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The Importance of Enhanced Visual Acuity in Evaluation of Polishing Composite Resins

İhsan YIKILGAN[1], Suat ÖZCAN[2], Özgür UZUN[3], Özgür TOPUZ[4] & Sinem AKGÜL[5]

Abstract

Objectives: The aim of this study was to evaluate the importance of enhanced visual acuity in evaluation of polishing composite resins. **Material and Methods:** Forty-five composite samples were used. Finishing and polishing discs were used to produce samples with different surface roughness values (Ra). The observers examined the resin surfaces according to the following scale: 1: Smooth (0.01-0.2) (Ra); 2: Medium (0.2-0.6) (Ra) and 3: Rough (0.6-1.0) (Ra). Observers used following evaluation methods: 1: Naked eye; 2: 4× magnification dental loupe; 3: Same loupe with an LED lamp; 4: DOM (Dental Operation Microscope) at 5× magnification, with a Xenon lighting system; 5: Same DOM at 12.5× magnification with a Xenon source. **Results:** Moderate magnification (4× and 5×) with LED or Xenon lighting is more accurate than the naked eye in terms of rating surface smoothness. The results at moderate magnifications (4× and 5×) were more accurate than those at high magnification (12.5×). **Conclusions:** The naked eye, low magnification with reflector light, and high magnification with xenon light were unsatisfactory methods of evaluating surface smoothness. **Clinical Relevance:** Moderate magnification with xenon or LED light was more satisfactory for evaluating the surface smoothness of a resin material in clinical conditions.

Keywords: Finishing and polishing, composite resin, magnification, operation microscope

1. Introduction

Precision is important for successful dental procedures, and visual acuity is important for precision because operations are performed in small fields under poor lighting (Eichenberger et al., 2013). Clinically, visual acuity can be enhanced by using optical magnification devices or lighting devices, such as dental operating microscopes (DOM) and dental loupes with or without lighting sources (Syme et al., 1997; Christensen, 2003; Friedman, 2004; Carr and Murgel, 2010). However, there is no scientific evidence demonstrating the direct effects of these optical aids on the success of operations. The smoothness of a composite restoration surface (degree of polishing) is important in restorative dentistry. Rougher surfaces contribute to staining, plaque accumulation, gingival irritation, and recurrent caries (Hervas-Garcia et al., 2006).

[1] Assist. Prof. Dr., DDS, PhD.Gazi University, Faculty of Dentistry, Department of Restorative Dentistry, Ankara, TURKEY.
e-mail: suatozcan@gazi.edu.tr
[2] Assist. Prof. Dr., DDS, PhD.Gazi University, Faculty of Dentistry, Department of Restorative Dentistry, Ankara, TURKEY.
e-mail: ihsanyikilgan@gazi.edu.tr
[3] Prof. Dr.,DDS, PhD. Gazi University, Faculty of Dentistry, Department of Endodontics, Ankara, TURKEY.
e-mail: ozguruzun@gazi.edu.tr
[4] Prof. Dr.,DDS, PhD. Gazi University, Faculty of Dentistry, Department of Endodontics, Ankara, TURKEY.
e-mail: topuz@gazi.edu.tr
[5] Dr., DDS, PhD. Gazi University, Faculty of Dentistry, Department of Restorative Dentistry, Ankara, TURKEY.

Clinicians must decide whether the smoothness of dental composite resins is adequate. This decision is directly related to how the clinician perceives the surface smoothness. Some devices can be used to evaluate the surface smoothness of composite resins and give qualitative results (Bollen et al., 1997), such as the profilometer, which measures the surface profile to quantify its roughness (Chiodera et al., 2013). Clinically, however, the evaluation method used most commonly is visual; *i.e.*, clinicians typically evaluate the smoothness of a resin surface based on their visual perception.

As visual acuity has a critical effect on visual perception, enhancing the clinician's visual acuity might be important when evaluating the smoothness of a restoration. To our knowledge, the effects of different magnification devices and lighting sources on the evaluation of surface smoothness have not been examined. Typically, when the restoration surface is evaluated using the naked eye, the dentist uses a dental reflector and light source. Therefore, this *in vitro* study sought to answer three questions:

• Is the assessment of surface smoothness using various magnification and illumination devices more accurate than that with the naked eye and dental reflector illumination?
• Are the effects of different magnification devices and lighting equivalent in terms of decisions regarding the smoothness of resin surfaces?
• Does the clinician's experience using magnification devices affect the accuracy of the smoothness assessment?

