



## PROBLEMS IN STANDARD SHADE MATCHING AND REPRODUCTION PROCEDURE IN DENTISTRY: A REVIEW OF THE STATE OF THE ART

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**Summary:** Shade matching is a much more complicated task than it may look like. The final judgment about tooth shade should be made by a dentist, who could eventually consult a dental technician. Dentists should be educated about the basics of color science. Dentists, dental technicians and dental students should go through some of the color vision tests.

Variability of the factors which influence the shade matching procedure should be minimalised. There is a need for new, better, logically and scientifically arranged shade guides which would cover the complete color range of natural teeth. They should be made in the same way the porcelain–fused–to–metal (PFM) restoration is being made, with metal alloys and opaque layer. Until they are not made, it is advisable to use shade guides and materials of different manufacturers. Thus, the possibility of matching proper shades increases.

The communication with laboratory should also be improved, by sending more precise and clear information to dental technician. It is essential for dental technicians to follow strictly both manufacturers' instructions concerning working technology and dentists' instructions concerning the chosen shade.

**Key words:** Color matching, tooth, shade guide, color science

### Introduction

Many scientific projects whose subject of investigation is natural tooth color reproduction, using visual and instrumental techniques, have been done worldwide. However, many problems connected with proper shade matching, information transfer to the laboratory and adequate shade reproduction, have still remained. The contemporary color reproduction process lacks precision and depends a lot on dentists' and dental technicians' individual effort and skill. To achieve natural and harmonic restoration color, it is necessary to have an objective, precise and systematic method, beginning with shade matching procedure in dental practice up to its reproduction in laboratory. Subjective and objective problems in the standard shade matching procedure must be analyzed to approach this complex problem and to suggest possible improvements.

Color can be matched by visual and/or instrumental methods. In dental practice the visual method is commonly used for shade matching. Shade matching and reproduction are a difficult task themselves – it is almost unbelievable that

chromacity of artificial teeth covers only 1.17% of colors that can be perceived (1). Besides, dentists do not study color science in their curriculum. So, it is normal that color mismatching appears frequently in practice. Thus, studying and application of modern color science in dentistry must be seriously considered.

### Final decision about color of the tooth is up to a dentist

Some dental schools suggest alibi–attitude that shade matching should be done by a dental technician, because he will reproduce it. Normally, it is good to consult a dental technician if possible, but the fact that the dentist with his signature is responsible for restoration, should be more than enough to reject this approach. Having that in mind, it is necessary for every dentist to learn essential elements of color science and possibilities of its application in practice. To achieve this, certain, not so small, efforts will be required from dentists. In that case, the results will be more significant for patient's health, but also for the therapists' ego (2).

### Differences of color vision

Color matching is complicated by individual differences in color perception and different ability of color discrimination. Culipepper (3) has found differences among dentist concerning shade matching for the same tooth. It happens that the same dentist matches different shade for the same tooth in two days. Dentists, dental technicians and dental students should go through some of the color vision tests having in mind that about 8% of males and about 0,5% of females have color deficiency (4,5). The most popular color vision tests are Ishihara Charts (3,6) and 100 Hue Farnsworth Munsell test (7-9). If one has color deficiency it certainly does not mean that he can not study dentistry or be a dentist, that is dental technician – it only means that he needs help in shade matching.

### Viewing conditions for shade matching procedure

Tooth color matching is usually done under different light sources without paying attention to compatibility of light conditions in dental practice and laboratory. It happens that a dentist matches the color in daylight, while a dental technician, who has different color vision besides, produces the restoration under incandescent light source. Can the proper shade of restoration be expected in those circumstances? Light conditions for tooth shade matching procedure should be standardized (5,10) and compatible with light conditions in dental laboratory. Standard light source in dentistry is defined as: Washington D.C., June, 12:00-1:00 pm with a slight overcast. Color temperature 5500 Kelvin. Color Rendering Index (CRI) – method developed by Commission Internationale De L'Eclairage (CIE). A scale of 100 is used to indicate the relative ability of the light source to match the rendition of a standard reference illuminant (equal energy or pure white light). CRI should be of 90 or greater (11).

Ideal light source for dentistry should have the following characteristics:

1. to be color corrected, i.e. to have a full visible spectra range (12,13);
2. to have enough intensity to eliminate ambient light, but not to be so strong to "wash" the color and to mask the color differences<sup>10</sup>. Task-to-ambient-light ratio should not succeed 3:1 (14);
3. to be diffuse and pleasant for the eye, enabling it to percept the color without fatigue;
4. to be standard, that is not to change its quality and quantity depending on time of the day or season and for purposes of

communication with laboratory, from place to place (5).

In color matching procedure, it is necessary to pay attention to viewing geometry (15,16) and influence of the background and the surrounding. Perception distance, patients' clothes and make up, color of the uniform, equipment, furniture, walls and ceiling of a dental practice are also factors of importance.

According to all of this, it is obvious that there are many different factors on which proper color matching depends. Their variability should be minimalised.

