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Original Article

In vitro Comparative Study of Compressive Strength of Different Types of Composite Resins in Different Periods of Time

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Abstract

To evaluate the ultimate compressive strength of five composite resins after 1 hour, 24 hours, 7 days and 1 month. Twenty four cylindrical 4 mm×8mm specimens of each commonly used composite resins in posterior region (Nulite-F , Z250 , P60, Biscore, Tetric ceram HB) were prepared. Each group of composite resins were divided into four time groups of 1 h, 24 h, 7 days and 1 month. All of specimens stored in an incubator with 37 °C. After each period of time all of the specimens were tested by Zwick/Roell Z020 (Germany) for ultimate compressive strength at cross head speed of 0.5 cm/min. Results were analyzed by ANOVA and Scheffe test. P60 and Z250 had the highest and Nulite-F and Tetric ceram HB had the lowest compressive strength at all the times. The difference between these two groups was statistically significant (p<0.05). The results of the Biscore was steady among the other groups. It is suggested to use Z250 or P60 in posterior restorations instead of the other composite resins tested.

Keywords: Compressive strength; Composite resins; Fiber reinforced composite resins.
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1. Introduction

Mechanical properties of core build up restorative materials have important role in efficacy and longevity of the tooth and restoration. A badly broken down tooth in anterior or posterior region of oral cavity which has happened because of caries or root canal therapy, needs to be restored with a suitable restorative material which can resist complicated forces of mastication [1, 2]. Since the majority of mastication forces in posterior region are particularly compressive, the restored endodontically treated tooth or the complex and extensive restoration should bear these kinds of forces [2, 4]. It is said that compressive strength is the most important mechanical property of core build up materials. A restorative material with lower compressive strength than tooth, tends to fail, fracture and it ends with periodontal problems or extraction of the broken tooth [3, 4].

Compressive strength is a useful property to compare materials which are brittle and generally weak in tension such as amalgams, cements or composite resins. Amalgam has been the core material of choice in posterior

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Table1. Mean , standard deviation and CV of compressive strength of composite resins after 1 hour(Mpa)

Composite resin	Mean±Std	C.V
Nulite - f	126±14	11
Biscore	179±21	12
P60	235±44	19
Z250	200±35	17
Tetric ceram HB	143.5±41	29

region for a long time but in recent years core buildup glass ionomers and posterior composite resins have been introduced as a core build up material. During the past recent years many new composite resins have been introduced to market such as condensable composite resins, core build up types and fiber reinforced composite resins in order to restore the coronal portion of a vital or endodontically treated tooth with an adhesive restoration [2, 4].

Composite resins are improving everyday because of their chemical ingredients, bonding ability, conservative preparation, preservation of tooth structure and esthetics. In anterior region composite resins are the materials of choice but in posterior region the composite resins should have mechanical properties like tooth structure and they should have a compressive strength equal or more than tooth structure to resist the mastication forces [2].

Many researches have been undertaken to evaluate the compressive strength of the different restorative materials. The studies in this area showed different results. In some studies amalgam showed the highest compressive strength [1], but in some of them composite resins had the higher strength [5], however, some have shown no significant difference between amalgam and composite resin. Also the compressive strength has changed with time of evaluation [6-14].

The aim of this study was to compare the compressive strength of different types of composite resins which have introduced as posterior composite resins in different times.

2. Materials and methods

Compressive strength of five commonly used composite resins in Iran was measured at 1 h, 24 h, 7 days and 1 month. Six samples were prepared for each time group of related composite resins, so they were 24 specimens for each composite resin and 120 specimens totally. The groups were as follows:

Group 1: Nulite -F (NSI, Australia), light cure fiber reinforced composite resin [15].

Group 2: P60 (3MESPE, USA), light cure posterior composite resin [16].

Group3: Z250 (3MESPE, USA), light cure hybrid composite resin [17].

Group 4: Biscore (Bisco,USA) , two components core build up self cure hybrid composite resin [18].

Group 5: Tetric Ceram HB (Vivadent , Liechtenstein), light cure hybrid composite resin [19].

2.1. Specimens preparation

According to ISO9917 standard specification [12], specimens prepared with 8.0 mm length and 4.0 mm diameter. A two part stainless steel cylindrical mold was used to prepare the specimens. The mold was placed on a glass slab and a mylar matrix was placed under the mold to obtain flat surface. Composite resins were applied in the mold in 2 mm layers to fill the mold. For the last layer a mylar matrix was placed over the layer.

For light cure composite resins light curing was done with Coltolux 2.5 (Coltene, Switzerland) light curing unit for 40 seconds per layer with the intensity of 400 mW/cm^2. In order to have maximum curing, each specimen was post-cured 10 minutes after preparation for 60 seconds at all directions.

