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Effect of Sloped Shoulder and Deep Chamfer Finish Lines on Marginal Adaptation of Zirconia Restorations

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ABSTRACT

Marginal adaptation of full-coverage restorations is an important factor determining their long-term success. Preparation design and finish line can significantly affect marginal adaptation. This study aimed to assess the effect of deep chamfer and sloped shoulder finish lines on marginal adaptation of zirconia restorations. In this in vitro, experimental study, a standard die measuring 7 mm in length and 5 mm in diameter received sloped shoulder finish line with 1 mm depth at one side and deep chamfer finish line with 0.8 mm depth at the other side with 10° taper. Ten impressions were made of the die and poured with epoxy resin. Ten zirconia copings (Ceramill) were fabricated and vertical gap (at one point for each finish line) before cementation and marginal gap and internal gap (at five points for each finish line) after cementation (with glass ionomer under 5 N load for 10 minutes) were measured using a scanning electron microscope (SEM). The mean values were compared using t-test. Vertical gap was 42.06±15.2 µm for deep chamfer and 25.2±10.3 µm for sloped shoulder design. Marginal gap was 98.3±7.06 µm for deep chamfer and 94.3±27.17 µm for sloped shoulder design. The internal gap was 154.75±46.94 µm for deep chamfer and 162.35±43.49 µm for the sloped shoulder design. The difference in vertical gap was significant between the two designs (P<0.01) while the difference in marginal and internal gap was not significant (P>0.05). The results showed that the preparation design had no significant effect on marginal gap of zirconia restorations but affected the vertical gap.

Key words: Marginal Gap, Zirconia, Marginal Adaptation, Deep Chamfer, Sloped Shoulder

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INTRODUCTION

Assessment of the marginal adaptation of dental restorations is important to determine their clinical efficacy. Clinicians have always tried to minimize the marginal gap of restorations. Cement dissolution over time creates an empty space between the tooth and restoration, which may serve as a suitable place for plaque accumulation and lead to consequent inflammation of periodontal tissue, development of caries, increased gingival crevicular fluid, bone destruction and treatment failure. Marginal adaptation of full-coverage restorations plays an important role in their long-term success. Evidence shows that marginal gap can be 34 to

120 µ for all ceramic restorations [1, 2]. Marginal gap of all-ceramic restorations depends on their manufacturing process, preparation design and the ceramic system used [3, 4]. A previous study showed that 79.3% of zirconia-based fixed partial dentures had problems in marginal adaptation [5]. Marginal adaptation of different restorations such as inlays, onlays, veneers and fixed partial dentures (crowns) has been previously evaluated [6-8].

Development of computer aided design/computer aided manufacturing (CAD/CAM) systems allows for the fabrication of alumina and zirconia crowns. At present, use of all-ceramic restorations has greatly increased due to improved clinical parameters and decreased biological complications of the gingiva as well as greater demands for esthetics. High-strength ceramics such as ZrO_2 manufactured by the CAD/CAM technology are particularly popular due to having high flexural strength and fracture toughness [9-11]. At present, deep chamfer and sloped shoulder designs are commonly used for tooth preparation for subsequent fabrication of zirconia restorations. However, information about the effect of these preparation designs on marginal adaptation of restorations is scarce [12].

Previous studies comparing the effect of preparation design and finish line on marginal adaptation have shown controversial results. For instance, a previous study compared the effect of two finish lines on marginal gap of zirconium dioxide crowns and found significant differences. Marginal gap in the shoulder finish line group did not significantly change during the fabrication process but significant changes were noted in the chamfer group. They showed that marginal adaptation was affected by the finish line. Glazing significantly affected the marginal adaptation of chamfer group. However, marginal gap was within the clinically acceptable range [13]. Another study was conducted on Cerec 3 and CAD/CAM crowns with chamfer and shoulder finish line designs and revealed that the finish line design did not affect the marginal adaptation [14]. Considering such controversies and limitations of previous studies, this study aimed to assess and compare the marginal adaptation of zirconia restorations with sloped shoulder and deep chamfer preparation designs.

MATERIALS AND METHODS

In this in vitro, experimental study, sample size was calculated to be 10 samples in each group according to previous studies [15,16]. A standard brass die measuring 7 mm in length and 5 mm in diameter was fabricated. Using a milling machine, 120° sloped shoulder design with 1 mm thickness was prepared in one wall (Figure 1) and deep chamfer design with 0.8 mm thickness was prepared in the other wall. The walls were prepared with 10° taper (5° each) towards the occlusal surface (Figure 1) [17, 18].

