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Review Article

# Effect of "Recurring" Procedure on the Surface Micro hardness Values of Different Composite Resins

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### Abstract

**Aim:** The goal of this study was to investigate the effect of the recurring procedure on the surface micro hardness values of different composite resins after the finishing procedure.

**Material and Methods:** Five brands of composite resins were selected according to their viscosity and type of filler particle content (Esthetic X HD, Spectrum TPH3, Tetric N-Ceram, Filtek Z350 XT, and Prime- Dent). Twenty specimens were prepared for each type of composite in cylindrical form (2mm length and 4 mm diameter) by metal molds then placed in a numbered, dark, completely covered container and stored in an incubator for 24 hours. The first Vicker micro hardness measurement was conducted on the most polymerized superficial layer, and then it was stored in an incubator for 24 hours. The second measurement was conducted after the finishing procedure using600 grit wet sandpaper, and then it was stored in an incubator for 24 hours. The third measurement was conducted after the recurring procedure.

**Results:** The mean hardness values of the prefinishing test, showed the highest values in Spectrum TPH3 (46.5) while the lowest was found in Prime Dent (39.4). Post-finishing values showed higher significantly different values in all specimens tested, with Spectrum TPH3still having the highest value (79.8). The lowest value this time was found in Esthetic X HD, with 59.3. Post-recurring values also demonstrated that Spectrum TPH3would still have the highest significantly different value of 93.3, and Esthetic X HD was still found to have the lowest value of 71.0.

**Conclusion:** The finishing procedure removed surface topographical irregularities and improved the hardness of the composite material. By contrast, the recurring procedure returned the most polymerized superficial layer, which will be removed after the finishing procedure, and the composite material further improved the hardness.

***Keywords:*** *Composite resins; Micro hardness; Finishing and polishing; Recurring procedure*

## Introduction

Dental composites are one of the most popular direct restorations, and their demand has increased recently because of the improvements in dental adhesives, their superior aesthetics, and the improvement of their physical properties. Composites can be used in multiple clinical applications such as filling materials, luting agents, indirect restoration, metal facing, and endodontic posts and cores. For these reasons, multiple types of composites have been produced to improve their aesthetics and mechanical properties [1].

Recently, the demand for aesthetic dentistry has increased, leading to improvements of the mechanical properties and an increase in their longevity and martial performance in high-stress areas such as Class II. In order to improve the mechanical properties, a study was performed by Hossein., et al. [], which showedan increase in fracture toughness, flexural strength, and Vickers micro hardness when the material fillers' load increased [2]. The shape of filler particles also plays an important role in increasing mechanical properties such as hardness. Composites with round particles are able tohave higher filler content than composites with irregular particles [3].

Adequate polymerization also plays a role in improving the mechanical properties. A higher degree of conversion from monomer to polymerwill increase dental composite hardness [4]. A decrease of toxic components from the material and a decrease in water sorption can cause the restoration color to become more stable and more wear-resistant [5], whereas inadequate polymerization may lead to fracture because of lack of support at the cervical margins caused by the wash out of the uncured restorative material and the development of recurrent caries [6].

A lot of studies were performed to gain harder surface composite material. Curing time had to be increased in order to achieve maximum hardness and compressive strength of the restoration. It was found that upon exposing the dental composites to the LED curing units for a long time, higher hardness measurement and compressive strength readings were obtained, thus emphasizing the importance of properly increasing the time needed for curing composites. It is important for the curing light to have ample time to reach deeper uncured resin [7].

The surface hardness of composite resins can be measured bya surface micro hardness tester with the use of an indenter, which can be in the shape of a ball (Brinell), a pyramid (Vickers or Knoop), or a cone (Rockwell), and the indenter should be harder than the material being tested.

In order to improve composite hardness, one study was performed on the correlation between surface roughness and surface micro hardness of experimental composites with varying filler concentration. The study demonstrated that hardness was increased in the high filler composite after every finishing procedure. For the low filler composite, hardness increased only after the final finishing procedure [8].

