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Effect of design and material on vertical margin gap distance of all-ceramic bridges

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Abstract

Objective: The aim of this study was to compare the vertical margin gap distance of fixed-fixed and cantilever bridges made of two types of ceramics, translucent full-contour zirconia and press-veneered zirconia.

Materials and Methods: A total number of twenty samples were constructed then divided into two equal groups according to the design of the bridge. Each group was then subdivided into two subgroups according to the material of construction.Vertical marginal gap distances were measured and statistically analyzed.

Results: fixed-fixed full contour zirconia showed the lowest mean vertical margin gap distance followed by fixed-fixed veneered zirconia, cantilever veneered zirconia, and cantilever full-contour zirconia (21.01±9.63 µm, 24.99±7.52 µm, 39.17±8.3 µm and 63.26±13.92 µm respectively).

Conclusion: The marginal gap distancesfor the testeddesigns and materials were within the clinically acceptable range. However the effect of the cantilever design should be further investigated.

Keywords: Cantilever, All-ceramic, Full-Contour Zirconia, Translucent zirconia, Vertical margin gap distance

Introduction

The use of all-ceramic crowns and bridges is gaining popularity between dentists and patients as well due to their biocompatibility, superior mechanical properties and the development of CAD/CAM technology.

After milling of zirconia it has to be veneered with ceramic veneer in layering or press technique. This veneering ceramic shows lower strength compared to high strength zirconia. Moreover, it is directly exposed to chewing, clenching and moisture which might weaken the veneering resulting in cracks or chipping. Alternatively, full-contour zirconia restorations can be fabricated with occlusal design without veneering. Fabricating mono-block restorations from zirconia could increase the mechanical stability and enlarge the scope of indications.

Apart from the mechanical properties and esthetics, the long term clinical success of all-ceramic fixed prosthodontics can be affected significantly by marginal discrepancies. Poor marginal adaption increases plaque retention and alters the distribution of the micro flora which can induce the onset of periodontal diseases.

In this study, vertical margin gap distance measurement is conducted to evaluate the effect of using monolithic translucent zirconia, compared to press-veneered zirconia either with traditional fixed-fixed design or with cantilever design for the replacement of a missing posterior tooth. The null hypothesis of this study was that vertical margin gap distance of all ceramic bridges was neither influenced by bridge design nor by bridge material.

Materials and methods

A total number of twenty fixed partial dentures were constructed. The FPDs were divided into two equal groups according to FPD design.

Group I: FPDs replacing missing upper first bicuspid with a fixed-fixed design where upper canine and second bicuspid served as abutments

Group II: FPDs replacing missing upper first bicuspid with a cantilever design where upper second bicuspid and first molar served as abutments.

Each group was further subdivided into two equal subgroups (5samples each) according to the material of construction of the FPDs:

Subgroup A: the FPDs were constructed from zirconia frameworks and veneered by pressed ceramic veneer.

Subgroup B: the FPDs were constructed from translucent non-veneered zirconia

A special partially edentulous maxillary model with missing maxillary first bicuspid was prepared to simulate the two designs. The two prepared designs were duplicated into metal models which were scanned in 3Doptical scanner (S600, ZirkonZahn, Gais, Italy). The fixed-fixed and cantilever designs were performed using CAD software (Modellier, ZirkonZahn, Gais, Italy). The core frameworks for the two designs were milled from zirconia blocks (Inceram YZ, VITA Zahnfabrik, Bad Sackingen, Germany) in a 5-axis milling machine (5 Tec, ZirkonZahn, Gais, Italy). The frameworks were sintered (Zirkonfen 600,ZirkonZahn, Gais, Italy) and seated onto the metal models.

The frameworks for the two designs were scanned and the wax pattern of the veneer were designed and milled from wax discs using CAD/CAM system (ZirkonZahn, Gais, Italy) and were seated on the frameworks. The whole assembly was sprued, invested and the veneering material (ZirPress ingots, IvoclarVivadent, Schaan, Lichtenstein) was heat-pressed over the zirconia framework as shown in figure 1.

Fig. 1: Fixed-fixed and cantileverveneered zirconia bridge.

The veneered frameworks of both designs were scanned in order to fabricate the full-contour restorations with the same dimensions, after that the scanned images were adapted to the corresponding scanned models. The full-contour zirconia restorations were milled from translucent zirconia discs (Prettau, ZirkonZahn, Gais, Italy), sintered and seated on the metal models as shown in figure 2.

Fig. 2: Fixed-fixed and cantileverFull-contour zirconia bridge.

