Marginal Integrity of CAD/CAM Ceramic Crowns Using Two Different Finish Line Designs

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Highlights of the Study

- Evaluation of marginal integrity of typodont teeth was done by dividing them into 2 groups with chamfer and shoulder finish lines, respectively. Both the groups showed overall clinically acceptable crowns.
- Z-test was used to show that there was no statistically significant difference between the 2 groups.
- Rating of margins at each site was alpha, beta, charlie, or delta as per the modified US Public Health Services (USPHS) criteria.

Keywords

Marginal gap · Marginal integrity · Chamfer · Typodont

Abstract

Objective: Research on evaluation of crowns made by the latest contemporary dental computer-aided design/computer-aided manufacturing (CAD/CAM) systems for their marginal adaptation is scarce. The purpose of this in vitro study was to evaluate the marginal integrity of crowns fabricated by the latest Chairside Economical Restorations of Esthetic Ceramic (CEREC) system using 2 different finish line preparation designs: chamfer and shoulder. **Materials and Methods:** Typodont teeth were divided equally into 2 groups, A and B. The teeth were prepared for full coverage crowns with a shoulder (group A) and chamfer (group B) finish line design. An experienced prosthodontist prepared all crown preparations. Evaluation of 6 sites per sample was completed by 2 calibrated, experienced prosthodontists using the modified US Public Health Services (USPHS) criteria. The descriptive statistics and Z-test were used to evaluate the results. **Results:** A total of 180 teeth were included in the

study (90 teeth in each group). Only 2 crowns in group A and 1 crown in group B were clinically unacceptable. There was no statistical significance ($p = 0.282$) between the 2 groups regarding finish line design. **Conclusions:** The CEREC system provides clinically acceptable crowns and can safely be utilized in dental treatment. Therefore, CAD/CAM restorations could be considered as a safe treatment modality by dental professionals.

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Introduction

Chairside Economical Restorations of Esthetic Ceramic (CEREC) was the first intraoral digital impression with contemporary dental computer-aided design/computer-aided manufacturing (CAD/CAM) technology in dentistry and was introduced in 1985 [1]. The 3 major components of the CAD/CAM system are a digitalization scanner, the software that processes information, and a milling device [2].

Table 1. Marginal integrity of CEREC 3D crowns using modified USPHS criteria

Rating	Characteristic
Alpha	Explorer does not catch when drawn across the restoration margin, or if the explorer does catch, there is no visible crevice along the margin
Beta	Explorer catches at the restoration margin or there is visible evidence of crevice into which the explorer will penetrate; however, the dentin is not exposed
Charlie	The explorer penetrates into crevice, and the dentin is exposed
Delta	The restoration is fractured

Several researchers have focused on the marginal integrity of the crowns prepared by CEREC. Mörmann and Krejci [3] evaluated CEREC1 restorations and found marginal gap of 192 μm on an average which was clinically unacceptable. In 1994, Sirona[®] launched the CEREC2 system with upgraded hardware and software. Several studies looked at the marginal integrity of CEREC2 restorations and found that they were still clinically unfavorable [4, 5]. Sirona[®] then introduced CEREC3 in 2003, in which the overall number of acceptable marginal gaps, clinically, was still unfavorable [6]. The launch of Sirona[®] CEREC Omnicam was in 2012. The optimization for it was powder-free scanning of natural tooth structures in 1 continuous color imaging process [2].

In the last 2 decades, innovative developments in dental materials and computer technology have resulted in CAD/CAM technology's success. As a result, the CEREC system has been evolving to ease the usage of the system and to overcome deficient aspects of the system, such as marginal integrity [7, 8]. The CEREC system has shown many positive aspects that make the prosthetic workflow easier, convenient, efficient, and faster. Furthermore, the operator-dependent errors are minimized with CEREC compared to the conventional prosthetic protocol, and a better acceptance level for the impression procedure has been shown by the patients. According to Sannino et al. [1], the only major drawback to the CEREC system is the subgingival placement of the margins as compared to the supra/juxta gingival margins, as both impression taking and the adhesive luting phase require more time [1, 9].

However, there are limited data available on the clinical performance of the crowns prepared by the CEREC system as very few studies have been conducted in this area. The purpose of this study is to evaluate the margin-

al integrity of crowns produced by the latest CEREC system and to evaluate the effect of different finish lines on marginal integrity of CEREC crowns. This study was conducted in simulated clinical setup in preparation of teeth, obtaining optimal impression, computer-aided designing of crowns, fabrication of crowns, and evaluation of marginal integrity as done in clinical setup.

Materials and Methods

Study Design

This in vitro study was conducted from June 2018 to January 2019 on typodont teeth at the Faculty of Dentistry of Kuwait University. This was not a clinical investigation.

Study Groups

Two groups of typodont teeth (tooth number 30) were used to prepare all ceramic crowns. The groups were distinguished on the basis of finish line geometry. The finish line for group A was shoulder, while for group B, the finish line was chamfer. The occlusal and axial reductions of preparations in both groups were similar. Polyvinyl siloxane template was used to verify the reduction of the preparations. There were no inclusion-exclusion criteria of teeth in the study.

