치의학석사 학위논문

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레진시멘트가 세라믹/시멘트 이중층의 굴곡강도에 미치는 영향

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서울대학교 대학원

치의학과

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치의학과
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김희원의 치의학석사 학위논문을 인준함
2013 년 10 월

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위 원 ______________________ (인)

초 록

1. 목 적

접착치의학의 발전과 더불어 다양한 종류의 복합레진 시멘트가 소개되어 현재 복합레진 및 세라믹을 이용한 간접 치아 심미수복이 매우 빈번하게 시행되고 있다. 그 중에서도 세라믹은 복합레진에 비해 일반적으로 증가된 기계적 강도, 탄성계수, 및 화학적 불활성의 특징을 지니고 있다. 하지만 세라믹이 하중을 받아 균열이 발생할 때 스트레스 강도가 세라믹의 파괴인성 역치 이상이 될 때 crack tip에서 응력이 집중되어 파절이 일어난다. 도재수복물의 임상적인 성공여부는 세라믹과 치아 경조직간의 합착제의 접착력에 의해 영향을 받는다.

이러한 합착에 각종의 시멘트를 사용하게 되는데, 이들 시멘트들의 물성은 각각 다르다. 글라스아이오노머 시멘트는 일반적으로 강성이 낮고 탄성 변형에 민감하다. 이런 문제 때문에 전부도재관을 접착하는 경우 인산아연 시멘트보다 바람직하지 않으며 교합력이 적용될 때 더 큰 인장응력이 발생될 수 있다. 또한 균열이 전파되는데 필요한 에너지인 파괴인성이 복합레진보다 낮다. 레진시멘트는 구강내 타액에서 불용성이며 파절강도도 다른 시멘트보다 높다. 접착제를 사용하여 복합레진 시멘트는 상아질에 접착할 수 있고 법랑질에는 내구성이 강한 접착을 형성한다. 레진시멘트는 모든 종류의 보철물 접착에 적용할 수 있는데, 특히 유지가 불량하거나 심미적인 요구도

가 높은 전부도재관 같은 경우에 유용하다. 특히, 전부도재의 합착에서는 높은 기계적 물성과 합착강도를 보이는 레진 합착 시멘트가 선호되고 있다.

두 층의 구조를 가진 세라믹의 경우, core 층의 강도에 의해 파절저항성이 달라진다는 보고가 있다. 세라믹의 파절저항성에는 물성과 균열의 분포가 영향을 미친다고 알려져 있다. 세라믹의 물성을 평가하기 위해 사용되는 지표로서 굴곡강도가 있다. 굴곡강도는 재료의 기계적 성능을 평가하는 항목으로 널리 사용된다. 실제로 세라믹 수복물을 합착한 경우, 세라믹의 합착면에 대한 산(HF)처리와 더불어 연결재(silane)의 효과적인 처리에 의해 부착시멘트와의 접착면에서 균열(crack)의 생성 정도에 의해 재료의 강도가 결정된다.

본 연구에서는 이러한 합착용 시멘트의 물성에 의해 세라믹 수복물의 파절저항성이 달라질 것이라는 가설을 증명해보고자 한다. 치아에 접착된 세라믹 수복물과 합착시멘트의 층구조를 가정하여 하중이 가해졌을 때 합착시멘트의 종류에 따른 세라믹 수복물의 굴곡강도(flexural strength)를 측정하여 레진시멘트가 세라믹의 파절에 미치는 영향에 대하여 조사하고자 한다.