2. Materials And Methods

2.1. Sample preparation

Forty-five samples were prepared from an A2 shade nano-hybrid composite resin (Tetric N-Ceram, Ivoclar Vivadent, Liechtenstein) using a sectional metal mold (8-mm diameter × 3-mm depth). The cavities were slightly over-filled with resin, and a polyester strip (Hawe Neos Dental, Bioggio, Switzerland) was placed on the composite surface to smooth the surface. A glass slide was placed over the polyester strip to ensure that the excess composite resin material was extruded after applying pressure and to minimize the inhibition of the polymerization reaction by oxygen. The composite disc specimens were cured with a light-emitting diode (LED) unit (Elipar Free Light 2, 3M ESPE, St. Paul, MN, USA) at 1100 mW/cm^2 for 20 s. Before curing, the light intensity of the curing unit was verified with a curing light meter (Hilux, Benlioglu Dental, and Ankara, Turkey) (Uçtaşlı et al., 2007).

2.2. Preparation of surfaces with different roughness values

After polymerization, different finishing and polishing discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA) were used to produce samples with different surface roughness values (Ra). Samples were prepared with the range of roughness values shown in Table 1. The abrasive discs used are shown in the same table. The surface roughness values of the samples were checked using a profilometer (SJ 301 Surftest, Mitutoyo Corporation, Kanagawa, Japan) three times in different directions for each sample after the finishing procedures. For visual evaluations, the samples were divided into three groups (n=10 each) according to their surface roughness value (Table 1). All samples were prepared and checked by an expert who had 10 years of clinical experience in restorative procedures.

2.3. Visual evaluation of surface smoothness

Each sample was evaluated by three observers using five different methods and scored using the scale in Table 1. All of the observers had normal vision. The first had 20 years of clinical experience, but no magnification device experience; the second had 5 years of clinical experience, but no magnification device experience; and the third had 15 years of clinical experience and 5 years of dental loupe and operation microscope experience (Table 2). The order of sample evaluation was randomized by an assistant. The methods used to evaluate the samples were as follows:

1. With the naked eye under dental reflector lighting (Venus, Anthos, Imola, Italy). The observer was free to choose the working distance between the eyes and object.
2. With a 4× magnification dental loupe (Eye Mag Smart S, Carl Zeiss) under the same dental reflector illumination. The working distance of the dental loupe was 450 mm.
3. With the same loupe with an LED lamp (product code 304121-9001; Carl Zeiss). Again, the working distance was 450 mm.
4. With a DOM (PMI Pico, Carl Zeiss) at 5× magnification, with a Xenon lighting system. The focal length of the DOM was 250 mm.
5. With the same DOM with a Xenon source, but at 12.5× magnification. Again, the focal length of the DOM was 250 mm.

To avoid bias, only one observer at a time was present in the room making the evaluations. The positions of the loupes, microscopes, and reflector, and the eye – object distances were controlled by the same assistant who prepared the samples. The observer was allowed a maximum of 20 s per sample.

2.4. Statistical analysis

Cohen's kappa was used for comparisons. The profilometer results for the samples were compared with the observers' scores using each device and lighting combination (Table 2).

3. Results

The results are compared in Table 2. It was difficult to compare the results for the first two observers' scores for the naked eye and magnification devices. The third observer's scores were more easily interpreted. Using the results for the third observer, we can say the following:

- Moderate magnification (4× and 5×) with LED or Xenon lighting is more accurate than the naked eye in terms of rating surface smoothness.
- The results at moderate magnifications (4× and 5×) were more accurate than those at high magnification (12.5×) in terms of evaluating surface smoothness decisions, regardless of the type of device used.
- The magnification experience of the observers was important in the decisions; the experienced observer's scores were easier to interpret than those of the inexperienced observers.

