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The effect of different finish line and convergence angle on the marginal fit of zirconia all-ceramic restorations

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ABSTRACT

Background and Objectives: The precise degree of marginal fit is one of the most significant criteria for the durable success of all-ceramic restorations. Since the finishing line designs and preparation angles can affect the marginal fit, the aim of the present study was to compare the effect of different finish line and convergence angle on the marginal fit of zirconia all-ceramic restorations. *Materials and methods:* In the present in vitro study a total of four brass dies were designed with Auto CAD software and manufactured with CNC machine (Siemens, SI Numerik 802D-SL; USA) as follow: Die A: Convergence angle of 12° and radial shoulder margin, Die B: Convergence angle of 6° and sloping shoulder of 135°, Die C: Convergence angle of 6° and radial shoulder margin, Die D: Convergence angle of 12° and sloping shoulder of 135°. A total of 40 plaster dies were divided in four groups of 10 (n=10), ten impressions were carried out by the double impression technique with a poly vinyl siloxane impression material for each master die. The impression was poured with type IV Plaster. A ceramic restoration was made for each plaster die then the marginal gaps were measured with SEM. Data were analysed using the two-way analysis of variance (ANOVA) and SPSS ver.16. *Results:* The lowest mean (±standard deviation) marginal gap was observed in group A (31.9423), group D (36.03), group B (40.9537), group C (46.703), respectively. Different convergance angle had significant effect on marginal fittness ($P < 0.05$), but marginal design had no significant effect on marginal fitness ($p>0.05$) and both of them together could affect on marginal fitness ($p<0/05$). *Conclusion:* The type of the finish line did not influence the marginal fit. The convergence angle influences the distance from the edge of the crown to the edge of the tooth finish line. It seems that use the convergance angle of 12 degree and radial shoulder margin can reduce the marginal gap in zirconia all-ceramic restorations.

Keywords: Finish Line, Convergence Angle, Marginal Fit

1. INTRODUCTION

All ceramic restorations exhibit many outstanding material properties in fixed dental prosthesis including desirable aesthetics, low thermal conductivity, abrasion resistance, and colour stability (Beuer et al., 2009). In earlier times, the application of all-ceramic restorations due to low fracture toughness was limited to the mandibular anterior fixed prostheses. Recently, with the introduction of Zirconium dioxide (ZrO2) and the progress made in all-ceramic veneers, their use has been greatly enhanced for posterior fixed dental prostheses (Beuer et al., 2009). The most widely used zirconium ceramic systems are Y-TZP (yttria-stabilized tetragonal zirconia polycrystal). Y-TZP presents a high resistance and remarkable mechanical properties compared to other ceramic cores (Denry and Kelly, 2008).

In addition to physical properties and biocompatibility of restorative materials in dentistry, marginal precision is also considered as a determining technical factors in the long-term success of a dental restoration (Bindl and Mormann, 2003; Coli and Karlsson, 2004; Quintas et al., 2004). Inadequate marginal fit can cause damage to the tooth, periodontal tissues, and the restoration (Lang et al., 1983). Poor marginal fit can lead to microleakage of bacteria and consequently results in inflammation of the vital pulp and secondary caries (Bindl and Mormann, 2003; Lang et al., 1983; Valderhaug and Heloe, 1977; Bindl and Mormann, 2005). As well as, poor marginal adaptation can influence the longevity and strength of dental restorations (Jacobs and Windeler, 1991). Several factors can directly or indirectly affect the marginal fit of of dental restorations, including the type of restoration, finish line form, and the angle of convergence (Miura et al., 2007).

Various studies evaluated the effect of different preparation angles on the marginal and internal fit of zirconia all-ceramic restorations and various results have been reported (Beuer et al., 2008; Beuer et al., 2009) . Since the finishing line designs and angle of convergence can affect the marginal fit, the aim of the present study was to compare the effect of different finish line and convergence angle on the marginal fit of zirconia all-ceramic restorations.