2. 방 법

본 연구에서는 CAD/CAM 수복에서 사용되는 feldspathic porcelain인 Vita Mark II ceramic (VMII, Vita Zahnfabrik)을 Z-250 (Z250, 3M ESPE), FujiCem (FC, GC), Variolink N (Ivoclar) dual-cured(VL-DC), 및 Variolink N light-cured(VL-LC)의 4가지 시멘트와 합착하여 굴곡강도를 측정하고 파절단면을 관찰하였

다. cement와 합착된 두층의 재료의 물성과의 비교를 위해 각각의 cement만으로 구성된 시편과 ceramic만으로 구성된 시편의 굴곡강도 또한 추가로 측정되었다. 본 연구에서는 만능시험기를 이용하여 시편의 시멘트합착면을 지지점이 위치한 하방으로 향하게 하고 상방으로부터 누르는 3점 굴곡강도를 하중속도 0.5 mm/min로 측정한다. 측정된 굴곡강도는 각각의 시멘트의 종류에 따라 one-way ANOVA를 이용하여 통계분석하고, 균열의 분포에 대한 평가는 weibull 통계를 이용하여 비교, 분석한다.

3. 결 과

합착된 cement에 따라 세라믹-시멘트 합착시편의 굴곡강도간에 유의한 차이가 있는 것으로 나타났다. Z-250으로 합착된 세라믹이 가장 높은 굴곡강도값을 보이며, VL-DC군에서 가장 낮은 굴곡강도값을 보였다($p < 0.05$). FC군과 VL-LC군 간에는 유의한 차이를 보이지 않았다. 추가로 사용된 재료 자체만으로 제작된 시편에서 얻어진 굴곡강도값을 비교해보면 VMII와 Z250군이 가장 높은 굴곡강도값을 나타내었고, VL는 두 가지 중합모드에서 비슷한 평균값을 보였다. FC군에서 가장 낮은 굴곡강도를 보였다($p < 0.05$). FC군의 낮은 굴국강도에도 불구하고 VMII/FC군의 경우 VMII/VL-LC군과 같은 굴곡강도를 보였다.

Weibull modulus 또한 합착된 cement에 따라 서로 다른 값을 보였다. VMII/FC군의 경우 FC의 낮은 굴곡강도에도 불구하고 높은 굴곡강도를 보이는 것은 이 군의 높은 Weibull modulus(m)으로 설명할 수 있었다. 또한 VL-DC군의 높은 굴곡강도에도 불구하고

VMII/VL−DC군의 굴곡강도가 낮은 것은 이 군의 낮은 m값으로 설명이 가능하다. 반면에 VL−DC군의 m값이 높음에도 불구하고 VMII/VL−DC군의 m값이 낮은 것은 VMII 세라믹과 VL−DC시멘트의 합착계면의 조작성 또는 적합성의 문제가 있음을 시사한다. 이상의 결과에서 시멘트로 합착된 시편의 굴곡강도의 해석을 위해서는 합착시멘트의 굴곡강도 뿐 아니라, 시멘트 및 시멘트로 합착된 세라믹 시편의 m값도 고려하여야 함을 알 수 있었다.

주요어 : 레진시멘트; 세라믹; 굴곡강도; 이중층시편; Weibull modulus
학 번 : 2010−22448

Content

Effect of resin cements on the flexural strength of ceramic/cement bilayer

Summary

Objectives: Ceramic restorations are cemented with various luting cements. The fracture resistance of the luted ceramic restorations would be affected by the mechanical properties of the luting cements. This study investigated whether the mechanical properties of luting cements influence the flexural strength (FS) of bilayered ceramic-cement specimens. In this study, we tested the hypothesis that the FS of ceramic restorations luted with various cements be different according to the luting cements. ***Methods:*** Four groups of bilayered specimens were fabricated with four different cements. Z-250 (VMⅡ/Z250, 3M ESPE), FujiCem (VMⅡ/FC, GC), Variolink N dual-cured (VMⅡ/VL-DC, Ivoclar) and Variolink N only light-cured(VMⅡ/VL-LC) were luted on a feldspathic porcelain (Vita Mark II, Vita Zahnfabrik). Furthermore, the monolithic specimens of the materials used were also prepared. FS values were measured with the cement layer bottom on a three point bending test assembly. FS values were analyzed with one-way ANOVA and Weibull statistics.

