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The Effect Of Photo-Activation Method in Polymerization Process Of Different Light-Cured Composite Resins On Hardness And Compression

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Abstract

Three resins were analyzed: Swiss TEC restorative composite resin, Composan Ceram Syringes, and Ivoclar Vivadent Tetric N-Ceram Light Cured Hybrid. The LED.F gadget, which emits blue light at 494 nm, was used to process the samples. For each composite type, nine samples were created and subsequently put through pressure and hardness tests. Utilizing a simple statistical test of the correlation coefficient, T-tests were used to examine the relationship between the variables in the study. Compressive strength (CS) and hardness tests were conducted as part of the physical testing. Tetric N-Ceram composite resin had the highest compressive strength compared to the other materials under investigation, and the hardness test increased as the curing time intervals increased. Composan Ceram Syringes composite

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Introduction

A variety of new procedures have been developed in the field of cosmetic dentistry to improve the material's physical, mechanical, and aesthetic features [1].Most composites work well with blue and violet laser diodes that emit short-wavelength light (400–500 nm) consistently and effectively [2].

These lasers have an absorption peak at 470 nm, the same wavelength as camphorquinone (468 nm). The photoinitiator in the majority of composites is camphorquinone (2,3-bornanedione) [2-4].

Resin-based composite materials are frequently re-evaluated since their properties can be influenced by a variety of factors, including hardness, basic strength, treatment length, processing unit weight, radiation, light spectrum, and thickness [5].

Hardness is an essential mechanical property in dentistry that must be defined. The hardness of a material is determined by its capacity to resist deformation. Composites' surface hardness can be changed by water absorption and hydrolysis due to the load and length of the test. The Vickers hardness test is the method most widely used to determine the hardness of resin composites and denture teeth. Hardness has a direct effect on the compressive strength, wear resistance, and conversion rate of a given material. If the hardness of a resin composite is low, it indicates that the matrix and filler interfaces are not effectively connected. [7].

Color stability and control of polymerization can both be achieved using LEDs or lasers. Filler particles improve the organic matrix's physical and mechanical qualities. When employing fillers, it is critical to use a high proportion because fillers minimize thermal expansion and total shrinkage, make the material radio-opaque, make it easier to work with, and improve its appearance. [8].

This study investigates the effects of LED curing lamps with three polymerization durations on mechanical qualities, strength, and surface hardness.

Methodologies and Materials

Three composites materials were used in our study include

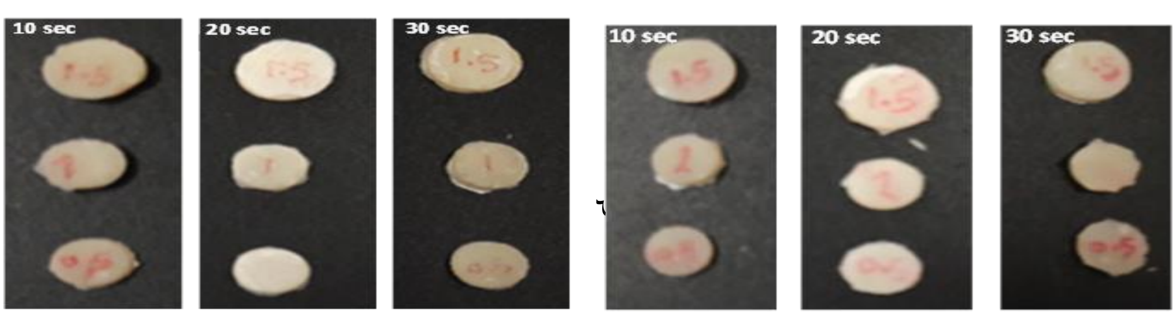
- Shade A2 Composan Ceram Syringes (Glass Ceramic Micro-Hybrid Composite) : it is a Light-curable micro-hybrid and offers physical properties such as high color stability, high translucency and low shrinkage
- Light-cured hybrid shade A1 of Ivoclar Vivadent Tetric N-Ceram : it is a light-curing, radiopaque nano-hybrid composite based on nano-optimized technology for direct restorative procedures.
- Swiss TEC shade A2 composite resin. It is a syringeable, sculptable, radiopaque, highly filled fine hybrid composite which is cured on the model with visible halogen light Figure 1.

