EVALUATION OF THE FILM THICKNESS OF NEW ADHESIVE LUTING RESINS[+]

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تم حديثًا تعديل وتطوير مادة الكومبوزيت وذلك بتصغير جزئياته وتخفيف لزوجته لغرض الحصول على انطباق أفضل بين حواف التاج وحواف التحضير. ولقد حددت سماكة بعض أنواع الاسمنت الراتنجي سابقًا في بعض المقالات. الهدف من هذه الدراسة هو مقارنة سماكة بعض الأنواع الحديثة من الأسمنت الراتنجي اللاصق مع اسمنت فوسفات الزنك وذلك باستخدام طريق مطوره.

تحضيـــر العينات :-

قورنت في هذه الـدراسة سماكة خمسة أنواع من الاسمنت الراتنجي مع اسمنت فوسفات الزنك وطريقة تحضير العينات مماثلة بشكل كبير لمواصفات الجمعية الأمريكية لطب الأسنان رقم (٨) والتي تستخدم لتحديد سماكة اسمنت فوسفات الزنك. ولكن بدلاً من استخدام قرصين زجاجيين مسطحين ومن ثم تحديد السماكة بجهاز قياس السماكة **(Micrometer)** فقد استخدمنا قرصين بلاستيكيين مسطحين بالامكان قطعهما في عدة مستويات معروفة ومن ثم قياس سماكة الاسمنت بين القرصين مباشرة بالمجهر المتحرك **(Travelling Microscope)**.

النتـــائـــج :-

كانت سماكة اسمنت **(Mirage FLC)** هي الأقل بينما سماكة اسمنت **(Panavia Ex)** و **(Voco F21)** كانت أكثر قليلاً من **(Mirage FLC)** وأقل قليلاً من **(C & B metabond)** و **(Zinc phosphate)** ومع ذلك فاحصائيًا ليس هناك فرق واضح. ولكن احصائيًا كان هناك اختلاف بين **(Mirage FLC)** وكلا من **(C & B Metabond)** و **(Zinc phosphate)**. أمـا سماكـة اسمنت **(All-BOND)** فكانت أعلى من بقية المجموعات بفرق احصائي واضـح. لقـد كانت غالبية سماكة أنواع الاسمنت الراتنجي شبيهة أو أفضل من سماكة فوسفات الزنك ماعدا اسمنت **(All-BOND)** فإن سماكته كانت نسبيًا مرتفعة.

توصلت هذه الدراسة لبعض الاقتراحات التي يجب مراعاتها عند اختيار اسمنت راتنجي لاصق.

Recently, several composite resins have been reformulated as adhesive luting agents. The film thickness of some resinous cements has been reported in the literature, however the results were inconsistent. The purpose of this investigation was to compare the film thickness of five relatively new adhesive luting resins with that of zinc phosphate cement. The method used was generally in compliance with the American Dental Association (ADA) specification No. 8 for zinc phosphate cement. Tested materials were manipulated as described by the manufacturer. The film thickness of each cement was measured 10 times. The results, presented in an increasing order of film thickness were: Mirage FLC, Panavia Ex, Voco F21, Flecks zinc phosphate, C & B Metabond, and finally All-Bond. The film thickness of the adhesive luting resins tested were comparable to or thinner than zinc phosphate cement except for All-Bond luting resin. Suggestions are made regarding the selection of an adhesive luting resin.

Received 17/10/94; revised 18/12/94; accepted 19/02/95

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tPresented at the *8th International Saudi Dental Meeting,* January 1994, Riyadh, Saudi Arabia.

Introduction

When Bowen[1] first introduced resins, based on aromatic dimethacrylates of the Bis-GMA type, they exhibited improved properties over resins based on methyl methacrylate. This was especially true regarding viscosity, wettability, lower polymerization shrinkage, and a strong bond to tooth structure. A variety of Bis-GMA based restorative resins are used as luting agents.[2] A commonly reported disadvantage of these luting agents was their high film thickness, a situation that may prevent complete seating of the restoration, and could lead to decreased retention and increased solubility.[3,4] However, the chemical components, filler particle size, viscosities, diluting monomers, and setting reactions were reformulated to result in a lower film thickness of the various new adhesive luting resins.[2,5,6] Reformulated adhesive luting resins are marketed and used more routinely for the cementation of conventional fixed partial denture.[7] Although the film thickness of certain available brands has been reported in the literature,[8,11] the results were inconsistent.