Results: There were significant differences in the FS between the groups of bilayer specimens ($p < 0.05$). The VMⅡ/Z250 specimens were stronger than the other groups ($p < 0.05$). It was attributed to the highest FS of Z-250. However, although the FS of FC was the lowest among the cements, the FS of VMⅡ/FC was similar to VMⅡ/VL-LC and higher than VMⅡ/VL-DC.

Conclusion: FS of ceramic restorations luted with resin cements were affected by the FS of the cements. In addition to the FS, Weibull modulus should also be considered as a statistics on crack size distribution.

INTRODUCTION

Development of adhesive dentistry has led to the introduction of various composite resin cements into the market and the extensive use of indirect esthetic restorations in the clinic. Compared to composite resins, ceramics has superior properties in terms of mechanical strength, elastic modulus, and chemical stability [1]. However, the low resistance to brittle fracture is a drawback of dental ceramic restoratives, particularly when flaws exist at the area under tensile stresses within a ceramic restoration [16]. The fracture resistance of the ceramic restorations can be influenced by adequate polymerization of resin cement that is necessary for optimal mechanical properties and adhesion strength, as well as the adaptation between the ceramic and resin cement [2-4].

The properties of various cements differ from one another. Hence the choice of cement is mandated to a large degree by the functional and biological demands of the specific clinical situation. If optimal performance is to be attained, the physical and biological properties and the handling characteristics must be considered when selecting a cement for a specific task. Glass ionomer cement (GIC) is generally less stiff and more susceptible to elastic deformation [4]. In this regard, it is not as desirable as zinc phosphate cement to support an all-ceramic crown, because greater tensile stress would develop on the intaglio surface of the crown under occlusal loading [4]. Restorative GIC is also much inferior to composite resins in its fracture toughness, a measure of the energy required to cause crack propagation that leads to fracture [4]. On the other hand, resin cements as a luting agent have attractive advantages, such as insolubility in oral fluids, high fracture strength compared to other cements, compatibility with restorative resins and ceramics with improved properties, and the potential to bond to enamel and dentin by virtue of the acid-etch technique [4].

In the clinical situations, the fragile ceramic restorations were cemented to tooth substrates with luting cements in terms of retention and resistance. As a result, the cemented ceramic restorations can be simulated as a ceramic/cement bilayer. The connection between the ceramic and luted cement is influenced by hydrofluoric acid etching and silane application [6, ref]. At the interface, the strength of the bilayered ceramic/cement specimens can be interpreted using a crack initiation mode [7]. Therefore, to predict the fracture modes and fracture resistance of bilayered ceramic/cement restorations with different designs, it should be standardized as a generalized simple model. Flexural strength (FS) tests and Weibull analysis of the values may be used for evaluating the mechanical properties of the bilayered materials. Factors such as thickness of ceramic layers, mechanical properties of ceramics, elastic modulus of supporting substrate materials, direction, magnitude, and frequency of applied loads, size and location of occlusal contact areas, residual stresses induced by processing, restoration/cement interfacial defects, and environmental effects were suggested to be associated with the stress state created in dental ceramic restorations. [5]

The purpose of this study was to investigate the influence of the luted cements on the FS of the bilayered ceramic-cement specimens. In this study, we tested the hypothesis that the fracture resistance of ceramic restorations would be different according to luted cement. For the purpose, the FS of the resin cements and bilayered ceramic/cement specimens were measured and interpreted using Weibull statistics.

