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Original article

# Three-dimensional evaluation of marginal and internal fit of 3D-printed interim restorations fabricated on different finish line designs

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ABSTRACT

PurposeTo evaluate the influence of fabrication method and finish line design on marginal and internal fit of full-coverage interim restorations.

MethodsFour typodont models of maxillary central-incisor were prepared for full-coverage restorations. Four groups were defined; knife-edge (KE), chamfer (C), rounded-shoulder (RS), rounded-shoulder with bevel (RSB). All preparations were digitally scanned. A total of 80 restorations were fabricated; 20 per group (SLA/3D-printed n = 10, milled n = 10). All restorations were positioned on the master die and scanned using micro-computed tomography. The mean gaps were measured digitally (ImageJ). The results were compared using MANOVA ($\alpha = .05$).

ResultsInternal and marginal gaps were significantly influenced by fabrication method ($P = .000$) and finish-line design ($P = .000$). 3D-Printed restorations showed statistically significant lower mean gap compared to milled restorations at all points ($P = .000$). The mean internal gap for 3D-printed restorations were 66, 149, 130, 95 μm and for milled restorations were 89, 177, 185, 154 μm for KE, C, RS, RSB respectively. The mean absolute marginal discrepancy in 3D-printed restorations were (30, 41, 30, 28 μm) and in milled restorations were (56, 54, 52, 38 μm) for KE, C, RS, RSB respectively.

ConclusionsThe fabrication methods showed more of an influence on the fit compared to the effect of the finish-line design in both milled and printed restorations. SLA-printed interim restorations exhibit lower marginal and internal gap than milled restorations. Nonetheless, for both techniques, all values were within the reported values for CAD/CAM restorations.

Significance3D-printing can offer an alternative fabrication method comparable to those of milled restorations.



## 1. Introduction

In contemporary prosthodontics, interim restorations are used as a transitional phase to evaluate the functional and esthetical outcomes [1–4]. The restorations should offer adequate fit to ensure mechanical stability and durability of the restoration and thus the health of the surrounding tissues [5,6]. Lack of adequate fit can result in plaque accumulation, cement microleakage, marginal

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discoloration, poor esthetics, teeth sensitivity, caries and periodontal diseases [5]. Wide variation in the definition of adequate fit and a clinically acceptable marginal gap exists in the literature and can be attributed to different study designs including different restorative materials, examination method, finish line designs and fabrication methods [7]. A recent systematic review on the fit of CAD/CAM restorations fabricated from different materials reported an absolute marginal gap (AMG) of crowns to be in the range from 10–110 μm with the majority of values less than 80 μm. In the same context, the internal gap at axial part was 23–154 μm and at occlusal part was 45–219 μm [8].

With the ongoing developments in the field of data acquisition and manufacturing processes, digital technologies are gaining more acceptances. Additive manufacturing (AM) is being increasingly applied in the field of prosthodontics. Dental restorations can be fabricated using resin based AM techniques both directly and indirectly; stereolithography and or digital light processing (SLA/DLP) [2,4,9–13]. Both techniques use light/laser to cure a photosensitive liquid polymer layer by layer, following a specific path of the designed model.

Limited studies have evaluated the marginal and/or internal fit of AM copings fabricated using SLA/DLP techniques. Kim et al. [10] found that the mean marginal gap of Co–Cr crowns was significantly larger when fabricated indirectly using SLA technique (96 μm) compared to traditional, lost-wax fabrication method (67 μm). The authors also reported an axial and an occlusal gap of 84 μm and 114 μm respectively for the indirectly manufactured SLA crowns [10]. In contrast, Park et al. [2] found PMMA DLP-fabricated implant restorations to have better marginal fit compared to milled and conventionally fabricated counterparts fabricated from PEEK and PMMA respectively. Nevertheless, the authors found the fit of the three manufacturing methods to be within the clinically acceptable range.

Munoz et al. [12] used DLP technique to fabricate wax patterns for indirect manufacturing of cast gold crowns and revealed that the marginal gap was significantly larger for DLP fabricated patterns compared to the milled or manually fabricated wax patterns.