2. MATERIALS AND METHODS

In the present in vitro study a total of four brass dies were designed with AutoCAD software and manufactured with CNC machine (Siemens, SI Numerik 802D-SL; USA) as follow: Die A: Convergence angle of 12° and radial shoulder margin, Die B: Convergence angle of 6° and sloping shoulder of 135°, Die C: Convergence angle of 6° and radial shoulder margin, Die D: Convergence angle of 12° and sloping shoulder of 135°. Dimensions of these dies were considered to be in line with the average size of a second mandibular premolar tooth (height=7 mm, diameter =6 mm).

The study was approved by the Human Subject Research Ethics Committee of The Ahvaz Jundishapur University of Medical Sciences (Ethical code: IR.AJUMS.REC.1390.270).

For marginal design, ditching process was performed on the underside of the finish line. In order to avoid the rotation of the casting around the point on the opposite margin, the bevel was made at a 45° angle to the horizon at one of the edges of the occlusal dies. The occlusal surface was prepared perpendicular to the long axis of the die. After designing and fabricating the desired dies, the dies were mounted in a gypsum cube (50mm×50mm) using a surveyor (Surveyor GDJT-009; Gao Din Medical; Shanghai; China Medical Co Ltd.), the distance from the gypsum to the finish line for each of the model was 2mm. Then a special tray was made using self-cured Meliodent acrylic resin (Bayer UK Limited-Bayer House, Strawberry Hill Newbury, Berkshire) as follow:

A die relief (6mm) was applied to a die to provide space for the luting agent. For equal distribution of pressure, a constant weight of 5 kg was placed in the middle of special tray. At all levels of the special tray, holes were created at intervals of 6 mm. Then, the special tray was filled with additive silicone impression material (Elite, zhermack S.P.A, Badia polesine, Rovigo, Italy). When the final putty was set, the additive silicone impression material was injected around the dies using auto-mixing gun –molding. At that point, the special tray containing molding material was placed on the dies and the weight was placed on the embedded place. After 5 minutes, the tray was removed and after gentle drying the dental cast was fabricated using dental stone type IV (Ernst HINRICHS GmbH, Dental, Rosa pink Rosa OT 306190, Germany). This process was conducted ten times in the same time under the same conditions.

The dies were sent to the dental aboratory for the full range of manual operation using copy-milling machine (Zirkograph 025 ECO, ZirkonZahn, Bruneck, Italy). A ceramic restoration was made for each plaster die then the marginal gaps were measured using scanning electron microscopy (SEM) (Leo 1457 VP, Germany 2002). Data were analysed using the two-way analysis of variance (ANOVA) and SPSS ver.16 (Figures 1-3).

Figure1 Samples preparation (1)

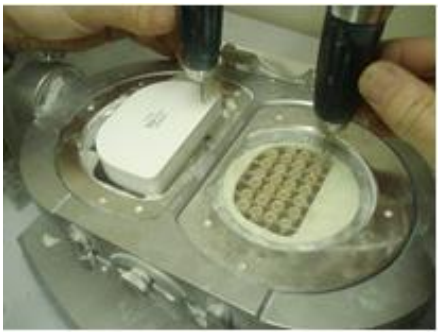


Figure 2 Samples preparation (2)

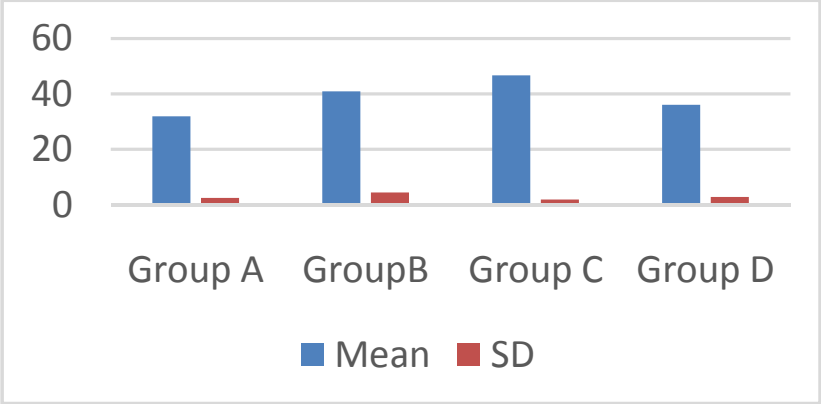
Figure 3 Samples preparation (3)

