

INFLUENCE OF FINISH LINE DESIGN ON THE VERTICAL MARGINAL DISCREPANCY OF ENAMIC HYBRID CERAMIC: IN VITRO STUDY

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ABSTRACT

Aim of the study: The aim of this study was to evaluate the effect of finish line design (chamfer and shoulder) on the vertical marginal gap distance, and fracture resistance of Hybrid ceramic (Vita Enamic, VITA Zahnfabrik, Bad Sackingen, Germany).

Materials and Methods: Two stainless steel dies were machine milled to simulate a tooth preparation for a ceramic crown of a mandibular second molar with two finish line configurations 1mm chamfer and 1 mm shoulder. Each die was 6-mm in height, 8-mm in cervical diameter, 6mm in occlusal diameter and had a total occlusal convergence of 16°. Digitalization of both dies and milling of hybrid restorations was made using CAD-CAM technology. Sixteen full coverage hybrid ceramic crowns were constructed from milled Vita Enamic hybrid ceramic blocks. The samples were divided into two equal groups' eight samples for each finish line tested.-Group Ac: eight samples (n=8) with Chamfer finish line.Group Bs: eight samples (n=8) with Shoulder finish line. All restorations were positioned onto a digital-microscope, magnification 50 X, and the images were captured and transferred to a IBM personal computer equipped with the Image-tool software to measure the vertical marginal gap distance.

Results: The results showed a statistically significant difference between the two groups (Ac, Bs) where the mean values were (35.44µm and 48.36µm) respectively at $p=0.002$.

Conclusions: the vertical marginal gap values of both finish line designs are within the clinically accepted range.

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INTRODUCTION

Dental crowns have been used for decades to restore compromised or heavily restored dentition, and for esthetic improvements. New CAD/CAM materials and systems have been developed and evolved in the last decade for fabrication of all-ceramic restorations.

Chair side Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) is recently gaining rapid popularity because it allows the dentist to eliminate the need for a technician for certain laboratory steps, and to obtain a constant quality of work. Ceramic material has been advocated rather than metal ceramic restorations because of their excellent esthetic and acceptable Mechanical properties.

The incorporation of dental technology has not only brought a new range of manufacturing methods and material options but also some concerns about the processes involving restorations fit, quality, accuracy, short and long-term prognosis.

All ceramic restorations must have adequate strength to resist fracture and precise marginal adaptation for clinical success. Increased marginal discrepancies increase the incidence of cement solubility, microleakage, caries, periodontal problems, and eventually failure of the restoration.

Most all ceramic materials exhibit low resilience and are more susceptible to fracture; Hybrid Enamic is a recently introduced polymer infiltrated ceramic network material that has higher resilience, lower wear resistance (less damage to opposing teeth), and allow for easy repair.

Finish line design has great impact effect on precision of marginal fit, as well as mechanical properties of the restoration, and so the longevity of this restoration.

Different finish line designs have been proposed for ceramic restorations where the most

recommended ones are shoulder and chamfer finish lines. It has been assumed that the finish line design may affect the fracture resistance and marginal adaptation of all ceramic restorations. This needed further study.

MATERIALS AND METHODS

Master dies construction

Two stainless steel dies were machined using a lathe to simulate a tooth preparation of a ceramic crown for a mandibular second molar. Each die was 6-mm in height, 8-mm in cervical diameter, 6mm in occlusal diameter and had a total occlusal convergence of 16°. Two finish lines designs were prepared with the same diameter but with two different configurations: (1) 1mm circumferential chamfer, and (2) 1mm circumferential shoulder. The dies were machined occlusally in 2 planes one buccal and one lingual with 130° angle in between using a custom made V-shaped metallic device.

Samples preparation

1- Scanning, Designing, and Milling of the restorations

Indirect hybrid ceramic crowns were constructed using VITA ENAMIC blocks. A Sirona CAD/CAM system (scanner, computer with version 4.3 software, milling machine) was used to fabricate the hybrid ceramic restorations. All steps of fabrication were made following the manufacturers recommendations and were the same for the two finish line designs as follow:

The stainless steel dies were sprayed with **Cerec Optispray** to remove optical highlights from the surface of the dies and to enhance the precision of the optical impressions acquired by creating a uniformly reflective surface. An optical impression was then taken using the intraoral camera of the CEREC Omnicam system.

