

Comparative study of composite, compomer and ormocer bi-axial flexural strength

Nadia M. Taher, BDS, MSc

مقاومة الالتواء ثنائية المحور دراسة مقارنة بين الكمبوزيت الراتنجي والكمبومير والأورموسير هدفت الدراسة لتقييم مقاومة الالتواء لمادة حشو جديدة (أورموسير) ومقارنتها مع مواد أخرى مستحدثه من الكمبوزيت الراتنجي والكمبومير. اختبرت ثمانية أنواع كالتالي: مادتان من الأورموسير هما (Definite, Admira) وثلاث مواد من الكمبوزيت الراتنجي (Z 100, Z- 250, Pyramid) وثلاثة مواد من الكمبومير هي (Composan Glass, Compoglass F, Dyract AP) ولقد تم تجهيز خمسة عينات من كل مادة على شكل قرص بنفس المقاسات (قطرها ١٤ مم وسماكتها ٢ مم) باستخدام قالب التفلون المطلي بمادة شحمية ثم خزنت العينات في ماء مقطر لمدة ٢٤ ساعة في درجة حرارة ٣٧ درجة مئوية وأجري بعد ذلك اختبار مقاومة الالتواء باستخدام جهاز الانسترون. دلت نتائج التحليل الاحصائي أن مادة Definite لها صلابه أقل بينما سجلت مادة (Compoglass- F) أعلى صلابه. ولم يلاحظ أي اختلاف احصائي ذو دلالة بين مجموعة الأورموسير بالرغم من أن Admira حققت نتائج أعلى من مادة Definite ولم يكن هناك فرق بين مادتي Compoglass F, Composan Glass ولكن هناك اختلاف واضح بينهما وبين مادة Dyract AP وبالنسبة لمادتي الكمبوزيت الراتنجي (Z 100, Z-250) لم يلاحظ أي اختلاف احصائي ذو دلالة ولكن Z-250 سجلت اختلافًا احصائيا ملحوظًا مع مادة (Pyramid).

The aim of this study was to measure and compare the bi-axial flexural strength of newly developed restorative ormocers with other composite and compomer restorative materials. Eight restorative materials were selected: two ormocers (Admira and Definite), three composite resins (Z-100, Z-250, and Pyramid), and three compomers (Compoglass F, Dyract AP and Composan Glass). Five 14 mm diameter x 2 mm thick disc-shaped specimens were prepared of each material using a silicone lubricated teflon mold. The specimens were stored in distilled water at 37°C for 24 hours before the biaxial flexural strengths were measured using an Instron universal testing machine. Definite had the lowest flexural strength mean (160.63 MPa) while Compoglass F had the highest (291.93 MPa). Admira had a statistically insignificant difference (201.53 MPa) when compared to Definite. The strength of Compoglass F and Composan Glass were statistically equal to but different statistically from Dyract AP. The figures for Z-100 and Z-250 were not statistically different, but the strength of Z-250 was statistically different from Pyramid.

Introduction

New dental restorative materials have made great strides in recent years.¹ The use of amalgam as a standard filling material has become more and more controversial. Since Bowen's early studies (1962), the demands made on resin-based restorative materials have been considerable and fundamental changes have occurred in the matrix chemistry.¹ In the last few years, hybrid resin-modified glass ionomer cement (RMGIC) restorative materials have been introduced. The RMGICs have higher resistance than regular glass ionomer cement restorative materials to early moisture contact and desiccation and also have improved mechanical properties.³ Another class of restorative materials, the polyacid modified resin composites, or compomers, were marketed in the early 1990s.³ Their mechanical properties were higher than those of glass-ionomer cement restorative materials but less than those of composites (Z-100).⁴

New filling materials, called ormocers, were developed in 1998.¹ Ormocer is an abbreviation for organically modified ceramic. Ormocers combine glass-like components with polymer

components nearly as hard as glass and with similar characteristics as synthetic material.³ Ormocers are equipped with an inorganic SiO₂ backbone to which polymerizable organic units are added. This results in three dimensionally cured co-polymers with filler particles incorporated into the cross-linked inorganic organic network. No studies have been done regarding its physical and mechanical properties. Flexural and tensile strengths are considered the most important mechanical properties of resin-based material. The flexural strength test is considered to be sensitive to surface imperfections such as cracks, voids and related flaws which can influence the fracture strength of brittle materials.² High flexural strength values reflect a limited tendency to crazing and high resistance to surface defects and erosion.⁵

Therefore, the aim of this study was to investigate the bi-axial flexural strength of these new materials (Admira and Definite) and compare it to composite resins and compomers.

