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IMPROVEMENT IN THE COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH OF DENTAL COMPOSITE

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ABSTRACT

This paper gives the detailed comparison of the physical properties of dental composite material. In this study we analyses various dental composite material and effect of variation of different physical properties of composite, Also gives the full description and dealt with the basics of composites and its classification. Lastly it gives the detailed comparison on two composite materials their related compressive and flexural strengths.

Keywords: dental composite, compressive strength, flexural strength, physical properties.

1. INTRODUCTION

Tooth may be defined as one of a set of hard, bonelike structures rooted in sockets in the jaws of vertebrates, typically composed of a core of soft pulp surrounded by a layer of hard dentin that is coated with cement or enamel at the crown and used chiefly for biting or chewing food or as a means of attack or defense. Each tooth consists of a crown, which projects above the gum; two to four roots embedded in the alveolus; and a neck, which stretches between the crown and the root. Each tooth also contains a cavity filled with pulp, richly supplied with blood vessels and nerves that enter the cavity through a small aperture at the base of each root. The solid part of the tooth consists of dentin, enamel, and a thin layer of bone on the surface of the root. The dentin composes the bulk of the tooth. The enamel covers the exposed part of the crown. A cavity (caused by a disease called caries) happens when bacteria in the mouth produce acids that attack your teeth. In time, this acid can dissolve away the enamel on your teeth and cause a hole, which is known as a cavity. Unlike some other diseases or injuries, a cavity will not heal by itself, but if the early signs of dental decay are promptly treated before a cavity forms, it can be stopped and even reversed by your dentist. Without treatment by your dentist, dental decay may continue to advance. Extreme decay can result in the loss of the affected tooth or teeth, potentially preceded by great discomfort, infection and other health problems. Fracture or decay causes a portion of a tooth to break off, and in some cases, there’s simply not enough tooth left to place a crown. Fracture or decay causes a portion of a tooth to break off, and in some cases, there’s simply not enough tooth left to place a crown. Fortunately, we can replace the missing portion and save the tooth by building it up with one of the new resin/plastic filling materials. Hence for avoiding these decay various filling materials have been used which are known as dental composites. Figure-1 shows the result of decay in the teeth when not enough tooth left for crown and Figure-2 shows the result of build ups when it is been filled by filling material. A cavity (caused by a disease called caries) happens when bacteria in the mouth produce acids that attack your teeth. In time, this acid can dissolve away the enamel on your teeth and cause a hole, which is known as a cavity. Unlike some other diseases or injuries, a cavity will not heal by itself, but if the early signs of dental decay are promptly treated before a cavity forms, it can be stopped and even reversed by your dentist. Without treatment by your dentist, dental decay may continue to advance. Extreme decay can result in the loss of the affected tooth or teeth, potentially preceded by great discomfort, infection and other health problems.

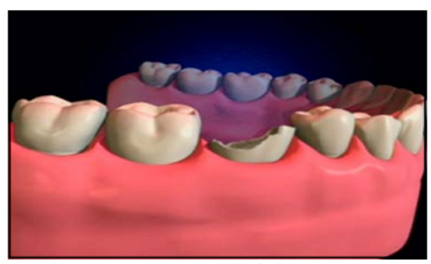

Figure-1. Tooth buildups.

Figure-2. Tooth buildups.

2. LITERATURE SURVEY

A. Filling material

The material which is used to fill the cavity of teeth is called filing material.

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a) Requirements of an ideal filling material

- It should have satisfactory mechanical properties to withstand the force applied example Abrasion resistance, compressive and tensile strength, modulus of elasticity.
- Ideally filling materials should be good thermal insulators, protecting the dental pulp from harmful effect of hot and cold stimuli.
- It should adhere well to the tooth walls and seal the margin to prevent ingress of fluid and bacteria.
- It should be harmless to the operator and to the patient and should not irritate dental pulp and soft tissues.
- Easily polished.
- It should be bacteriostatic and anticariogenic.
- It should be radiopaque.

b) Properties of filling material

- Mechanical properties must withstand the biting and chewing force in the posterior area of the mouth.
- Force is any push or pull on matter.
- Stress is the reaction within the material that can cause distortion.
- Strain is the change produced within the material that occurs as the result of stress.