On the computer screen a 3D model was created, the margins were identified and the path of insertion was determined to prepare the restoration for editing. To create the restoration, the cement space was set to be (30 μ m). Adjusting the buccolingual, mesiodistal dimensions, and cusp height of the restoration outline were done on design window. The block was inserted and fixed into milling machine. The milling time was 13 minutes. The restorations were separated from the block at the end of milling and checked on the master dies to be ready for testing.

2- Allocation samples into groups

Sixteen full coverage hybrid ceramic crowns were constructed from milled Vita Enamic hybrid ceramic blocks. The samples were divided into two equal groups' eight samples for each finish line tested.

- Group Ac: eight samples (n=8) with Chamfer finish line.
- Group Bs: eight samples (n=8) with Shoulder finish line.

3- Polishing and cleaning of the restorations:

The milled restorations were cleaned using ultrasonic cleaner before polishing . The milled restorations were polished with vita Enamic polishing set technical using a micro motor. First the pink polishers of the vita enamic Polishing set were used under water coolant at (7000-10000 rpm), Followed by high gloss polishing with the grey diamond-coated polishers at (5000-8000rpm) which was carried out without any water coolant.

Vertical marginal gap distance measurements:

All restorations were positioned onto a digital-microscope, magnification 50 X, and the images were captured and transferred to a IBM personal computer equipped with the Image-tool software.

For vertical marginal gap measurements, pictures of the margins were taken for each restoration

at the buccal, mesial, distal, and lingual surface. Then morphometric measurements were done for each picture at nine equidistant spots, the total number of measurements for each sample was thirty six. Means were calculated and statistical analysis was made.

Within the Image J software, all limits, sizes, frames and measured parameters were expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the Image J software, then; the images of traced marginal path were overlaid and transferred to Image J software in order to calculate the vertical marginal gap which was measured in (μ m). Finally the data obtained were collected, tabulated and statistically analyzed.

RESULTS:

Results of vertical marginal gap distance measurements of Hybrid Enamic crowns using shoulder and chamfer finish lines:

The mean vertical marginal gap distance of each Hybrid Enamic crown was calculated in microns representing the vertical marginal discrepancy without cementation.

The chamfer finish line design showed a mean vertical marginal gap distance of **(35.44 μ m)**. The shoulder finish line design showed a mean vertical marginal gap distance of **48.36 μ m**.

Comparison between vertical marginal gaps using different finish line designs:

When comparing the vertical marginal gap distance measurements of **chamfer** and **shoulder** finish line designs for hybrid Enamic restorations, it was apparent the lower values of vertical marginal gap at chamfer finish line compared to the higher mean values for shoulder finish line.

The results showed a statistically significant difference between the two groups (Ac, Bs) where the mean values were (35.44 μ m and 48.36 μ m) respectively at $p=0.002$.

DISCUSSION

CAD/ CAM systems produce standardized restorations, and reduce production costs, labor and time. Given the simplicity of automatic margin detection and restoration design compared to manual waxing, it makes the most sense to use the CAD/CAM features where possible¹.

In dental field they always search for new innovative biomaterials with the intention to offer improved products. The new so-called “hybrid ceramic” have been introduced to the market with the idea of combining the positive aspects of both composites and ceramics. The manufacturers claim that these materials, integrating both ceramic and polymer materials, provide less brittleness, excellent machinability and edge stability².

Vita Enamic is an innovative CAD/CAM material, referred to as a “hybrid ceramic”. It has been defined in the literature as “a material consisting of a ceramic substructure infiltrated with a composite material”. It consists of a ceramic component of aluminum oxide-enriched, fine-structure feldspar matrix (86 wt%) infused by a polymer component of urethane dimethacrylate and triethyleneglycol dimethacrylate (14 wt%)³.

Various aspects of tooth-preparation designs have been cited in the literature. Nowadays, considerable focus has been directed toward the most appropriate margin design with the introduction of innovative restorative systems. Manufacturers and authors offer different suggestions to the optimal form, but little scientific data were available.