3. RESULTS

The lowest mean marginal gap was observed in group A and the highest mean marginal gap was related to group C (Table 1). Two-way analysis of variance (Table 1 & Graph 1) showed that the line angle has a significant effect on the distance between the edge of the crown and the dye edge ($p < 0.001$). As well as, the effect of finish line/convergence angle on the distance between the edge of the crown and the dye edge was significant ($P<0.05$). However, the type of the finish line did not influence the marginal fit ($P>0.05$) (Table 1 & Graph 2).

Table 1 Mean ± SD of the marginal gap for the experimental groups

Groups	Mean	SD
A	31.9423	1.81559
B	40.9537	2.17905
C	46.7030	2.35349
D	36.0300	1.98126



Graph 1 Mean ± SD of the marginal gap for the experimental groups

The lowest mean (±standard deviation) marginal gap was observed in group A (31.9423, convergence angle of 12 degrees and radial shoulder margin), group D (36.03), group B (40.9537), group C (46.703), respectively.

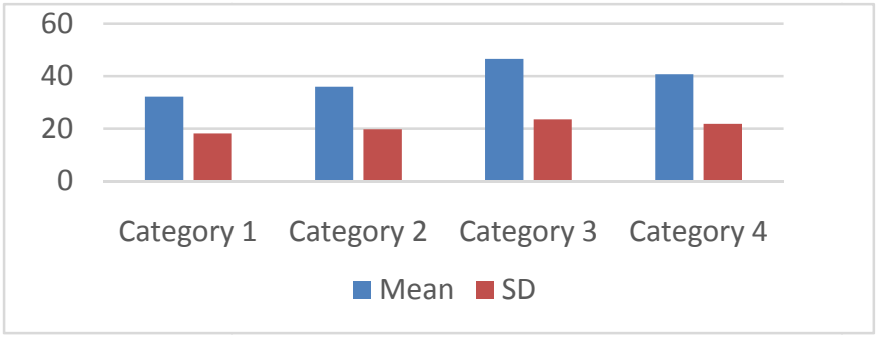
Table 2 Two way-ANOVA test among the studied groups

Types of effect	P value (Sig.)
Convergence angle/Marginal fit	0.000
Finish line/Marginal fit	0.618
Convergence angle- Finish line/Marginal fit	0.024

The results of Table 2 represent that the axial wall convergence affects the marginal fit of zirconia-supported ceramic restorations. Additionally, the interaction of convergence angle/marginal fit was sifnificant, but the type of finish line alone did not have significant effect on marginal fit.

Table 3 Mean ± SD value of marginal and internal gaps depending on the distance between the edge of the crown and the die edge and convergence angle- finish line/Marginal fit

Category in Graph 2	Convergence angle	Finish line	Mean	SD
1	12°	Radial Shoulder	32.2199	18.15586
2	12°	Radial Shoulder 135°	35.9343	19.81261
3	6°	Radial Shoulder	46.5720	23.53486
4	6°	Radial Shoulder 135°	40.7714	21.79048



Graph 2 Mean ± SD value of marginal and internal gaps depending on the distance between the edge of the crown and the die edge and convergence angle- finish line/Marginal fit.

The results of the Table 3 and graph 2 display that the convergence angle of 12° the radial shoulder of finish line has the lower marginal gap compared to 135° radial shoulder finish line. However, with the 6° convergence angle and 135° radial shoulder finish line lower marginal gap formation was found. No significant difference was found between the radial shoulder finish line and 135° radial shoulder finish line.

