

## Marginal Adaptation versus Esthetics for Various Dental Restorations: A Review Article

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### Introduction

Porcelain jacket crown was considered the most esthetic restoration. However, the inherent weaknesses and brittleness of dental porcelain together with the high sintering shrinkage have been recorded as severe drawbacks against its universal acceptance as a complete veneer restoration [1].

Metal ceramic restoration was developed in order to provide a metal substructure to reinforce the porcelain and improve marginal integrity. However, the gingival band of metal substructure along with the high reflectivity of metal and opaque porcelain compromised the esthetics of the restoration [1].

Several attempts have been described to eliminate or mask the cervical metal collar while retaining the strength of cast metal substructure such as thin metal collar design in an attempt to visually eliminate it, but Donovan and Prince found that these margins could distort when the porcelain was fired, greatly compromising the fit of the restoration [2]. Facial butted porcelain margin was developed by covering the facial collar of metal with porcelain in an attempt to hide it from view. This modification cannot be done without over contouring the restoration which can lead to gingival irritation [3]. Collarless design was an alternative approach to fabricate the metal ceramic restoration. Such an approach would combine the Strength of the metal ceramic crown with the esthetics of the porcelain jacket crown at the margin. Several techniques were developed in an attempt to simplify fabricating these restorations such as platinum foil, refractory die and direct lift technique [4].

Despite the numerous techniques available, the increasing desire for better esthetics and improved biocompatibility has led to the development of a large number of all-ceramic restorative systems. Some of them use a single-layer glass-ceramic material E.g., Dicor and IPS Empress, whereas others have a dual-layer design E.g., In-Ceram and Procera System. Further improvements in high-strength all-ceramic technology have been achieved with the advent of computer-aided design and milling (CAD/CAM) systems [5].

### Definition & Terminology

Marginal discrepancy has been defined as the closest distance between retainer and tooth preparation to avoid over-extension or under-extension of the retainer [6]. Different methods were used in various studies to determine the adaptation of a restoration. The first important step was established in 1989 [7] describing the marginal gap, absolute marginal gap, vertical marginal gap, horizontal marginal gap, as well as over- and under-extension (Figure 1).

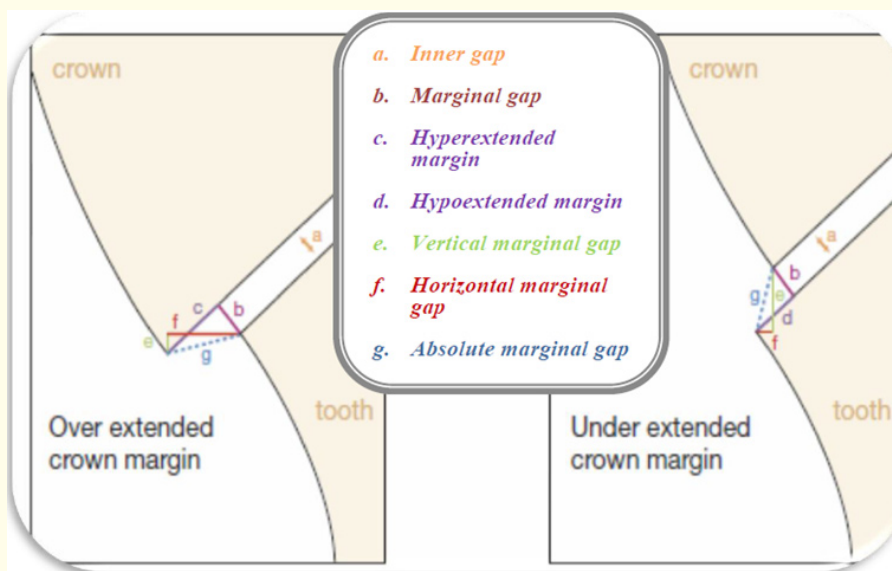
Poor marginal adaptation of restorations increases plaque retention and changes the composition of subgingival microflora, leading to periodontal disease [8]. Moreover, the micro leakage at the restoration-cavity interface can cause pulpal inflammation [9].

### Clinical acceptability for marginal discrepancy

Several authors have attempted to determine the clinically acceptable marginal discrepancies that are not visible to the naked eye and undetectable with a sharp explorer. Christensen, *et al.* reported that the range of clinically acceptable marginal gap to be 34-119  $\mu\text{m}$  for subgingival and 2-51  $\mu\text{m}$  for supragingival margins [10]. However, McLean and von Fraunhofer investigated the cement film thickness by an *in vivo* technique and stated that a marginal discrepancy of 120  $\mu\text{m}$  should be the limit of clinical acceptability [11].

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**Figure 1:** Terminology for fit determination of restorations according to Holmeset., et al. [].

