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COMPARISON OF DIAMETRAL TENSILE, FLEXURAL, AND COMPRESSIVE STRENGTHS OF FIVE CORE BUILD-UP MATERIALS

BEŞ FARKLI KOR MATERYALİNİN ÇAPSAL GERİLİM, BÜKÜLME VE SIKIŞTIRMA DİRENCİNİN KARŞILAŞTIRILMASI

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ABSTRACT

The purpose of this laboratory investigation was to evaluate three mechanical properties; the compressive, diametral tensile and flexural strengths of five different core build-up materials. In this study, a light-actived Hybrid composite resin (President), resin modified glass ionomer (RMGIC) (Vitremer), amalgam (Cavex avalloy), glass-ionomer (GIC) (Logofil) and compomer (Dyract AP) restorative materials were used. 120 samples were prepared according to American Dental Association specification No. 27 for testing diametral tensile strength (DTS), compressive strength (CS) and flexural strength (FS). Forty specimens were prepared in cylindric molds (6 mm in height, 3 mm in diameter) for the CS measurements and forty specimens (3 mm in height, 6 mm in diameter) for diametral tensile strength (DTS). Forty specimens were prepared (25X 2 X 2 mm) for the FS measurements. All cores materials were prepared according to manufacturer's instruction at a temperature of 23.0 +/- 1.0 degrees C. Haunsfield press and pull machine was used for compressive and flexural strength and the module were determined at a crosshead speed of 0.5 mm/min. Diametral testing was carried out at 1 mm/min. Analysis of variance was used for statistically evaluation. Mean compressive, diametral tensile and flexural strengths with associated standard deviations were calculated for each material. The results of this study indicated that the diametral tensile strength, flexural strength and compressive strength of the resin composite (President) and amalgam material were significantly higher than the other tested materials (p<0.001). On the other hand, the diametral tensile strength, flexural strength and compressive strength of glass ionomer based materials (Logofil, Vitremer) were statistically lower than for resin composites, compomer and amalgam.

Key Words: *Core materials, diametral tensile strength, compressive strength.*

ÖZET

Bu çalışmanın amacı, beş farklı kor materyalinin üç mekanik özelliği; çapsal germe direnci, sıkıştırma direnci ve bükülme direncini değerlendirmektir. Bu çalı şma için, ışıkla sertleşen hibrid kompozit rezin (President, Light cure Dynamic Universal hibrit Compozit, München, Germany), rezin modifiye cam iyonomer (Vitremer, 3M Dental Products, St. Paul MN, USA), amalgam (Cavex Avalloy, Harlem, Hollanda), cam iyonomer (Logofil, D-Dental Alten, Alten Walde, Germany) ve compomer (Dyract AP) materyalleri kullanıldı. Çapsal germe direnci, sıkıştırma direnci ve bükülme direnci testi için toplam 120 örnek American Dental Association 27 nolu spesifikasyonuna göre hazırlandı. 6mm yüksekliğinde ve 3mm çapında 40 silindirik örnek, çapsal germe direnci için ve 25X2X2 mm boyutlarında 40 örnek ise bükülme direnci testi için hazırlandı. Tüm kor materyalleri üretici firma önerileri doğrultusunda 23.0 +/- 1.0 ^{0}C'de hazırlandı. Testler Hounsfield çekme-sıkıştırma makinesinde, bükülme ve sıkıştırma gerilim testleri 0.5 mm/dak.ve çapsal gerilim testi için 1 mm/dak. başlık hızı ile yapıldı. İstatistiksel değerlendirme için varyans analizi kullanıldı. Her bir materyal için Çapsal germe direnci, sıkıştırma direnci ve bükülme direncine ait ortalama ve standart sapma değerleri hesaplandı. Çalışmanın sonuçlarına göre Çapsal germe direnci, sıkıştırma direnci ve fleksural gerilim direnci açısından Kompozit resin (President) ve Amalgam(Cavex avalloy), diğer test edilen materyallere göre önemli derecede yüksek bulundu. (p<0.001). Diğer yandan cam iyonomer esaslı materyallerin Çapsal germe direnci, sıkıştırma direnci ve bükülme direnci resin kompozit, kompomer ve amalgama göre düşük bulundu.

