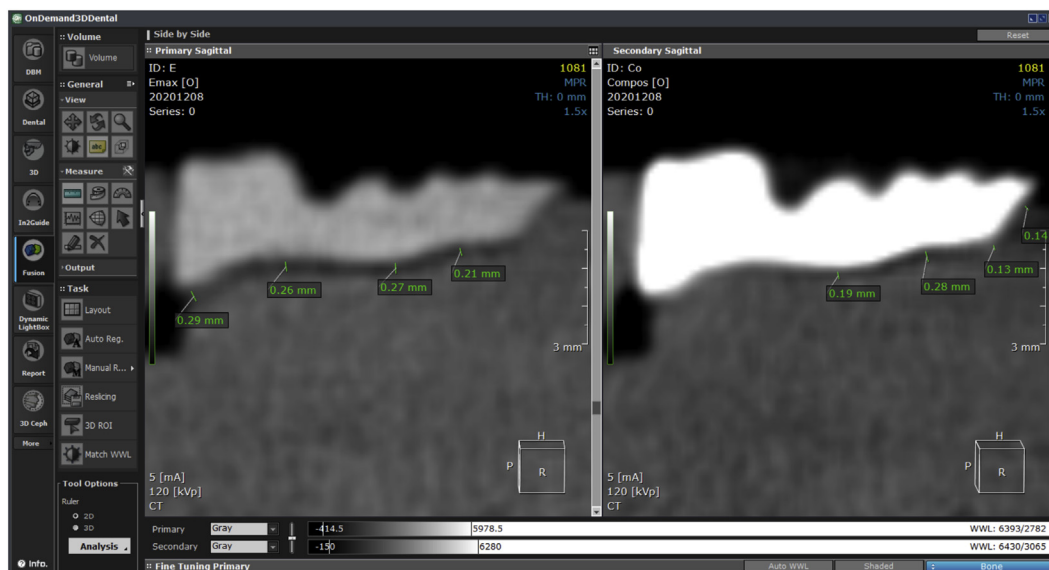
Figure 3. Internal fit measurement mesiodistal section for Emax (left) and composite (right).
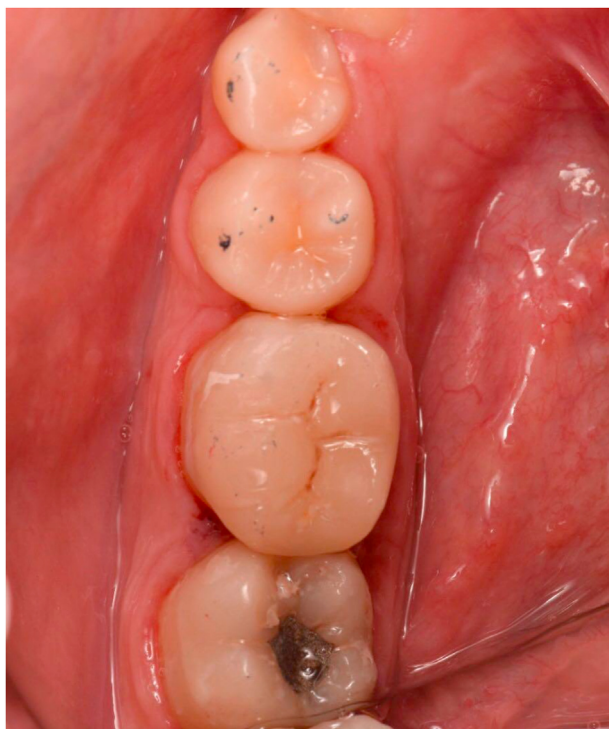

Figure 4. Indirect composite restoration (Grandio) after one year follow-up period.

was used to analyze intergroup comparison. The significance level was set at p < 0.05 within all tests. Statistical analysis was performed with R statistical analysis software version 4.0.4 for Windows [32].