MATERIALS & METHODS

1) Fabrication of specimens

A feldspathic porcelain block (Vitablocs Mark II, 2M2C I10, Vita Zahnfabrik, Bad Sackingen, Germany), which was used as a CAD/CAM restorative material, was sectioned into plates (10 x 8 x 1.9 mm) using a low-speed diamond saw (Isomet, Buehler Ltd., Lake Bluff, IL, USA). For the surfaces to be luted, a standardized roughness was obtained by polishing the luting surface of the ceramic plates on a 600 grit silicon carbide paper using an automatic polishing machine (Rotopol-V, Struers Ltd., Glasgow G60 5EU, UK) under running water. Four sets of bilayered specimens were fabricated with four different cements. Z-250 (3M ESPE, St. Paul, MN, USA), FujiCem(GC Corp., Tokyo, Japan), and dual-cured and light-cured Variolink N (Ivoclar Vivadent AG, Schaan, Liechtenstein) were bonded to the plates. The thickness of the luting cements were controlled to a thickness of approximately 100 μm using a spacer(home-made). We used spacer to get uniform thickness.The bilayered ceramic/cement plates were sectioned into bar-shaped specimens in a dimension of 10 x 2 x 2 mm using the same diamond saw.

The bar-shaped bilayered specimens were divided into four groups according to the cements used: VMⅡ/Z250, bilayered specimen group of Vita Mark Ⅱ and Z250; VMⅡ/FC, bilayered specimen group of Vita Mark Ⅱ and FujiCem; VMⅡ/VL-LC, bilayered specimen group of Vita Mark Ⅱ and light-cured Variolink N; VMⅡ/VL-DC, bilayered specimen group of Vita Mark Ⅱ and dual-cured Variolink N.

- VMⅡ/Z250: The polished surface of the ceramic plate was etched with 4% hydrofluoric acid (HF, Ceramic etchant, Bisco Inc., Schaumburg, IL, USA) for 4 minutes, rinsed with water, and dried with compressed air. Then, one coat of silane coupling agent (ESPE-Sil, 3M ESPE) was applied and left to sit for 5 min to allow the condensation reaction of silane. Subsequently, one coat of adhesive resin (Adhesive of Scotchbond Multi-Purpose Adhesive System, 3M ESPE) was applied to the silanated surface of the ceramic plate with a microbrush and light-cured for 20 seconds with an LED curing unit (Elipar FreeLight 2, 3M ESPE). The light intensity of 800 mW/cm^2 was frequently monitored with a radiometer (Demetron 100, Demetron Research Co., Danbury, CT, USA). Resin composite (Z250) was luted with a spacer and a cover glass and light-cured for 40 seconds through the ceramic plate using the same curing unit.

- VMⅡ/FC : The polished surface of the ceramic plate was etched using the same protocol with the VMⅡ/Z250 group. Then, one coat of the same silane coupling agent was applied and left to sit for 5 min to allow the condensation reaction of silane. Subsequently, FC was applied with the spacer and a cover glass for 5 minutes until initial setting.
- VMⅡ/VL-LC : Etching and silane coating were performed using the same protocol with the previous groups. Subsequently, one coat of adhesive (Excite F DSC, Ivoclar) was applied to the silanated ceramic surface with a microbrush. The base paste of Variolink N (Ivoclar) was applied with the spacer and a cover glass and photopolymerized for 40 s using the same curing unit used in the VMⅡ/Z250 group.
- VMⅡ/VL-DC : Etching, silane coating, and adhesive application were performed using the same protocol with the previous VMⅡ/VL-LC groups. The base and catalyst pastes of Variolink N (Ivoclar) were mixed and applied, and photopolymerized for 40 s using the same curing unit used in the previous groups.

The monolithic specimens were also prepared for composite resin cement (Z250), RMGI cement, FujiCem (FC), Variolink light-cured (VL-LC), Variolink dual-cured (VL-DC), and Vitablocs Mark II Ceramic (VMⅡ).

2) Flexural strength measurement

The flexural strength tests were performed using a universal testing machine with the porcelain layer (top surface) facing the loading plunger and the cement layer (bottom surface) facing the supporting arms during testing. The flexural strength value of each specimen was calculated by means of following expression with maximum load at failure.

$$\sigma(MPa) = \frac{3Fl}{2bh^2}$$

F is the maximum load, in newtons, exerted on the specimen

l is the distance, in millimetres, between the supports

b is the width, in millimeters, of the specimen measured immediately prior to testing

h is the height, in millimetres, of the specimen measured immediately prior to testing

3) Statistical Analysis

One-way ANOVA was used to appraise whether there was any statistical difference among groups. To predict effect of crack, the variability of strength was estimated by calculating the Weibull modulus (m) from the Weibull distribution [8,9]. The lower m, the greater the variability of the strength.