Materials and Methods

The materials used in this study are listed in Table 1. These materials included two ormocers

Address reprint requests to:
Dr. Nadia M. Taher
P.O. Box 60169
Riyadh 11545, Saudi Arabia
E-mail: nmtaher@ksu.edu.sa

Received 15 April 2001; Revised 24 June 2001;
Accepted 18 August 2001
Lecturer, Department of Restorative Dental Sciences
College of Dentistry, King Saud University
Riyadh, Saudi Arabia

(Definite and Admira), three compomers (Composan Glass, Compoglass F, and Dyract AP) and three composites (Pyramid, Z-100, and Z-250).

Table 1. Materials investigated.

Material	Type	Manufacturer	Filler Weight %	Lot Number
Definite	Ormocer	Degussa	77	4991707
Admira	Ormocer	Voco Germany	78	002710
Composan Glass	Compomer	Promedica Germany	77.5	92537
Compoglass F	Compomer	Vivadent	77	919771
Dyract AP	Compomer	Dentsply/Caulk	75	9711000115
Pyramid	Composite	Bisco	75	9900007749
Z-100 19970623	Composite	3M Dental Products U.S.A.	85	
Z-250	Composite	3M Dental	86	98N

Specimen preparation

Five disc shaped specimens (14 mm diameter x 2 mm thickness) were prepared for each material utilizing a silicone lubricated teflon mold. The mold was placed on a transparent matrix strip supported by a glass microscope slide. The mold was overfilled with material. The mold and material were covered with another matrix strip and a glass microscope slide. Light pressure was applied until the upper matrix strip and slide came into contact with the mold to expel excess material and avoid air entrapment. The material was light cured in four quadrants from each opposing surface to ensure adequate polymerization of the material. All eight curing times were for the duration recommended by the manufacturers. The specimens were removed from the molds without any flexing and stored in distilled water at 37°C for 24 hours. Particular care was taken to ensure that the discs were flat to avoid uneven loading during subsequent testing.

Measurement procedure

Each specimen was placed on a circular 10 mm knife-edge support and loaded centrally at a rate of 0.2 mm/min with a 1mm diameter steel piston in an Instron Universal testing machine. The specimens were tested to failure and the maximum load was recorded by the Instron software. The bi-axial flexural strength of each disc was calculated according to the equation:^{6,7}

$$\sigma_{\max} = \frac{P}{h^2} \left\{ (1+\nu) \left[0.485 \ln \left(\frac{a}{h} \right) + 0.52 \right] + 0.48 \right\}$$

σ_{\max} = The maximum flexural strength

P = The measured load at fracture

a = The radius of the knife-edge support

h = The specimen thickness

ν = The poisson's ratio for all the materials (0.25)⁸

Results

The mean bi-axial flexural strength values and standard deviation of the tested materials are listed in Table 2 in order of increasing stress and depicted graphically in Fig. 1. Definite was the weakest and had the lowest mean strength (160.63 ± 28.73 MPa). The material that had the highest mean strength value was Compoglass F (291.93 ± 19.98 MPa). As seen in Table 2, One-way Analysis of variance (ANOVA) and a Student Newman Keuls multiple comparison test revealed that there was no significant difference between Definite (160.63 MPa) and Admira (201.53 MPa). Z-100 (234.10 MPa) and Z-250 (259.00 MPa) were statistically equal but differed from Pyramid (198.87 MPa). There was no difference between Composan Glass (275.33 MPa) and Compoglass F (291.93 MPa) although they were significantly different from Dyract AP (175.63 MPa). Definite, Dyract AP, Pyramid, and Admira were statistically equal. Z-100, Z-250, Composan Glass, and

Table 2. The mean and standard deviations of bi-axial flexural strength for the tested materials.