3. Results

3.1. Demographic data

A total of 42 participants were enrolled in this study. Mean ages of all subjects was 29.8 ± 7.5 years old. Fifteen were males (35.7%) and 27 were female (64.2%). Seventeen maxillary (40.4%) and 25 mandibular (59.5%) teeth were restored. Eleven restorations (26.2%) were placed in

Figure 5. Marginal discoloration of Emax restoration after one year follow-up period.

premolars; whereas 31 (73.8%) were placed in molars. There was no significant difference in age, gender, arch and tooth type distribution between both study groups (P = 0.530, P = 0.334, P = 0.753 and P = 0.292, respectively).

3.2. Internal gap analysis

There were no outliers, as assessed by the boxplot of grouped data presented in Figure 6. The data were normally distributed, as assessed by Shapiro Wilk's test of normality (p > 0.05) and there was homogeneity of variances (p > 0.05) as assessed by Levene's test. Results of the independent t-test presented in Table 1 demonstrating the mean and standard deviation of composite samples Grandio (0.25 mm ± 0.03) that revealed to have a significantly better adaptation than ceramic samples having mean and standard deviation (0.29 mm ± 0.04) at p-value (p = 0.008) and the difference in effect size between both groups was large (1.20 [95%CI; 0.56–2.22]). Descriptive statistics for internal fit values for both groups are presented in Table 2 and mean and standard deviation values are presented in Figure 7]. In descriptive statistics, the interquartile range (IQR)is a measure of statistical dispersion, indicates how spread out the middle 50% of our set of data is. The interquartile mean (IQM) is the mean of the middle 50 percent of data in a data set. As previously explained in IQR, There were no outliers, as assessed by the boxplot of
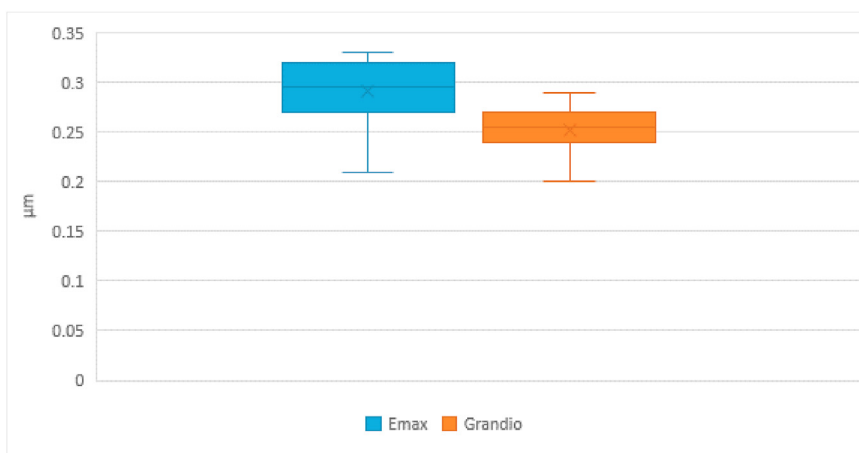
Figure 6. Box plot showing internal fit (μm) values in different groups.

Table 1. Descriptive statistics for internal fit values (mm).

Treatment	Mean	95% CI		SD	Median	IQR
		Lower	Upper			
Emax	0.29	0.27	0.31	0.04	0.30	0.05
Grandio	0.25	0.24	0.26	0.03	0.26	0.03

95%CI = 95% confidence interval for the mean; SD = standard deviation; IQR = interquartile range.

Table 2. Intergroup comparison.

Internal fit (Mean ± SD)		Mean difference [95%CI]	Cohen's d [95%CI]	t-value	p-value
Emax	Grandio				
0.29 ± 0.04	0.25 ± 0.03	0.04 [0.02–0.06]	1.20 [0.56–2.22]	3.70	**0.008***

95%CI = 95% confidence interval; *significant (p < 0.05).

grouped data presented in Figure 6, thus there was homogeneity of variances.

