ORİJİNAL ARAŞTIRMA / *ORIGINAL RESEARCH*

An Evaluation of the Fracture Resistance of Four Different Restorative Materials

DÖRT FARKLI RESTORATİF MATERYALİN KIRILMA DİRENÇLERİNİN DEĞERLENDİRİLMESİ

Emin Caner TÜMEN, DDS PhD,[a] Fatma ATAKUL, DDS PhD[a]

[a]Department of Pedodontics, Dicle University Faculty of Dentistry, DİYARBAKIR

Abstract

Objective: This study was intended to determine the fracture resistance of four different materials to vertical forces, frequently used in the restoration of posterior group teeth. In our study, 60 extracted premolar teeth prepared with Class II cavities were used.

Material and Methods: Sixty caries free and unrestored premolars, extracted for periodontal and orthodontic purposes, were fixed in cold acrylic blocks and randomly divided into four groups of 15, by preparing standard approximal cavities. The restorative material Valux Plus was applied to the first group, Herculite XRV to the second, Vitremer to the third, and Chelon Silver to the fourth, all according to the manufacturers' recommendations. The fracture resistances of the restorations were measured by using a Testometric micro-500 machine.

Results: The data obtained as a result of the measurements were statistically analysed by using One-Way ANOVA and the Post-Hoc tests. The mean fracture resistance values obtained were; 66.9113 kgf for Valux Plus, 55.2187 kgf for Herculite XRV, 51.1493 kgf for Vitremer, and 38.0633 kgf for Chelon Silver. The fracture resistance values, obtained as a result of the statistical analyses performed, are from highest to lowest: Valux Plus > Herculite XRV > Vitremer > Chelon Silver ($P<0.001$).

Conclusion: It was concluded from our findings that glass ionomer cements should be used less frequently in restorations in both primary and permanent posterior group teeth. However, due to their similar fracture resistance properties to those of composite resins, in terms of resistance to vertical forces and their fluoride releasing properties, resin-modified glass ionomers can be used in all restorations, particularly in children's primary teeth; a group at high risk of caries.

Key Words: Composite resins; glass Ionomer cements; fracture resistance

Özet

Amaç: Bu çalışma, sıklıkla arka grup dişlerde kullanılan dört farklı tip restoratif materyalin dik kuvvetler karşısındaki kırılma dirençlerinin değerlendirilmesi amacıyla yapıldı. Çalışmamızda çekilmiş ve üzerinde Class II kavite hazırlanmış, 60 adet premolar diş kullanıldı.

Gereç ve Yöntemler: Periodontal ve ortodontik nedenlerle çekilmiş 60 adet çürüksüz ve restorasyonsuz premolar diş, soğuk akrilik bloklar içerisine sabitlendi ve standart arayüz kaviteleri hazırlanan dişler, 15erli 4 eşit gruba rastgele ayrıldı. Birinci gruba Valux Plus, ikinci gruba Herculite XRV, üçüncü gruba Vitremer ve dördüncü gruba Chelon Silver materyalleri üretici firmaların önerileri doğrultusunda yerleştirildikten sonra, restorasyonların kırılma dirençleri Testometrik mikro-500 makinesinde ölçüldü.

Bulgular: Elde edilen veriler, istatistiksel olarak Tek Yönlü Varyans analizi ve Post-Hoc testleri kullanılarak değerlendirildi. Ortalama kırılma direnci değerleri; Valux Plus için 66,9113 kgf., Herculite XRV için 55,2187 kgf., Vitremer için 51,1493 kgf. ve Chelon Silver için ise 38,0633 kgf. olarak tespit edildi. İstatistiksel analiz sonuçlarına göre elde edilen kırılma direnci değerleri, büyükten küçüğe doğru aşağıdaki gibidir: Valux Plus > Herculite XRV > Vitremer > Chelon Silver ($P<0.001$).

