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Dear Reader,

_Welcome to the first issue of **cosmetic dentistry**! The year 2011 was very successful for us and I would like to thank our readers, authors, supporting companies and the entire team of the **cosmetic dentistry** magazine for their support.

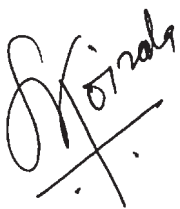
This year, we are planning to present articles in **cosmetic dentistry** in a different way. In each issue, we will focus on certain clinical aspects, such as porcelain restorations, direct bonding, implant treatment, occlusion, etc. We will focus on introducing new authors with a variety of clinical cases and treatment strategies.

With the recent advancement in materials, science and technology, the dental practice is becoming increasingly technology based, leading to an increase in treatment costs. In many developing countries, people cannot afford regular dental treatment owing to their inability to afford health insurance and poor government health care. However, it is interesting to note that even in these countries, the demand for cosmetic dentistry is growing. The influence of global media, increased migration and exposure to global fashion trends are the main reasons for the global popularity of cosmetic dentistry.

Reducing the cost of cosmetic treatment should be the focus of today's cosmetic dentists if we wish to deliver services to everyone who needs and wants them. During my international lecture activities, I have noticed that most young clinicians today want to treat cases using complex procedures immediately rather than use simple cosmetic procedures, such as anterior tooth alignment, tooth whitening, bonding and cosmetic contouring procedures (type I cases), which can enhance smiles significantly. Certainly, procedures like implant and bridge placement and full-mouth restorations generate good financial income; however, these services demand extensive knowledge and a vast amount of clinical experience. It is to be noted that a large number of type I cases are treated in the general cosmetic dental practice. Once these cases are treated properly, with long-term health, function and aesthetic in mind, the volume of type II and type III cases will slowly start to increase as well.

Ongoing education is a fundamental requirement in dentistry, but choosing the right knowledge and skills training is not an easy job. In this issue of **cosmetic dentistry**, we present clinical articles mostly related to type I cases. I hope you will enjoy reading our first issue of 2012!

Yours faithfully,



Dr Sushil Koirala
Editor-in-Chief
President Vedic Institute of Smile Aesthetics (VISA)
Kathmandu, Nepal



Dr Sushil Koirala
Editor-in-Chief



page 06



page 12



page 16

| editorial

03 **Dear Reader**

| Dr Sushil Koirala, Editor-in-Chief

| special topic

06 **Shade analysis and communication: 2012**

| Prof Edward A. McLaren

12 **TouchWhite—Next-generation tooth whitening**

| Dr Jugoslav Jovanović

16 **The problem of white spot lesions**

| Dr Derek Mahony

| practice management

18 **My marketing plan**

| Dr James Goolnik

| clinical technique

22 **RED bonding: Predictable cementation of indirect aesthetic restorations**

| Dr Irfan Ahmad

| industry report

34 **Shining results**

| Dr Monica Basile & Michele Temperani

| industry news

38 **CLEARFIL S³ BOND PLUS:**

High-tech and high speed for high performance

| Kuraray

| meetings

40 **International Events**

| about the publisher

41 | submission guidelines

42 | imprint



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page 22



page 34



page 40



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Shade analysis and communication: 2012

The essential elements of evaluating and communicating tooth colour

Author_Prof Edward A. McLaren, USA



Fig. 1

Fig. 2

Fig. 3

Fig. 1 _Using two OttLites held at tooth level 24 inches from the patient to control lighting colour temperature.
Fig. 2 _Using the Trueshade light and magnifier to control light.
Fig. 3 _Image of two of the same shade guides with different surface texture. Notice the one with a different texture is perceived as a different colour.

_With ever increasing emphasis on aesthetics in dentistry, and patient demands to fabricate ceramic restorations that mimic natural teeth that are indistinguishable from adjacent natural teeth, the ability to evaluate tooth shade information correctly and communicate it to the ceramist effectively is now more critical than ever. Correctly evaluating tooth shade is as much an art as a science.