The purpose of this study was to determine the film thickness of five new adhesive luting resins and compare it with that of zinc phosphate cement, since it is the most "tried and proven" material for permanent conventional cementation.[3]

Materials and Methods

Five adhesive luting resins plus zinc phosphate cement were evaluated in this study (Table 1). The total was six groups, each group included 10 samples. The technique for measuring the film thickness was generally in compliance with ADA specification No. 8 for Zinc phosphate cement. Tests were conducted at room temperature of 23°C ± 2°C and a relative humidity of 50% ± 10%. Materials were manipulated according to the manufacturer's instructions. Immediately after mixing each cement, the materials were placed between two identical flat plastic discs*, 3/4 inch in diameter and of uniform thickness and smoothness, then sustained under 15 kg static load for 10 minutes with a custom made loading device [Fig 1]. Following loading, the composite of 2 plastic discs with the cement film in between was sectioned at three levels [Fig.2] to facilitate direct measurement of the resin film at different localities under a magnifying lens of a travelling microscope equipped with a filar unit measuring eyepiece with an accuracy of 0.5 micrometer**. The lowest reading was registered as film thickness for each specimen. The mean film thickness for each group and it's standard deviation was then calculated. The resulting data were subjected to one way analysis of variance (ANOVA) to determine whether differences exist among the groups, and Tukeys' multiple range test to determine which groups are statistically similar.

Table 1. Brand names, formulations and manufacturers of luting agents tested in the study.

Material	Formulation	Manufacturer
Flecks	Phosphate-based	Keystone, Cherry Hill, NJ, USA
Mirage FLC	Resin-based	Chameion Dental Products Inc, Kansas City, KS, USA
Panavia Ex	Resin-based	Kuraray, Okayama, Japan
VocoF21	Resin-based	Voco, Cuxhaven, Germany
C & B Metabond	Resin-based	Sun Medical, Kyoto, Japan
All Bond	Resin-based	Bisco, Downers Grove, IL, USA

Figure 1. Loading Device.

*Plastic Products Co Inc, Birmingham,Alabama, USA.
**Micromet II, Buehler Ltd., Lake Bluff, Illinois, USA.

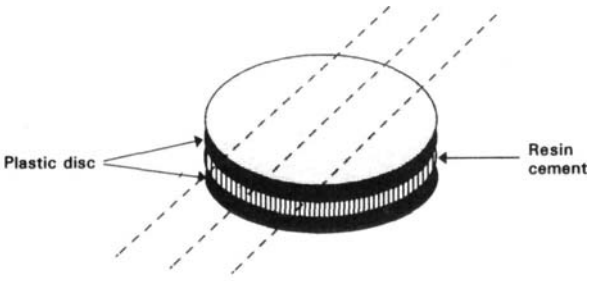

Figure 2. Schematic illustration of two plastic discs sandwiching a resin cement. (Dotted lines indicate the sectioning levels.)

Results

The mean film thickness and standard deviations for all the groups are presented in Figure 3. ANOVA revealed significant differences among groups at the $p < 0.05$ level. Table 2 shows a summary of Tukeys' multiple range test.

Luting resins with the least film thicknesses were: Mirage FLC, Panavia Ex and Voco F21 with no statistical differences among them. Zinc phosphate cement and C & B Metabond luting resin had statistically significant higher film thickness than Mirage FLC, but not when compared to Panavia Ex and Voco F21. All-Bond luting resin exhibited the thickest film among the six cements tested in this study with highly significant differences when compared to the other groups.

Discussion

The standard test for film thickness outlined in ADA specification No. 8 for zinc phosphate cement[12] requires loading of the cement between two glass discs. The film thickness was then determined by subtracting the initial thickness of the two glass discs before loading the cement from their thickness and after loading using a micrometer. In this study, a modification of the ADA testing technique was used. The glass discs were replaced by plastic discs. This modification allows multiple sectioning of the discs in order to make direct measurement of the film thickness at different localities. Interestingly, a variation in the film thickness was observed at various localities between the two discs. The authors attributed the differences of film thickness at various localities on each specimen to

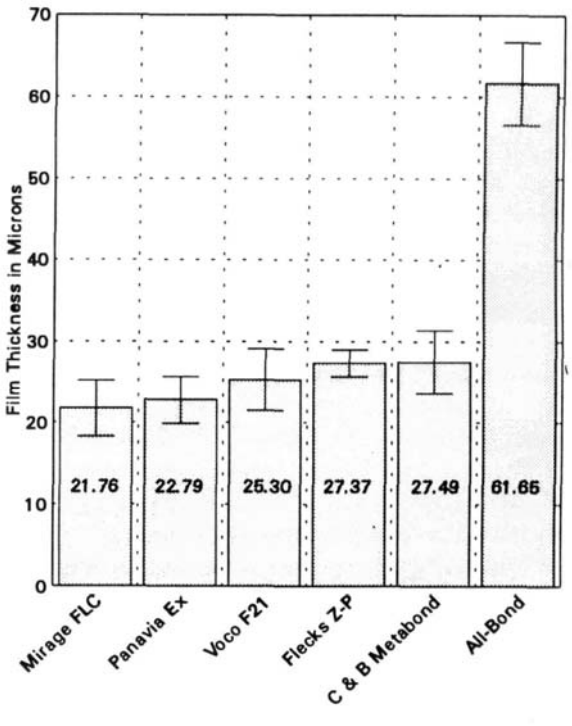

Figure 3. Means and SD of film thickness in micrometers.