Studies have shown that upon curing dental composites, the most polymerized layer would always be the top one. This is related to the depth of curing and the dissipation of the curing energy as it reaches deeper layers, resulting in weaker layers. Finishing procedures tend to remove the top layer, which leads to having a weaker layer of cured resin. Recurring the dental composite after the finishing procedures might lead to reestablishing a stronger layer of composite, which will remain since no further finishing is needed. This would lead to having a stronger restoration, which might lead to having a longer life span compared with non-recurred ones. The purpose of this study was to evaluate the effects of recurring on surface microhardness on different types of dental composites and determine whether the effects will be significant enough to make recurring an important clinical step.

So the first hypothesis was there was no difference between the recurred specimens and the finished specimens. The second hypothesis was there was no difference between the different types of composites used in the study.

## Materials and Methods

### Materials

Five brands of composite resins were used in this study, three packable and two flow able.
Five resin composites (shade A3) were selected according to viscosity, type of filler particle size, and content.

## Methods

### Specimen preparation

A stainless steel mold that can be split in half was used to prepare the 20 specimens for each type of composite. The mold had dimensions of 2 mm length and 4 mm diameter. An acrylic ring was used to hold the mold in place. During preparation, the mold was put on a glass slab to provide a uniform surface for all specimens. Composite was filled in one increment and then pressed by a glass slide on top to remove excess composite and make a flat surface and a uniform distance between the tip of the light curing unit and the composite for all samples. The bases of all specimens were marked with a marker of varying colors.

| Material | Manufacturer | Flowable/packable | Type according to fillers | Filler % and size |
|---|---|---|---|---|
| Esthetic X HD High Definition | Densply | Packable | Microhybridfilled | 60% fillers below 1 µ |
| Spectrum TPH3 | Densply | Packable | Sub-micron Hybrid | 77 % fillers 0.04 – 5 µ |
| Tetric N-Ceram | Ivoclarvivadent | Packable | Nanohybrid | 63 % fillers <1 µ and<100 µ for nanoparticles |
| Filtek Z350 XT | 3M ESPE | Flowable | Nanocomposite | 78.5% fillers 0.6 – 1.4 µ |
| Prime Dent | Prime Dental Manufacturing, Inc. | Flowable | Microfilled | 6 7% fillers 0.7 µ |

***Table 1:*** *The materials used in the study according to fillers, filler percentage, and filler size.*

**Light curing**

The specimens were activated by a soft-start LED unit (Blue phase G2, Ivoclar Vivadent, Liechtigtien, Austria) for 40 sec, which was standardized by using a radio meter (Bluephase Meter, IvoclarVivadent, Liechtigtien, Austria) to have an intensity of approximately 1700 $mW/cm^2$. The light guide tip was pressed against the glass slide that was on the top of the mold, and then the material was light cured for 40 sec.

***Photo***

**Storage**

After specimen preparation, the specimens were placed in distilled water in small, numbered, dark, and completely covered containers that were stored in an incubator for 24 hours in complete darkness at 37°C and 100% humidity before each Vicker surface micro hardness measurement.

**Measurement**

Each specimen had three measurements. The first measurement was conducted prefinishing using a Micromet 2100 surface micro hardness tester (Buehler, Ltd., 41 Waukegan Road Lake Bluff, Illinois 60044) to test Vicker micro hardness with a load of 300g applied for 15 sec, and two indentations were made across the center of each specimen.

The second measurement was conducted on the finished specimens. The specimens were finished immediately after the first measurement by trimming approximately 0.5 mm of the superficial layer using an automatic grinding and polishing unit (Jean-Wirtz GmbH & Co., Charlottenstraße, Dusseldorf, West Germany) and 600 grit wet sandpaper. Then the specimens were placed in the same distilled water in small, numbered, dark, and completely covered containers that were stored in an incubator for 24 hours in complete darkness at 37°C, as done before. There after, the second measurement was done as before.

