

Aesthetic dentistry: Chromatic appreciation in the clinic and the laboratory

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ABSTRACT

Aesthetic requirement in dentistry is getting more and more important every day. One of its basic principles is the correct selection of colour for the restorations. Colour is a quality which is modulated by a series of factors, environmental and individual, that the clinic must know. Colour measurement by the human eye can induce to an appreciation mistake if it doesn't follow a correct protocol of light conditions and observation technique, checked by the authors, simplifying it with a practical focusing. Colour measurement instruments have appeared recently, trying to correct the problems of conventional technique.

Key words: *Aesthetic dentistry.*

RESUMEN

La demanda estética en Odontología va en aumento, una de sus bases es la correcta selección del color de las restauraciones. El color es una cualidad que se ve modulada por una serie de factores ambientales e individuales que el clínico debe conocer. La valoración ocular del color, puede inducir a error de apreciación si no se sigue un protocolo correcto de iluminación, y técnica de observación los autores lo revisan, simplificándolo con un enfoque práctico. Recientemente, han aparecido instrumentos de medición del color que intentan corregir los defectos de la técnica convencional.

Palabras clave: *Odontología estética.*

INTRODUCTION

Today's dental restoration is consolidated around three mainstays: the use of non-metallic materials, such as composite resins and ceramics; adhesion to dental structures; and the achievement of a natural cosmetic look.

The level of aesthetic requirement in restorations has risen spectacularly in recent years, and this has made it necessary for dentistry professionals to explore this field in order to satisfy the existing social demand in this area.

The dental materials that are available nowadays offer us the possibility of imitating the tooth's natural aesthetic look, so long as the right one is chosen for a given situation. The first step to achieving clinical success in cosmetic dentistry will therefore be to correctly identify the tooth colour we need to imitate and the material that most closely matches, and to communicate this information to the laboratory if the restoration is to be carried out there.

NATURE OF COLOUR

When we talk about colour, we are making reference to a sensation which is captured by our eyes. The human eye is an organ specialized in the reception of images obtained from an electromagnetic radiation that we refer to as light, and which actually corresponds to a narrow segment of the entire spectrum, situated between the 400 and 800 nm wavelengths approximately, and which we perceive as the so-called "colours of the rainbow". Radiations below these wavelengths are not visible to the human eye, and are referred to as ultraviolet; those which are situated above these wavelengths are not visible either, and are referred to as infrared.

The sensation we call colour would be that which corresponds to the wavelength of luminous radiation that reaches the eye. If this corresponds to the wavelength of one of the colours of the rainbow, we see that colour; if it contains the combined wavelengths of two colours, we perceive a new colour composed of both of these colours; and when it contains all of them, we see the resulting colour as white. Black would be the absence of visible radiation.

When we observe an object illuminated by a white light, the colour we see corresponds to those wavelengths that this object has not absorbed, and which therefore have been reflected in its surface towards the exterior; this phenomenon emphasizes the tremendous importance that the quality of light plays in the perception of the colour of a given object (1).

MEASUREMENT OF COLOUR

The first problem we face when we communicate the colour of a tooth to the laboratory so that they will be able to reproduce it is to be able to obtain a clear and precise description of the colour, a description that can be understood and reproduced by our technician, and which can also be verified in the resulting restoration. This necessarily involves a process of measurement, a process which must be exact, reproducible and communicable.

This problem is not only limited to Dentistry, but is common in many other fields, in industry as well as medicine. There are generally three accepted dimensions of colour:

-Hue, tonality: this indicates the feature which is normally referred to as colour, directly related to the wavelength of the observed luminous radiation observed (e.g. red, green, blue, yellow...).

-Value, luminosity: this expresses the amount of light that makes up the colour under study, and would be like the black and white image of the observed object, corresponding to the tonalities of grey ranging from a maximum value, white, and a minimum value, black.

-Chroma, saturation: this refers to the amount of dye that the colour contains, the chromatic brightness that we observe. This dimension refers to the different dilutions of the base colour we are starting from.

To these three dimensions, and within the field of dentistry, we must add a fourth one which would include all of the chromatic features that personalize the tooth apart from its average colour, and which are fundamental for the reproduction of the colour of a tooth (2).