In addition to esthetics, marginal fit and fracture strength are important criteria to ensure clinical success. Increased marginal discrepancies increase

the incidence of cement solubility, micro-leakage, caries, periodontal problems, and eventually failure of the restoration. The majority of researchers proved the importance of marginal fit and fracture resistance for the long-term success of restorations⁴.

The aim of this study was to evaluate the effect of finish line designs (chamfer and shoulder) on the marginal fit and the fracture resistance of Enamic hybrid ceramic, which may offer more conservative preparation with high success rate.

In this study the assessment of the marginal fit was performed on the stainless steel dies using the direct view technique with the aid of a digital microscope. The use of metal dies to measure marginal fit was supported by several researchers. Metal dies offer a standardized preparation that lacks abrasion during the manufacturing processes and measurements⁵.

In this study the dies were machine milled to the dimensions of a prepared lower second molar. The convergence angle of the dies was 16 degrees. Doyle *et al.* (1990)⁶ reported that a 16° occlusal convergence angle of abutment increases the fracture strength of all-ceramic crowns. This convergence angle would result in a thicker axial restoration, and decreasing the seating pressure.

Thickness of the die spacer affects the seating and fitness of the restoration. Nakamura *et al.* (2003)⁷ and Reich *et al.* (2005)⁸ confirmed that the amount of die spacer appeared to be a significant factor for the marginal fit. Nakamura *et al.* (2003)⁷ advocated that setting the die spacer thickness to 30 μ m would lead to smaller marginal discrepancies. In the present study, the cement space was set at 30 μ m for both chamfer and shoulder finish line designs.

The vertical cervical marginal gap measurement method was implemented in the present study as it is considered to be the most frequently used method to verify the accuracy of fit of restorations. Many other

methods for evaluation of the marginal gap distance exit including the cross sectional view, impression replica technique and in vivo clinical examination.

In the present study the vertical marginal gap distance measurements of each crown were evaluated between the outer cervical margins of each crown and the surface of the prepared tooth finish line using a digital microscope. (Coli and Karlsson 2004)⁹.

The null hypothesis stating that there is no difference between the chamfer and shoulder finish lines regarding the vertical marginal gap distance of Hybrid Enamic was rejected.

The results of the vertical marginal gap distance of group chamfer finish line in the hybrid Enamic crown group samples (Ac) showed statistically significant difference with lower mean vertical marginal gap distance compared to shoulder finish line group (Bs) where the mean values were ($35.44 \pm 6.77 \mu\text{m}$) for restorations with a chamfer finish line and ($48.36 \pm 7 \mu\text{m}$) for restorations with shoulder finish line).

These findings were in agreement with the study of (Maghrabi et al. 2011)¹⁰ that evaluated the marginal adaptation of composite crowns with different finish line designs. It was reported an improved marginal fit of the composite crowns fabricated on chamfer compared with shoulder finish line, although they did not explain the cause.

The lower vertical marginal gap of the chamfer finish line may be attributed to longer length of curvature of the finish line compared to the lesser curve radius of the shoulder finish line because the chamfer finish line has some length on axial wall of the preparation, so the closing of margin is more probable along this length. On the other hand, shoulder margin has a butt joint form, without any length on axial wall. This is why if any distortion happens due to the milling process, it will affect the whole marginal gap.

This improved adaptation of Enamic restoration in case of chamfer finish line may be due to easy seating of the restoration with less strain these results were found to be in agreement with Adriana et al. (2004), lee Racho et al. (2004), but in contradiction with Maria et al. (2003).

The vertical marginal gap distance of both the finish of the finish line designs were considered with clinical acceptable range up to $120 \mu\text{m}^{11}$. There is a lot of controversy in the dental literature regarding the clinically acceptable marginal fit. Theoretically, the restoration needs a luting cement film of 20 to $40 \mu\text{m}^{11}$.

Finally this study involved in vitro testing, thus giving an idea about clinical expectations; however, clinical trials are the final determinant to the performance of these new hybrid ceramic restorations.

CONCLUSION

Conservative preparation using chamfer finish line provided lower vertical marginal gap of Enamic Hybrid ceramic restorations compared to shoulder finish line. Although the vertical marginal gap values of both finish line designs are within the clinically accepted range.

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