B. Composites

A combination of two or more materials (reinforcement, resin, filler, etc.), differing in form or composition on a macro scale. The constituents retain their identities, i.e., they do not dissolve or merge into each other, although they act in concert. Normally, the components can be physically identified and exhibit an interface between each other. Composite materials are solids which contain two or more distinct constituent materials or phases, on a scale larger than the atomic. The term "composite" is usually reserved for those materials in which the distinct phases are separated on a scale larger than the atomic, and in which properties such as the elastic modulus are significantly altered in comparison with those of a homogeneous material. The physical, mechanical and aesthetic properties and the clinical behaviour of composites depend on their structure. Basically, dental composites are composed of three chemically-different materials. Composites are used because it has wide variety of advantages over traditional materials. It is corrosion resistant having high strength to weight ratio also require low maintenance.

(i) Composition

- **Resin Matrix:** The nature of resin may alter slightly from one product to another, essentially, they all contain dimethacrylate monomer, like Bis-GMA (Bis phenol-A and glycidyl methacrylate) or UDMA (Urethane dimethacrylate), Bis-GMA and UDMA are viscous and sticky so, TEGMA (Triethylene glycol dimethacrylate) a low molecular weight monomer added as a dilute to control the consistency of composite paste. Bis-GMA, UDMA and TEGMA are characterized by carbon double bond the react to convert them to polymers.
- **Fillers:** Fillers are irregular or spherical in shape depending on the mode of manufacture. They are silicate particles in two forms crystalline forms (quartz) and non crystalline form (glass like alumino silicates and boro-silicates), the type of filler, particle size, and distribution in resin matrix are the major factors controlling properties, Zinc, Barium, Zirconium ions may be added to produce radiopacity in the filler particles.

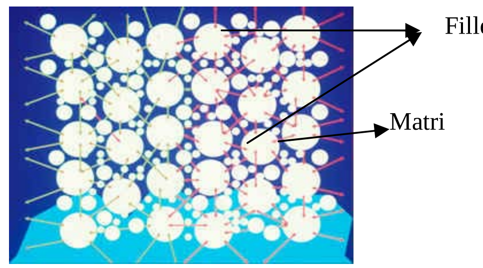

Figure-3. Filler matrix.

a) Advantages of composites

- Maximum conservation of tooth structure is possible
- Aesthetically acceptable.
- Less complex cavity preparation is required.
- Insulative have low thermal conductivity hence no insulation base is required.
- Restorations are bonded with enamel and dentin hence has good retention.
- Can be finished immediately after curing.

b) Disadvantages of filling material

- Gap formation on margins may occur, usually on root surfaces. This occurs because the force of polymerization shrinkage is greater than the initial bond strength of composite to dentin.
- More difficult, time consuming and costlier than amalgam.
- More technique sensitive.
- Greater occlusal wear in areas of high occlusal stress.
- High LCTE may result in marginal percolation around composite restorations.

3. PERFORMANCE ANANLYSIS OF COMPOSITE MATERIAL

This study evaluated the fracture pattern of four composites for indirect dental restoration relating to three-point flexural strength, compressive strength and modulus of elasticity (Solidex, Artglass, belle Glass, and Targis). Ten specimens of each composite were tested in a universal testing machine 0.5 mm/min crosshead speed for flexural strength and 1mm/min for compressive strength. Fracture pattern was classified as complete or partial fracture. Modulus of elasticity was calculated from flexural strength data. Composites polymerized under high temperatures (belle Glass and Targis) had higher flexural

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strength and elasticmodulus values than composites polymerized by light (Artglass and Solidex). However, they failed earlier under compression because they were more rigid and showed partial fracture in the material bulk.