4. Discussion

Decision-making with regards to the best management for badly broken vital teeth can be challenging for dentists. Marginal discoloration

and recurrent caries are commonly associated with indirect esthetic restoration. Patients often refuse metallic restorations, so practitioners must choose between the two esthetic materials: esthetic ceramic or composite [33]. Most of the studies available in literature that compare the physico-mechanical properties of these materials were conducted in vitro, so the present study aimed to compare the clinical performance of indirect esthetic restorations fabricated from nano hybrid composite CAD CAM blocks (Grandio blocks) and ceramic blocks (e-max) after one year. In this study, it was assumed that each type of indirect restoration used to dictate certain preparation design and the degree of divergence of the cavity wall to optimum clinical performance would not have an impact on the internal fit owing to the scanning accuracy of 3-dimensional scanners [34].

The marginal and internal adaptations of restorations are very crucial for their clinical outcome. Restoration with poor marginal adaptation would conversely increase the cement thickness and degradation of adhesive cement, with subsequent marginal discoloration and recurrent caries or accumulation of debris and plaque with subsequent ginigival and periodontal inflammation and pockets formation [34]. Similar inflammatory reaction would occurs in case of improperly fitted crowns or crowns over implant resulting in periimplantitis [17, 19, 21]. In order to assess and correlate the internal fit to the clinical relevance it was found beneficial to carry out this clinical trial and to assess the internal fit of all restorations over their die models before intraoral cementation, furthermore, to correlate the impact of internal fit and the existing internal gap on the clinical performance and longevity of the restorations over time.
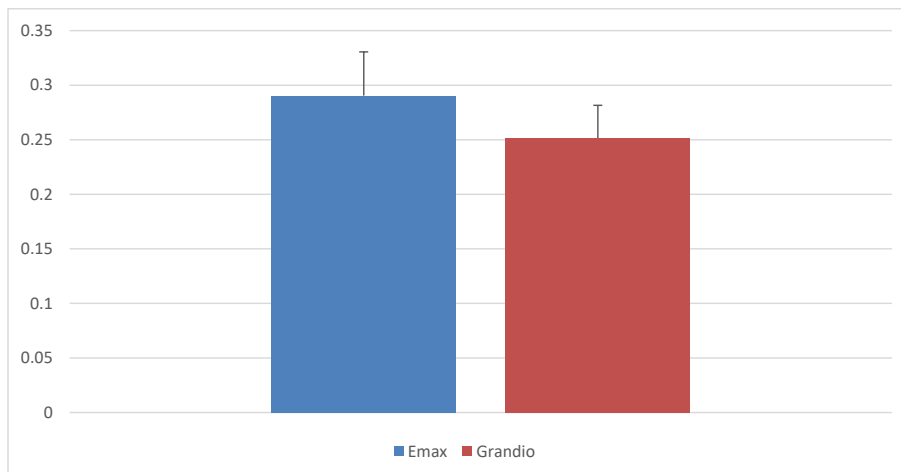

Figure 7. Bar chart showing mean and standard deviation values of internal fit (μm).

In previous studies, some systems had been used to assess the adaptation of indirect restoration qualitatively and quantitatively. In this clinical trial, for the accurate 3D qualitative and quantitative measurement from various angles, the assessment method of cone beam computed tomography (CBCT) was performed. As per available resources in the country, CBCT was the chosen method of measurement. Moreover, as compared to micro-CT, both scans showed the same inherent noise, if it wouldn't be applied equally at different materials so measurements are comparatively descriptive. The internal fit and gap measurement using CBCT was performed for restoration over the cast, thus providing accurate analysis without subjecting the patients to the hazards of radiation. This method provides a 3D assessment of the internal gap at different points: gingival, axial, and occlusal in bucco-lingual and mesio-distal sections. Thus, the internal fit of all the ceramic restoration was assessed from all aspects that enable to calculate the accuracy of a restoration fit. All the measurements were performed by one operator to determine the consistency of the obtained data and to avoid statistical variance as much as possible. Scans were taken at the exact same parameters. This method standardize the cuts at which measurements were taken and minimize human error.