Sonuç: Sonuç olarak, hem süt hem de sürekli dişlerin arka grup restorasyonlarında cam iyonomer simanların daha az kullanılması gerektiği, ancak dik kuvvetler karşısındaki dirençleri açısından kompozit rezinlere yakın özellik gösteren ve bunun yanında florit salınımına da sahip olan Rezinle modifiye cam iyonomer simanların, süt dişlerinin bütün restorasyonlarında özellikle de yüksek çürük riskli çocuklarda ki süt dişlerinde kullanılabileceği kanısına varılmıştır.

Anahtar Kelimeler: Cam iyonomer simanlar; kompozit rezinler; kırılma direnci

Turkiye Klinikleri J Dental Sci 2007, 13:97-102

Geliş Tarihi/*Received:* 25.12.2006 **Kabul Tarihi/*Accepted:*** 28.05.2007

This study had been presented orally in the congress of the BASS 9th International Dental Congress 2004 Ohrid- MACEDONIA.

Yazışma Adresi/*Correspondence:* Emin Caner TÜMEN, DDS PhD,
Dicle University Faculty of Dentistry,
Department of Pedodontics, DİYARBAKIR
emin.caner@isnet.net.tr

In dentistry, the materials to be used in the restoration of posterior group primary and permanent teeth need to possess such properties as ease of preparation and application, adaptation to the cavity walls, a similar thermal expansion coefficient to that of teeth, biocompatibility, an aesthetic appearance, and to be economical and anti-cariogenic. To that end, the composite resin and glass ionomer cements initially used for aesthetic reasons in anterior group teeth have gradually begun to be used for posterior group teeth, as well.

Composite resins; possess such positive features as a bonding capacity to enamel and dentin, the fact that the timing of their hardening can be controlled, low thermal conductivity, a pleasant aesthetic appearance, ease of application, resistance and low solubility in the oral environment. These materials are used in many indications, such as the rectification of erosion, abrasion and developmental defects, diastema closing, in inlay manufacture, and the restoration of teeth which have fractured as a result of caries or trauma.[1,2]

It is of great importance in the evaluation of materials' physical properties, the volume and weight levels of the fillers in the inorganic structure, be known. Composite resins are classified according to the forms in which inorganic filler particles appear in the weight to size or polymer to volume percentage matrix, polymerisation forms and viscosity. In addition to being mechanically resistant, composite resins, which contain macro-fill particles in their inorganic parts, they also give rise to weak bonding between the organic and inorganic structures due to the size of the particles, surface irregularities and discolouration. For such reasons, while a good surface regularity is obtained by reducing the filler particle size, decreases have been observed in their mechanical properties. The hybrid composites widely used today are obtained by combining fillers of different sizes. With their physical and mechanical properties, these exhibit similar properties to macro-particle composites, and with their surface regularity to micro-particle composites.[1,2]

In addition to all these positive features, composite resins also possess a number of disadvantages, such as a high thermal expansion coefficient, a low elasticity module, debateable biological compatibility, gradual polymerisation shrinkage, low abrasion resistance, margin leakage and post-operative sensitivity.[1]

Compared to other restorative materials, glass ionomer cements, which have attracted interest due to their caries-inhibiting effect and chemical bonding to the tooth structure,[3] possess such advantages as fluoride release, biological compatibility, a thermal expansion coefficient close to that of teeth, compression property and high tension resistance, a minimal need for cavity preparation and the opportunity of working at mouth temperature, less polymerisation shrinkage, and a good level of marginal unity.[4] For these reasons they are frequently used under enamel tissue deprived of dentin support, in Class I cavities in low load bearing permanent teeth, in Class II and III slot and tunnel cavities, in Class III and IV cavities in which aesthetic appearance is unimportant and in cervical erosion and abrasion lesions of idiopathic origin.[1,5-7]