The vertical marginal gap distance between the cervical margin of the samples and the master models was measured using a stereomicroscope (Olympus, SZ-PT; Japan) at three definite fixed points for each surface of the retainer. For the buccal surface, a point was marked at the mid buccal, another two points: 2 mm mesial and 2 mm distal to the mid buccal point were marked too. The same was done for all the surfaces. The inaccessible surfaces were marked at two points only at the axial line angles.

A measuring jig was specially designed in order to hold the samples during the microscopic measurements. For each retainer, the area of interest was captured by CCD digital camera (DP 10-Olympus, Japan), mounted in the stereomicroscope. The vertical marginal gap distance between the cervical margin of the retainers and the finish line on the metal master model was assessed at the predetermined, previously marked, points. These readings were calculated using image analysis software (Image J-1b, USA).

Data were presented as mean and standard deviation (SD) values. Data were explored for normality using D'Agostino-Pearson test for Normal distribution. Marginal gap distance (µm) data showed a non-parametric distribution; Mann Whitney U-test have been used to study the effect of fixed partial denture design and construction material on mean Marginal gap distance (µm) within each group and subgroup respectively. Kruskal Wallis test was used to study the interaction between the variables. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA).

Results

The mean vertical margin gap distance of each surface for every retainer in the different groups and subgroups was calculated in microns (µm).

Fig. 3: Vertical margin gap distance of veneered fixed-fixed bridge (Group I, Subgroup A).

Fig. 4: Vertical margin gap distance of translucent zirconia fixed-fixed bridge (Group I, Subgroup B).

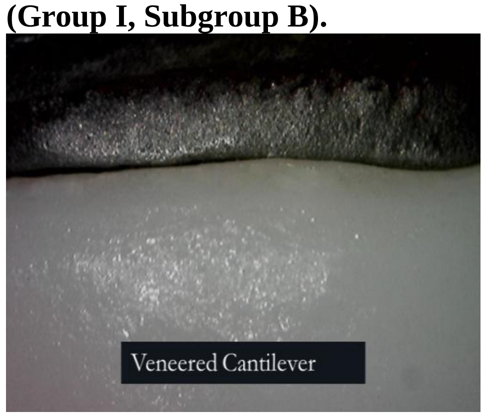

Fig. 5: Vertical margin gap distance of veneered cantilever bridge (Group II, Subgroup A).

Fig. 6: Vertical margin gap distance of translucent zirconia cantilever bridge (Group II, Subgroup B).

Photomicrographs were taken at magnification 50X (Figures 3-6)

1. Effect of different fixed partial denture design on mean vertical margin gap distance (µm):
   Significant difference resulted between Group I (fixed-fixed) (23±8.82 µm) and Group II (cantilever) (51.22±16.63 µm) at $p \leq 0.001$.
2. Effect of different construction materials on mean vertical margin gap distance (µm):
   Insignificant difference resulted between Subgroup A (zirconia frameworks + pressed ceramic veneer) (32.08±10.62 µm) and Subgroup B (translucent non-veneered zirconia) (42.14±24.36 µm) at p=0.139
3. Effect of different groups and subgroups on mean vertical margin gap distance (µm):
   Fixed-fixed translucent non-veneered zirconia bridges (21.01±9.63 µm) showed the lowest mean vertical margin gap distance (µm) followed by fixed-fixed zirconia frameworks with pressed ceramic veneer bridges (24.99±7.52 µm) followed by cantilever zirconia frameworks with pressed ceramic veneer (39.17±8.3µm) followed by cantilever translucent non-veneered zirconia (63.26±13.92)

A significant difference between each group and subgroup was found at p=0.001, with the exception of the veneered and non-veneered fixed-fixed bridges which showed non-significant difference at P=0.05 as shown in Table 1 and Figure 7.

Table 1: Means and standard deviations (SD) of vertical margin gap distance (µm) for different groups and subgroups.

	fixed-fixed + zirconia framework + pressed ceramic veneer		fixed-fixed + translucent non-veneered zirconia		cantilever +zirconia framework + pressed ceramic veneer		cantilever +translucent non-veneered zirconia		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Vertical margin gap distance	24.99^{c}	7.52	21.01^{c}	9.63	39.17^{b}	8.30	63.26^{a}	13.92	≤0.001*

*Means with the same letter within each row are not significantly different at p=0.05. *=Significant*

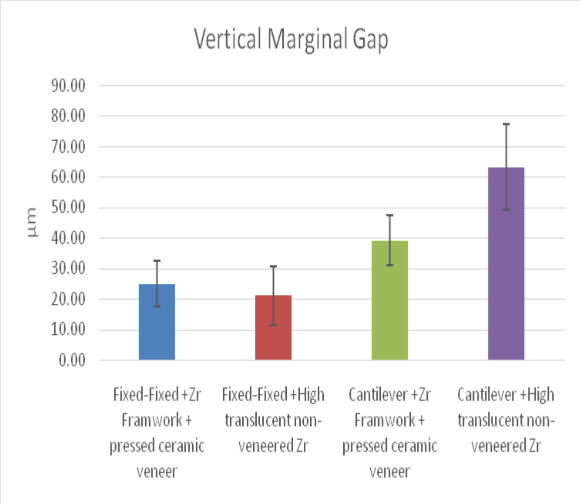

Fig. 7: Bar chart showing the mean vertical margin gap distance (µm) for different tested groups and subgroups.