In the same context, different finish line designs have been shown to influence the marginal gap of the dental restorations. Comlekoglu et al. [14] compared the marginal gap of zirconia crowns with knife-edge, mini-chamfer, chamfer and rounded shoulder finish line designs and found the lowest absolute marginal discrepancy values with knife-edge design (87 μm) compared to mini-chamfer (114 μm), chamfer (144 μm) and rounded shoulder (114 μm) finish line designs. Euán et al. [15] found lower mean marginal gap values for Lava All-Ceramic System with round shoulder finish-line design (52 μm) compared to chamfer counterpart (64 μm). In contrast, Tsitrou et al. [16] and Akbar et al. [17] revealed no significant difference in margnial gap of dental restorations with shoulder and chamfer finish line designs. The margin gap of CEREC 3 system composite resin crowns was 94 μm in chamfer finish line and 91 μm with shoulder finish line [16].

To the authors' best knowledge, no previous study has evaluated the internal and marginal adaptation of 3D-printed directly fabricated restorations using the SLA technique with different finish line designs. Therefore, the aim of this study was to evaluate the influence of fabrication method and finish line design on the marginal and internal fit of full coverage interim dental restorations in two digital workflows (3D-printing versus milling). Our null hypothesis is that there is no difference in marginal and internal fit between 3D-printing and milled restorations in different finish line designs.

## 2. Materials and methods

### 2.1. Study design

Four typodont models of maxillary central incisors were prepared to receive full coverage dental restorations; each with a different finish line design. The four finish line designs were; knife-edge (KE), chamfer (C), rounded shoulder (RS), rounded shoulder with bevel (RSB). In both digital workflows, the prepared models were digitally scanned and then the data was exported as a standard tessellation language (STL) format to a CAD software for the design and the fabrication of full coverage restorations (n = 80). For each finish line design, the restorations were fabricated using 3D-printing (n = 10) and milling (n = 10) techniques. All restorations were fitted on the master die without cementation and scanned using micro-computed tomography (Skyscan 1072, Bruker microCT, Kontich) [18]. The marginal and internal gaps were measured using digital imaging processing software (ImageJ 1.51; NIH). The flow of the study design is shown in Fig. 1.

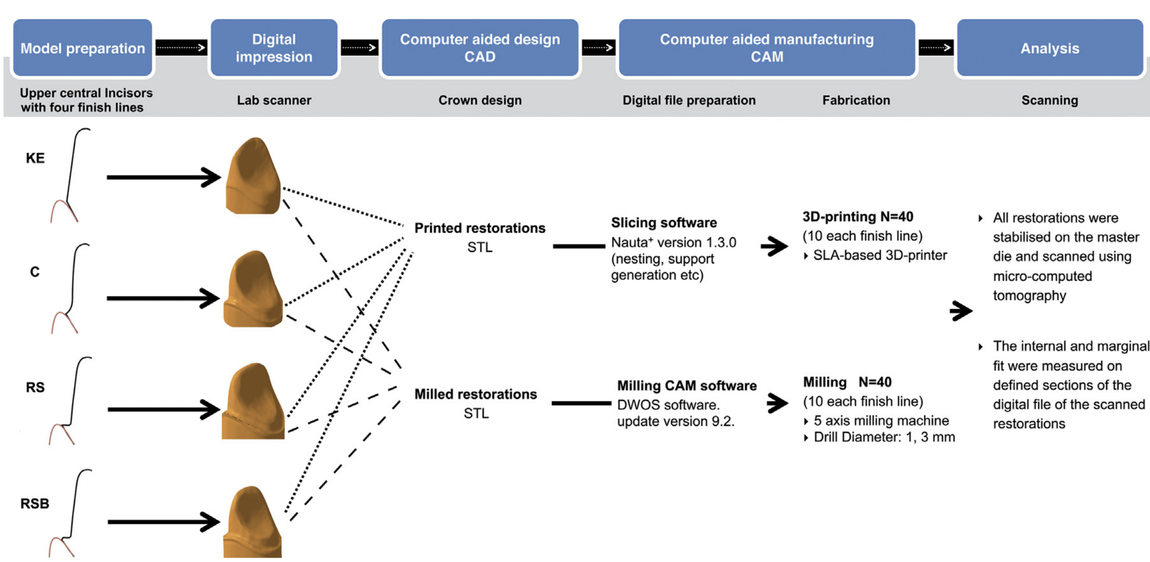


**Fig. 1.** Flow of study design.

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