The materials were polymerized using a 494 nm blue LED, as illustrated in Figure 2.

Fig.(1) Three bulk fill resin used under investigation

Fig.(2) Blue light emitting diode (LED) unit

For each material, Steel molds with same diameter 10mm and different thicknesses 0.5,1, and 1.5mm have been used in the preparation of all samples. The samples were polymerized with different periods 10,20 and 30 sec. Polymerization in each part of the mold should be activated in two-step process using a light source that illuminates the both sides of the mold. Seventy-five percent of the light treatment happened in the first 10 minutes. The response might extend up to 24 hours. [9].



Ceram

N- Ceram

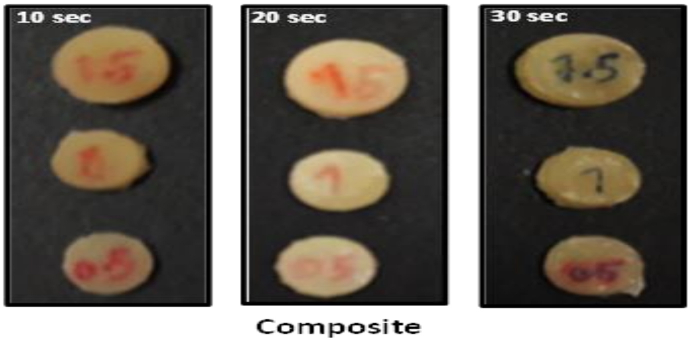


Figure (3) Hardness test samples with different ticknesses

Hardness test:

The hardness test was carried out using an (Amsler, KARL-KOLB/Germany) tester Figure (4). Samples were in contact with the indenter for 30 seconds, with a one kilogram applied load .The measurements were taken straight from the scale in five separate places on each sample . the hardness then calculated using Vickers Law .

$$HV = \frac{2p \sin \frac{136}{2}}{d^2}$$

Where : HV Vickers hardness number

p load (Kg)

d= (d1+d2)/2 mm

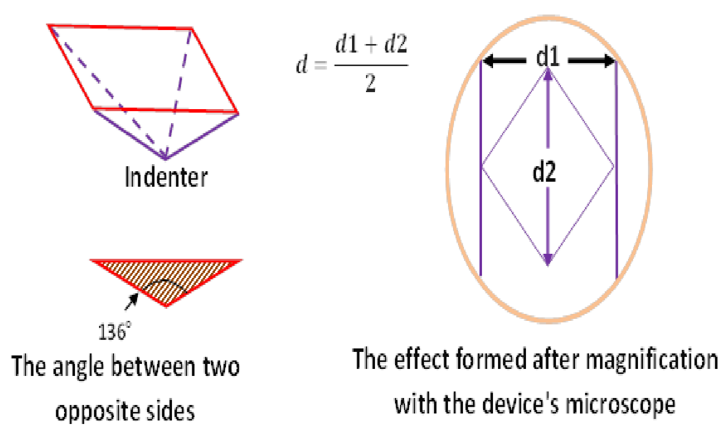


Fig.(4)(Amsler, KARL KOLB/Germany) machine for measuring the indentation hardness

Compressive Strength:

The material samples for each specific time have been prepared as a cylindrical shap with a radius of 0.5 cm and height of 1 cm to be suitabile for the compression machine tester, i.e. 9 samples have been prepared figure (5) .

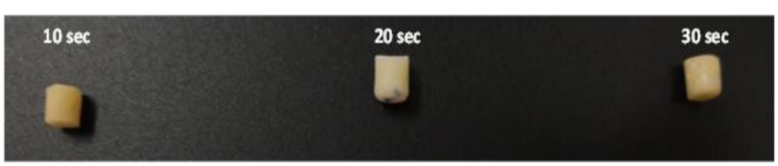
A compressive force was applied to the samples using a universal test instrument to bring about failure in this test Figure 5. Each sample was put in the middle of two flat surfaces that were parallel to each other. The compressive force was slowly increased until the sample broke. Extreme caution was needed to guarantee that a load was transported correctly from the testing equipment to the sample.