Study Procedure

Teeth in group A received 1.0-mm-wide shoulder finish line preparation, whereas teeth in group B received 0.5-mm-wide chamfer finish line preparation. The occlusal and axial reductions of preparations in both the groups were 1.5–2.0 mm and 1.0–1.5 mm, respectively. All the crown preparations were performed by an experienced prosthodontist on Frasco Phantom head to resemble genuine clinical setup.

Optical impressions of the tooth preparations were made using CEREC 4.5.1 software version and milled using Sirona[®] CEREC MC XL unit. The same software was used for designing all the crowns. After the design completion of each crown, the information was sent to the milling unit. The ceramic block used for milling was Sirona[®] bloc C size 14 (12 $\times$ 14 $\times$ 18 mm) for all crowns. Each crown was fabricated with a uniform spacer thickness of 100 μm . An experienced CEREC user ran all acquisitions, designs, and milling of the crowns for both the groups. All crowns were seated with finger pressure during evaluation. Blinded evaluation was done for evaluation of marginal adaptation.

Study Objective: Evaluation of Marginal Integrity

Eight sites of evaluation were premarked on each crown, namely, mesiobuccal, midbuccal, distobuccal, distal, distolingual, midlingual, mesiolingual, and mesial. All evaluations were anonymously carried out by 2 calibrated prosthodontists using a periodontal explorer (EXD 11/12; Hu-Friedy, Chicago, IL, USA) and magnification loupes with the power of 2.5X based on US Public Health Services (USPHS) criteria. Margins at each site were rated as alpha, beta, charlie, or delta as per the characteristics described in Table 1.

Specimen size per group was calculated based on power analysis of the work done by Akbar et al. [6] using the following formula: $n = z^2 pq / (d^2)$, where n = the specimen size, z = the critical value for achieving $(1 - \alpha)$ % confidence level (here we use $z = 1.96$), p = the

Table 2. Frequencies of crowns in mesiobuccal, midbuccal, distobuccal, and distolingual sites as per the USPHS criteria

	Shoulder count (column), N (%)	Chamfer count (column), N (%)
Mesiobuccal		
Alpha	89 (98.9)	89 (98.9)
Beta	1 (1.1)	1 (1.1)
Charlie	0 (0.0)	0 (0.0)
Delta	0 (0.0)	0 (0.0)
Proportion acceptable, %	100	100
Midbuccal		
Alpha	86 (95.6)	87 (96.7)
Beta	4 (4.4)	3 (3.3)
Charlie	0 (0)	0 (0)
Delta	0 (0)	0 (0)
Proportion acceptable, %	100	100
Distobuccal		
Alpha	83 (92.2)	89 (98.9)
Beta	7 (7.8)	1 (1.1)
Charlie	0 (0)	0 (0)
Delta	0 (0)	0 (0)
Proportion acceptable, %	100	100
Distolingual		
Alpha	85 (94.4)	88 (97.8)
Beta	5 (5.6)	1 (1.1)
Charlie	0 (0.0)	1 (1.1)
Delta	0 (0.0)	0 (0.0)
Proportion acceptable, %	100.0	98.9

Table 3. Frequencies of crowns in midlingual, mesiolingual, mesial, and distal sites as per the USPHS criteria

	Shoulder count (column), N (%)	Chamfer count (column), N (%)
Midlingual		
Alpha	84 (93.3)	90 (100.0)
Beta	6 (6.7)	0 (0.0)
Charlie	0 (0.0)	0 (0.0)
Delta	0 (0.0)	0 (0.0)
Proportion acceptable, %	100.0	100.0
Mesiolingual		
Alpha	86 (95.6)	86 (95.6)
Beta	3 (3.3)	4 (4.4)
Charlie	1 (1.1)	0 (0.0)
Delta	0 (0.0)	0 (0.0)
Proportion acceptable, %	98.9	100.0
Mesial		
Alpha	87 (96.7)	88 (97.8)
Beta	2 (2.2)	2 (2.2)
Charlie	1 (1.1)	0 (0.0)
Delta	0 (0.0)	0 (0.0)
Proportion acceptable, %	98.9	100.0
Distal		
Alpha	82 (91.1)	84 (93.3)
Beta	8 (8.9)	6 (6.7)
Charlie	0 (0.0)	0 (0.0)
Delta	0 (0.0)	0 (0.0)
Proportion acceptable, %	100.0	100.0

anticipated population proportion which is chosen from previous studies, $q = 1 - p$, and d = the desired margin of error.

Data Analysis

Data were analyzed using SPSS version 25 Software. Z-test was used for comparing acceptable proportion between shoulder and chamfer finish lines, since the sample size was >30. Frequency distribution tables were used to evaluate frequencies and percentages.

Result

Study Groups

Ninety identical typodont crowns were included in each study group, that is, group A and group B, with similar axial and occlusal reductions prepared in all specimens.