Glass ionomer cements are examined under three groups, according to their powder liquid levels and fields of application. Type I cements have fine particles and are used in the adhesion of crown-bridges. Since Type IIa and IIb cements have superior physical properties these are used as a filling material. Because of their weak physical properties, Type III cements are used as a cavity floor material and for pit and fissure coverage.[1,5,7]

Glass ionomer cements are grouped in 3 types according to their physical structures; traditional, metal-reinforced (cermet) and restoration materials, which include both ionomer and polymer structures (resin-modified glass ionomer and polyacid modified composite).[5-7]

There have been attempts to increase the resistance of traditional glass ionomer cements, the use of which is limited due to their low resistance to erosion and fracture, their moisture sensitivity and short working time, by the addition of metal particles.[1,7-9]

Resin-modified glass ionomer cements developed as a result of the combination of glass ionomer and composite resin technologies are superior to traditional glass ionomer cements because they have a lower solubility level in water, greater resistance to acids, lower friability and micro-leakage, better mechanical properties, a shorter hardening time and a better aesthetic appearance. Alongside these advantages they also possess certain disadvantages. Due to their resin contents and hardening with light, they exhibit greater polymerisation shrinkage than glass ionomer cements.[1,7]

This study was intended to determine the fracture resistance of 4 different materials to vertical forces, frequently used in the restoration of posterior group teeth. In our study, 60 extracted premolar teeth prepared with Class II cavities were used.

Material and Methods

In this study, 60 caries free and unrestored premolar teeth extracted for periodontal and orthodontic reasons were used. The teeth were kept in a 0.1 formol solution until the cavity preparations were made. Following the removal of soft tissue residue, all the teeth were fixed on acrylic blocks in such a way that their long axes were perpendicular to the horizontal, in order to permit them to be held easily during the preparing of the Class II cavities and their adaptation to the test machine (Figure 1).

The inter-surface cavity preparations were standardised with a 3 mm width and 1.5 mm depth in the occlusal, an occlusal-gingival margin height of 3 mm in the approximal, and a bucco-lingual distance of 4 mm and depth of 1.5 mm.

The 60 premolars with prepared cavities were randomly divided into four groups of 15 teeth each, for use with a different material, following the recommendations of the manufacturing firms.

Figure 1. View of teeth fixed in cold acrylic blocks.

Valux Plus (Z100/3M Dental Products-USA) was used in Group I, Herculite XRV (Kerr, Italy) in Group II, Vitremer (3M Dental Products-USA) in Group III and Chelon Silver (3M-ESPE-USA) in Group IV.

Following polymerisation of the materials, excesses at the edges of cavities were removed with the help of microgranular flame type diamond burs (NTI-Kahla GmbH Rotary Dental Instruments, Diamond Instruments, Germany) and the finishing process was completed with Sof-lex (3M Dental Products, USA) discs.

Restored and polished teeth were kept in separate glass bottles in a drying oven at 37 °C until the fracture test. The fracture resistance of the restorations was measured by using a Testometric micro-500 machine. Measurements were performed on the marginal edge of the filler on the occlusal surface by making contact with the pressure tip of the machine (Figure 2).

Pressure speed was at such a level as to apply a 0.1 mm/min force. When fracturing or block breakage occurred in the restoration materials (Figure 3), the values obtained with the automatic stopping of the machine were recorded as kilogram-force (kgf). The data obtained as a result of the measurements were statistically analysed by using One-Way ANOVA and the Post-Hoc test.

Results

The mean fracture resistance values obtained by using One-Way ANOVA are shown in Table 1 and Graphic 1. As a result of One-Way ANOVA it was determined that the differences in the mean fracture resistance of the different materials were statistically significant ($P < 0.001$).