Many articles¹⁻⁷ and even whole books⁷ have been devoted to this topic, yet in hundreds of informal polls of technicians, problems with shade analysis is the second reason given for remakes, with impression/preparation problems being the first.

Many factors contribute to this problem: lighting variables that contribute to perception errors; multiple shade systems available with a lack of standardisation in colour systems and corresponding porcelain systems; individual human variables in colour perception; lack of understanding of colour science, especially as it relates to tooth shade; and the ability to interpolate shade information into a porcelain layering technique that obtains the desired shade. A full article could be devoted to each of those topics. There are many references in dental and non-dental literature on the topics of colour,

colour as it relates to teeth and human perception of colour. The objective of this paper is not to offer an exhaustive review of these topics but to distil the essential aspects of evaluating and communicating tooth colour. Also, to offer the reader an efficient and effective method for evaluating and communicating tooth shade.

This article will focus on:

- _understanding how lighting (illumination) affects colour perception, and more importantly how to control it;
- _understanding the parameters of colour that are most critical in evaluating tooth shade and how to access them relative to the tooth;
- _the ideal set-up and use of current shade guides;
- _the use of digital photography for communication; and
- _the integration of computerised shade-analysis devices into the technique of taking and communicating tooth colour.

_Understanding lighting and the effect on colour perception

The perception of colour is affected by three primary factors:

- the character of the light;
- the observer; and
- the object being viewed.

A change in the condition of any of the three will cause a change in perception of colour. Thus, differing viewing conditions, that is changes in light or changes in position, can alter perception.⁸ It is impossible to try and match tooth colour under every lighting and positional possibility. One then should try to match under the conditions in which the restoration is most likely to be viewed. Relative to tooth position most people are viewed standing up at conversational distance, so this is the best position in which to place the patient to evaluate shade. Too often, shade is taken with the patient lying back, which increases the chance of a misperception. The reason this happens is the shade guides do not have the same optical properties as the natural tooth. At different viewing angles, they look different, that is a perceived match from one viewing angle may not be a perceived match at another viewing angle.

Shade-analysis rule 1: take the shade with the patient sitting up, eye to eye at conversational distance.

There are many different types of light we are all exposed to, as will be your patients and the restorations you make. When the shade guides are manufactured, they are compared to a standard in a controlled lighting situation. It is very controversial as to what colour temperature light to use to view shade, that is 5,000, 5,500, or 6,500 K.⁹⁻¹² Most shade guides are fabricated to match a standard in a 5,500 K light source. As already stated, shade guides do not have the same optical properties as natural teeth. This means they do not reflect light in the same manner in all lighting conditions as the corresponding shade tooth would. Thus, visual shade matching should only be done in a lighting environment that is close to 5,500 K. From my experience, if the shade guide is matched to the teeth in a 5,500 K light, then it will match well in most lights, but if it is matched in a strongly biased light (for example blue) the restoration will only match in that light.

There are many different companies that sell florescent lights. Full-spectrum, colour corrected with a colour temperature of 5,500 K are the lights best suited for visual shade taking. Ideally, it is best to outfit the operatory with this type of lighting, but an inexpensive way to control light is to use two OttLites (Fig. 1) held



Fig. 4



Fig. 5

at 61 cm from the patient at tooth level. Also, there are several innovative self-contained lighting devices available in dentistry. Optilume Trueshade (Optident Dental Products) works well for this and has a magnified viewer (Fig. 2).

There are many other things that could be covered about controlling the viewing conditions. The quantity of light and the hydration of the tooth are very important. Make sure when you are shade matching that there are no overt shadows on the teeth or shade guide and that the light is not so strong as to create specular highlights (reflective white spots). Also, the teeth need to stay hydrated. Saliva dries quickly, especially with cheek retractors in the mouth. We use a medium viscosity clear glaze liquid (Smile Line Glaze liquid, Smile Line USA) to wet the teeth and the shade guide. It is important to wet both, as differences in surface texture between the shade guide and the tooth can create a misperception. The same liquid on both surfaces can neutralise this (Fig. 3).

