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Comparison of the Marginal Fit of Pressable Ceramic to Metal Ceramic Restorations

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Abstract

Purpose: The aim of this in vitro study was to compare the marginal adaptation of a pressed ceramic material, when used with and without a metal substructure, to a traditional feldspathic porcelain-fused-to-metal restoration with a porcelain butt margin.

Materials and Methods: A maxillary central incisor typodont tooth was prepared with a 1.5 mm 360° shoulder with rounded internal line angle, and 30 polyether impressions were made. Dies were poured in type IV dental stone, and 30 restorations were fabricated: 10 metal ceramic restorations (MCR) with porcelain butt joints, 10 pressed to metal restorations (PTM), and 10 all-ceramic restorations (PCR). All restorations were evaluated on their respective dies at 45× magnification using an Olympus SZX-12, measurements of the marginal openings were made, and ANOVA and Scheffé post hoc tests were used to evaluate the data.

Results: The mean marginal opening was 72.2 ± 5.9 μm for MCR, 49.0 ± 5.9 μm for PTM, and 55.8 ± 5.9 μm for PCR. The post hoc tests showed that there was a statistical difference between the marginal adaptation of the PTM and MCR groups ($p < 0.05$). There was no significant difference in marginal adaptation between the PTM and the PCR groups, or the PCR and the MCR groups.

Conclusions: The PTM group demonstrated a smaller mean marginal opening than the MCR group. The mean marginal openings of all three groups were within a clinically acceptable range.

The desire for improved esthetics has resulted in increased popularity and widespread use of all-ceramic crowns in dentistry. These all-ceramic restorations must meet requirements for strength, color stability, and precision of fit for clinical success.[1] Due to the solubility of luting agents,[2] minimizing marginal opening is paramount in decreasing prosthetic failure resulting from caries, plaque and food accumulation, and inflammation of the periodontal tissues.[3,4] A marginal gap ranging from 25 to 40 μm for cemented restorations has been suggested as a clinical goal;[5] however, these measurements are seldom achieved in a clinical scenario. There have been numerous studies of various all-ceramic crown systems with a wide range of marginal openings from 0 to 313 μm and a reported mean marginal opening of 155 μm.[6,7] McLean and Fraunhofer[8] examined more than 1000 crowns after a 5-year period and concluded that a marginal opening of $\leq$120 μm was clinically acceptable.

Following the introduction of the metal ceramic restoration,[9] an all-porcelain labial margin was developed by modifying the tooth preparation and metal coping. This restoration design has proven to be a viable option in esthetically demanding situations. More recently, pressable glass ceramic systems have gained in popularity due to their ease of fabrication, good mechanical properties, and decreased porosity.[10,11] The more predictable dimensional stability of pressed porcelain and the ability to eliminate the metal substructure has made these restorations an esthetic alternative to traditional metal ceramic crowns.[12]

The aim of this study was to compare the marginal adaptation of a pressed porcelain restoration, with and without a metal substructure, to a metal ceramic restoration with feldspathic porcelain margins by determining the precision of fit between the crowns and their respective dies.

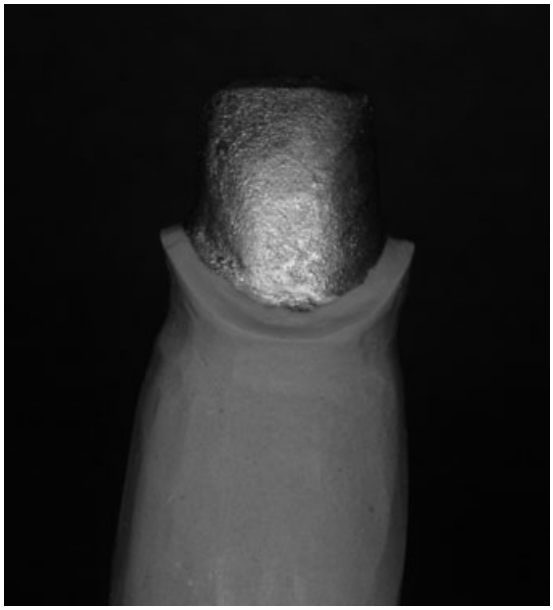

Figure 1 Stone die of preparation.