According to the Post-Hoc test results, the difference between the mean fracture resistance of Valux Plus and Herculite XRV was not statistically significant ($P > 0.05$). The difference between the mean fracture resistance of Valux Plus and Vitremer was statistically significant ($P < 0.05$). The difference between the mean fracture resistance of Valux Plus and Chelon Silver was also statistically significant ($P < 0.05$). The difference

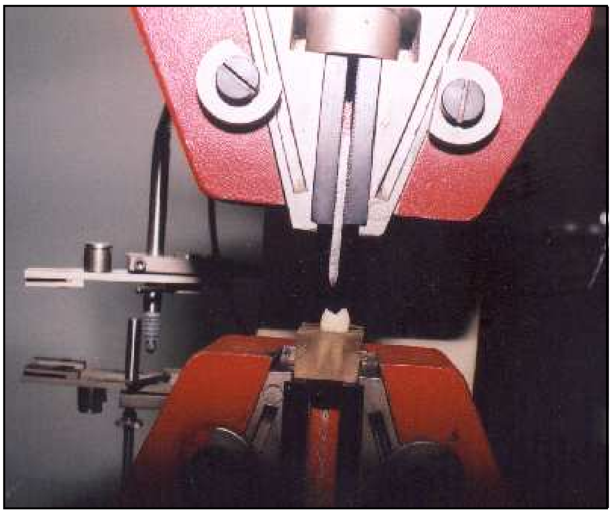

Figure 2. View of the location of the acrylic block in the Testometric micro-500 machine.

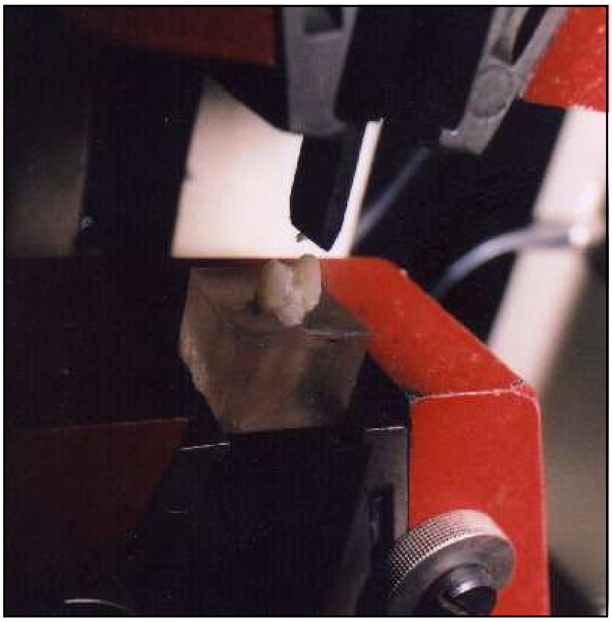

Figure 3. View of breakage or block-type shearing in restoration material.

between the mean fracture resistance of Herculite XRV and Vitremer was not statistically significant (P> 0.05). The difference between the mean fracture resistance of Herculite XRV and Chelon Silver was statistically significant (P< 0.05). The difference between the mean fracture resistance of Vitremer and Chelon Silver was statistically significant (P< 0.05). The mean fracture resistance values obtained were; 66.9113 kgf for Valux Plus, 55.2187 kgf for Herculite XRV, 51.1493 kgf for Vitremer, and 38.0633 kgf for Chelon Silver. Of the 4 different restorative materials used, it was determined that Valux Plus had the highest fracture resistance and Chelon Silver the lowest.

The fracture resistance values, obtained as a result of the statistical analyses performed, are from highest to lowest:

Valux Plus > Herculite XRV > Vitremer > Chelon Silver (P< 0.001).

Discussion

Starting from the premise that the materials to be used in the restoration of primary and permanent posterior group teeth need to possess a high fracture resistance, researchers have conducted intensive studies in this field. Research is generally conducted into restoration materials' resistance to pressure, resistance to abrasion, elasticity module, and contraction and tension stresses.

Jagadish and Yogesh compared the fracture resistance of composite resin and glass ionomer

Table I. Statistical analysis of the fracture resistance of 4 different types of restoration.

