

Effect of Thickness of Zirconia Core on Marginal Adaptation of All-Ceramic Restorations

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Abstract

Background and Aim: Marginal adaptation is important for long-term success of full-coverage restorations. Thickness of core is one of the important factors influencing the marginal integrity. Thus, the aim of this study was to evaluate the effect of different thicknesses of zirconia core on marginal adaptation of all-ceramic restorations.

Materials and Methods: In this single blind in vitro study, a standard brass die 7 mm in length and 5 mm in diameter was prepared with a classic chamfer finish line with 0.8 mm depth and 10 degrees of wall taper. Copings were made using the CAD / CAM system. We had three groups of 10 samples each. Group 1 with a zirconia thickness of 3.0 mm, group 2 with a thickness of 0.5 mm and group 3 with a thickness of 0.7 mm. Copings were then placed on the die and randomly numbered. The vertical gap in the margin was measured at 10 points using scanning electron microscopy (SEM). Data were collected. The mean and standard deviation values were calculated and ANOVA was used for the comparison of the three groups. Tukey's test was also applied.

Results: The gap in 0.3, 0.5 and 0.7 mm thicknesses of zirconia before porcelain firing was 89.21 ± 28.90 , 79.55 ± 39.32 and $40.813 \pm 10.3 \mu$, respectively. The difference in marginal gap between the three groups was statistically significant ($p=0.001$). Tukey's test failed to find a significant difference in marginal gap between 0.3 and 0.5 mm thicknesses ($p=0.006$). But, the difference between 0.3 and 0.7 mm ($p=0.001$) and also 0.5 and 0.7 mm ($p=0.001$) was statistically significant.

Conclusion: Based on the results, by increasing the thickness of the zirconia core marginal gap decreases in all ceramic restorations.

Key Words: Marginal gap, Zirconia, CAD / CAM, Marginal adaptation

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Introduction

Marginal fit of full coverage restorations is an important element in their long-term success [1, 2]. The material and thickness of core play an important role in this respect [1, 3]. Recent studies have shown that 73.9% of zirconia fixed partial dentures (FPDs) have poor marginal integrity [4], which may lead to microbial plaque accumulation [5],

change the subgingival flora [6], cause gingivitis [7, 8], cause gingival margin discoloration [9, 10] and in severe cases, increase pocket depth and cause loss of periodontal support [11-14]. Severe caries and periodontal disease may result in treatment failure and eventual tooth loss [6,7]. With an increase in marginal discrepancy, more cement is exposed to the oral cavity causing eventual failure

of the restoration because of the solubility of most cements. In addition, poor marginal fit of all-ceramic crowns decreases their fracture resistance and compromises the bond strength [15, 16]. All-ceramic restorations are highly esthetic restorations because of their perfect translucency [17]. Thus, these restorations are highly popular especially the high strength types like ZrO_2 which are made using the CAD/CAM system. They have high flexural strength and fracture toughness [18]. Little is known about the marginal fit of partially sintered- ZrO_2 restorations [19]. One study reported 29μ of marginal gap for E-Max system and 49μ for the In-Ceram system [20]. Another study reported 61μ of marginal gap for Procera and 98μ for Cercon system. In most investigations, a marginal gap of 120μ is acceptable for different core thicknesses [21-24].

Given the gap of information in this respect, this study aimed to investigate the effect of different zirconia core thicknesses on the marginal fit of all-ceramic restorations.

Materials and Methods

This single blind experimental study was conducted in vitro. First a standard brass die with a length of 7 mm and a diameter of 5 mm was fabricated. The die was then prepared by a milling machine using classic chamfer preparation with a depth of 0.8 mm [25] and 10° wall taper [26]. Also, the die had a flat incisal edge, which created a uniform path for seating and removal of the copings on the die. Copings were made using the MC-XL Sirona Dental CAD/CAM System (Sirona Dental Systems GmbH, Germany). The metal die was scanned using Sirona inEos X5 laboratory scanner and a 3-dimensional image was created, reconstructed and processed using the inLab® MC XL software [27]. Three groups of 10 with different coping thicknesses were prepared; the first group with the thickness of 0.3 mm, the second group with the thickness of 0.5 mm and the third group with the thickness of 0.7 mm and the die spacer had 35μ thickness. Then appropriate presintered zirconia blocks were placed in MC XL milling unit. After milling, their thickness was controlled and a liquid dye was used for color-coding the thicknesses. For example, 0.7 mm thickness was color-coded A3, 0.5 mm was color-coded A2

and 0.3 mm was color-coded A1. Then, they were placed in the Sintramat high-temperature sintering furnace (Ivoclar, Vivadent) for 8 hours at a temperature of $1500^\circ C$ to $1600^\circ C$ to have copings sintered. Before veneering, cores were seated on the die and randomly numbered. In order to avoid rotation of the copings, the die and the copings were marked (Figures 1 and 2). Then, 10 points were marked on the margin of crowns and the vertical gaps at the respective points were measured using an SEM (XL30, Phillips, Netherlands) in microns [28] (Figures 3 and 4) at 1000X magnification.