a) Flexural strength test

Ten specimens of each composite system were made using a 25 x 2 x 2 mm metallic matrix, according to the ISO Specification No. 4049 (1988) for flexural strength test. The composite was packed into the metallic matrix in one increment. A transparent plastic stripe was positioned over the metallic matrix, and a glass slab was pressed against the matrix-composite. The glass slab was removed for initial composite polymerization for 20 s (curing unit XL-1500, 3M-ESPE, Seefeld, Germany) with light intensity above 400mW/cm^2, which was monitored by a radiometer (Curing Radiometer, model 100, Demetron/Kerr, Danbury, CT, USA). After this step, the specimen was removed from the metallic matrix and received additional polymerization according to the composite system. Solidex specimens were submitted to additional polymerization in the Solidilite system (Shofu, California, USA) at a wavelength of 420-480 nm and temperature of 55ºC for 3 minutes. Artglass specimens were placed inside the stroboscopic light unit UniXs (Heraeus-Kulzer, Hanau, Germany) for 180 Belle Glass specimens were treated in the curing unit (KerrLab Corporation, West Collins Orange, CA, USA) under 60 psi nitrogen pressure at 140^{o}C for 20 minutes. Targis specimens were coated with glycerin gel (Targis Gel) to prevent formation of oxygen-inhibited surface layer and were placed in the curing unit Targis Power (Ivoclar Vivadent, Liechtenstein - Switzerland) for the following cycle: light emission in the first 10 min, increase of temperature to 95^{o}C for 10 s, and cooling for 5 min. After this, the specimens were rinsed in running water and dried with air blasts. All specimens were stored in individual light-protected plastic tubes with distilled water (1 design group per vial) at 37^{o}C for 1 week. Specimens were placed on a 25 mm-length supporting base and assembled in a universal testing machine (EMIC DL-2000, EMIC, São José dos Pinhais, PR, Brazil). A customized device was adapted to the upper holder to allow vertical loading of the specimens according to a three-point bending test design. Axial load was applied until failure at a crosshead speed of 1.0 mm/min.

Flexural strength data were obtained in kgf and transformed in MPa using the following ISO 4049 formula:

s = 3 F L / 2 b h2

where

s = flexural strength (MPa),
F = recorded force (kgf),
L = length between the supporting points (21 mm), b is the width of the prism (2 mm), and
h = thickness of the prism (2 mm).

b) Compressive strength test

Compressive strength test was performed according to previous studies. Samples were made with 2 mm thick increments of each composite resin using a cylindrical Teflon matrix with 3 mm diameter and 6 mm height. Polymerization method for each system followed the procedures previously described for the flexural strength test. After storage for 24 h, specimens were tested in a universal testing machine at a crosshead speed of 1mm/min. Data were obtained in kgf and transformed in MPa using the following formula:

RC = F x 9.807 / A

Where

RC = compressive strength (MPa),
F = recorded force (kgf) multiplied by the constant 9.807 (gravity), and
A = base area (7.06 mm^2)

4. RESULTS

Mean values (MPa) of flexural strength and compressive strength are shown in Table-1. Belle Glass and Targis had higher flexural strength and modulus of elasticity than Artglass and Solidex, but lower compressive strength.

5. DISCUSSIONS

As flexural strength reflects resistance to compressive and tension stresses that act in the material simultaneously, the evaluation of this property is important for materials used in posterior teeth, particularly in multi-unit fixed partial dentures. In our study, the composite polymerized by light, heat, and pressure (belle Glass system) had the highest flexural strength, followed by the composite polymerized by light and heat Targis (Ivoclar Vivadent). The composite system with additional polymerization under stroboscopic light (Artglass) had intermediate values of flexural strength and was not different from Targis and Solidex. High flexural strength for belle Glass may be related to its polymerization under nitrogen environment and pressure, which decreases porosity and oxygen inhibition, and increases adhesion of fillers to resin matrix. This combination of high temperature and pressure for additional polymerization increases flexural strength, and may improve wear resistance, hardness, and diametral tensile strength because of high monomer conversion rate. It has been reported that systems that only use light polymerization have lower flexural strength even with increased light intensity and longer polymerization. However, Artglass (only light polymerization) exhibited flexural strength similar to the composite additionally polymerized by heat (Targis) probably because of the presence of monomer with multifunctional groups. BelleGlass and Targis showed higher modulus of elasticity than Artglass and Solidex, with values ranging from 15.61 to 21.55 GPa. It can be speculated that additional polymerization and increase of monomer conversion rate result in higher modulus of elasticity, which also may be influenced by