RESULTS

Table 1. Mean flexural strength and Weibull modulus of ceramic/cement bilayered specimens with Vitablocs Mark II (top surface) facing the loading plunger and the cement layer (bottom surface) facing the supporting arms during testing

Bilayered ceramic/cement group	n	Flexural strength mean ± S.D. (MPa)	Weibull modulus (m)	F value/ P-value
VMⅡ/Z250	29	107.9 ± 11.9[1]	10.8	25.533/ 0.000
VMⅡ/FC	21	88.7 ± 6.9[2]	15.4	
VMⅡ/VL-LC	21	89.2 ± 9.4[2]	10.5	
VMⅡ/VL-DC	19	70.2 ± 25.8[3]	2.9	

VM Ⅱ/Z250, bilayered s

composite (bottom surface); VM Ⅱ/FC, bilayered specimens of Vitablocs Mark Ⅱ (top surface) and FujiCem (bottom surface); VM Ⅱ/VL-LC, bilayered specimens of Vitablocs Mark Ⅱ (top surface) and Variolink light-cured (bottom surface); VM Ⅱ/VL-DC, bilayered specimens of Vitablocs Mark Ⅱ (top surface) and dual-cured (bottom surface).

Table 2. Mean flexural strength and Weibull modulus of the monolithic material itself used in the study

Monolithic material group	n	Flexural strength mean ± S.D. (MPa)	Weibull modulus (m)
Z250	11	106.0 ± 31.4	3.0
FC	7	37.0 ± 8.0	4.1
VL-LC	10	73.8 ± 26.3	2.6
VL-DC	10	87.3 ± 16.2	4.8
VMⅡ	10	112.7 ± 10.6	9.8

Z250, monolithic specimens of Z250 resin composite; FC, monolithic specimens of FujiCem; VL-LC, monolithic specimens of Variolink N light-cured; (VL-DC, monolithic specimens of Variolink N dual-cured; VMⅡ, monolithic specimens of Vitablocs Mark Ⅱ.

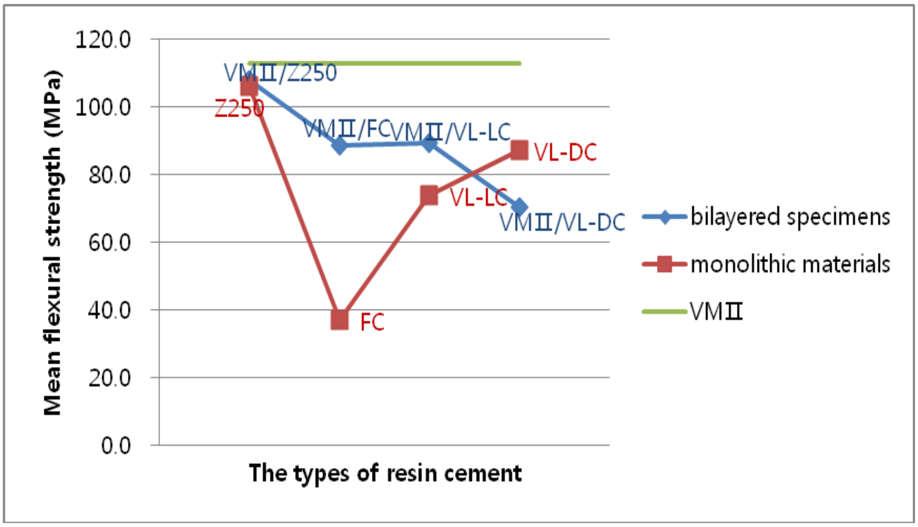

Figure 1. Mean flexural strength of bilayered ceramic/cement specimen groups and monolithic material groups. VM Ⅱ/Z250, bilayered s

