Effect of roughness on the color in dental composites

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ABSTRACT

Photoactivated composed resins are today the most employed sealing material in the world for dental restoration. The volumetric contraction produce during the polymerization causes different levels of roughness on the composite surface. On the other hand, color is one of the most important parameters in the field of esthetics and dental restoration. Apparent color differences may be related to surface roughness from polishing procedures and wear. The aim of this study is to analyze in a quantitative form the effect of roughness on the color in dental composites. For this aim, we have evaluated the color and the parameters of roughness R_a, R_q and R_{tm} of new 13 composite resins with 5 different roughnesses. Results show that, generally, the change of color is in chroma and luminance. Besides, the parameters of roughness do not present correlation with the color of the composite resins, probably because these parameters can not be adequated for the study of composites, since they are not sensitive to small changes in profile.

1. INTRODUCTION

In the era of esthetic composite restoration, the demand for ever all good color stability is increasing. Most anterior restorations are replaced because of unacceptable color match. In fact, studies carried out on the suitability and reproducibility show that more than 80% of patients find differences of color between the restoration and natural (or real) tooth[1]. Apparent color differences may be related to surface roughness from polishing procedures and wear[2].

Photoactivated composed resins are today the most employed sealing material in the world, in spite of the clinical problems they still present, such as gaps, marginal filtration, loss of color, etc. Most of these problems derive from what is known as contraction of polymerization, and that is not other thing but the volumetric reduction undergone by the material during its reaction of hardening. This contraction causes different levels of roughness on the surface of the composite; for it, in the clinical practice it is usual the dentist to employ different polishing systems to correct this kind of roughness inherent in the contraction.

Surface roughness is very important for many problems such as friction contact deformation, heat and electric current, tightness of contact joint and positional accuracy. For this reason surface roughness has been the subject of experimental and theoretical investigation. Different manufacturing processes produce different surface characteristics. Also, different applications require different surface properties. Each of these parameters indicates a particular property of the surface and it could be the most important for the particular application. The most significant parameters of roughness[3] are arithmetic average height (R_a), root mean square roughness (R_q), mean of maximum peak to valley height (R_{tm}), largest peaks to valley height (R_y), and skweness (R_{sk}) and Kurtosis (R_{ku}).

For all this, it is of great interest to know the effect of the final roughness on final color of the composite, since this last one will be very important for a suitable restoration; nevertheless, currently there are no studies making possible to know the relation between roughness of dental composites and their color.

The aim of this study was to determine the influence of roughness presented by the dental composite on their color.

2. MATERIAL AND METHOD

For our study, measurements of the three most important 3D parameters used nowadays for the measurement of a surface roughness have been performed:

Arithmetic average height (R_a), also known as the centre line average (CLA). It is the most universally used roughness parameter for general quality control, defined as the average absolute deviation of the roughness irregularities from the mean line over sampling length. This parameter is easy to define, easy to measure and gives a good general description of height variations.

$$R_a = \frac{1}{l}\int_0^l \left|y(x)\right| dx \tag{1}$$

$$R_a = \frac{1}{n}\sum_{i=1}^{n}\left|y_i\right| \tag{2}$$

Root mean square roughness (Rq), also known as RMS. It represents the standard deviation of the distribution of surface height. This parameter is more sensitive than the arithmetic height to large deviations from the mean line. The mathematical definition and the digital implementation of this parameter are:

$$R_q = \sqrt{\frac{1}{l}\int_0^l \left\{y(x)\right\}^2 dx} \tag{3}$$

$$R_q = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^{\,2}} \tag{4}$$

Mean of maximum peak to valley height (R_{tm}), defined as the mean of all maximum peak to valley heights obtained within the assessment length of the profile. The mathematical definition of this parameter is as follow:

$$R_{tm} = \frac{1}{n}\sum_{i=1}^{n} R_{ti} \tag{5}$$

For the evaluation of these parameters a Sensofar confocal microscope was employed, provided of software Plus, at 100x. The image resolution was 762 x 560 pixels, and the evaluated area 138,88 x 102,02 um. Topographies were obtained with the following parameters: Z of 19 symmetrical with 0,2 um resolution in height, and X and Y with a 0.18 um one.