Table 2. Tukey's multiple range test results.

Cement	Count	Mean	Homogeneity		
Mirage FLC	10	21.76	*		
Panavia Ex	10	22.79	*	*	
VocoF21	10	25.36	*	*	
Flecks Z-P	10	27.37		*	
C & B Metabond	10	27.49		*	
All-Bond	10	61.65			*

*Statistically similar groups are linked in vertical columns.

the viscosity and unequal distribution of the material during loading. This observation confirms the findings of Jorgensen[13] and Windeler[14] that the ADA film thickness testing method, and the method used in this study determines the viscosity and not the grain size of the cement. However, having sectioned the plastic discs, we were able to determine the minimum film thickness of the tested cement sandwiched between the two plastic discs. The results of this study indicated that the film thickness of Panavia Ex and All-Bond luting resins were considerably lower than the findings reported by White.[10] The differences in the results of the two studies could be attributed to replacing the glass

discs with plastic discs. Since multiple sectioning of the discs was possible, we were able to measure the minimum film thickness rather than the maximum. However, the film thickness of Panavia Ex in this study was in general agreement with those recorded by Sadig[15] and Tjan[9] confirming the lower film thickness of Panavia Ex luting resins when compared to zinc phosphate cement. The agreement is attributed to the fact that both previous studies used the tapered die system, i.e. natural teeth and castings. The determination of film thickness using the tapered-die system always demonstrated a lower film thickness when compared to the ADA technique.[1314] Tjan[9] theorized the improved seating of crowns cemented to natural teeth with resin cement to the thixotropic phenomenon and the good flow of the cement and the lubricating effect, thereby eliminating or reducing the coefficient of friction between the casting and the prepared tooth.

According to ADA specification No. 8, type I cements with film thickness less than 25 */xm* are designed for the accurate seating of precision appliances. ADA type II cements can have maximum film thickness of 40 */xm* which had been recommended for all uses, except the cementing of precision appliances.[12] All materials tested in this study can generally be categorized under type I cement excluding the All-Bond luting resin. This exception is because the mean film thickness of the All-Bond cement was quite high, around 60 */xm.*

While the ADA standard test for film thickness registers the maximum film thickness, the sectioning method employed in this study allows for the determination of the minimum film thickness sandwiched between the two plastic discs. Since the reported film thickness of cements per ADA glass discs technique is higher than what had been observed in this study, the authors are of the opinion that the standard ADA film thickness test might not represent detailed experimental determination, and the classification of cements as type I or II might not be clinically significant. This conclusion is supported by the fact that cements with film thickness exceeding the ADA recommendations are used routinely and successfully in cementing cast restorations with acceptable marginal gap integrity and clinical longevity.[7,1113] Fusayama[16] reported that a film thickness of 25 ^tm provide maximum resistance to dissolution. However, when Mesu[17] and Plum[18] compared the solubility rates of different classes of luting agents, they found that the solubility rate of resinous cements was almost nil in addition to their acceptable wear characteristic. Hence, Christensens[19] stated that the significance of the film thickness of luting resins is questionable, since the cement is insoluble. Further, Burke[7] reported that because of the high bond strength of the adhesive luting resins to both tooth structure and castings, these materials are used routinely for the cementation of conventional fixed partial dentures even when the film thickness exceeds the ADA specification. One particular study,[20] showed that the strongest bond strength of resinous cements occurred when the film thickness was 80 */xm,* which was later confirmed by Dixon et al.[21] It is also worthwhile to note the findings of Jorgan[22] that a restoration with a film thickness of 25 */xm* is ideal but 50 micrometer does not present a noticeable biological risk. In addition to this, several investigators had considered marginal gaps, less than 100 m, as clinically acceptable.[2425] Therefore, the authors believed that the film thickness is just one factor to be considered when selecting an adhesive luting resin. Other factors of important consideration include compressive and tensile strengths, handling characteristics, shelf life, ability to release fluoride, esthetics and economics.

Conclusions

From the results of this study, it is concluded that:

1. Excluding All-Bond resin cement, the film thickness of all the resin-based cements investigated in this study ranged between 22 and 27 */xm.* Thus, categorized as type I cement which is used for the accurate seating of precision appliances.
2. The mean film thickness of All-Bond resin cement was approximately 60 ^tm. Therefore, according to the ADA specification No. 8 it is recommended for all uses, except for cementing precision appliances.
3. Replacement of the ADA testing glass discs with plastic ones allows sectioning and determination of the actual film thickness of the tested cement sandwiched between the two discs at various localities with greater certainty.

4. The modified testing method used in this study confirms the previous findings showing that the ADA standard film thickness test is a measurement of viscosity rather than the grain size of the cement.

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