After the end of sample preparation in

Table 2. Mean , standard deviation and CV of compressive strength of composite resins after 24 hours (Mpa)

Composite resin	Mean ±Std	C.V
Nulite - f	191±12	6
P60	278±31	11
Z250	252±36	14
Biscore	229±36	15
Tetric ceram HB	209±18	9

each group of composite resin they divided into 4 groups of 6 samples and stored at 37±1 °C in an incubator for different times prior to compressive strength testing.

2.2. Measurement of compressive strength

Compressive strength of specimens was measured after 1 h, 24 h, 1 week and 4 weeks. Test was carried out on a universal testing machine (Zwick/Roell,Z020,Germany) at a crosshead speed of 0.5 cm/min.Ultimate Compressive strength (UCS) was calculated from the formula $UCS=4f/\pi d^2$, where F is maximum applied load(N) and D the cylindrical Specimen diameter (mm)[3, 4, 12]. Data were analyzed by ANOVA one-way and Scheffe test.

3. Results

The Results are given in Tables 1 to 4 and Figure 1. Mean compressive strength of all groups after 1 h has been shown in Table 1. The ANOVA analysis showed that the Mean compressive strength of P60 after 1 h was the same as Z250 and higher than Nulite-F, Biscore and Tetric Ceram HB ($p<0.05$). The Mean compressive strength of Z250 was higher than Nulite-F and Tetric Ceram HB ($p<0.05$). Comparison of the results with Scheffe analysis showed that Nulite-F was significantly different from Biscore, P60 and Z250 but not with Tetric Ceram HB.

The Mean compressive strength of all groups after 24 h has been shown in Table 2. ANOVA showed that P60 had the highest compressive strength among all the composite resins tested ($p<0.05$) except the Z250 which had the same compressive strength.

Table 3 shows The Mean compressive strength of all groups after 1 week. P60 had

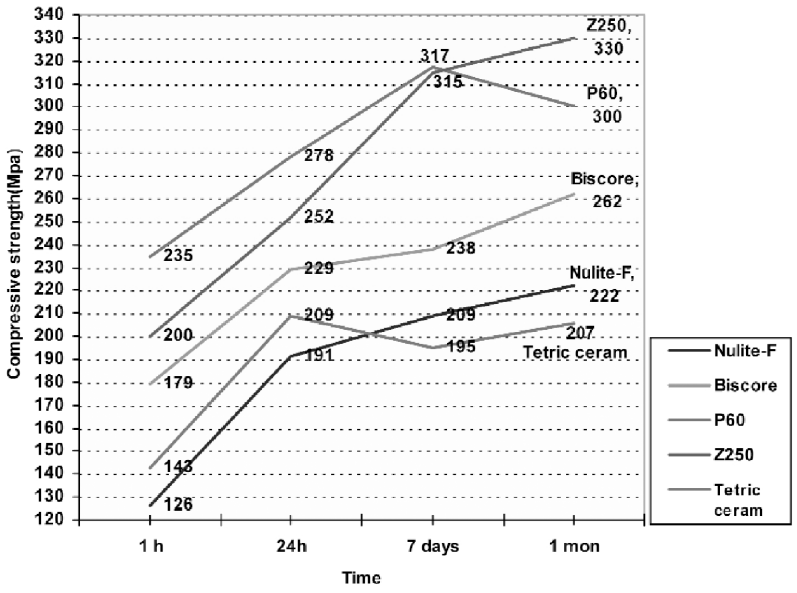

Figure 1. Mean compressive strength of composite resins in different times.

Table 3. Mean , standard deviation and CV of compressive strength of composite resins after 1 week (Mpa)

Composite resin	Mean ±Std	C.V
Nulite - f	209±18	9
P60	317±23	7
Z250	315±54	18
Biscore	238±28	12
Tetric ceram HB	195±54	28

the highest compressive strength among all the composite resins tested ($p<0.05$) and Tetric Ceram HB had the lowest. ANOVA showed that the difference is significant and Scheffe test revealed that there were no significant difference between p60 and Z250 and both of them have significantly higher compressive strength than the other groups.

The results of compressive strength of composite resins after 4 weeks are given in Table 4. It shows that the highest mean compressive strength is related to P60 and Z250 and the lowest is related to Tetric Ceram HB and the difference is significant according to ANOVA test ($p<0.05$). Also Scheffe test showed that Z250 had significantly higher compressive strength in comparison to Nulite-F, Biscore and Tetric Ceram HB ($p<0.05$). Also P60 was better than Nulite-F and Tetric Ceram HB ($p<0.05$).

Figure1 shows the changes of compressive strength of each composite resin during the time intervals. As it shows Tetric ceram HB and Nulite-F have the lowest compressive strength and P60 and Z250 highest at all the times.

4. Discussion

Compressive strength is one of the most important mechanical properties of a core buildup material which restores the structure of a tooth in posterior region [1-4, 20]. A core buildup material should have the same mechanical properties as tooth structure. A material with higher or lower amount of a property will adversely affect on longevity of the tooth structure and the restoration and a premature failure of each will happen.