(top surface) and Z250 (bottom surface); VM Ⅱ/FC, bilayered specimens of Vitablocs

Mark Ⅱ (top surface) and FujiCem (bo

specimens of Vitablocs Mark Ⅱ (top surface) and Variolink ligh

surface); VM Ⅱ/VL-DC, bilayered specimens of Vitablocs Mark Ⅱ (top surfac

Variolink dual-cured (bottom surface); Z250, monolithic material specimens of Z250; FC, monolithic material specimens of FujiCem; VL-LC, monolithic material specimens of Variolink N light-cured ; VL-DC, monolithic material specimens of Variolink N dual-cured.

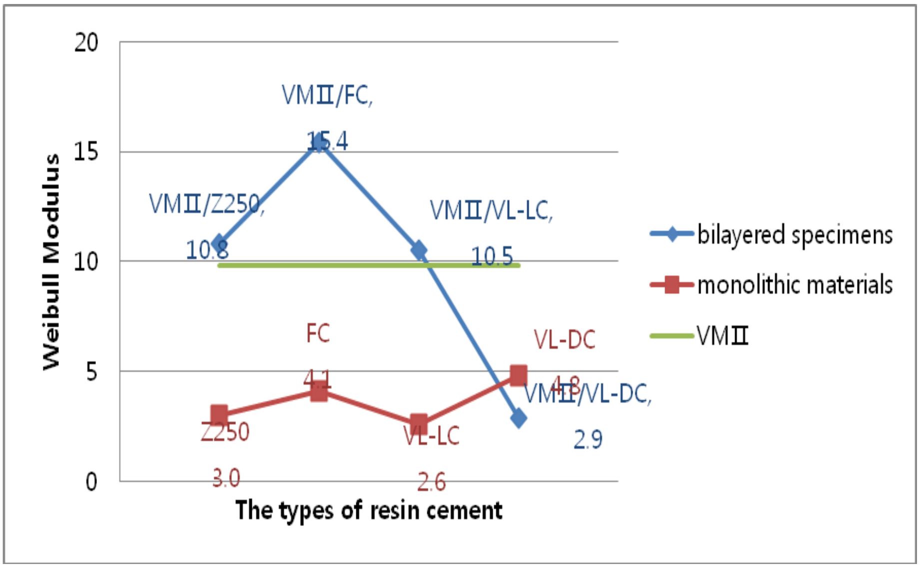

Figure 2. Weibull moduli of bilayered ceramic/cement specimen groups and monolithic material groups. VMⅡ/Z250, bilayered samples of Vita Mark Ⅱ(top surface) and Z250(bottom surface); VM Ⅱ/FC, bilayered sam

surface) and FujiCem (bottom surface); VM Ⅱ/VL-LC, bilayered samples of Vita

Mark Ⅱ (top surface) and Variolink only light cured (bot

bilayered samples of Vita Mark Ⅱ (top surface) and Variolink dua

surface).

The mean flexural strength with standard deviation and Weibull modulus are summarized according to the ceramic/cement bilayered specimen groups and the monolithic material groups in Table 1 and Figure 1. Based on one-way ANOVA, there were significant differences between the mean FS of the bilayered specimen groups ($p < 0.05$). The VM Ⅱ/Z250 was sign stronger than the other groups (VM Ⅱ/FC, VM Ⅱ/VL-LC, and VM Ⅱ/VL-DC, $p < 0.05$). However, there was no significant difference between the FS of VM Ⅱ/VL-LC and VM Ⅱ/FC (Table 1). The mean FS of monolithic specimens were similar to the values in the bilayered specimens except in the FC group (Figure 1). The VM Ⅱ ceramic materia FC showed the lowest FS in this study. However, in spite of the low FS of FC, the FS of the VMII/FC was the same with that of the VMII/VL-LC.