Materials and methods

The following protocol was adapted from the technique described by Goldin et al.[13] A master model was created by preparing a maxillary right central incisor typodont tooth (Columbia Dentoform, Long Island City, NY) with a uniform 1.5 mm circumferential shoulder with rounded internal line angle and 2 mm incisal reduction. Impressions were made with a polyether impression material (Impregum/Permadyne, 3M ESPE, St. Paul, MN) in disposable stock trays (Coe #32-D, GC America, Alsip, IL). Working dies were fabricated with type IV dental stone (Die-Keen, Heraeus Kulzer, South Bend, IN) using the manufacturer's recommended water/powder ratio, pindexed (Coltène/Whaledent Inc, Mahwah, NJ), and trimmed. One layer of die hardener (Clear Coat, American Dental Supply, Easton, PA) and die spacer (Tru-Fit, George Taub, Jersey City, NJ) were applied to the dies, which were randomly divided into three groups of ten (Fig 1). Group 1 was a traditional metal ceramic restoration (MCR) fabricated from feldspathic porcelain fused to metal (Creation, Jensen, North Haven, CT and Argedent 65SF, The Argen Corporation, San Diego, CA) with 360° porcelain butt joints and served as the control. These restorations were fabricated by a commercial laboratory using the direct-lift technique as described by Vyronis.[14] Group 2 was a leucite-glass ceramic pressed to metal (PTM) (Pulse, Ceramay, Ulm, Germany and Argedent 65SF) with porcelain butt joints using the lost wax technique. Group 3 was fabricated from all leucite-glass-pressed ceramic (PCR) (Authentic, Ceramay) with porcelain butt joints. Both the PTM and the PCR groups were fabricated by a different commercial laboratory than the MCR group.

After fabrication, the restorations were examined for debris and steam cleaned. Each die was mounted using acrylic resin (GC Resin, GC America) on a rotating platform. Four positions were marked (mid facial, mid mesial, mid distal, mid lingual)

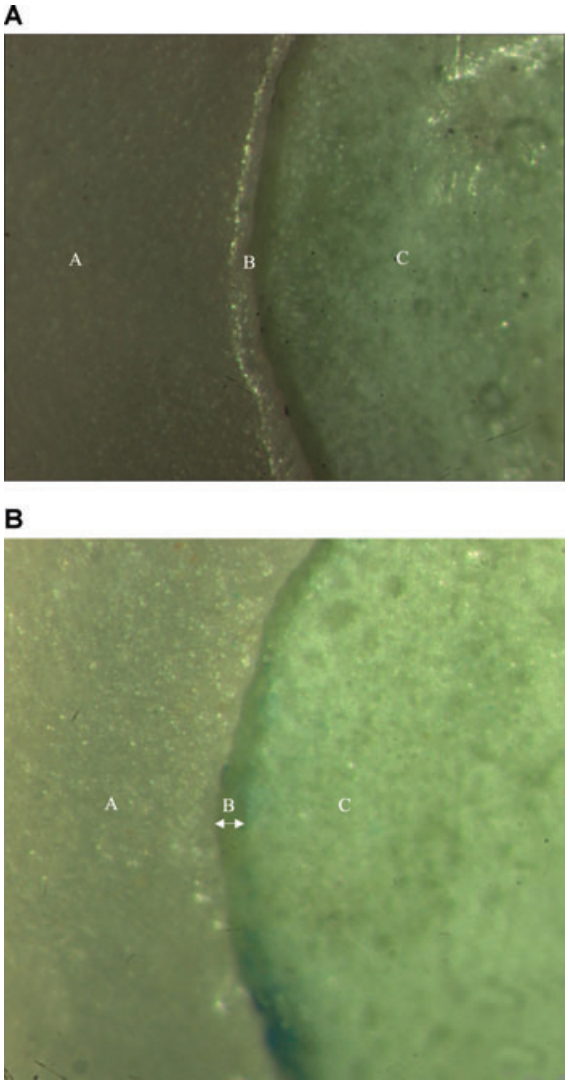

Figure 2 (A) Well adapted pressed-to-metal restoration margin under 45× magnification. A. PTM restoration; B. Marginal opening; C. Stone die. (B) Metal ceramic restoration margin under 45× magnification. A. MCR restoration; B. Marginal opening; C. Stone die.