The third measurement was performed to the light-cured specimens. The specimens were light "recurred" immediately after the second measurement by the same soft-start LED unit. The light guide tip pressed on the glass slide that was on top of the mold, and then the specimens were light recurred for 40 sec, as done before. There after, the specimens were placed again in distilled water in small, numbered, dark, and completely covered containers that were stored in an incubator for 24 hour in complete darkness at 37°C. Then the third measurement was conducted.

## Results

The following figure (Figure 1) shows the estimated means for all types of composite resins tested in the experiment. Starting with the prefinishing test, the highest value for hardness was found in Spectrum TPH3, which had a mean value of 46.5. The lowest was found in Prime Dent with a value of 39.4. The three other types of composite resins fell in between these two, with Esthetic X HD taking the lead followed by Filtek Z350 XT and Tetric N-Ceram having values of 46.1, 45.8, and 45.3, respectively.

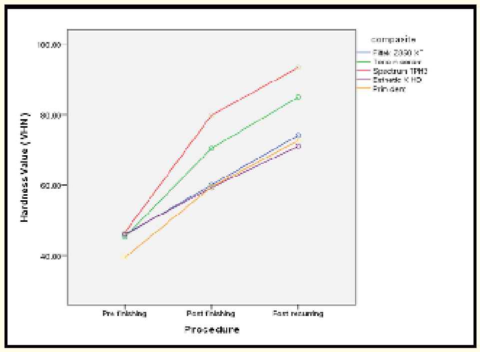


***Figure 1:*** *The mean hardness values of different composites used afterprefinishing,post-finishing, andpost-recurring.*

Post-finishing values showed higher values in all specimens tested, with Spectrum TPH3still having the highest value of 79.8. The lowest value this time was found in Esthetic X HD, with 59.3. The three other types, Tetric N-Ceram, Filtek Z350 XT, and Prime Dent, had values of 70.4, 60.0, and 59.5, respectively.

Post-recurring values also demonstrated that Spectrum TPH3 would still have the highest value of 93.3, and Esthetic X HD was still found to have the lowest value of 71.0. Tetric N-Ceram took the lead compared with the three other types of composite with a value of 84.9. The last two were found to be Filtek Z350 XT and Prime Dent having values of 74.1 and 72.6, respectively

After the prefinishing measurement, Prime Dent showed the least value of approximately 39.4, and it was significantly different than all types of composites. The other types of composites (Tetric N-Ceram, Filtek Z350 XT, Esthetic X HD, and Spectrum TPH3) showed no significant difference among them, and their values were approximately 45.3, 45.8, 46.1, and 46.5,respectively (Table 2).

| Prefinishing | | | | |
|---|---|---|---|---|
| | **Composite** | **N** | **Subset for alpha = 0.05** | |
| | | | **1** | **2** |
| TukeyHSD[a] | PrimeDent | 20 | 39.4 | |
| | Tetric N-Ceram | 20 | | 45.3 |
| | Filtek Z350 XT | 20 | | 45.8 |
| | Esthetic X HD | 20 | | 46.1 |
| | Spectrum TPH3 | 20 | | 46.5 |
| | Sig. | | 1.000 | .673 |
| Means for groups in homogeneous subsets are displayed. | | | | |
| a. Uses Harmonic Mean Sample Size = 20.000. | | | | |

***Table 2:*** *Mean hardness values (VHN) of different composite resins tested prefinishing.*

After thepost-finishing measurement, Esthetic X HD, PrimeDent, and Filtek Z350 XT showed no significantly difference among them, and they had the least values of 59.3, 59.5, and 60.0, respectively. Tetric N-Ceram showed a significantly higher value of approximately 70.4. Spectrum TPH3 showed the significantly highest value of approximately 79.8.