Anahtar sözcükler: *Kor materyali, Çapsal germe direnci, sıkıştırma direnci.*

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INTRODUCTION

Tooth structure badly destroyed by caries or trauma is often rebuild with suitable dowel or core material to enhance the success and longevity of a subsequent cast restoration.[1]

Several dental materials as amalgam, composite resin, glass ionomer cements, resin modified glass-ionomer cements and compomers have been used for core build-up procedures. Compressive and tensile strengths of core materials are thought to be important because core build-ups usually replace a large amount of tooth structure and must resist multidirectional masticatory forces for many years.[2-7] Compressive strength is considered to be a critical indicator of success because a high compressive strength is necessary to resist masticatory and parafunctional forces. Tensile strength is important because dental restorations one exposed to tensile stresses from oblique or transverse loading of their complex geometric forms.[8] Flexural strength tests are considered to be sensitive to surface imperfections such as cracks, voids, and related flaws, which can influence the fracture strength of brittle materials. High flexural strength values reflect a limited tendency for crazing and high resistance to surface defects and erosion. Therefore, flexural and tensile strength are considered to be the most important mechanical properties.[2]

The clinician must know which material to select for core build up and which techniques to apply to reach optimum results. Therefore, the purpose of this study was to compare the compressive, diametral tensile and flexural strengths of five common used core materials.

MATERIALS AND METHODS

Five core materials, a light-actived Hybrid composite resin (President), resin modified glass ionomer (RMGIC) (Vitremer), amalgam (Cavex avalloy), glass-ionomer (GIC) (Logofil) and compomer (Dyract AP) restorative materials were used (Table 1). Forty specimens were prepared in cylindric molds (6 mm in height, 3 mm in diameter) for the CS measurements and forty samples were prepared in cylindrical molds (3 mm in height, 6 mm in diameter) for diametral tensile strength (DTS). Forty specimens were prepared in Teflon molds (Dupont Co., Wilmington, Del.) (25X 2 X2 mm) for the FS measurements (Fig.1). All cores materials were prepared according to manufacturer's direction at a temperature of 23.0 +/- 1.0 degrees C. For the visible light cure resin composite, curing was achieved using a Translux light-activating unit (Translux EC, Kulzer,Wehrheim, Germany). Each specimen was cured for 60 s according to the manufacturer directions. The specimens were stored for 20 days 37 C^o at 100 % humidity.

Table 1. Core materials tested in this study

Core materials	*Brand name*	*Manufacturer*
Composite	President	Light cure Dynamic Universal Composite Munchen, Germany
Glass-ionomer(GIC)	Logofil U	D-Dental Alten Alten Walde-Germany
Resin modified glass-ionomer(RMGIC)	Vitremer	3M Dental Products, St. Paul-USA
Amalgam	Cavex Avalloy	Cavex, Haarlem-Holland
Compomer	Dyract AP	Dentsply DeTrey, Konstanz-Germany

Fig.1 The master models of testing samples

The samples were tested on a Haunsfield tensometer (Haunsfield Test equipment company, HTE 37 Fullerton Road Craydon, England) (Fig.2) with three mechanical tests, compressive strength (CS) flexural strength (FS) and diametral tensile strength (DTS). Compressive and flexural strength and the module were determined at a crosshead speed of 0.5 mm/min. The module was calculated from the slopes of the linear portions of stress–strain curves. Diametral testing was carried out at 1 mm/min.

Diametral tensile strength was calculated from the formula:

$$T=2F/\pi DL$$

where F is the maximum applied load (N); D the mean diameter of the specimen (mm) and L the length (height) of specimen (mm).