The Weibull modulus is also influenced by the type of the cement at the bottom surface. The Weibull moduli (m) of the bilayered specimens were different among the groups with different luting cements. Even with the lowest FS of FC, the Weibull modulus of VMⅡ/FC (15.4) group was the greatest , while VMⅡ/VL-DC (2.9) group showed the lowest weibull modulus even with the high FS of the VL-DC (Table 2 and Figure 2).

DISCUSSION

The results of the mechanical strength test of the present investigation were consistent with previous studies, which had indicated that the properties of the layer subjected to the tensile stresses, or more precisely on the bottom surface, dictate the ultimate FS in the bilayered specimen [10,11,12,13,14]. The results were therefore different according to which cement was luted on the bottom surface in the specimen configuration tested (ceramic /cement material on the bottom surface). Other investigators have shown that the fracture origin and the fracture mode were greatly influenced by the test configureations and methodologies [10,11,13]. There were statistically significant differences in the FS between groups, along with the highest values in VMⅡ/Z250 and the lowest values in VM II/VL-DC(Table 1). The mean FS of monolithic specimens were similar to the values in the bilayered specimens except in the FC group. This would indicate that the properties of the cement layer affected the ultimate FS of the ceramic/cement bilayered specimen. Clinically, the results suggested that when the ceramic restorations were luted with cements, the clinical performance such as fracture resistance of those restorations can be improved with the cement showing improved strength.

A trend was detected in this study, where the FS of bilayered ceramic/cement (on the bottom surface) was less than the FS of the monolithic samples of porcelain. This result has been related to the development of residual stresses due to the mismatch of the coefficient of thermal expansion, fabrication procedures or surface damage [10,15]. Especially, FC showed the lowest FS in this study. However, in spite of the low FS of FC, the FS of the VMII/FC was the same with that of the VMII/VL-LC. In this case, although there was a considerable FS difference was detected between VMⅡ/FC groups and FC group, the FS of the VMII/FC was dictated by the stregnth of the porcelain layer.

In this study, all ceramic specimens were etched and received one coat of silane coupling agent (ESPE-Sil, 3M ESPE) that was left to sit for 5 min to allow the condensation reaction of the silane. Organo-silanes, generally referred to simply as “silanes” in dentistry, are compounds that contain a silicon (Si) atom or atoms, are similar to ortho esters in structure, and display dual reactivity. Their use in clinical dentistry and the effect on adhesive bonding has been described in detail in the scientific literatures [17,18]. Silanes are commonly used in dentistry to coat glass filler particles in polymer matrix composites, to achieve adhesive bonding of porcelain to resin luting cements for restorative applications. Silanes are also believed to promote surface wetting, which enhances potential micromechanical retention with low viscosity resin cements [17,18].

The conclusion drawn from the mechanical strength tests was also supported by the variability of the strength, here discussed in terms of Weibull modulus, m. If the m which is an empirical constant related to the properties of flaw size distribution in a material, becomes small, a large crack is more likely to be present and so the mean strength for a given volume decreases [19]. The VMⅡ/VL-DC group showed the lowest value of m. It represented the influence of weak chemical bonding of Variolink N and the variability of the specimens.

CONCLUSION

The present study indicates that the flexural strength of the ceramic-cement bilayered specimens were affected by the flexural strength and the modulus of the luting cement itself and the luting procedures dictated by the Weibull modulus of the bilayered specimens. The clinical significance of this study can be found in that the fracture resistance of the ceramic restorations luted with cements were considered with the mechanical properties of the cement itself and the adaptation during the luting procedure.

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Abstract

Effect of resin cements on the flexural strength of ceramic-cement bilayer

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1. Objectives

Development of adhesive dentistry has led to the introduction of various composite resin cements into the market and the extensive use of indirect esthetic restorations in the clinic. Compared to composite resins, ceramics has superior properties in terms of mechanical strength, elastic modulus, and chemical stability. However, the low resistance to brittle fracture is a drawback of dental ceramic restoratives, particularly when flaws exist at the area under tensile stresses within a ceramic restoration. In addition to adequate polymerization of resin cement that is necessary for optimal mechanical properties and adhesion strength, the fracture resistance of the ceramic restorations can be influenced by the adaptation between the ceramic and resin cement.