| Post-finishing | | | | | |
|---|---|---|---|---|---|
| | **Composite** | **N** | **Subset for alpha = 0.05** | | |
| | | | **1** | **2** | **3** |
| TukeyHSD[a] | Esthetic X HD | 20 | 59.3 | | |
| | Prim Dent | 20 | 59.5 | | |
| | Filtek Z350 XT | 20 | 60.0 | | |
| | Tetric N-Ceram | 20 | | 70.4 | |
| | Spectrum TPH3 | 20 | | | 79.8 |
| | Sig. | | .999 | 1.000 | 1.000 |
| Means for groups in homogeneous subsets are displayed. | | | | | |
| a. Uses Harmonic Mean Sample Size = 20.000. | | | | | |

***Table 3:*** *Mean hardness values (VHN) of different composite resins tested after finishing.*

After post-recurring measurement, Esthetic X HD, Prime Dent, and Filtek showed no significant difference among them, and they had the least values of 71.0, 72.6, and 74.1, respectively. Tetric N-Ceram showed significantly higher value than the previous group, which was approximately 85.0, whereas Spectrum TPH3 showed the significantly highest value of approximately 93.3.

| Post-recurring | | | | | |
|---|---|---|---|---|---|
| | **Composite** | **N** | **Subset for alpha = 0.05** | | |
| | | | **1** | **2** | **3** |
| TukeyHSD[a] | Esthetic X HD | 20 | 71.0 | | |
| | PrimeDent | 20 | 72.6 | | |
| | Filtek Z350 XT | 20 | 74.1 | | |
| | Tetric N-Ceram | 20 | | 85.0 | |
| | Spectrum TPH3 | 20 | | | 93.3 |
| | Sig. | | 0.953 | 0.097 | 0.302 |
| Means for groups in homogeneous subsets are displayed. | | | | | |
| a. Uses Harmonic Mean Sample Size = 20.000. | | | | | |

***Table 4:*** *Mean hardness values (VHN) of different composite resins tested after recurring.*

Generally speaking, all types of composites showed significant increase in hardness after finishing. Another significant increase was shown in hardness after recurring. The significant improvement in hardness after recurring was lower than the significant increase in hardness after post-finishing (Figure 2).


***Figure 2:*** *The mean hardness values of all composites used after prefinishing, post-finishing, and post-recurring.*

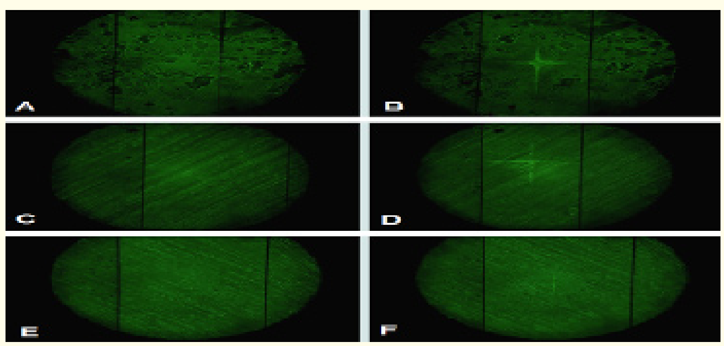


***Figure 3:*** *(A) The specimen's surface before finishing and the topographical irregularities that appeared on it. (B) The indentation on irregular surface. (C) The specimen's surface after finishing with no topographical irregularities. (D) The indentation on finished surface. (E) The specimen's surface after recurring. (F) The indentation on recurred surface.*

## Discussion

This study was based on the idea that after finishing of the composite resin restoration and trimming of the hardest layer, it might need recurring to obtain an appropriate restoration with adequate hardness.