Material	N	Minimum*	Maximum*	Mean ± SD**
Valux Plus	15	36.74	102.40	66.91 ± 17.83
Herculite XRV	15	25.67	98. 39	55.21 ± 22.42
Vitremer	15	28.62	62.38	51.14 ± 9.80
Chelon Silver	15	16.78	75.32	38.06 ± 18.36
Total	60	16.78	102.40	52.83 ± 20.14

* Kgf
** Standard Deviation

Graphic 1. Diagram of the mean fracture resistance values of four different types of restoration

cements in Class II cavities and reported that composite resin possessed greater fracture resistance.[10]

The physical properties of composite resins are determined by the size, shape and amount of filling particles they contain. In one study on this subject Ferracane et al. reported that the fracture resistance of composite resins depended on the filler composition and that composite resins containing macro-fill exhibited higher levels of resistance than micro-fill composites.[11-13]

In a similar study, Shortall et al. stated that the material Z100 (Valux Plus), a hybrid composite resin with mini-fill, exhibited a greater level of fracture resistance than Silux Plus, containing micro-fill, and Herculite XRV, a hybrid composite resin with micro-fill. They reported that the reason for this greater fracture resistance stemmed from the filler volume of this material being at a level of 65% and above.[14]

Wilson and Uctasli reported that fracture resistance was directly related to the level of filler, without being dependent on the resin matrix structure, and that the higher the level of filler, the higher the resistance.[15]

In another study, Lutz and Phillips referred to hybrid composite resins with high resistance to pressure due to the macro-fills in their structure being capable of use in posterior group restorations.[16]

In a study using compression and three-point loading test, Dhummarunrong et al. compared the mechanical properties of three different types of glass ionomer cement and a hybrid type composite resin, and reported that the material Z100, a hybrid type composite resin, was more resistance than traditional and metal-added glass ionomer cements. In the same study, they reported that the metal reinforced material Ketac Silver was more resistance to breaking than traditional glass ionomer cement but less resistance than light cured glass ionomer cement.[17]

Due to their caries-inhibiting effect and chemical adhesion to the tooth structure, glass ionomer cements, which began being developed in the mid-1970s, have enjoyed a wide sphere of use in dentistry. However, due to their lack of resistance to erosion and pressure, it has been emphasised that the use of traditional glass ionomer cements in areas of posterior group teeth subjected to stress needs to be restricted, and efforts have been made to increase their resistance by eliminating this disadvantage by means of adding metal particles.[9]

In a study on 274 teeth, Mjör and Jokstad reported that they observed a higher frequency of tubercle breakage in teeth restored with cermet cement than with amalgam and composite resins. They attributed this breakage to the low level of elasticity resistance of glass ionomer cement.[18]

It has been reported that Ketac Silver and Chelon Silver, developed by adding silver ions to traditional glass ionomers, could be an alternative to amalgam in the restoration of Class I primary teeth, but should not be used in Class II restorations subject to masticatory pressure.[8,19]

The resin-modified glass ionomer cements developed in recent years have begun to be widely used. Features of these cements, such as their resistance to breaking and erosion, and to pressure and elasticity, have been reported to be better than those of chemically hardened glass ionomers.[20]

In a study in which they tested different materials' resistance to pressure, elasticity and microhardness, El Kalla and Godoy reported that Z100 (Valux Plus) had a higher resistance than Vitremer and compomers.[21]

Significant statistical differences were found in the fracture resistance of the four different restorative materials whose resistance to vertical forces we tested ($P < 0.001$).

Based on the findings of our study, Valux Plus (Z100), a hybrid composite resin with mini-fill, had the highest resistance to breaking, followed by Herculite XRV, a hybrid composite resin with micro-fill. Chelon Silver (3M-Espe) was determined to possess the lowest fracture resistance. These results are in good agreement with the findings of Jagadish and Yogesh, Ferracane and Condon, Shortall et al, Dhummarunrog et al, Mjör and Jokstad, and El Kalla and Godoy.