The load was evenly put on the end of the sample as a stress in N.mm^{-2}, which was calculated from the following equation:

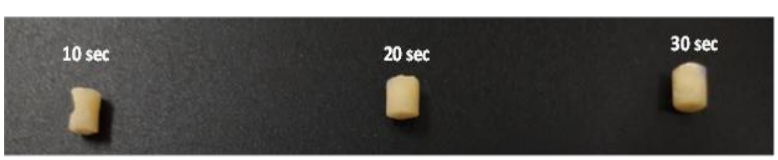
Compressive Strength = F/A

where F is the force that causes failure (in Newtons) and A is the smallest cross-sectional area (in millimeters).

Ceram



N- Ceram



Composite

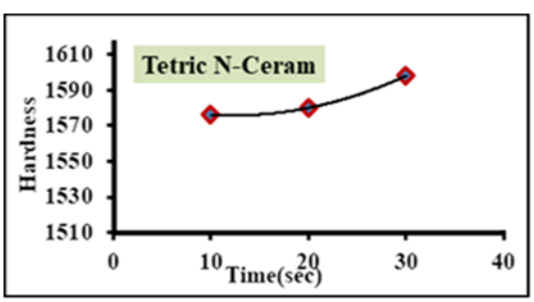
Figure (5) samples for compressive strength test

Results and Discussion

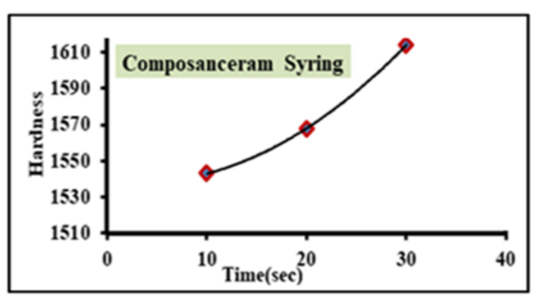
All of the samples were separated into six groups, each with three sub-groups (n =3), and the tests were assessed using the SAthe S2012 program for Vicker hardness and compressive strength after 24 hours of storage, then the data have been analyzed by ANOVA, T-test. Hardness tests for all samples over the used time are shown in Table.(2) and Figure(6). It was clear that all of the differences were statistically significant for all of the parameters examined ($p< 0.05$). Tab. (1) and Fig. 6 shows that the samples with a 30 sec exposure time have the best hardness among the others. These three figures also show that the hardness of all resin composite materials increases with the duration of irradiation [7].

LEDs are increasingly being used for composite resin curing since they create a modest temperature increase while in operation. Their small range of wavelengths is the same as the wavelength at which camphorquinone absorbs best.[10]. This was done with nanocomposite material. At the nanoscale, strong interfacial contacts between the resin and the fillers improved the physical properties of the nanocomposite. This led to high strength and thermal stability[12].

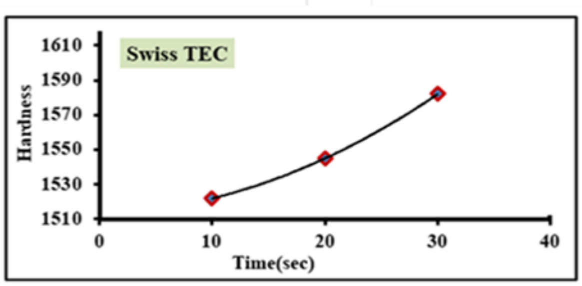
The composite hardness values of Composan Ceram Syringes with thinkness 1mm were determined to be maximum at 1614 (HRR) for 30 seconds and lowest at 1522 (HRR) for a period of 10 seconds (Figure 6). On the other hand, curing with light for a minimum of 40 s made the material much harder than curing with light for 20s.