ELEMENTS THAT INFLUENCE THE APPRECIATION OF COLOUR

The elements that intervene in the clinical measurement of colour are many, and they all intervene at the same time. They must all therefore be taken into account simultaneously, in order to not make mistakes that could lead our work to failure.

We human beings appreciate the colour of an object when we perceive through our eyes the light that reflects in it, or that goes through it, or both at the same time. And this is why we must pay attention to each of the different elements one by one.

THE HUMAN EYE AS RECEIVER OF COLOUR

The perception of colour can be seen to be altered by specific chromatic appreciation problems such as daltonism, which manifests itself fundamentally in the confusion of the colours red and green (3), and others, which need to be identified by the practitioner, such as the variation of the perception of colour between both eyes. We need to take in colour by opening both eyes, as there can be notable differences in the perception of each one of the eyes separately. In the event the practitioner suffers from one of these problems, he/she should take appropriate measures, such as delegating the measurement of colour to staff with a normal chromatic vision if the alteration is irreversible, or avoiding as much as possible the intake of substances that can modify perception, such as alcohol and morphine, which lighten the warm colours (yellow, orange, red) and darken the cold ones (purple, green, blue); caffeine, which darkens warm colours and lightens cold ones; or in the case of drugs such as Viagra®, which modifies chromatic perception giving a blue tint to colours; contraceptives, which can at times induce difficulty in discriminating red-green or blue-yellow

(Chu J., Devigus A., Miesleszko A. 2004 Fundamentals of Colour: Shade Matching and Communication in Aesthetic Dentistry, pg. 40-43, Ed Quintessence Chicago).

In the event of awareness of the possibility of suffering these alterations, substances or situations in which they are produced must be avoided, or some electronic measuring device must be used in order to avoid subjectivity and circumvent the problem.

There is also another very important element, which is the eye itself. If the eye observes a given colour over an excessively long period of time, a virtual image superimposes itself, an image which corresponds to the complementary colour of the one observed, as a result of fatigue. This is known as complementary post-imaging, and it makes short readings of colour necessary, thus impeding the occurrence of this phenomenon.

Another characteristic of our chromatic perception is the fact that we have a short chromatic memory, and this is why we must observe two objects simultaneously and very closely in order to be able to appreciate whether their colour is the same or different.

ENVIRONMENTAL LIGHT

Since the human vision process requires three elements (light, object and receiver), and supposing that the receiver is functioning correctly, i.e., no chromatic perception pathology exists, let us centre our attention on the influence of light in the measurement of colour.

The nature of the light source that illuminates the clinic is essential. In fact, its spectrum will influence chromatic appreciation in a critical way. The ideal light for colour measurement will be that which is closest to the light spectrum of daytime sunlight; this is the reason why a correct natural illumination is desirable at the moment of colour taking. Since this is not always possible because not all the clinics have access to this ideal natural light, and because at certain hours of the day, or at certain seasons of the year, daylight is insufficient, we must use artificial light sources. In this case the use of incandescent light sources such as common or halogen light bulbs must be avoided, since they emit a spectrum with a greater proportion of colours close to red, which can alter chromatic appreciation. This eliminates from the start surgical light from the dentist's chair; the environmental lighting of the clinic must be used, and the use of the light sources known as "day" light sources is recommended. These are corrected fluorescent light sources which offer colour temperatures of between 5,000° and 6,500°K, and are commonly known as day light D_{50} y D_{65} respectively, and are suitable for all processes that require a correct chromatic perception.

Observation under two different light sources (natural light and artificial light) is also interesting, in order to assure the selection to an even greater degree, because sometimes two objects (e.g. the colour guide and the tooth) can be seen as the same colour under one light source and as a different colour under another one; this phenomenon is called me-

tamerism and it must always be taken into account when a colour is determined by eyesight.

Industry has been trying to solve this problem through the use of normalized light sources, with a pre-established colour temperature, which would help us to have available constant observation conditions at any time of the day. At the present time, the "Shade Light™" (KERR) (fig.1 y 2) lamp is on the market, offering D_{65} light that provides ideal observation conditions, and given its relatively low cost and ease of use, it is feasible for a great number of professionals (4,5).