Flexural strength was calculated from the following equation:

$$\sigma = \frac{3Fl}{2bh^2},$$

where F is the maximum load exerted on the specimen; l the distance (mm) between the supports ±0.01 mm; b the width (mm) of specimen immediately prior to testing; and h the height (mm) of specimen measured immediately prior to testing. Three-point bending tests were carried out on the test bars at a span of 22mm at across –head speed of 0.5mm/min. Eight bars of each material were used.

Fig.2 Haunsfield tensometer

The descriptive statistics including means and standard deviations were calculated for each group. Statistical evaluation of findings was performed with 2-way ANOVA by using SPSS 10.0 software programme. When there where a significant result in the ANOVA, Duncan's test was computed to determine which core materials were statistically different from other materials.

RESULTS

Compressive strength varied from 116.34 MPa for glass ionomer to 147.22 MPa for a resin composite. Diametral tensile strength ranged widely from 18.80 MPa for glass ionomer core materials to 147.1 for an amalgam. Flexural strength varied 11.76 MPa for compomer to 16.73 for composite resin materials.

Light cure composite resin (President) was statistically significantly different for compressive and flexural strength than the other materials tested. Visible light-cured composite (President) is considered to be the best of the materials tested in terms of compressive strength and flexural strength, but it does not achieve the ultimate Diametral strength of amalgam

In terms of both diametral and flexural strength, of glass ionomer based cement were lower than those of light cure composite resin compomer and amalgam (Table 2). The Duncan's post hoc test identified many differences among groups (Table 3). According to univariate analysis of variance there was a statistically significance among groups ($p<0.001$). Light cure composite resin and amalgam had the highest flexural, diametral tensile and compressive strength and were statistically stronger than compomer followed by resin modified glass ionomer and conventional glass ionomer core materials.

Table 2. The means, standard deviations flexural strength (FS), compressive strength (CS) and diametral tensile strength (DTS) values of tested core materials.

Materials	Properties	Mean (MPa)	Std. Deviation	N
Amalgam	CS	142.81	10.17	8
	FS	14.4	1.2	8
	DTS	147.1	7.9	8
Composite	CS	147.22	10.92	8
	FS	16.73	1.80	8
	DTS	135.56	2.16	8
RMGIC	CS	119.60	2.21	8
	FS	13.43	1.86	8
	DTS	18.54	2.20	8
GIC	CS	116.34	1.85	8
	FS	11.85	1.22	8
	DTS	18.80	1.14	8
Compomer	CS	125.16	4.67	8
	FS	11.76	1.56	8
	DTS	114.24	2.41	8
Total				120

DISCUSSION

Laboratory evaluation of the mechanical properties of core materials can be a useful guide to the clinician who must determine when and where to use the core materials.[9]

Amalgam has been considered to be the material of choice for cores and both mechanical tests and finite element analyses have indicated that amalgam cores have superior performances in comparison to resin composite cores.[3,4,10] The metallic colour of amalgam may not be aesthetic, but it is easy to differentiate from tooth structure during tooth preparation.[11] Unfortunately, the relatively slow set of amalgam delays preparation of amalgam cores.[8]

Improvements in composite resins and the development of enamel-dentin bonding systems have stimulated trends toward more conservative techniques. In addition, modern concepts of total-etch procedures are presently contributing to such trends.[12]

Composite resin has been promoted as a core material because it is light cured and allows crown preparation to be started immediately after curing. Resin composites have several practical advantages. It can be translucent and tooth colored, thus they do not darken teeth. It can also be selected for contrast against tooth structure, to facilitate tooth preparation for crowns. In addition, it can be bonded to teeth using dentinal adhesives. For convenience, either light iniated or auto curing materials can be selected. As they set quickly, core and tooth preparation can be completed using rotary instrumentation without delay. However, resin composites also have some disadvantages. Light cured materials may not undergo complete curing if insufficient light intensity or curing time is used[8].