For the measurements of color a spectroradiometer SpectraScan PR-704 equipped with adequate software was employed. Each one of the composite samples was inserted in sheets of silicone and was placed inside an illumination/observation cabin Verivide CAC 120, with a D65 source. The geometry of illumination was 45º/0º and we used the color representation system CIELAB (L*,a*,b*). The spectroradiometer was focused on the first surface of the composite, at its center, with a field size 1°, one integration cycle, and the Standard Observer CIE1964.

13 new commercial resins have been evaluated: Artemis dentina A3, Helio molar A3, Miris Dentina shade 4, Synergy Duo color A1/D2 and Tetric color A1, corresponding to dentine, and A110 B1, Artemis esmate A3, Artemis super clear, Inte-S A3, Miris Esmalte neutral, Synergy Nano A2/B2, Tetric Ceram C3 and Z100 B2 corresponding to enamel, 8 of them based on the VITA system and the rest based on the “natural stratification” system. 5 copies were made of each one of the samples.

To obtain different values of roughness, each one of the composite resins was polished with different sandpapers, usual in the clinical practice, of 500, 1200, 2000, 4000 GRIFT. Finally, to obtain the most polished surface alumina and silica powder was used. The depth of the sample was 2 mm, usual in clinical practice.

3. RESULTS

For the analysis of results, we have separated the results of the composite resins employed for the dentine restoration of dentine and those corresponding to enamel. As example, figures 1 and 2 show the planes a*b* (for dentine) and a*L* (for enamel). For dentine and enamel, it can be seen that the a*, b* and L* values diminish when the value of the GRIFT of the sandpaper diminishes as well (the least polished surface). There is a color difference clearly perceptible (> 2 units CIELAB) and very much higher than the instrumental error (2 % for L *) between the resin polished with the alumina and silica powder and the rest, presenting, generally, very similar color coordinates for the rest of roughness values. Nevertheless, the value of ΔE depends on the studied material. Also we can point out that, in the plane a*b *, this decrease fits to a straight line with correlation coefficients in the interval 0.940-0.980 (P <0.05). We find similar results for the plane a*L *, but in this case with lower r corfficients for the resins Tetric and Z100.

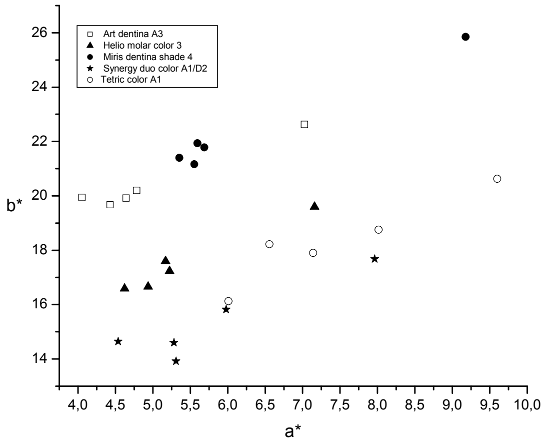

Figure 1: a* and b* coordinates for every sample corresponding to dentine.

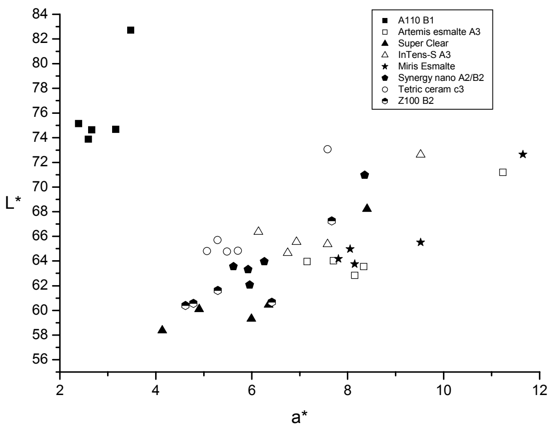

Figure 2: a* and L* coordinates for every sample corresponding to enamel.

We analyze now the parameters of roughness. As example, figures 3, 4 and 5 show the values of R_a, R_q and R_{tm} for some of the samples. R_{tm} has been divided by five for a better comparison. The error bars show the standard deviation for the 5 measurements made with the confocal miscroscope. Generally, the values of the parameters of roughness are slightly highers for the resins corresponding to enamel than those corresponding to dentine, due to the fact that the grain diameter for dentine is larger than those used for enamel. This does not happen for the materials specifically used for teeth with a bleaching treatment such as Artemio Super Clear, that presents a translucency of 50%[4]. Also, as it was expected, the dentine materials have less saturation than those corresponding to enamel, as it can be seen in figures 1 and 2 for the materials Artemis dentine/enamel A3, which belongs to the same company and the same sample.