4. Discussion

The surface roughness of a dental composite resin affects bacterial colonization of the resin surface. A study by Bollen et al. (1997) reported that a surface roughness greater than 0.2 µm resulted in increased colonization and adhesion of bacteria on composite surfaces. Therefore, the samples in Group 1 had roughness values < 0.2 µm, while the samples in the other two groups were rougher than acceptable clinically. Groups 1 to 3 had respective scores of 1 to 3.

Under clinical and laboratory conditions, different finishing and polishing methods are used to obtain clinically acceptable composite resin surface roughness using carbide and diamond finishing burs, abrasive-impregnated rubber cups and points, aluminum oxide coated discs, abrasive strips, and polishing pastes (Üçtaşlı et al., 2007; Jefferies, 1998; Barbosa et al., 2005; Rai, 2013). The main polishing mechanism involves abrading the surfaces until an acceptable surface roughness is obtained. The Sof-Lex (3M ESPE) system consists of aluminum-oxide-coated discs with abrasive particles of different sizes. To produce composite resin samples with three different ranges of surface roughness values (Table 2), we used Sof-Lex finishing discs with superfine, fine, and course abrasives. The surface geometry of materials can be evaluated using scanning electron microscopy (SEM), atomic force microscopy (AFM), and optic or tactile profilometer (Chiodera et al., 2013).

The results obtained with a profilometer are verifiable and reliable (Chiodera et al., 2013), and this method is less expensive than AFM or SEM. Therefore, we used profilometer to evaluate the roughness values of composite resin surfaces.

When evaluating whether the smoothness is sufficient, it is important to detect any irregularities on the surface. In this study, all three observers scored poorly with the naked eyes and reflector illumination. The resolution of the human eye can be defined as the ability to distinguish two objects in close proximity as separate and distinct (Carr and Murgel, 2010). It is likely that the resolution of the eyes is insufficient to detect irregularities. By increasing the magnification and illumination, the resolution of the eye can be increased (Friedman, 2004; Carr and Murgel, 2010; Castellucci, 2003). The intensity of light observed from a source at a constant intrinsic luminosity decreases with the square of the distance from the object (Carr and Murgel, 2010; Del Fabbro and Taschieri, 2010). The Xenon and LED systems used in this study were more powerful than the halogen light reflector. Thus a positive impact of Xenon and LED was logical, even though all light sources were used at the same working distance.

The working distance for a visual system is the nearest point on which the eyes can focus accurately (Carr and Murgel, 2010; Del Fabbro and Taschieri, 2010). In this study, the dental loupe and operating microscope were used at the working distances recommended by their manufacturers (450 mm for the loupe; 250 mm for the DOM). Using the naked eye, the working distance was chosen freely by the observer to mimic clinical conditions, since the human eye can focus on objects at different distances (Carr and Murgel, 2010).

When we analyzed the scores of the experienced observer, the favorable effects of lighting (xenon and LED) and moderate magnification (4× with the loupe and 5× with the DOM) were evident, as were the unfavorable effects of the naked eye and high magnification (12.5× with DOM). As magnification and illumination devices enhance visual acuity (Eichenberger et al., 2013; Perrin et al., 2014), the unfavorable effect of the naked eye was an expected result, but the poor results of high magnification were not.

In this study, clinically acceptable surface roughness values were evaluated by the observers as inadequate at increased magnification. This result might due to misperception related to the higher degree of magnification. At high magnification, the observer might see small surface irregularities that are acceptable as smooth clinically. In addition, the field of view decreased as the magnification increased (Castellucci, 2003). Consequently, the observer will see a small area of the sample surface and not the entire surface. Therefore, the evaluation of smoothness might change if this small area is the roughest area of the sample surface.

When using the magnification devices, especially the operating microscope, experience must be gained to achieve satisfactory results (Carr and Murgel, 2010; Erten et al., 2005; Erten et al., 2006). Two of the two observers (I and II) in this study had no experience with those devices, while the third observer had 5 years of experience. The experienced operator had the most coherent scores with the loupe and LED lighting, and the dental operating microscope at 12.5× magnification with Xenon lighting.

5. Conclusion

This study showed that the naked eye, low magnification with reflector light, and high magnification with xenon light were unsatisfactory methods of evaluating surface smoothness. Moderate magnification with xenon or LED light was more satisfactory for evaluating the surface smoothness of a resin material.

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