The results of this study revealed that the compressive strength of all the composite resins increased with time from 1 h to 24 h. This is the same as the result of the studies of other researchers (1, 6, 8, 9, 11) but even after 24 h none of the composite resins reached to the amount of the compressive strength of the tooth structure which is 384 Mpa for enamel and 297 Mpa for dentin. After 7 days only p60 and Z250 reached to dentin's amount.

It seems that the compressive strength is related to the type of composite resin. P60 and Z250 had the highest compressive strength at all the times. Biscore placed in second position and Tetric ceram HB and Nulite-F had the lowest compressive strength. In recent years composite resins have introduced as core build up materials because they have some advantages to dental amalgam. Composite resin needs more conservative preparation and adheres to tooth structure due to the application of the adhesive agent prior to it and this will help to preserve the tooth structure [3]. But they have some negative points which need more careful techniques in restoration such as polymerization shrinkage, water sorption, high sensitivity to contamination during the restoration and incomplete polymerization especially in light cure composite resins which light does not reach to the deep parts of the cavity [2-4]. All of these factors will affect on the mechanical properties of the composite restorations and lead to premature failure than amalgam restorations. So it is necessary to select the right composite resin to apply as a core build up material in complex and extensive cavities.

In this study we evaluated the compressive strength of five different types of composite

Table 4. Mean, standard deviation and CV of compressive strength of composite resins after 4 week (Mpa)

Composite resin	Mean ±Std	C.V
Nulite - f	222±7	3
P60	300±48	16
Z250	330±56	17
Biscore	262±22	8
Tetric ceram HB	207±23	11

resins which each of them has been introduced for some applications in posterior region but they have some structural and chemical differences. One of the composite resins ingredients which affects on the mechanical properties is filler size, type and content [2-4]. P60 is a packable composite resin which can use as a direct and indirect material, core buildup, cusp buildup and splinting the teeth [16]. It has 61% V filler [16]. P60 had the highest compressive strength among the groups at all the times examined.

Z250 is a universal composite resin with 60%V zirconia-silica fillers [17]. It was statistically the same as P60 at all the times.

In contrast to all the other groups, Biscore is a chemically-cure core buildup composite resin with 50-80% V filler [18]. The results of Biscore were very steady in comparison to the other groups.

Tetric Ceram HB was a composite resin which was specially produced to restore posterior teeth. It has 63% V filler [19]. This composite resin had almost the lowest compressive strength between groups at all the times evaluated.

Nulite-F is a fiber reinforced composite resin which is introduced for posterior fillings and fiber reinforced bridges. It has 71 % V filler addition to Glass Micro Rods as fiber. We hypothesized that the presence of fiber in a composite resin will increase the compressive strength but this did not happen and Nulite -F had lowest compressive strength. Maybe the fibers in this composite resin affect on other properties such as flexural strength and fracture toughness which is important in bridges.

The results show that volumetric percentage of fillers in these composite resins is not the only factor to affect on the compressive strength. Composite resins with almost the same filler had not the same compressive strength. It seems that there are other factors like degree of conversion, filler-matrix bond in mouth environment, type of polymerization, polymerization shrinkage and many other factors which affect on mechanical properties of composite resins [3, 4, 7]. The polymerization pattern of composite resin is important in mechanical properties too. In this study Biscore which was a chemically cured composite resin had very steady results. This seems to be related to the stress production in a chemically cured composite resin which is slower and longer than the light cure composite resin so the latter has time to release the stresses.

In this study the ISO standard for sample preparation was followed and it's very important in compressive strength test. Some studies did not follow the ISO standard for sample size and this have affected on the results [2, 4, 13]. Also we prepared a two part mold to bring out the samples from the mold without any force but in some studies force was applied at the end of sample to bring it out [1, 2].

The cross head speed of the universal testing machine is also important in the results. It's said that with very low speed the material will used to force and the results will not right. In our study like some of the researches the cross head speed was 0.5 cm/min [1, 5, 6].

This study was a basic research for evaluation and comparison of the compressive strength of some new composite resins which have introduced to the market. It needs more

researches to examine the other properties to understand the responses of composite resins in the mouth environment which is a humid and full of different forces with various magnitudes.

The conclusions of this study showed that:

1-The highest compressive strengths were for P60 and Z250.

2-The compressive strengths of all groups in different times were:

P60 >Z250 >Biscore >Tetric ceram HB > Nulite-F at 1 h

P60 >Z250 >Biscore >Tetric ceram HB > Nulite-F at 24 h

At 1 week P60 >Z250 >Biscore >Nulite-F >Tetric ceram HB

Z250, P60 >Biscore >Nulite-F >Tetric ceram HB At 4 weeks

3-The compressive strength increased with time.

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