These problems of chromatic perception are shared by the prosthesis laboratory, which should have the same illumination system as our clinic if we want their colour readings during the making of restorations to coincide with ours.



Fig. 1. Shade Light by Demetron.



Fig. 2. Clinical shade matching with Shade Lighth.

THE OBJECT OF OBSERVATION

The usual chromatic estimation technique consists in comparing the colour of the tooth with an artificial guide and checking which of the samples of the guide is most similar to the studied tooth.

The main problem in this case is that there are as many colour guides as there are manufacturers, and at the same time, they are organized in different ways. The traditional guides that are most used are the Vita Classic and Chromascop, and these are organized by groups of hues: A, B, C, D for Vita; and 100, 200, 300, 400, 500 in the case of Chromascop. Dimensions relative to brightness and saturation (chroma and value) are noted from 1 to 4 in the Vita guide and from 10 to 40 with Chromascop.

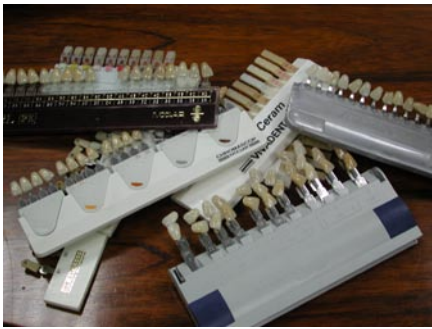


Fig. 3. Some clinical shade guides.



Fig. 4. Shade guide Vitapan 3D-Master, by Vita.



Fig. 5. Shade guide Chromascop, by Ivoclar.

Today there is a tendency to order the colour guides on the basis of the luminosity of the colours and not according to tonality, due to the fact that our eye is more sensitive to changes in brightness than to differences in tonality. It is also important that a guide include homogeneous chromatic differences between the different steps of these, but this normally is not the case.

These present-day concepts take form in the guide which is known as the Vitapan 3D-Master, from Vita, which establishes groups by their luminosity, decreasing from 1 to 5, and divides them into subgroups according to chromatic saturation, increasing from 1 to 3. It is then determined whether within these groups the medium colour tone M is maintained, or whether it moves towards yellow L or red R. It would appear, according to the manufacturer, that this kind of organization facilitates work in dentistry, due to the fact that as we have seen, the eye better appreciates changes in brilliance and saturation than changes in tonality, espe-

cially in lighter and less chromatic colourations, such as the those that correspond to normal colours in human teeth. There are even those who recommend reorganization of the colour guides on the basis of lightness, instead of tonality. In this way, the Vita Classic guide would be organized as follows: B1, A1, A2, D2, B2, C1, C2, D4, D3, A3, B3, A3, 5, B4, C3, A4, C4 (6) (fig 3-5).

THE CLINICAL PROCESS OF COLOUR MEASUREMENT

The process begins with the cleansing of the tooth in order to eliminate all adherence, plaque, pigmentation, tartar, etc... that can hinder the appreciation of the colour. Also to be eliminated, if possible, all those elements which because of their intense color can obstruct, such as strong color lipstick in women, and if this is the case, abundant, dark moustaches in men. This principle is applicable to the colors of walls and furniture of the clinic and the laboratory; if they are very intense they will reflect from the walls onto the working area, thus influencing the process of colour taking.

Having adequate illumination, the practitioner proceeds to observe the tooth in short periods, of less than 15 seconds (to avoid chromatic fatigue of the eye) and refers to the guide for the piece that most closely approximates the studied tooth. It is very important to maintain the tooth completely moist all through the process, not letting it dry, because it will immediately appear to be lighter and whiter than it really is (and it will take quite some time to regain its original colour, which will induce to an error in appreciation, and the consequent selection of a colour that is excessively light). Between observation and observation it would be a good idea for the practitioner to rest his/her eyesight by fixing it on a soft coloured surface, preferably light blue (the complementary colour to light yellow, the predominant color in teeth) to avoid visual fatigue.