Conclusion

The fracture resistance values, obtained as a result of the statistical analyses performed, are from highest to lowest:

Valux Plus > Herculite XRV > Vitremer > Chelon Silver (P< 0.001).

Due to our statistical findings glass ionomer cements should be used less frequently in restorations in both primary and permanent posterior group teeth. However, due to their similar fracture resistance properties to those of composite resins, in terms of resistance to vertical forces and their fluoride releasing properties, resin-modified glass ionomers can be used in all restorations, particularly in children's primary teeth; a group at high risk of caries.

REFERENCES

1. Dayangaç GB: Kompozit rezin restorasyonlar. Ankara, Güneş Kitabevi Ltd Şti, 2000, s.7.
2. Koray F, Yücel T: Kompozitin ön dişlerde kullanımı. TDBD 71: 16, 2002
3. Türkün LŞ, Çelik EU: Antibakteriyel adeziv ile uygulanan kompomer ve nanofil kompozit restorasyonların bir yıllık klinik performansı. GÜ Diş Hek Fak Derg 24: 1, 2007
4. Eren D, Bektaş ÖÖ: Dental adezivler. CÜ Diş Hek Fak Derg 9: 63, 2006
5. Ersöz E: Cam iyonomer simanların sınıflandırılması. TDBD 71: 52, 2002
6. Azillah MA, Anstice HM, Pearson GJ: Long-term flexural strength of three direct aesthetic restorative materials. J Dent 26: 177, 1998
7. Gökçe YB: Cam iyonomer simanların kullanım alanları ve çeşitleri. TDBD 64: 32, 2001
8. Croll TP, Phillips RW: Six years' experience with glass-ionomer-silver cermet cement. Quintessence Int 22: 783, 1991
9. Mclean JW, Gasser O: Glass-cermet cements. Dent Res 16: 333, 1985
10. Jagadish S, Yogesh BG: Fracture resistance of teeth with class II silver amalgam, posterior composite and glass cermet restorations. Operative Dent 15: 42, 1990
11. Ferracane JL: The fracture toughness (kic) of composite filling materials and crack-tip radius. J Dent Res 67: 884, 1988
12. Ferracane JL, Antonio RC, Matsumoto H: Variables affecting the fracture toughness of dental composites. J Dent Res 66: 1140, 1987
13. Ferracane JL, Condon JR: In vitro evaluation of the marginal degradation of dental composites under simulated occlusal loading. Dental Mater 15: 262, 1999
14. Shortall AC, Uctasli S, Marquis PM: Fracture resistance of anterior, posterior and universal light activated composite restoratives. Operative Dent 26: 87, 2001
15. Wilson AC, Uctasli S: Fracture toughness of dental composites. Ankara Üni Dişhek Fak Derg 17: 233, 1990
16. Lutz F, Phillips RW: A classification and evaluation of composite resin systems. Operative Dent 50: 480, 1983
17. Dhummarungrong S, Moore BK, Avery DR: Properties related to strength and resistance to abrasion of Variglass VLC, Fuji II LC, Ketac-Silver and Z100 composite resin. J Dent for Child 61: 17, 1994
18. Mjör A, Jokstad A: Five year study of class II restorations in permanent teeth using amalgam, glass polyalkenoate (ionomer) cermet and resin-based composite materials. J Dent 21: 338, 1993
19. Marks LAM et al: Ketac molar versus dyract class II restorations in primary molars: Twelve month clinical results. J Dent for Child 67: 37, 2000
20. Croll TP, Killian CM: Glass ionomer resin restoration of primary molars with adjacent class II carious lesions. Operative Dent 24: 723, 1993
21. El Kalla IH, Garcia-Godoy F: Mechanical properties of compomer restorative materials. Operative Dent 24: 2, 1999