Figure 1. Standard die

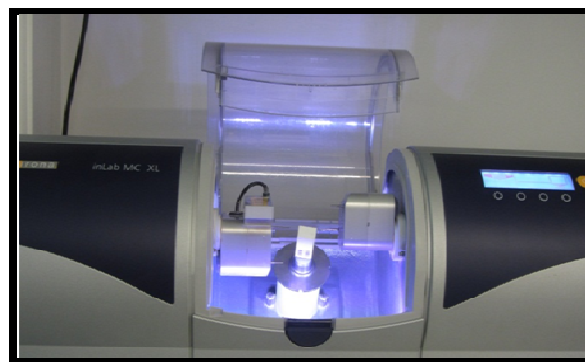


Figure 2. The CAD/CAM machine for milling of copings



Figure 3 And 4. Gap measurement with SEM

After collecting the data and determining the mean and standard deviation values, the data were analyzed using ANOVA. To compare the 3 groups of core thicknesses post hoc Tukey's test was used. Normal distribution of the data in each group was determined using Kolmogorov Smirnov test with a minimum of 0.25 probability (Odds Ratio) and the equality of variances was determined using Levene's test with a probability of 0.25.

Results

The results of Tukey's test showed that there was no significant difference between 0.3 mm and 0.5 mm core thicknesses ($p=0.006$); but there was a significant difference between 0.3mm and 0.7mm and also 0.5mm and 0.7mm thicknesses. The results of ANOVA showed that the three groups did not significantly differ in terms of the amount of gap ($p=0.0001$) as the maximum mean gap belonged to 0.3 mm group and the minimum mean gap belonged to the 0.7 mm group. Therefore, it can be concluded that increasing the thickness significantly reduces marginal gap (Table 1).

Discussion

A restoration can function well for a long time in the oral cavity if it has appropriate mechanical, biological and esthetic properties [29, 30].

Porcelain fused to metal restorations have been used by dentists for years, but their biological and esthetic aspects have always been questioned and cannot often satisfy dentists and patients. Following the advances in the techniques and materials used for all-ceramic restorations, their application increased significantly [1-2].

Marginal fit is among the most important criteria in success of fixed restorations [29, 30], as poor marginal fit can cause complications such as caries, gingivitis and bone resorption, and compromise tooth vitality. This parameter is more important in all-ceramic restorations [3-10].

This study showed that marginal gap in all three groups was clinically acceptable before and after veneering (less than 120μ) [6], and all three thicknesses of zirconia cores can be successfully used in the clinical setting. However ANOVA showed that the gap in 0.7 mm core thickness was significantly

Table 1. The mean and standard deviation of marginal gap of the three core thicknesses in microns

Zirconia core Thickness (mm)	Quantity	Mean	Standard deviation	Min	Max	CI 95%		P-value
						Min	Max	
0/3	10	89/21	28/90	57/5	139/7	68/52	109/89	
0/05	10	79/55	39/32	17/6	137/6	51/41	107/68	0/0001
0/7	10	8/40	3/10	6	15/4	6/17	10/62	

less than that in other thicknesses (0.5 and 0.3 mm) ($p=0.0001$) and 0.7 mm thickness of zirconia core had superior marginal fit. Therefore, recurrent caries are expected to be less around 0.7 mm core thickness.

This study showed that there was no significant difference in vertical marginal gap between 0.3mm and 0.5 mm core thicknesses. Thus, for esthetic purposes, particularly in the anterior teeth, 0.3mm core thickness can be used. Resultantly, more space would be available for the application of veneering ceramics.

Jalilian et al. studied the effect of the two preparation designs of chamfer and radial shoulder on marginal

fit of all-ceramic restorations. The results showed that chamfer had superior marginal fit in all-ceramic restorations than radial shoulder [22], but they used only 0.5 mm zirconia core thickness while we studied three different thicknesses of zirconia core with chamfer finish line.

The amount of gap in our study was comparable to that reported by Bindl who compared the marginal and internal fit of all-ceramic CAD/CAM crowns [26]. Similar to our study, they used CAD/CAM and SEM, and showed that marginal fit was less in crowns fabricated by the CAD/CAM system than in those fabricated by In-Ceram.

In order to assess the precision of restorations,

measurements should be made in horizontal and vertical planes. We assessed only the vertical marginal gap. Furthermore, crowns were not under mechanical loading like in the oral cavity. SEM was used in this study, which is an acceptable method for assessing the precision of marginal fit in vitro [2].

Conclusion

Given the significant differences among the three thicknesses of zirconia cores, it can be concluded that increasing the zirconia core thickness can decrease marginal gap in all-ceramic crowns. At thicknesses of 0.3 and 0.5 mm, there was no significant difference in marginal gap, but at 0.7 mm thickness of zirconia core, marginal gap was less.

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