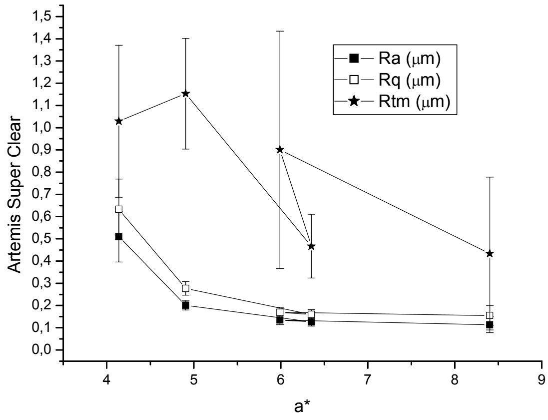

Figure 3: Values of R_a, R_q and R_{tm} for Artemis Super Clear.

If we analyze the parameters R_a and R_q, the results are similar, although these values are higher for the highest roughnesses (500, 1200 and 2000 GRIFT) and diminish slightly for the most polished samples. It is necessary to say that for most of the materials the results for the two most polished surfaces (4000 GRIFT and alumina and silica powder) are very similar. Nevertheless, as it is observed, these ones present values of the chromaticity coordinates with color differences higher than 5 CIELAB units.

As for the parameter R_{tm}, the high value of the obtained standard deviation presents difficulties for a good interpretation of the results. Nevertheless, the conclusions obtained from this results are similar to those from R_a and R_q, but in this case with more irregularities.

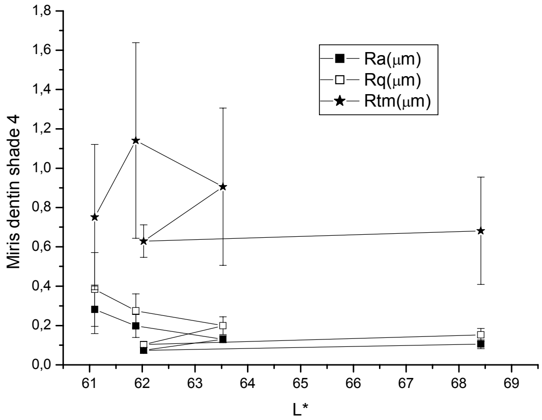

Figure 4: Values of R_a, R_q and R_{tm} for Miris dentin shade 4.

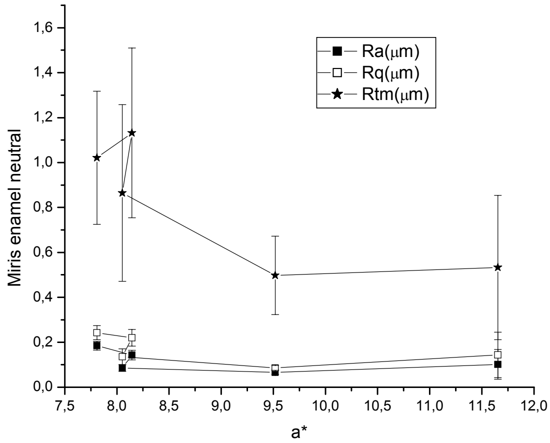

Figure 5: Values of R_a, R_q and R_{tm} for Miris enemel neutral.

4. CONCLUSIONS

We have performed measurements of color and roughness of 13 samples of composite resins, of which 5 samples with different roughness levels have been made. Results show that when the surface is more polished, samples increase their values of a*, b* and L*, specially the sample most polished. This fact can be represented by a straight line indicating that the samples present almost the same hue angle and that they differ principally in chroma, being the least polished surfaces those that generally present lower chroma and lower luminance. Finally, it must be pointed out that the traditional physical parameters for the measurement of the surface roughness do not present a clear correlation with the color of the composite resins, so that samples presenting $\Delta E > 5$ CIELAB units have similar values for R_a, R_q and R_{tm}. If we bear in mind that from all these results roughness seems to have influence on the composite color and nevertheless this fact is not reflected in the values of the roughness physical parameters (with a high standard deviation), we can conclude that maybe these parameters are not adequate for the evaluation of these roughness levels, since they are not sensitive to small changes in profile[3], specially for the most polished surfaces.

References

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