Ranking order	Materials	Mean (MPa)	Standard deviation (MPa)	
1	Definite	160.6	28.7	a*
2	Dyract AP	175.6	56.8	ab
3	Pyramid	113.0	24.9	ab
4	Admira	201.5	33.6	ab
5	Z-100	234.1	13.5	bc
6	Z-250	259.0	29.5	cd
7	Composan Glass	275.3	54.5	d
8	Compoglass F	291.9	20.0	d

*Identical letters indicate mean values with no significant differences. (p < 0.05)

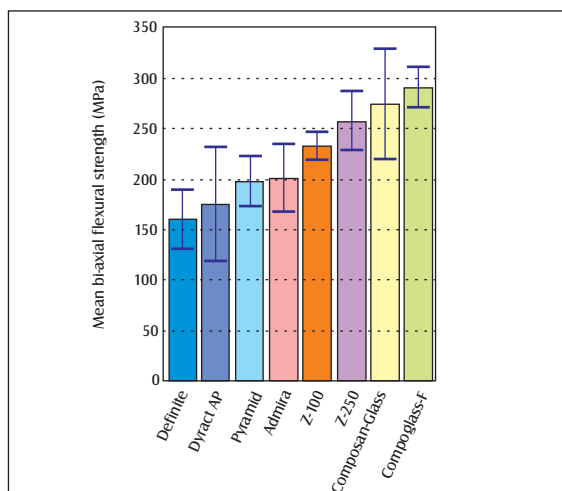


Fig. 1. Mean bi-axial flexural strength of the tested materials (MPa).

Compoglass F were also statistically equal.

Discussion

Bi-axial flexural strength is considered one of the significant parameters to characterize the bulk of a material.⁹ It usually involves supporting a disc shaped specimen on either a ring with a knife-edge or on three or more points near the periphery and equidistant from the center of the disc. The central portion is then loaded such that maximum stress occurs at the center of the lower face of the disc. The results obtained are independent of the condition of the edge of the specimen disc.³

The bi-axial flexural test has been used frequently in many studies where different formulas⁷⁻¹⁰ have been used to determine the flexural stress. Timoshenko's formula,⁶ the basis for many studies^{2,7,10} was used here. From the results of this study, the materials tested can be ranked as follows: The compomer group (Compoglass F and Composan Glass) had the highest flexural strength values and it was close to the composite group (Z-100, Z-250) but different from Dyract AP. This may be related to filler content as noted in Table 1. This result was in agreement with El-Kalla and Godoy⁴ who reported that the flexural strength of Dyract was less than for Z-100. Pyramid and Dyract AP were statistically equal (amount of filler was 75% by weight for both) suggesting that composites and compomers would behave similarly.

Z-100 and Z-250 are representative of hybrid composites known to be the most universal composites and having superior strength

characteristics.¹¹ While Z-100 has been used in many studies as a control or reference composite material,^{4,11} Z-250 has little, if any, published studies regarding its properties. The results of this study showed that the flexural strength of Z-250 was not significantly higher than Z-100. Z-250 had a significantly higher flexural strength than Pyramid. This difference may be related to the filler type or the resin (Bis-GMA, TEGDMA)¹² since filler weight % was close to Z-100. The manufacturer has claimed that changes were made to the resin matrix for Z-250. Pyramid is a highly filled packable composite with a unique resin. According to this study, its strength was the lowest among the composite group.

Although the flexural strength of materials in the ormocer group (Admira, Definite) were statistically similar, Admira was lower in flexural strength than Composan Glass and Compoglass F and Definite was lower in flexural strength than the composite materials (Z-100, Z-250) and the compomer materials (Composan Glass, and Compoglass F). This difference may be related to the filler characteristics or the resin¹³ since the inorganic filler content is similar (Table 1). The ormocer group can be ranked between the composite and compomer groups. The newly developed ormocer restorative materials have desirable flexural strength properties, especially Admira. However, further research is indicated to gain a clearer picture of other properties. For clinical success, the dentist should know the properties of the materials, choose accordingly, and manipulate them properly.

Conclusion

1. The Ormocer materials were not significantly different in flexural strength.
2. Compoglass F and Composan Glass are the hardest, are statistically equal, and different from Dyract AP in flexural strength.
3. The figures for Z-100 and Z-250 are statistically equal, and Z-250 differs statistically from Pyramid.
4. The Ormocer material can be ranked between the compomer group and the composite group.

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