The surface microhardness values of all groups tested were found to be significantly lower before finishing and polishing than the values after finishing and polishing. These results were in accordance with the study conducted by Munchow., et al. [], who studied the correlation between the surface micro hardness and the surface roughness of composite resin. It was shown that there was an increase in smooth ness after each finishing procedure for both composites, and the hardness also increased after the finishing and polishing procedure [8]. Because of the absence of surface topographical irregularities, which is responsible for the hardness measurement variation caused by the indenture of the surface micro hardness tester, the elevation of the hardness after finishing and polishing will not be close enough to the rough surface of the composite specimen [9]. This is why Spectrum TPH was found to have significantly higher hardness values caused by its higher filler content (77%) that interfere with the indenture of the surface micro hardness tester [3]. Although Spectrum TPH has a high percentage of filler content, it also has a wide range of sizes from 0.04 to 5 µm, which makes its unfinished surface as resistant to indentation as the finished one. So the first hypothesis was then rejected.

After the finishing procedure, the three types of composite categorized as nanohybrids will gain a highly smooth surface that reflects on their surface micro hardness values. The presence of fillers of the nanosize together with the very fine particles occupy a large amount of the composite resin structure, making it difficult to be indented by the surface micro hardness indenter. This will be reflected by the highest hardness numbers obtained by the nanohybrid composite resins. The inferior hardness of Prim Dent can be explained by their lower filler contents used for obtaining reduced viscosity [10].

It was obvious that curing of composite resin depends on a great deal with the depth of cure, which was studied by many investigators. It was revealed by Poggio., *et al*. (2012) that the top surfaces of all composite resins tested showed higher hardness values than the bottom surfaces. The top surfaces of many composites will have higher hardness that may reach 80% of that of the bottom surfaces to be within the range estimated by ISO 4049 [11]. In micro hardness tests (Vickers, Koop), magnitude of load has a significant effect on micro hardness results. It should be in the range of 1 grf to 1 kgf and the most common is 100-500 grf. The indenter with higher load penetrates deeper into the composite, reaches the harder layer and there- fore measures a greater hardness [12].

Pires., *et al.* [] found that the top surface hardness of composites was less independent on light intensity than the bottom surface. The top surface is actually receiving the maximum energy from the curing light. At the top surface it has also been established that even relatively low intensity lights can cure the resin matrix to an extent almost equal to when high intensity lights are used [13].

At the bottom surface, a significant difference in VK was observed, depending on their chemical composition, but hardness ratio values were not affected by these differences. Regarding the properties of the composite resins, the results were generally dependent on the material evaluated, especially with regard to filler features. Moraes., *et al*. [14]. Suggested that no trend toward the size or shape of fillers affected hardness. It was presented that the highest top and bottom VK values, probably because of its large particles and the highest filler content [15].

From this point, the finishing procedure will trim the hardest layer of composite resin restorations. That is what gives authors the idea of recurring the composite resin again, which might lead to increasing the hardness values.

Recurring composite restoration was found to have significantly higher hardness in all the composite resin materials tested. Again, it was found that the specimens of nanohybrid composite resins, Spectrum TPH3, Tetric N-Ceram, and Filtek Z350 XT, gave the highest hardness values that may reach about double the value, respectively.

Nanofillers have higher contact surfaces with the organic matrix than micro particles of conventional composites. This leads to the improvement of the hardness of composites containing nanofillers [16], and it also explains why the hardness values for Spectrum TPH3, Tetric N-Ceram, andFiltek Z350 XT, were significantly higher than that of the others. The significant differences between the hardness values of the composite resin groups could be explained by their nanofiller content (wt%).

The filler mass fraction is directly correlated to surface micro hardness values [17]. Therefore, the significant increase in the hardness values of nano-filled composite resin is due to the increase in their filler content. So the second hypothesis was also rejected.

## Conclusion

The finishing procedure will remove surface topographical irregularities, so finishing will improve the hardness of the composite materials. Recurring will return the most superficial polymerized layer, which is going to be removed after the finishing procedure, and the hardness of the composite materials will improve more.

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