The majority of authors approve that marginal discrepancies in the range of 100 μm appear to be clinically acceptable with regard to longevity of the restorations. Others claimed that marginal discrepancies exceeding 100 μm are clinically inadequate [23, 24, 25, 26, 27, 28, 35, 36].

In the present study, two types of indirect restoration were compared; indirect esthetic restoration fabricated from nano hybrid composite CAD/CAM blocks (Grandio blocks) and ceramic blocks (e-max). Ceramics blocks (Lithium disilicate-based glass ceramics) have been well known for their excellent esthetic, optical and mechanical properties, chemical stability, and biocompatibility. However, their brittleness and stiffness might cause some disadvantages. A breakthrough in the technology of resin composite was the development of novel composite blocks (Grandio blocks). The advantages offered by Grandio blocks as claimed by the manufacturer are as follows: the highest fillers content (80% by weight), excellent physical values for flexural strength and abrasion, no firing required (a real one step), and can be polished and repaired optimally. It was based on nano-hybrid technology and as claimed by the manufacturer, it can be used in the fabrication of inlays, veneers, crowns, and implant-supported crowns [11]. In the present study, evaluation of the early clinical performance of the Grandio blocksindirect restorations was very important, especially because no clinical trial has been published about its performance. Moreover, these restorations would be functioning in threatening high stress-bearing areas; therefore, accurate measurements of the internal adaptation of these restorations were essentials to predict the clinical outfit of the restoration.

The results of the current study revealed that composite samples (0.25 ± 0.03) had a significantly better adaptation than ceramic samples (0.29 ± 0.04) (p = 0.008). The large sample size gives a clinically relevant result. These promising results were reflected clinically in terms of better marginal integrity, absence of postoperative hypersensitivity or recurrent caries and less cavo-surface marginal discoloration when compared to ceramic restorations. These results were in accordance with those of Darwish et al. 2017, who found that resin nano ceramic CAD/CAM blocks exhibited significantly better internal fit compared with IPS e.max® CAD endocrowns both before and after adaptation [27]. Margin adaptation was previously discussed as a critical factor in the longevity of indirect restorations. It has been suggested that degradation of the adhesive bond is attributed to an increase in margin gap size, with consequent microleakage and recurrent caries. This might be attributed to the absence of post milling firing process in composite blocks, thus eliminating any dimensional changes that occur. Moreover, the densification of ceramic restorations during their crystallization process resulted in 0.2% shrinkage, as a consequence of microstructure transformation, during which lithium disilicate crystals grew in a controlled manner, resulting in material relocation [27]. These results revealed that the internal fit might

be affected by several factors other than cavity wall divergence, cavity design, and accuracy of the milling process, along with the type of restorative material as a dominating factor when eliminating the other confounders. Borbaa et al. [36] declared in a previous study, that there are other factors related to the processing method that might be responsible for the observed difference in the internal fit level between the two systems. In the present study, the two materials used have different microstructural and mechanical properties. This might be another factor affecting milling quality and accuracy as stated by Darwish et al. in 2017. The materials might interact differently with the CAD/CAM burs that make composite blocks less brittle compared with ceramic blocks milled in their soft stage, in which the material has low strength against chipping [27].

A study performed by Fasbinder et al. (2005) [29] compared the clinical performance of CEREC feldspar ceramic blocks (VITA Mark II) and CAD/CAM composite (Paradigm) inlays using modified USPH criteria at different follow-up periods. The authors reported no significant difference in the marginal fit between both groups at the one-year follow-up period, which agrees with the findings of the present study. However, the follow-up period in this study was extended 2–3 years. After 2 years, a significant decrease in the marginal fit was noted in the ceramic group compared to the composite group. whereas after 3 years, both groups eshibited a similar decrease in the marginal adaptation, which could be related to the similarity in wear resistance between the resin-based composite inlay and that of the resin-based composite luting agent; therefore, concealing the initial wear of the inlay margin. Till sufficient wear at the margin occurs, the enamel margin cannot be exposed, to be detected in porcelain [37].