### Factors affecting marginal adaptation

Several factors can affect the marginal adaptation of dental crown such as the type of finish line, Geometry of Tooth preparation, Relief of the internal crown surface, the crown material, fabrication technique, porcelain veneering, cementation and aging.

### Effect of finish line

Several studies observed better marginal adaptation for ceramic crowns with round shoulder finish lines followed by the deep chamfer ones which can be due to the larger volume of tooth structure in the round shoulder margins. Besides, the sharper borders, in deep chamfer margin, can be more easily damaged during finishing or sandblasting [12,13]. Conversely, others found no significant difference in marginal adaptation between the different finish lines tested [14].

### Geometry of tooth preparation

Beuer and his colleagues found that increasing the convergence angle of the lateral walls of tooth preparation (between 4 and 10 degrees) can decrease the hydraulic pressure of luting agent and thus, allowing excess cement to discharge better [15].

### Relief of the internal crown surface

The cement space or internal adaptation has the importance of preventing the cement layer from interfering with the crown's complete seating [16]. This is of paramount importance particularly; for all-ceramic restorations, as ceramic is a brittle material and sensitive to tension [17]. Theoretically, the restoration needs a luting cement film of 20 to 40  $\mu\text{m}$  and hence, setting the cementing gap thickness at 30 $\mu\text{m}$  was found to decrease the seating discrepancy without compromising retention and resistance forms [10,18].

### Effect of the crown material

Currently, there are several materials available than ever before for indirect restorations. They fall under the broad headings of all metal, ceramics, metal-ceramics and resin composites. A common perception is that the most reliable margins are achieved with metal rather than with ceramic. Whilst this contention is supported by some studies [19] others do not support it [20] Comparing ceramometal crowns to all ceramic crowns the former generally have better resistance to marginal distortion from repeated firings than the latter, which has implications for some all ceramic systems where the ceramic is applied incrementally [21]. However, some authors have

reported that the marginal fit of ceramic restorations is based more on the processing technique than on the crystal type, amount, and distribution of the crystal within the glass matrix [22].

### **Effect of fabrication procedures**

The ceramic coping fabrication procedures accounted for different marginal discrepancies of all-ceramic systems [23]. The all-ceramic systems can generate ceramic copings using either the lost wax technique (Castable ceramics and heat-pressed ceramics), the slip casting method (In-Ceram), or by machining (Manually Controlled System or Manual-aided Design/Manual-aided Manufacturing (MAD/MAM) Method and Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) Method) [24].

### **Castable ceramics**

Holmes and his colleagues compared the marginal discrepancy of Castable ceramic restoration to that of cast gold crowns and found that the marginal adaptation of Castable crowns was better than that of gold ones and attributed this finding to the ceramming process which achieves volumetric contraction over the crown margins during changing the glass into dense glass ceramic [20]. However, the low strength of DICOR (only 120 MPa) limits its use [25]. The marginal gap for DICOR crowns was reported to be  $48 \pm 7$   $\mu\text{m}$  [20].

### **Heat-Pressed ceramics**

The use of Heat-Pressed Ceramics as reinforced cores combined the lost-wax technique with heat pressed technology. This technique has the advantage of reducing sintering shrinkage during ceramic firing and hence improving the marginal adaptation. The marginal fit for heat pressing ceramics was reported to range from 44 to 63  $\mu\text{m}$  [9,23].

### **Infiltrated Glass ceramics**

Slip casting technology depends on infiltrating a molten lanthanum glass into the densely packed porous ceramic substructure. Thus, greatly increases the strength of the In-Ceram ceramics and offers good marginal integrity [26]. However, Careless shaving of excess slip material and adjustment of sintered framework at the marginal area could potentially lead to increased marginal discrepancy [27]. The reported marginal fit of infiltrated ceramics was found to range from 57 to 161  $\mu\text{m}$  [23].

### **Machinable ceramics**

#### **Copy-milled ceramics**

The copy-milled ceramics were found by several authors to have an inferior marginal adaptation in relation to pressed and infiltrated ceramics. This may be due to variations in milling process and size of milling burs which may increase the cracks at the crown margins. Moreover, the coping is subjected to distortion and shrinkage during the sintering stage. Consequently have a negative effect on marginal adaptation [28,29].

### **Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) technology**

#### **Basically all current CAD/CAM systems consist of three components**

Digitizing or scanning unit which captures and records data about the oral environment (tooth preparation, adjacent teeth and occluding tooth geometry). There are two types of digital 3-D scanning devices for dental use:

#### **Extra Oral Scanner: which can be either?**

**Optical:** An optical reading of the die surface is possible with white, colored or laser-beam projection through the collection of three-dimensional structures in a 'triangulation procedure' as in Cercon® smart system, LAVATM and Everest® systems [15].

**Mechanical:** A ruby ball reads the master model of the prepared tooth on the die producing high scanning accuracy as in Procera® system. However, more expensive and time consuming compared to optical scanners [15].