Mean of Hardness test values (HRR) for Tetric N-Ceram composite material



Mean of Hardness test values (HRR) for Composan ceram Syringes composite material



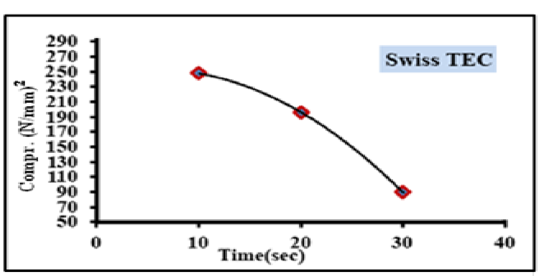
Mean of Hardness test values (HRR) for Swiss TEC composite material

Figure (6) Correlation between hardness means and time exposure with the tested materials

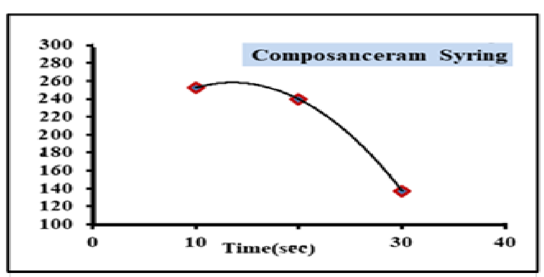
Table (1) the mean of compressive strength Test (N/mm)2 under different times for different Resin composite materials

Resin composite materials	Mean of compressive strength Test $(N/mm)^2$			T-test
	Time 10sec	Time 20sec	Time 30sec	
Tetric N-Ceram	**293.74**	**265.87**	**246.346**	**0.0087**
Composan ceram Syringes	**252.635**	**239.565**	**137.335**	**0.032**
Swiss TEC	**247.740**	**196.346**	**89.526**	**0.075**

By extending the time between curing cycles, the hardness of all tested materials was improved. Testing the compressive strength of restorative materials is critical in vitroanalyses, which have traditionally been considered a good predictor of the pressures that the materials are subjected to under mastication [8]. As a result, high-compressive-strength materials can withstand even the most powerful loads. According to the findings of this investigation (Fig.7), the compressive strength (CS) of the Tetric N-Ceram resin composite material was the highest, while the CS of the other materials examined was just ordinary.Solid, long-lasting resistance to weighly loads is provided by materiales with high compressive strengths(HSS)[11-13].



Mean of compressive strength test values for Swiss TEC composite material



Mean of compressive strength test values for Composan Ceram Syringes composite material

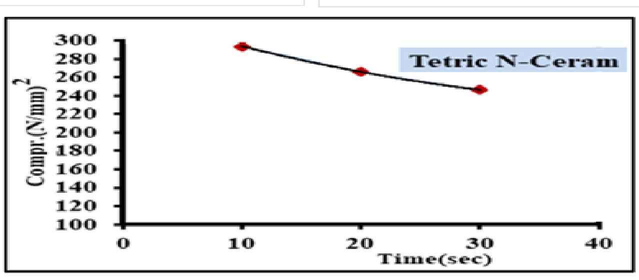


Fig. (7) Correlation between compressive strength means and time exposure with the tested materials

Table (2). The Hardness test (HRR) under different times for different Resin composite materials

Resin composite mterials	Mean of Hardness Test(HRR)			T-test
	Time 10sec	Time 20sec	Time 30sec	
Tetric N-Ceram	**1576**	**1580**	**1598**	**9.3**
Composan ceram Syringes	**1543**	**1568**	**1614**	**6.42**
Swiss TEC	**1522**	**1545**	**1582**	**2.9**

Conclusion

The hardness of the material was found to be significantly influenced by the thicknesses of the light quire (Ivoclar Vivadent Tetric N-Ceram Light Cured Hybrid, Composan Ceram Syringes (Glass Ceramic MMicro-HybridComposite), and Swiss TEC restorative composite resin) as well as the duration of polymerization. It is anticipated that these composites will be the subject of extensive future research.

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