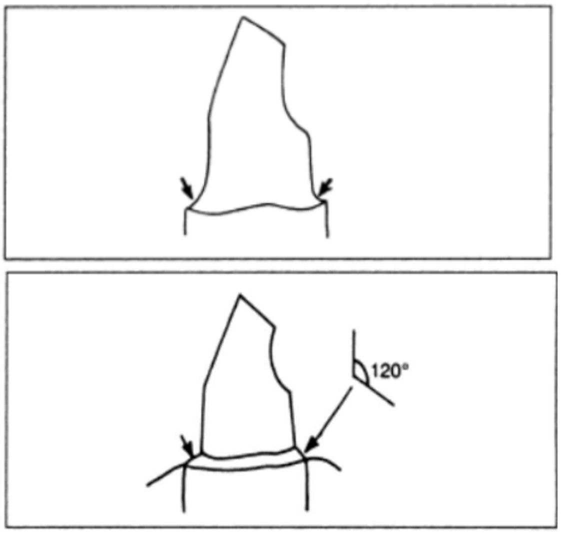

Figure 1: Schematic view of standard die with 120° sloped shoulder and deep chamfer designs

A special tray fabricated by milling was used to make impressions of the die. To standardize impression making, a vertical groove was carved on the base of the die, which was in alignment with a groove carved on the special tray. This was done to have only one path of insertion. To prevent rotation of the coping, a 45° slope was created in the occlusal surface of the die [18]. Using polyvinyl siloxane impression material (Elite HD+, Light body, Zhermack, Germany), 10 impressions were made of the die. Equal amounts of base and accelerator were mixed for each impression using a syringe. Impressions were poured with epoxy resin (Dalchem, Australia) with a base to catalyst ratio of 1:2. To fabricate copings, the samples were scanned by a scanner (Ceramill Map 100, Amann Girrbach, Germany) and the scans were transferred to a computer. Using Ceramill Mind software (Amann Girrbach, Germany), the thicknesses of the coping and die spacer (Tru-Fit, George Taub products, NJ, USA) were determined to be 0.5 mm and 30 µ [19]. Next, semi-sintered zirconia blocks (Ceramill Zi, Amann Girrbach, Germany) were transferred to the milling machine (Ceramill Motion, Amann Girrbach, Germany). After milling, they were sintered in Ceramill Therm (Amann Girrbach, Germany) at 1450°C. In this study, the porcelain veneering phase was eliminated. The fabricated copings were placed on their respective dies and randomly coded. Each die was divided into four equal segments using two hypothetical lines. The two mid-points of the two finish lines were named points A (sloped shoulder) and B (deep chamfer). Before cementation, vertical gap of each preparation design at a specific point was measured under a scanning electron microscope (SEM; KL30, Philips, Netherlands) [18]. The copings were then cemented with glass ionomer cement (GC Gold Labeled, Tokyo, Japan) under 5 N load for 10 minutes applied by the pressing universal testing machine (Zwick, Ulm, Germany). After 24 hours, they were longitudinally sectioned using a trimmer (Dentaurum, Bego, Germany) under water coolant such that each half had one of the preparation designs. The sectioned samples were marked and in each preparation design, marginal gap at one point and internal gap at four points were measured under a SEM [18]. The distance between the coping margin and die margin parallel to the path of draw of coping before cementation was considered as vertical gap. The distance between the coping margin and the die margin perpendicular to the path of draw of coping after cementation and sectioning was considered as the marginal gap and the distance between the coping margin and axial and occlusal walls of die perpendicular to the path of draw of coping was measured as the internal gap [20].

Figure 2: Sectioned sample for measurement of vertical and internal gap

After measuring the vertical gap, marginal gap and internal gap (Figures 2 and 3), data were tabulated, the mean values were calculated and comparisons were made using t-test [12, 17, 18].