on the rotating device to ensure the same location of each measurement. The crowns were seated with finger pressure, and a small (1×1 mm^2) amount of composite resin (TPH3 Dentsply International, York, PA) was adapted to the margin away from the measurement area. This was cured and served to "tack" each restoration in place. The crowns were then examined using 45 × magnification (Olympus SZX-12, Singapore), and digital images were captured at each of the four positions (Fig 2). A millimeter calibration slide was used at each viewing session at the same magnification and referenced for calibration. Using image analysis software (Image-Pro Plus, Media Cybernetics, Carlsbad, CA), three measurements were made at each of the four positions for a total of 12 measurements per crown. All measurements were performed by the same investigator. The different surfaces (mesial, lingual, distal, and facial)

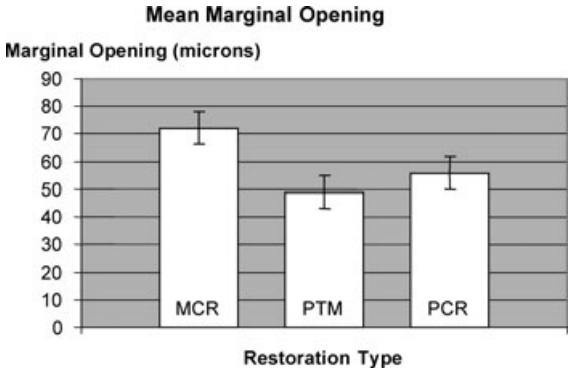

Figure 3 Mean marginal opening

were treated as a repeated measure variable within each sample type, and an ANOVA was conducted using SPSS 15.0 software (SPSS Inc. Chicago, IL). This accounted for the within-condition variances. The between-condition variances were the different materials. A post hoc Scheffé test was performed for pair wise comparison.

Results

A total of 30 restorations were fabricated with 12 measurements made per crown, for a total of 360 measurements. The mean marginal discrepancies are shown in Figure 3. The mean marginal opening was 72.2 $\pm$ 5.9 μm for MCR, 49.0 $\pm$ 5.9 μm for PTM, and 55.8 $\pm$ 5.9 μm for PCR. The post hoc tests showed no significant difference in marginal adaptation between the PTM and the PCR groups. Also, there was no significant difference between the PCR and MCR groups, however, there was a statistical difference between the marginal adaptation of the PTM and the MCR groups (Table 1).

Table 1 Scheffé post hoc test

Restoration type	Restoration type	Mean difference between specimens	Standard error	Significance $p < 0.05$
MCR	PTM	23.192	8.405	0.035
MCR	PCR	16.332	8.405	0.171
PCR	PTM	6.860	8.405	0.720

Discussion

Adaptation of the feldspathic porcelain margin is very technique sensitive,[15,16] and porcelain's tendency to shrink during sintering and spheroid during glazing requires multiple time-consuming steps to correct.[17] The introduction of shoulder porcelains with greater stability during firing and the use of special liquids to decrease shrinkage were an attempt to minimize the need for these corrections.[18] Pressable ceramic systems use the lost wax technique, which eliminates the need for multiple firings and potential marginal changes during conventional sintering techniques.[12,19] These restorations may be fabricated with or without the use of a metal undercasting.[20] If a metal substructure is used, it is waxed short of the margins on the axial wall of the preparation and cast using traditional laboratory techniques.[21] After the opaqing stage, a full contour wax pattern is fabricated and invested, and ceramic is pressed onto the undercasting. Restorations with pressed ceramic margins may be less technique sensitive for the laboratory technician to fabricate than conventional metal ceramic restorations with porcelain butt margins.