Several studies have reported excellent marginal adaptation for CAD/CAM systems utilizing laser scanning, which accurately measures the margin line of the stone model [31]. On the other hand, Kokubo and his friends found that the diameter of the scanning probe tip in mechanical scanners cannot reach the deepest areas of the rounded shoulder, feather-edge finish lines or proximal retentive features more than 0.5 mm deep thus, negatively affecting the accuracy of scanning process [32].

**Intra Oral Scanner (optical only):** An image of the prepared tooth and the anatomic structures of the adjacent teeth can be recorded intra orally providing a digital image as in Cerec 3D system [15].

Several authors have concluded that the CAD/CAM systems utilizing optical impression may experience problems with rounded edges due to the scanning resolution and positive error, which simulates peaks at the edges resulting in inferior marginal adaptation [32].

**Software (CAD) Or Restoration Design:** The data can be either translated to the milling device through (laboratory CAD/CAM) OR electronically sent to a compatible offsite milling center using the internet (Centralized CAD/CAM). According to Beuer, *et al.* (2009) Centralized fabrication performed significantly better marginal adaptation (51.7  $\mu\text{m}$ ) compared to laboratory CAD/CAM concept (56.0  $\mu\text{m}$ ) [33]. On the other hand, Beuer, *et al.* found that if the same scanning unit, software, and semi-sintered zirconia blanks were used in the fabrication of zirconia-based crown copings, both the laboratory and milling-center CAD/CAM systems achieved equal precision [15,17].

Sailer and his colleagues conducted a clinical study on a CAM only system (DCM prototype of Cercon, Degu Dent, Hanau, Germany) and reported poor marginal adaptation and a 22% rate of secondary caries after 5 years due to the complicated fabrication process required in the CAM only system (application of die spacer and waxing) which can cause distortion at the margin during removal of the wax pattern from the die. Additionally, scanning the internal aspects of wax pattern is difficult, thus; negatively affects the accuracy [34,33].

**CAM Unit (Processing Devices):** They can be classified according to the number of milling axes into three categories: 3-Axis milling devices, 4-Axis milling devices and 5-Axis milling devices. However, The accuracy of restoration does not necessarily increase with the number of processing axes as it depends much more on the result of digitalization, data processing and production process [17].

### **Factors affecting adaptation of restorations made out of CAD/CAM ceramics**

Material condition during the milling procedure: which can be either; Semi-sintered or fully-sintered zirconia material? Karataşlı and his friends found that the crowns made with fully-sintered zirconia blanks had an inferior marginal adaptation which can be attributed to the hard structure of zircon blanks, due to its full sintering, resulting in inconvenient milling procedures. Besides, during milling of dense sintered zirconia blocks, there is the danger of provoking unwanted surface and structural defects caused by diamond burs; these can negatively affect the marginal fit of crowns [35,36].

Chipping factor of the machinable materials: Tsitrou, *et al.* calculated the chipping factor of different machinable dental materials including a leucite reinforced glass ceramic (ProCAD, Ivoclar-Vivadent); a feldspathic ceramic (VITA Mark II, VITA Zahnfabrik), a hybrid composite (Paradigm MZ100, 3M ESPE dental products), and a lithium disilicate ceramic material (IPS e.max, Ivoclar-Vivadent) and found that the composite material had the lowest chipping factor (CF) while the lithium disilicate ceramic had the highest CF. The feldspathic and glass ceramic showed similar CF. Concluding that the material with greater level of chipping during milling is likely to have a reduced quality of marginal fit because of greater damage to the margins [37].

Layered or Monolithic CAD/CAM fabricated crowns: the marginal discrepancies of monolithic crowns were significantly smaller than those of layered crowns due to the negative effect of firing procedures for veneering porcelains [38].

**Size of milling burs:** The internal cutting bur may be larger in diameter than some parts of the tooth preparation, such as the incisal edge. This may result in restorations with larger internal gaps [32].

### The user's experience with the CAD system

#### Effect of porcelain veneering

Previous studies have shown that the fit of a ceramo-metal casting deteriorates during the firing of a porcelain veneer. The contributing factors remain uncertain however, certain causes have been suggested to be responsible for this distortion such as: porcelain contraction over the metal coping, tendency for spheroiding of porcelain margin, the contamination of porcelain to the inner surfaces of the metal framework, progressive reduction in the resilience of the metal caused by hardening of the porcelain upon cooling, design of the metal substructure (multi-walled metallic frameworks) and inadequate support of the metal framework during firing [39].

#### Effect of Underlying Cement

One problem recognized by clinicians is that the cementing medium may prevent the seating of the full crown, positioning it in hyper-occlusion and causing inadequately sealed margins [40]. The factors of: cement type, its viscosity and film thickness and cementation pressure were believed to have an effect on marginal seating [41].

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