In this study, the absence of postoperative sensitivity is attributed to several possible reasons starting from the rubber dam isolation controlling the operating field throughout the preparation, passing through the cavity design, designing of the restoration using CAD/CAM technique and cementation procedures that ensure the cleanliness and properly isolated tooth surface to achieve successful adhesive bonding. All these integrated components may have played a role in reducing postoperative sensitivity. Furthermore, the use of ceramic blocks and resin-based composite blocks diminished the effect of polymerization shrinkage as it would be limited only to the resin cement thickness. It is also worth mentioning that this could be mainly attributed to an immediate dentin sealing step, which has been demonstrated by previous study to minimize post cementation hypersensitivity [38].

In the present study, as the restorations where properly seated inside their prepared cavities so no changes would be expected to occur in the internal fit after cementation. Follow-up of the restorations revealed that the cavo surface marginal discoloration was associated with some ceramic restorations, which might be attributed to the nature of the two materials where a material with a greater level of chipping during milling is likely to have a reduced quality of marginal fit because of greater damage to the margins as mentioned by Tsitrou et al. (2007) [39]. This might be the case for the e-max ceramic which is a brittle material whose physical properties are improved by subsequent firing. However, composite block is a resilient material; which renders the margins of ceramic restorations more susceptible to chipping. This would subsequently lead to the exposure of cement to the oral environment, which may result in discoloration of the cement at e-max group margins. Other studies also have perceived that marginal quality deterioration was because of occlusal fatigue causing degradation of the resin-based luting agent. The low elasticity modulus of the resin-based luting agent compared with the high elasticity modulus of the ceramic materials combined with the fatigue of the adhesive luting agent under occlusal loading are considered as contributing factors for decreased marginal adaptation of partial ceramic restorations. Because marginal adaptation is closely related to marginal discoloration, deterioration at the margins may lead to recurrent caries that is manifested clinically by the appearance of discoloration at the margin and could be also manifested as restoration fracture. [40, 41, 42].

Based on the aforementioned findings, it can be stated that the null hypothesis of this study was rejected.

5. Conclusions

The type of CAD/CAM blocks materials dictate certain preparation designs that affect the internal adaptation measurements. The two systems inspected in this study demonstrated different internal fit levels. To summarize, both investigated materials have acceptable internal adaptation with a little difference that is reflected in the clinical performance.Although there is a significant difference in results, it is within 10 μm which appears to be very small.

5.1. Recommendations

The present study had some limitations such as cost of the materials used and milling procedures. Clinical evaluation with a longer follow-up period is recommended. Regarding the evaluation of the marginal adaptability, it is advised not to rely solely on clinical examination, but also to check the aid of image analysis of scanned replicas.

5.2. Clinical relevance

Both indirect esthetic CAD/CAM restorations exhibit acceptable internal and marginal adaptation in posterior teeth; however, composite blocks (Grandio) has a better adaptation than ceramic blocks (e-max CAD).

Research ethics committee approval

This study was conducted at the clinic of the Conservative Dentistry Department, Faculty of Dentistry, Cairo University. This study was registered in clinicaltrials.gov (NCT04784676) after approval of Research Ethics Committee (No.8-3-19).

Consent statement

An informed consent with an easy Arabic language was signed by the recruited participants.

Declarations

Author contribution statement

Shereen Hafez Ibrahim, Haitham Amr, Ahmed A. Hassan and Ahmed Elzohairy: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

The clinical trial described in this paper was registered at clinicaltrials.gov under the registration number NCT04784676.

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