Shade-analysis rule 2: use full-spectrum, colour corrected lighting, keeping the teeth adequately hydrated.

Understanding colour parameters critical to dental shade analysis

A basic understanding of colour terminology is necessary for one to be able to evaluate differences from the shade guide and to communicate colour to the ceramist. Colour has been defined in many

Fig. 4 Classical Shade Guide in colour with the correct value relationship. Note how tabs with dissimilar chromas look very different in value.

Fig. 5 Classical guide in black and white with the correct value relationship.

Fig. 6 Using the Classical guide arranged by value and working by a process of elimination to obtain to four tabs that cover the value range of the tooth being evaluated.

Fig. 7 Using the Classical guide to select the chroma level.



Fig. 6



Fig. 7

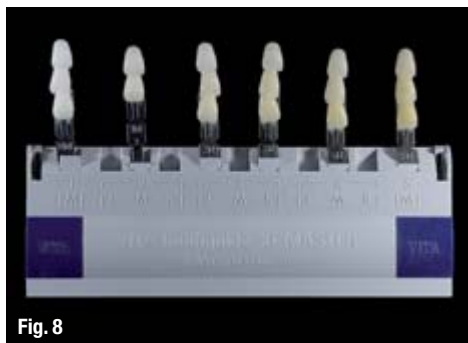


Fig. 8

Fig. 8_ The 3D-Master arranged with just the M shades from 0 to 5 value.



Fig. 9

Fig. 9_ Choosing the value for a patient case.

different ways. The most widely used colour ordering or descriptive system used in dentistry was developed by Mussell.¹³ He defined colour according to three dimensions:

- _hue, the specific wavelength of light energy that would be labelled red, green or blue and everything in between;
- _chroma, the intensity, concentration or amount of a given hue (for example lighter yellow or deeper yellow); and
- _value, or the lightness or darkness of a colour.

In real terms, if more light reflects off an object and hits our eyes, it will be perceived as brighter or higher in value. Conversely, if less light reflects off an object and hits our eyes, it will be perceived as darker or lower in value.

There is a fourth dimension of colour, translucency, that is important when evaluating tooth colour because teeth are translucent and translucency is directly related to the perception of value. When evaluating tooth colour, the most important colour dimension to match is the value and a close second the translucent zones. Next in importance are the chroma zones present in the teeth being evaluated. The least important dimension of colour relative to matching natural teeth is the hue. In natural teeth, the hue range is very narrow and in my experience matching the specific hue is unimportant as long as value/translucency and chroma

are closely matched. In the discussion on shade guides and their use, I will give detailed descriptions on how to evaluate value, translucency and chroma in the shade-analysis process.

Ideal set-up and use of current shade guides

The VITA Classical Shade Guide (Vident) has been the standard shade guide used in dentistry for several decades. More recently, the VITA 3D-Master Shade Guide and a recent significant upgrade, the VITA Linearguide, have been available for shade analysis.¹⁴ The 3D-Master guide and Linearguide are based on actual spectrophotometer analysis of natural teeth¹⁵ and are my preferred guide, but more than 50% of dentists still use the Classical guide, so I will go through its optimised set-up and use and then detail the use of the newer guides.

VITA Classical Shade Guide

Every dentist and ceramist is familiar with the VITA Classical guide. This shade guide was initially developed several decades ago with the last modification or update in the 1960s. It was adequate for that time but analysis of the shade guide shows several problems that lead to the many shade mismatches that still exist. First, the shade guide poorly covers the measured range of natural teeth.¹⁶ Nothing can be done about this except either changing the guide or using a different one. Second is the value arrangement. The value arrangement as reported by the company is different from what has been measured.¹⁶ Figures 4 and 5 show the value arrangement as we measured it in both grey scale and colour images. A1 as we measured is higher in value than B1 and D2 is lower in value than A3. You will probably notice that the colour image of the value arrangement will be hard to believe, that is the tabs right next to each other that have significantly different chromas will appear to have significantly different values, when in fact they are very similar (view the black and white image). This is a problem with human perception that has not been discussed in dentistry before: if two objects have similar values but different chromas the observer will perceive the higher in chroma tab as lower in value when this is not the case. This is exactly what is happening when A1 is compared with B1 (Fig. 5). As previously stated, A1 is higher in chroma than B1 and thus perceived as lower in value when in fact it is higher in value. The same is true for other areas on the Classical guide. This



Fig. 10 VITA Valueguide 3D-MASTER



Fig. 11

I believe is the fundamental reason for the level of shade mismatches with this guide.