The PTM group demonstrated the smallest mean marginal opening while the MCR group demonstrated the greatest ($p < 0.05$). An overall trend was noted that the lingual surface had the largest marginal openings in all three types of restorations, although this was not shown statistically. Previous authors have found that the mid-facial location demonstrated the greatest change in marginal adaptation during fabrication.[22] This has been attributed to greater shrinkage at the margin's center due to the increased bulk of porcelain or the lack of sufficient supporting metal undercasting.[23] It is also feasible that the greater curvature of the lingual margin was more technically challenging for the technician to adapt porcelain to. This would explain the findings in the MCR group, but not the PTM or PCR groups, as these were pressed using a full-contour wax up. The direct-lift technique used in the MCR group has been reported to have potential disadvantages, such as the displacement of the metal coping during shoulder build-up and deformation during firing. This seepage of porcelain under the crown during corrections to the ceramic margin may be responsible for the MCR group having the largest recorded marginal gap.[24,25]

All restorations exhibited a mean marginal opening that was clinically acceptable as described previously,[2-18,20] however, individual specimens demonstrated large differences in marginal openings between surfaces, resulting in large standard deviations. This is in agreement with previous studies,[26,27] which reported marginal openings in the range of 54 to 130 μm along a 300 μm distance on a margin. The term marginal gap, as defined by Holmes et al,[28] is "the marginal gap and the extension error (overextension or underextension)." In many of the specimens with large variations in marginal opening, one surface generally had a very small measurement, while the other three had larger openings. This may have been due to marginal overextension of one surface due to displacement of the crown during corrections, which could have resulted in incomplete seating of the remaining surfaces and the larger marginal openings.

Since all restorations were evaluated as they were returned from the laboratory, the results demonstrated a large range in marginal openings. Earlier studies[20] made measurements using a silicone disclosing medium, but no data exists on its potential film thickness and the effects on marginal opening. Previous studies have made measurements of marginal adaptation on the master tooth in an attempt to mimic a clinical scenario;[13] however, this protocol introduces several potential confounding variables. Since the master tooth was used to make an impression, and stone dies were fabricated for each restoration, there are potential confounding variables in the many laboratory steps including: time between impression making and pouring the die stone, slight variations in water/powder ratio, water temperature, wax distortion, etc. This study placed the

restorations on their respective dies to test the differences in the manufacturing techniques only. The process of restoration fabrication may have a greater effect on the results than the actual restorations themselves. It must also be emphasized that the specimens were placed on their respective dies and the measurements were made without luting material present. Previous authors have found larger marginal discrepancies after cementation.[29,30]

Conclusion

The PTM group demonstrated the smallest mean marginal opening, and the MCR group demonstrated the greatest. Mean marginal openings of all three groups were within a clinically acceptable range and in agreement with previous studies.