The first chromatic dimension to determine will be the value or brightness of the tooth, followed by saturation and tonality. It is important to note down the distribution of colours that we determine in a simple drawing, because all too frequently it is common to note down an average color for the whole tooth, and if the information is expressed in this way the data is very poor, and the laboratory will be obliged to "invent" a tooth without knowing whether or not it corresponds to the natural model. A more precise method would be to note down the colour by thirds (cervical, mid and incisal third), somewhat more descriptive, but still ignoring the fine shades that personalize the chromatic aspect of a tooth. The correct way is for these basic chromatic annotations to be accompanied with a topographic description of the colour, also referred to as a chromatic map, in which the distribution of the colors that the tooth presents (sometimes relatively many) must be precisely expressed, with special attention to a clear description of translucent areas and particular color areas of the tooth (orangish amber or whitish stains, cracks, incisal aura effect...). The inclusion

of color photographs of the tooth together with the selected samples of the color guide can be of great help. If these are in digital format, they can be sent to the laboratory through computer support (CD, DVD, memory cards or e-mail) and are very useful. The more information the dental technician has during the manufacturing of the restorations, the more natural and similar to the tooth they will be.

All this information must be interpreted by the technician and transferred correctly to the manufactured restoration. The practitioner should be able to confirm that the color of the restoration corresponds to that which was planned before the patient arrives to the clinic, checking to see that the colours in the work order have been reproduced in the way they were requested.

INSTRUMENTAL COLOR MEASUREMENT

Given the great subjectivity that predominates all during the colour measurement process in the clinic, a series of electronic instruments designed to facilitate and make more objective the process of colour measurement have recently been appearing on the market. The practitioner thus needs only to use these devices in order to be able to indicate the tooth's color in a more precise, reliable and repeatable way.

From the point of view of the clinical information that we are provided with, we can talk about one spot reading devices, devices which indicate the color at one spot of the tooth, and which therefore need several readings in order to be able to appreciate the regional colour variations of the tooth; and extensive reading devices, capable of capturing all of a tooth's surface each time, or even of several teeth simultaneously, and which with a computer program can draw up a chromatic map of the tooth.

Chromatic maps obtained with these devices are usually very detailed, and it is sometimes feasible to choose the color guide in which the annotation method is preferred; some of these devices even allow for the personalisation of the guides, which can be made up with specific combinations of restorative materials. This opens the door for allowing their intra-operating use in direct restoration with composite or with CAD-CAM manufacturing systems for in-clinic restorations (CEREC-3D, Sirona).

One of the most interesting applications for these devices is the objective measurement of the results obtained in vital whitening treatments, making it possible to clearly verify the degree of effectiveness obtained.

According to the action principle, clinical colour metres are based on the analysis of RGB digital imaging (Shadescan, ikam), spectrum photo metering (Spectroshade, Easyshade) or colour metering (Shadevision, Shadeeye-NCC, Digital Shade Guide) (7-13).

.The main disadvantage of these electronic systems is their cost, which is very high in some cases, and sometimes the technical complication, which makes some professionals decide not to use them.

The advantages are the elimination of subjectivity in the color measuring process, and a great improvement in being able to reproduce the colour (Paul S. et al. 02), the elimination of the environmental factor in colour measurement due to the utilization of constant light sources that are calibrated each time they are used. Another very important element is that if the laboratory is working with the same system, the control of the desired chromatic reproduction is total (fig.6 y 7).



Fig. 6. Easy Shade by Vita.



Fig. 7. Clinical shade matching with Easyshade.

Digital Shade Guide (Rieth)	Spot
Easyshade (Vita)	Spot
ShadeEye-NCC (Shofu)	Spot
ICAM (DCM)	Complete tooth
Shadescan (Cynovad)	Complete tooth
Shadevision (X-Rite)	Complete tooth
Spectroshade (MHT)	Complete tooth

CONCLUSION

Colour measurement may seem to be a minor element within the field of Restorative Dentistry, but its importance is essential, although not from the biological point of view. But given the present day level of aesthetic exigency,

a technically correct restoration can be a clinical failure if it fails to achieve the aesthetic integration the patient nowadays demands.

Knowledge of the correct use of the conventional colour measurement systems is becoming more and more important if we wish to satisfy present day aesthetic demands. This, together with the gradual entry and perfecting of the electronic colour metre systems, will serve to reduce the possibilities of aesthetic failure, and thus increase the quality of restorations.

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