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filler size and volume. Both filler morphology and filler loading are shown to influence flexural strength, flexural modulus, hardness, and fracture toughness of dental composites. Parallel conclusion was drawn by another study with the same composites tested here, which reported that Targis showed higher micro hardness than Artglass and Solidex. Contrary to our expectations that the resin additionally treated with heat would have higher compressive strength, Artglass and Solidex showed higher values than Targis and belle Glass. The opaque composites Targis and belle Glass have more Bis-GMA in the organic matrix and higher elastic modulus. On the other hand, Artglass and Solidex have high content of multifunctional monomers in the organic matrix and are more resilient. Artglass manufacturer claims that the material is more resistant to fractures because it is more resilient than the resins with large amount of Bis-GMA. The compressive strength test is easy to perform but its interpretation is complex as tension and shear forces act concurrently inside the material. He stated that compressive resistance cannot predict the capacity of the composite resin to support stress, and that this relationship is limited to frail materials. Composite resins would suffer a "barrel" effect when submitted to a compressive test and expand until plastic deformation occurs.

6. CONCLUSIONS

From this study we can conclude that the flexural strength and compressive strength of composite material are inversely proportional to each other also this properties are important in making composite very effective in application. These properties strengthen mechanical properties of composite material. By analyzing experimenting, studding and Appling different module on different properties of filler content of composite material we will try to improve the mechanical properties of filler material viz. the compressive strength and flexural strength.

Table-1. Comparison of flexural strength and compressive strength.

Filler material	**Flexural strength** (Mpa)		**Compressive strength** (Mpa)		**Pattern of fracture** (%)	
	Mean	**SD**	**Mean**	**SD**	**Bulk**	**Pattern**
Solidex	17.95^{c}	14.86	206.70^{a}	34.91	100%	
Artglass	94.76^{bc}	13.51	224.00^{a}	17.4	100%	
BelleGlass	132.48^{a}	22.19	163.00^{b}	18.42		100%
Targis	111.23^{b}	17.02	163.39^{b}	32.04		100%

REFERENCES

[1] Touati B and Aidan N. 1997. Second generation laboratory composite resins for indirect restorations. J. Esthet Dent. 9: 108-118.

[2] Vallittu PK. 2004. Survival rates of resin-bonded, glass fiber-reinforced composite fixed partial dentures with a mean follow-up of 42 months: a pilot study. J. Prosthet Dent. 91: 241-246.

[3] Shellard E and Duke ES. 1999. Indirect composite resin materials for posterior applications. Compend Contin Educ Dent. 20: 1166-1171.

[4] Miara P. 1998. Aesthetic guidelines for second-generation indirect inlay and onlay composite restorations. Pract Periodontics Aesthet Dent. 10: 423-431.

[5] Ferracane JL and Condon JR. 1992. Post-cure heat treatments for composites: properties and fractography. Dent Mater. 8: 290- 295.

[6] Cesar PF, Miranda WG Jr and Braga RR. 2001. Influence of shade and storage time on the flexural strength, flexural modulus, and hardness of composites used for indirect restorations. J Prosthet Dent. 86: 289-296.

[7] Miranda CB, Pagani C, Bottino MC and Benetti AR. 2003. A comparison of micro hardness of indirect composite restorative materials. J. Appl. Oral Sci. 11: 157-161.

[8] 1988. ISO 4049. Dentistry-Resin-based filling materials. International Organization for Standardization.

[9] McCabe JF and Kagi S. 1991. Mechanical properties of a composite inlay material following post-curing. Br Dent J. 171: 246-248.

[10] Kildal KK and Ruyter IE. 1997. How different curing methods affect mechanical properties of composites for inlays when tested in dry and wet conditions. Eur J. Oral Sci. 105: 353-361.