4. DISCUSSION

Re *et al*., 2014 examined the marginal fit of Lava Zirconia crown-copings on chamfer and shoulder preparations and concluded that chamfer and shoulder preparations did not show differences regarding the gap dimension which was consistent with the results of the present study (Re et al., 2014).

Euán *et al*., 2014 studied the marginal adaptation of zirconium dioxide copings: influence of the CAD/CAM system and the finish line design and showed that all marginal gaps were within the range of clinical acceptability for both groups which was in agreement with the results of the presents study (Euán et al., 2014).

Tinschert *et al*., 2001 in a study evaluated the marginal fit of alumina-and zirconia-based fixed partial dentures produced by a CAD/CAM system. The results of the study showed that the mean vertical discrepancies were in a range from 20.9 to 48.0 µm and mean horizontal discrepancies were in the range of 42.0 to 58.8 µm. In the present study the marginal gap of studied groups was in the range of 31.492 to 46.703µm. The results of the present study and Tinschert *et al*.'s study both were meet the clinical requirements, the selection of 100 µm as the limit of clinical acceptability (Tinschert et al., 2001).

Leonardo Buso *et al*., 2004 evaluated the the marginal fitness of coping made with the electroforming Gramm. Two identical stainless steel master casts were milled using long chanfer and round shoulder preparation designs. The results of the study showed that the type of finish line design did not influence the marginal adaptation which was consistent with the results of the present study (Leonardo et al., 2004).

Akbar *et al*., 2006 compared the marginal adaptation of Cerec 3 CAD/CAM composite crowns using two different finish line preparation designs, chamfer and shoulder. The results of the study suggested that both the chamfer and shoulder groups were considered clinically acceptable and concluded that the finish line preparation design had no effect on marginal adaptation for Cerec 3 composite crowns which was in agreement the results of the present study (Akbar et al., 2006).

Ayad, 2008 examined the effect of the crown preparation margin and die type on the marginal accuracy of fiber-reinforced composite crowns. The results oF the study showed significant differences among the die material used for the shoulder margin design. However, there was no significant difference between light chamfer and deep chamfer margin designs for both die materials. The difference berween the results of Ayad's study and the present study may be explained due to different restoration materials, the number of samples, finish line designs, and the measurement method (Ayad, 2008).

Beuer *et al*., 2008 compared the marginal and internal fits of three milling systems used for fabrication of zirconia substructures. The results of the study showed a significant difference among all studied systems and all systems tested showed marginal gaps within the standard of clinical acceptability whch was in agreement with the results of the present study (Beuer et al., 2009).

Seo *et al*., 2009 examined the effect of preparation designs on the marginal and internal gaps in Cerec3 partial ceramic crowns. Cerec3 PCCs of three different preparation designs were fabricated: 1- conventional functional cusp capping/shoulder preparation, 2- horizontal reduction of cusps, 3- complete reduction of cusps/shoulder preparation. The margins were finished with 1.5 mm shoulder preparation. The mCT method was used to evaluate the marginal and internal gaps between the tooth and the PCC. The results of the study showed that the preparation designs influence the mean marginal and internal gaps, simple designs displayed

superior results when compared to traditional cusp capping design. The difference between the Seo *et al*. and the present study could be explained due to different finish line design and measurement device (Seo et al., 2009).

Jalalian *et al*., 2010 evaluated the effect of chamfer and radial shoulder finish line designs on marginal adaptation of all-ceramic Cercon restorations and concluded that the marginal gap of chamfer preparation is less than that of radial shoulder which inconsistent with the results of the present study. The difference between the Jalalian *et al*. and the present study could be explained due to different finish line design and measurement method (Jalalian and Mirtorabi, 2010).

5. CONCLUSION

The type of the finish line did not influence the marginal fit. The convergence angle influences the distance from the edge of the crown to the edge of the tooth finish line. It seems that use the convergance angle of 12 degree and radial shoulder margin can reduce the marginal gap in zirconia all-ceramic restorations.

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Conflict of Interest

There is no Conflict of Interest

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