Discussion

The null hypothesis of this study that vertical margin gap distance of all ceramic bridges was neither influenced by bridge design nor by bridge material was partially rejected. All vertical margin gap distance measurements were performed on master metal models before cementation as some authors suggested that the cement layer complicates the possibilities of obtaining information about primary precision due to individual manufacturing process, in addition, cement layer may cover measurement points or at least make them difficult to precisely locate [5, 9].

Several authors have verified that the marginal discrepancy of all-ceramic crowns is influenced by several factors. While some investigations have evaluated clinical variables such as tooth preparation geometry or type of the cement, in other studies, factors related to dental laboratory fabrication techniques have been assessed[11, 12,15].

Throughout the veneering process the restoration undergoes multiple firing procedures and they can be distorted causing misfit [10]. Distortion creates a potential gap between the restoration and the preparation. As this gap increases, buildup of more plaque resulting in gingival inflammation and caries. In addition, variation in fit can create stress concentrations, which may lower the strength of the restoration[1, 18].

In the current study, the obtained results of the marginal gap distance have shown that there was a statistical significant difference in vertical margin gap distance between the tested groups, with the exception of the veneered and full-contour bridges of the fixed-fixed design group, where there was a non-significant difference.

The least marginal gap distance values were found in the fixed-fixed full contour with mean value of 21µm and the largest vertical marginal gap distance was detected in the cantilever full contour group with mean value of 63 µm. Fixed-fixed and cantilever veneered groups had a mean value of 25 and 39 µm respectively. The differences may be attributed to the effect of design and construction methods used on the quality of the marginal fit.

In the case of the fixed-fixed design, there was a non-significant difference between the veneered bridges (24.99 µm) and full contour bridges (21.01 µm). This is in accordance with Miura et al (2014)[8] who found no significant difference in margin fit after porcelain firing to zirconia cores.

On the contrary, in the case of cantilever bridges, the mean value of margin gap distance of the full contour bridges (63.26 µm) was larger than that of the veneered bridges (39.17 µm). The relatively opened margin observed in the cantilever bridges may have been too obvious to the technicians to seal the gap by wax during wax pattern construction of the pressed veneer. This is in accordance with Martinez-Rus et al (2013)[7] who stated that manual layering of veneering material of YTZP crowns demonstrated more favorable marginal fit compared to monolithic restorations.

In this study, the results have shown a significant difference in the vertical margin gap distance between fixed-fixed bridges

(23 µm) and cantilever bridges (51.22 µm) where the cantilever design had larger mean value than the fixed-fixed design. This may be attributed to decreased accuracy of scanning and/or machining due to the proximity of two abutments and retainers respectively.

The post-machining sintering should be taken into consideration, as some researchers pointed that it might influence the marginal and internal fit of the abutments of zirconia bridges [6]. We could assume that for the fixed-fixed bridges, the shrinkage of the pontic was in proximity to the two retainers simultaneously leading to slight shift in the two retainers axes. This might have led to distribution of the distortion on the two retainers, thus decreasing the effect on the marginal adaptation.

While for the cantilever bridges, where the pontic was mesial to both retainers, the increased shrinkage was related to one retainer only leading to significant shift of the center retainer alone which might have had a negative influence on the marginal adaptation of the bridge. The negative impact for the cantilever design might be exaggerated in the full contour zirconia bridges due to the larger dimension of the pontic as the space of the veneer was occupied by zirconia which might have led to increased shrinkage.

Moreover, a relationship between the extension of zirconia FPDs and marginal fit has been documented in the literature. The larger the FPD span, the higher the detected marginal discrepancy[14, 17]. This might have contributed to the results of this study as the cantilever design had a larger mesio-distal length than the fixed-fixed design.

Despite all these factors, the mean marginal gap distance values of all the all-ceramic FPDs constructed in this study were in the same range reported in the literature. The clinically acceptable marginal gap distance measurements include a wide range of values[5].The lack of concurrence may be explained by the variation in the method used for marginal gap distance measurements of cemented and uncemented restorations, the type of the abutment used for measurement, the location and number of points of measurements [16, 2].