References

1. Schwartz NL, Whitsett LD, Berry TG, et al: Unserviceable crowns and fixed partial dentures: life span and causes for loss of serviceability. J Am Dent Assoc 1970;81:1395-1401
2. Swartz ML, Phillips RW, Pareja C, et al: In vitro degradation of cements: a comparison of three test methods. J Prosthet Dent 1989;62:17-23
3. Waerhaug J: Tissue reactions around artificial crowns. J Periodontol 1963;24:172-185
4. Bergenholtz G, Cox CF, Loesche WJ, et al: Bacterial leakage around dental restorations: its effect on the pulp. J Oral Path 1982;11:439-450
5. American Dental Association, ANSI/ADA Specification No. 8 for zinc phosphate cement. In Guide to Dental Materials and Devices (ed 5). Chicago, IL: American Dental Association, 1970-1971: 87-88.
6. Adair PJ, Grossmann DG: The castable ceramic crown. Int J Periodont Restor Dent 1984;4:33-45
7. Pera P, Gilodi S, Bassi F, et al: In vitro marginal adaptation of alumina porcelain ceramic crowns. J Prosthet Dent 1994;72:585-590
8. McLean JW, von Fraunhofer JA: The estimation of cement film thickness by an in vivo technique. Br Dent J 1971;131:107-111
9. Kelly JR, Nishimura I, Campbell SD: Ceramics in dentistry: historical roots and current perspectives. J Prosthet Dent 1996;75:18-32
10. Cattell MJ, Knowles JC, Clarke RL, et al: The biaxial flexural strength of two pressable ceramic systems. J Dent 1999;27:1831-1896
11. Gorman CM, McDevitt WE, Hill RG: Comparison of two heat-pressed all-ceramic dental materials. Dent Mater 2000;16:389-395
12. Johnston JF, Dykema RW, Cunningham DM: The use and construction of gold crowns with a fused porcelain veneer – a progress report. J Prosthet Dent 1956;6:811-821
13. Goldin E, Boyd N, Goldstein G, et al: Marginal fit of leucite-glass pressable ceramic restorations and ceramic pressed-to-metal restorations. J Prosthet Dent 2005;93:143-147
14. Vryonis, P: A simplified approach to the complete porcelain margin. J Prosthet Dent 1979;42:592-593
15. Cooney JP, Richter WA, MacEntee MI: Evaluation of ceramic margins for metal-ceramic restorations. J Prosthet Dent 1985;54:1-5
16. Wanserski DJ, Sobczak KP, Monaro JG, et al: An analysis of margin adaptation of all-porcelain facial margin ceramometal crowns. J Prosthet Dent 1986;56:289-292
17. Omar R: Scanning electron microscopy of the marginal fit of ceramometal restorations with facially butted porcelain margins. J Prosthet Dent 1987;58:13-19
18. Kessler JC, Brooks TD, Keenan MP: The direct lift-off technique for constructing porcelain margins. Quintessence Dent Tech 1986;10:145-150
19. Shillingburg HT, Hobo S, Fisher DW: Preparation design and margin distortion in porcelain-fused-to-metal restorations. J Prosthet Dent 1973;29:276-284
20. Dong JK, Luthy H, Wohlend A, et al: Heat pressed ceramics: technology and strength. Int J Prosthodont 1992;5:9-16
21. Goodacre CJ, van Roekel NB, Dykema RW, et al: The collarless metal ceramic crown. J Prosthet Dent 1977;38:615-619
22. Arnold HA, Aquilino SA: Marginal adaptation of porcelain margins in ceramometal restorations. J Prosthet Dent 1988;59:409-417
23. Berger RP: The art of dental ceramics sculpturing. Dent Clin North Am 1977;21:751-768
24. Prince J, Donovan TE, Presswood RG: The all-porcelain labial margin for ceramometal restorations: a new concept. J Prosthet Dent 1983;50:793-796
25. Strating H, Pameijer CH, Gildenhuys RR: Evaluation of marginal integrity of ceramometal restorations. Part I. J Prosthet Dent 1981;46;59-65
26. Karlsson S: The fit of Procera titanium crowns. An in vitro and clinical study. Acta Odontol Scand 1993;51:129-134
27. Chan C, Haraszthy G, Geis-Gerstorfer J, et al: Scanning electron microscopic studies of the marginal fit of three esthetic crowns. Quintessence Int 1989;20:189-193
28. Holmes J, Bayne S, Holland G, et al: Considerations in measurement of marginal fit. J Prosthet Dent 1989;62:405-408
29. Belser U, MacEntee M, Richter W: Fit of three porcelain-fused-to-metal marginal designs in vivo: a scanning electron microscope study. J Prosthet Dent 1985;53:24-29
30. Hunt JL, Cruickshanks-Boyd DW, Davies EH: The marginal characteristics of collarless bonded porcelain crowns. Quintessence Dent Technol 1978:2;21-26