Evaluation of Marginal Integrity

Table 2 displays mesiobuccal, midbuccal, distobuccal, and distolingual sites evaluated using the USPHS criteria of alpha, beta, charlie, and delta. The mesiobuccal, midbuccal,

and distobuccal sites show the acceptable proportion of 100% in both shoulder and chamfer finish lines. The distolingual site shows an acceptable proportion of 100% in the shoulder finish line and 98.9% in the chamfer finish line. Only one ($n = 1$; 1.1%) tooth received charlie rating in the chamfer finish line. The midlingual and distal sites show the acceptable proportion of 100% in both shoulder and chamfer finish lines. The mesiolingual and mesial sites show the acceptable proportion of 98.9 and 100% in shoulder and chamfer finish lines, respectively. Only one ($n = 1$; 1.1%) tooth received charlie rating at the mesiolingual and mesial sites in the shoulder finish line group (Table 3).

It was observed that group A and group B had 97.8% ($n = 89$) and 98.9% ($n = 89$) overall clinically acceptable crowns, respectively (Table 4). There were 2 sites of unacceptable evaluation (charlie) in group A (mesiolingual and mesial) and 1 site in group B (distolingual). Table 4 displays the comparison between the acceptable proportion between shoulder and chamfer finish lines using the Z-test, which showed no statistically significant difference ($p = 0.282$) between the 2 groups.

Table 4. Proportion acceptable (overall 8 measures)

Group				Z value	p value
shoulder		chamfer			
count	column, %	count	column, %		
89	97.8	89	98.9	0.557	0.282

Discussion

Digital dentistry is becoming a reality, and chairside systems have started occupying the dental clinics [10]. With this technological advancement in consideration, this in vitro study was aimed at addressing the marginal integrity of CEREC crowns made of feldspar glass ceramic (Sirona® CEREC Blocs C) with chamfer and shoulder finish lines using modified USPHS criteria with the help of a periodontal explorer (EXD 11/12; Hu-Friedy, Chicago, IL, USA) and magnification loupes. As per the modified USPHS classification, alpha and beta ratings are considered clinically acceptable, while charlie and delta ratings are unacceptable. This study showed that there was no significant difference ($p = 0.282$) in the results obtained for both the finish lines prepared, and the CEREC 3D crowns prepared from both the finish lines were clinically acceptable. These results are similar to several other studies that reported that the marginal fit of CAD/CAM inlay and crown restorations was independent of preparation design; however, these studies also indicated that the restoration's marginal adaptation was clinically acceptable regardless of the kind of preparation design was used [11–13].

In this study, an effort was made to control the instrument variable used to evaluate the margin at the sites by using a new periodontal explorer for each crown to be assured of the accuracy of each evaluation. The most direct assessment method to clinically evaluate marginal gaps in fixed partial dentures is the use of a sharp-tipped periodontal explorer. Tactile perception is a reliable means of detecting open margin defects up to 36 μm wide [14]. Therefore, periodic evaluation should be done to check the marginal integrity of the prosthesis by running a sharp-tipped explorer over the prosthesis margins. Reliability of the tactile perception using explorers can help in discovering a surface defect and then the resistance it causes on the explorer [15].

This method of assessment is in agreement with several studies which considered the technique reliable for

classifying the margin integrity of CEREC restorations [11, 16–21]. Also, Akbar et al. [6] showed that the modified USPHS technique had an 81.2% agreement with the SEM evaluation technique.

For the CEREC system, several investigators have examined the effect of different tooth preparation designs like rounded and sharp internal line angles, class I and class II inlays, luting space in the marginal fit of restorations, and differences in the degree of axial wall convergence [4, 11–13, 22] which may have an effect on marginal adaptation of CEREC restorations. Even though the design of finish line preparation might not have direct effect on the marginal fit of ceramo-metal restorations, it may be an influencing factor on the marginal adaptation of CEREC crowns. Therefore, our study focuses on the effect of finish line design on the marginal integrity of crowns. In fixed prosthodontics, several investigators have reported that the finish line design, that is, chamfer and shoulder, has no effect on the marginal discrepancy of conventional full crowns [14, 23, 24]. Our results are in concordance with the previous literature.

In this study, the marginal integrity evaluation of crowns made with 2 different finish line geometries shoulder and chamfer was performed. Sirona® recommends that preparation should have a shoulder finish line of minimum 1 mm [25]. Several authors reported acceptable marginal gap for CEREC crowns when using a shoulder finish line [26–29]. Kricheldorf et al. [30] found that a 1.2-mm chamfer produces an acceptable marginal gap of <50 μm . In our study, we found that 1.0-mm shoulder and 0.5-mm chamfer produce acceptable marginal gap. The results of the current study coincide with the recent literature.

The strengths of this study include the simulated clinical setup, the evaluation of the latest CEREC technology, and the number of samples. Limitations of this study are that only 2 types of finish lines (shoulder and chamfer) were included in the study, typodont teeth were used instead of real teeth, and that it is a noncomparative study.

Conclusion

Within the limitation of this in vitro study, both chamfer and shoulder finish lines produce acceptable marginal integrity of CEREC 3D crowns. There is no significant difference between the results obtained with both the finish line geometries. However, more studies are needed to be conducted on real teeth to understand clinical acceptability.

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Statement of Ethics

An ethics statement was not required for this study type, as no human or animal subjects or materials were used.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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