Marginal gaps of 23-74 µm were measured for CAD/CAM fabricated all-ceramic crowns [4,17] While, values of 64-83 µm were reported whenzirconia servedas framework material for all-ceramic crowns [3, 16]. In another study investigating the clinical fit of three-unit FPDs constructed from CAD/CAM zirconia frameworks, the mean marginal gap distance of 80 µm was promoted as an acceptable value[13]. Accordingly, the mean vertical marginal gap distance measurements in this study were found to be in the clinically acceptable range.

Conclusion

Cantilever design has increased significantly the vertical margin gap distance of all-ceramic FPDs. The use of full contour zirconia has shown no significant effect on the vertical margin gap distance. Further investigations should be performed to understand the effect of post-machining sintering on the marginal adaptation of all-ceramic FPDs.

References

1. Alkumru, H., Hullah, W.R., Marquis, P.M., Wilson,H.J.. Factors affecting the fit of porcelain jacket crowns. Br Dent J 1988; 164:39-43
2. Beschnidt, S.M., Strub, J.R. Evaluation of the marginal accuracy of different all-ceramic crown systems after simulation in the artificial mouth. J Oral Rehabil 1999; 26:582-593.
3. Bindl, A., Mörmann, WH. Marginal and internal fit of all-ceramic CAD/CAM crown-copings on chamfer preparations. J Oral Rehabil 2005; 32: 441-7.
4. Coli, P., Karlsson, S. Precision of a CAD/CAM technique for the production

of zirconium dioxide copings. Int J Prosthodont 2004; 17: 577-80.

5. Gröten, M., Girthofer, S., Probster, L. Marginal fit consistency of copy-milled all-ceramic crowns during fabrication by light and scanning electron microscopic analysis in vitro. J Oral Rehab 1997; 24: 871-881.
6. Kunii, J., Hotta, Y., Tamaki, Y., Ozawa, A., Kobayashi, Y., Fujishima, A., et al. Effect of sintering on the marginal and internal fit of CAD/CAM-fabricated zirconia frameworks. Dent Mater 2007; 26(6): 820-6
7. Martinez-Rus, M., Ferreiroa, A., Ozcan, M., Pradies, G. Marginal discrepancy of monolithic and veneered all-ceramic crowns on titanium and zirconia implant abutments before and after adhesive cementation: a scanning electron microscopy analysis. Int J Oral Maxillofac Implants 2013; 28:480-487
8. Miura, S., Inagaki, R., Kasahara, S., Yoda, M. Fit of zirconia all-ceramic crowns with different cervical margin designs, before and after porcelain firing and glazing. Dent Mater 2014; 33(4):484-489
9. Nakamura, T., Dei, N., Kojima, T., Wakabayashi, K. Marginal and internal fit of Cerec 3 CAD/CAM all-ceramic crowns. Int J Prosthodont 2003; 16: 244-8.
10. Pak, H.S., Han, J.S., Lee, J.B., Kim, S.H., Yang, J.H. Influence of porcelain veneering on the marginal fit of Digident and Lava CAD/CAM zirconia ceramic crowns. J AdvProsthodont 2010; 2:33-8
11. Pröbster, L.,Geis-Gerstorfer, J., Kirchner, E. &Kanjantra, P. In vitro evaluation of a glass-ceramic restorative material. J Oral Rehabil 1997; 24: 636-645
12. Quintas, A.F., Oliveira, F. &Bottino, M.A. Vertical marginal discrepancy of ceramic copings with different ceramic materials, finish lines, and luting agents: an in vitro evaluation. J Prosthet Dent 2004; 92: 250-257
13. Reich, S., Wichmann, M. &Nkenke, E. &Proeschel, P. Clinical fit of all-ceramic three-unit fixed partial dentures, generated with three different CAD/CAM systems.Eur J Oral Sci 2005; 113:174-179
14. Reich, S., Kappe, K., Teschner, H., Schmitt, J. Clinical fit of four-unit zirconia posterior fixed dental prostheses. Eur J Oral Sci 2008; 116:579-84
15. Shearer, B., Gough, M.B. &Setchell, D.J. Influence of marginal configuration and porcelain addition on the fit of In-Ceram crowns. Biomaterials 1996; 17:1891-1895
16. Sulaiman, F., Chai, J., Jameson, L.M., Wozniak, W.T. A comparison of the marginal fit of In-Ceram, IPS Empress, and Procera crowns. *Int J Prosthodont*1997;10: 478-84.
17. Tinschert, J.&Natt, G.&Mautsch, W. &Spiekermann, H. &Anusavice, K.J. "Marginal fit of alumina- and zirconia-based fixed partial dentures produced by a CAD/CAM system ", Oper Dent 2001; 26:367-374.
18. Tuntiprawon, M., Wilson, P.R. The effect of cement thickness on the fracture strength of all-ceramic crowns. Aust Dent J 1995; 40:17-21.