The first step in minimising this problem and using this shade guide effectively is to arrange the guide by value as shown. As stated earlier, choosing the correct value is most important, as is recording the value zones within the tooth being evaluated. After arranging the guide by value, lightly wet the teeth and shade guide with a clear glaze liquid. The best way to choose a shade is not to see first what appears to be a match, but to look first for obvious mismatches and eliminate them from the shade guide. The goal is to eliminate enough tabs so that you have remaining a range of tabs in which clearly one tab is slightly higher in value and one tab is slightly lower in value. Experience has shown that no fewer than four tabs will accomplish this value range determination (Fig. 6). Several images will be taken and the discussion of how to do it and the importance of calibrated images will come in the next section. Next, to narrow and simplify the chroma and hue choices, I use a second VITA Classical guide set up conventionally, that is A series, B series, C series and D series. I have found at this point that I can work with just the A and B series. I evaluate the A shades that are in the red-yellow (orange) range and then the B shades next to the teeth. I determine whether the teeth appear to have an orangish or yellowish hue. If they appear yellowish, I use the B shades; if they appear reddish or orangish, I use the A shades. I then hold up either the A or B shades next to the teeth to choose the appropriate level of chroma and take chroma images (Fig. 7).

VITA 3D-Master Shade Guide and the Linearguide

The 3D-Master was developed to be able to cover the range of measured natural teeth.¹⁵ More recently, the Linearguide was developed. It is the same shades as the 3D-Master but in a much better tab holder that allows more accurate positioning and evaluation. Because of the similarities between the two, I will describe their use concurrently. Over ten years of personal experience has shown this to be the superior shade-analysis system.

The system is arranged first around choosing the value. There are six value levels that are equally spaced $5 \Delta E$ apart within the colour space.¹⁴ ΔE is a mathematical measurement of the distance between two points in colour space—the human eye can only differentiate points that are greater than $2 \Delta E$ apart.



Fig. 12



Fig. 13

I have found that the L and R shades can be removed from the shade guide, leaving only the M shades (Fig. 8). This vastly simplifies the value-taking process. The procedure for choosing the value is best done by a process of elimination as described earlier. The two or three closest value groups are chosen so that the range has something that is perceived as slightly higher in value and something slightly lower in value than the natural teeth (Fig. 9). With the Linearguide, it is even easier. The six value groups are in their own holder and tabs can be evaluated more easily (Fig. 10). Again, work by a process of elimination, choosing two or three of the closest values (Fig. 11). Several value images are then taken.

The next step is to determine the level of chroma, of which there are three in most of the M shades. They are labelled 1, 2 and 3 (Fig. 12). Again, it is best accomplished by a process of elimination, recording the closest match or noting if it is between two chroma levels. The chroma levels are all exactly equidistant from each other within the colour space. With the Linearguide, all the different chromas of all three hues are in a special holder (Fig. 13). Using this system makes it easier to determine whether the chroma is at an in-between level. I pass the chroma guide of the closest value in the same plane as the natural teeth and then photograph the two closest chromas (Fig. 14).

The last step is to choose the specific hue. If the value and chroma are matched, experience has shown that an observer would not notice a shade

Fig. 12 Image demonstrating chroma levels with the 3D-Master guide.

Fig. 13 Image demonstrating chroma levels with the Linearguide.

Fig. 14 Choosing the chroma for a patient case. The same image can be used to determine whether the teeth are redder or yellower than the M hue group shown.

Fig. 15 Image of hydrated tooth with shade tab.



Fig. 14



Fig. 15