Gateau et al[13] reported that under cyclic loading a core fabricated from amalgam has the lowest rate of defects, followed by composite. The glass-ionomer core material shows the highest rate of defects.

In this study, composite resin and amalgam materials demonstrated an increase in CS, DTS and FS when compared with these properties of glass ionomer materials. This study indicates that some resin composites may be used as alternatives to amalgam cores.

Glass ionomer cements were introduced in 1972. The prime advantages of GI application are the fluoride release, adhesion to both enamel and dentin, and a coefficient of thermal expansion that is similar to dentin.[14-17] However, their low wear resistance, low tensile strength and brittleness precluded their use as core materials.[18]Glass-ionomer-based materials are weaker than the composite resin and amalgam materials. This study demonstrated that resin modified glass ionomer material (Vitremer) was not significantly different than conventional glass ionomer (Logofil). Either Amalgam and composites cores are certainly to be preferred to glass ionomer or resin modified glass ionomer cores.[19]

Glass ionomers are also less fatigue resistant than resin composites.[20] In the further development of glass-ionomer cement materials, efforts should be directed towards improving the physical properties.[2] The development of resin-modified glass-ionomer cements has created a new choice in the selection of materials. These materials are still relatively new and, their long term clinical performance has been investigated.[21,22]

Only with a through understanding of the individual patient's oral conditions can an accurate assessment be made regarding material selection. Minimizing the risk associated with failure should include knowledge of the material's properties, the forces that the core build-up must withstand, the occlusal scheme of the patient, and the final type of restorations or prosthesis to fabricated.[23]

Compomers or poly acid-modified composites are used for in low stress-bearing areas, although a recent product is recommended by the manufacturer for Class I and Class II restorations in adults.[24]

Piwowarczyk et al.[25] stated that auto polymerizing resin composite (Corepaste) demonstrated greater compressive and flexural strength than the other tested materials. It was also indicated that flexural and tensile strengths of glass ionomer cement were lower than those of auto cured resin composites and compomer.

Irie and Nakai[26] showed that the flexural test of compomers to be statistically different and more resilient than the resin-modified glass ionomer cement or the microfilled composite, when tested immediately after light-curing and after 1 week of water storage. In addition, Momoi et al.[27] found that resin-modified glass-ionomers were stronger, more flexible and more resilient than conventional acid-base glass-ionomers.

This study showed that light-cure composite resin and amalgam had the highest flexural, diametral tensile, compressive strength and were statistically different than compomer, followed by resin modified glass-ionomer and conventional glass ionomer. As a result of, both resin composites and amalgam may be recommended for use as core materials. However, glass ionomer materials are not suggested for use as core materials because they are much weaker than the alternatives.

As concluded in many previous studies comparing and contrasting restorative materials indicated for specific applications, no one material may be considered ideal on the basis of its physical properties and characteristics. Furthermore it could be considered unlikely that there will even be an ideal restorative material capable of truly replacing lost tooth tissues, and thereby fully restoring the form, function and appearance of diseased and damaged teeth. As a consequence, clinicians should have an informed understanding of the advantages and limitations of alternative materials for specific applications and, with due regard to specific environmental circumstances, modify their clinical technique accordingly to enhance the best possible clinical outcome.[2]

CONCLUSION

When evaluating the results of this laboratory study, it should be noted that there may be limitations to the direct application of in vitro result to in vivo situations. Further clinical testing and in vivo investigation are still required to determine core materials have the best mechanical properties.

1- Compressive, diametral and flexural tensile strengths varied widely among the different types of core materials.

2-DTS, CS and FS of the light-cure composite resin (President) and amalgam (Cavex avalloy) were statistically different than the other materials tested. They are stronger than compomer followed by resin modified glass ionomer and conventional glass ionomer core materials.

3-Resin- modified glass-ionomer cement (Vitremer) and conventional glass ionomer cement (Logofil) showed the lowest value compared the other materials tested.

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