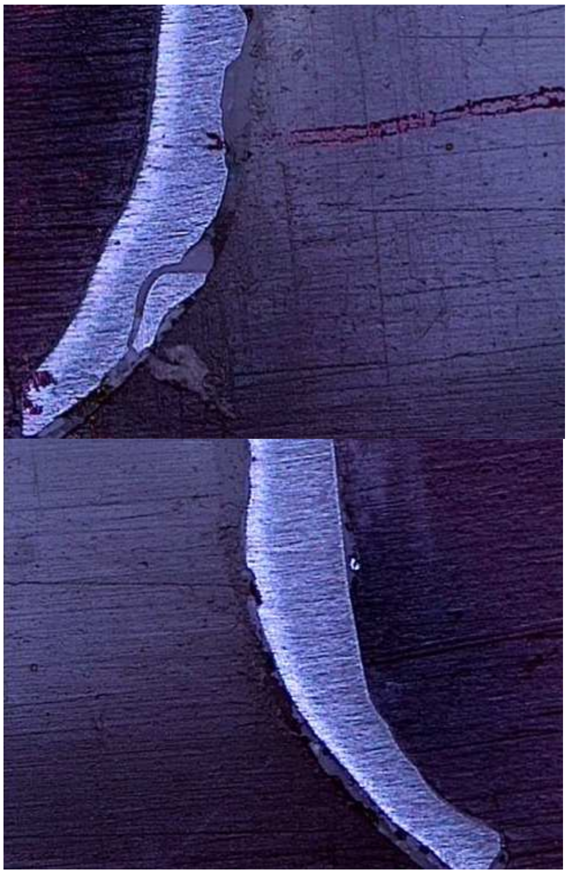

Figure 3: Marginal gap in sloped shoulder (upper image) and deep chamfer (lower image) finish lines

RESULTS

Vertical gap was 42.06±15.2 µm for deep chamfer and 25.2±10.3 µm for sloped shoulder design. Marginal gap was 98.3±7.06 µm for deep chamfer and 94.3±27.17 µm for sloped shoulder design. The internal gap was 154.75±46.94 µm for deep chamfer and 162.35±43.49 µm for the sloped shoulder design. One-sample Kolmogorov-Smirnov test showed that the data in the two groups had normal distribution. Thus, Student's t-test was applied to compare the two groups. The two preparation designs were significantly different in terms of vertical gap ($P<0.01$). However, the two groups were not significantly different in terms of marginal gap or internal gap ($P=0.8$ and $P=0.6$, respectively, Table 1).

Table 1: Vertical gap, marginal gap and internal gap values in the two groups

Design/ Gap	Vertical gap				Marginal gap				Internal gap			
	Mean	95% CI	Minimum	Maximum	Mean	95% CI	Minimum	Maximum	Mean	95% CI	Minimum	Maximum
	42.6±15.2	52.02 33.18	9	69	98.3±7.06	108.06 88.54	87	110	154.75±46.94	262.74 46.78	25	238
	25.2±10.3	31.58 18.82	7	42	94.3±27.17	238.98 50.38	82	171	162.35±43.49	255 69.68	42	237
	P<0.01				P=0.82				P=0.6			

DISCUSSION

This study assessed the effect of deep chamfer and sloped shoulder preparation designs on marginal adaptation of zirconia restorations and showed that marginal gap and internal gap in both groups were within the clinically acceptable range of 50 to 220 µ. Considering the lack of significant difference, both designs can be successfully used in terms of marginal adaptation. In our study, vertical gap and internal gap were also measured in addition to marginal gap. The mean vertical gap was 42.6 for deep chamfer and 25.2 µ for sloped shoulder design. Larger gap in deep chamfer finish line was probably due to its design, which may not be properly scanned and thus, may show less adaptation to the die. However, the mean internal gap was 154.75 µ for deep chamfer and 162.35 µ for sloped shoulder design. This difference may be due to increased gap particularly in the occlusal area in T preparation design and the significant difference in vertical gap of sloped shoulder group. The results showed that deep chamfer design showed better vertical adaptation than sloped shoulder while in terms of marginal and internal adaptation, sloped shoulder design was superior.

Komine *et al*., [21] evaluated marginal adaptation of zirconium dioxide single crowns with shoulder, round shoulder and chamfer finish lines. The three groups were not significantly different in terms of internal and marginal adaptation, and the gap values were within the clinically acceptable range. Ji *et al*., [15] compared marginal gap between shoulder and deep chamfer finish lines with Prettau ceramic system, Zenostar system and IPS E.max. They showed that type of ceramic system significantly affected the marginal gap while finish line design had no significant effect on marginal adaptation. Their study was different from ours in terms of methodology and sample size.

In the current study, SEM was used for measurement of marginal gap, which is a well-accepted tool for this purpose [22]. Use of a standard die to create ideal conditions was strength of this study. However, this study had an in vitro design and suffered the shortcomings of in vitro investigations. Thus, generalization of results to the clinical setting must be done with caution.

Similar studies using different types of ceramics are required to assess their effects on marginal adaptation. Also, the results of such in vitro studies should be confirmed in clinical studies.

CONCLUSION

Within the limitations of this study, the results showed that sloped shoulder and deep chamfer preparation designs were clinically acceptable in terms of marginal adaptation and both can be successfully used. The difference in marginal and internal gap between the two groups was not significant while vertical gap was significantly different between the two groups.

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