The properties of various cements differ from one another. Hence the choice of cement is mandated to a large degree by the functional and biological demands of the specific clinical situation. If optimal performance is to be

attained, the physical and biological properties and the handling characteristics must be considered when selecting a cement for a specific task. Glass ionomer cement is generally less stiff and more susceptible to elastic deformation. In this regard, it is not as desirable as zinc phosphate cement to support an all-ceramic crown, because greater tensile stress would develop in the crown under occlusal loading. Restorative GIC is also much inferior to composites in its fracture toughness, a measure of the energy required to cause crack propagation that leads to fracture. On the other hand, resin cements are virtually insoluble in oral fluids, and have higher fracture strength than other cements. Resin cement has attractive advantages as a luting agent, such as compatibility with restorative resins and ceramics with improved properties, and the potential to bond to enamel and dentin by virtue of the acid-etch technique

In the clinical situations, the ceramic restorations were cemented to the tooth substrates with luting cements. As a result, the cemented ceramic restorations can be simulated as a ceramic-cement bilayer. The connection between the ceramic material and luted cement is influenced by hydrofluoric acid etching and silane application. At the interface, the strength of the bilayered ceramic-cement specimens can be interpreted using a crack initiation mode. Therefore, to predict the fracture modes and fracture resistance of the bilayered ceramic restorations with different designs, it should be standardized as a generalized simple model and flexural strength (FS) tests and Weibull analysis of the values may be used for evaluating the mechanical properties of the bilayered materials.

The purpose of this study was to investigate the influence of the luted cements on the FS of the bilayered ceramic-cement specimens. In this study, we tested the hypothesis that the fracture resistance of ceramic restorations would be different according to luted cement.

2. Methods

Four sets of bilayered specimens were fabricated with four different cements bonded to the feldspathic porcelain, Vita Mark II ceramic (VMII, Vita Zahnfabrik). The cements used in this study were Z-250 (Z250, 3M ESPE), FujiCem (FC, GC), Variolink N dual-cured (VL-DC, Ivoclar), and Variolink N only light-cured (VL-LC). Furthermore, the monolithic specimens of the materials used in this study were prepared to compare with bilayered specimens. The specimens were fractured and tested in a FS test mode with the cement layer facing the supporting jigs using a universal testing machine. The FS values were statistically analyzed using one-way ANOVA and also interpreted with Weibull statistics.

3. Results

Based on one-way ANOVA, there were significant differences between the mean FS of the bilayered specimen groups ($p < 0.05$). The VMⅡ/Z250 was significantly stronger than the other groups (VMⅡ/FC, VMⅡ/VL-LC, and VMⅡ/VL-DC, $p < 0.05$). However, there was no significant difference between the FS of VMⅡ/FC and VMⅡ/VL-LC . The mean FS of monolithic specimens were similar to the values in the bilayered specimens except in the FC group.. The VMⅡ ceramic material showed the highest FS and FC showed the lowest FS in this study. However, in spite of the low FS of FC, the FS of the VMII/FC was the same with that of the VMII/VL-LC.

The Weibull moduli (m) of the bilayered specimens were different among the groups with different luting cements. The high FS of the VMII/FC even with the lowest FS of FC might be attributed to the high m value of the bilayered group. Even with the high FS of the VL-DC, the low FS of VMII/VL-DC can also be attributed to the low m values of this bilayered group. The difference between the high m value in the VL-DC and the low m value in the VMII/VL-DC suggested some problems in handling characteristics and adaptation of the cement to the ceramic in the dual cure mode. In conclusion, to interpret the FS of the ceramic restorations luted with cements, the m values of the bilayered specimens as well as the FS of the material itself need to be considered.

Keywords : Resin cement; Ceramic; Flexural strength; Bilayered specimen; Weibull modulus

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