### Shade guides

Shade guides of all dental materials are based on the long established porcelain shade guides which evolved to represent the available shades of porcelain teeth. The shades developed by a process of popular selection by which shades perceived to be nearer tooth color were added and the least popular eliminated. This concept has not changed since the introduction of porcelain over two hundred years ago (17).

A great number of authorities in dental ceramics point to numerous problems with existing commercial shade guides (18-28). Existing dental shade guides are not arranged logically or scientifically and do not even correspond to measured tooth color (19,27,29). Tooth samples are made without metal base, of porcelain whose antero-posterior thickness (about 4 mm) is much bigger than the thickness of ceramics layer of the finished porcelain-fused-to-metal (PFM) restoration will be. The choice of shades is more than narrow (11-25), and it happens that shade guides of the same manufacturer have differences among the shades that are stated to be the same. Shade guides made of resin are, above all, of inconsistent color if kept in certain disinfecting compounds (especially chlorine-containing ones) and it happens that they change the color (30).

It seems unavoidable for dental ceramics manufacturers to adjust their production conception to real needs and demands for the greater color assortment. This should be followed by new shade guides, made in the same way the PFM restoration is being made, with metal alloys and opaque layer.

### Shade matching procedure

Standard shade matching procedure is well known: tooth color is matched in daylight, using the shade guide. Can anything be unclear in this statement? Of course not, except that it provides

completely insufficient and incomplete information. If it is added that daylight is not constant itself and the color temperature ratio varies 1:20 depending on the time of the day and meteorological factors (5), the confusion is complete. Fortunately, there are certain improvements in shade matching procedure, especially in the last decade.

It is important that color selection is done when the patient is first seated in the dental chair. Pizzamiglio (13) explains this by following: by the end of the appointment, when the patient has held the mouth open with a cotton roll for most of the time dehydration has occurred, altering chroma and value. The teeth will take more than 24 hours to regain their normal coloration. Sorensen and Torres (24) have the same attitude, but a different explanation – they point out that during the appointment the therapist's eyes become fatigued, which lessens the ability for adequate shade matching.

The patient's mouth should be leveled with the dentist's eyes. Samples from the shade guide should be applied parallel with the tooth whose color is being matched, not in front of it (it will appear lighter), and not behind it (it will appear darker).

Some authors suggest that neck areas should be removed from the guides because they are higher in chroma and lower in value (11,13,31). Spencer (11) finds that the size of most brands of shade guides makes it impossible to place two guides together within the width of a natural tooth. This can make comparison difficult. A solution would be to have a complete set that has been reduced by one third mesial and distal. In case that natural tooth and the guide have different surface textures, both should be moistened by water.

Most of the dentists use only one shade guide in practice. The reason for that is because they are used to it, or because they prefer materials or colors of a certain manufacturer, or simply because they have only one ceramic available. Some authors' attitude (11,32,33) that the aesthetics can be improved if both the therapist and the dental technician use the shade guides and ceramics of different manufacturers is logical and acceptable (34). This attitude, as a tendency, should be supported, because by using more than one shade guides the shade assortment basically improves. Normally, it does not mean a shade is matched with one shade guide and the restoration is made with the other manufacturer's material.

The usage of one extended (e.g. Vita Shade Indicator) and two common shade guides (e.g. Vita VMK Lumin Vacuum) is suggested (11,13,24,31,33). One of them should be organized according to

hue. This is the standard organization of the shade guide as it comes from the manufacturer. The second shade guide should be arranged according to the value. Hue, value and chroma should be matched separately. The natural tooth should not be observed more than five seconds. It is advisable to look into some blue surface for one minute after this, because the possibility for perception of yellow color increases in that way. It is also advisable to verify the choice under different light sources.

### **Communication between dental practice and laboratory**

There are some objective problems in communication between dental practice and laboratory. Demands concerning the color are usually imprecise and unclear, which often results in the restoration whose color is dramatically different from the original.

To improve the communication between dental practice and laboratory, it is suggested that diagrams, i.e. schemes, should be used (24,32,33). A facial view of the clinical crown is used to indicate the position of the various shades, while a proximal view will tell the technician how the body and enamel porcelains should be layered. Photographs or slides can be very useful for showing shade gradation and characterization. Photographs can not however, accurately represent color, but the photograph should show the shade guide in the field and be correctly positioned as a reference point (11,35).

### **Color reproduction**

At the reproduction of a certain color different subjective and objective factors are present. Dental technicians are in a specific and ungrateful position between a dentist and a manufacturer. Without seeing a patient, they have to accomplish the information received from the dentist. On the other hand, their control and information about materials used are limited. Some investigations describe differences in color, size and shape among batches of porcelain powder of the same manufacturer (36–38).

There are many factors that influence the porcelain shade. Correct working technology is the most important factor. It is essential for dental technicians to follow strictly both manufacturers' instructions concerning working technology and dentists' instructions concerning the chosen shade. Increasing of firing temperature, for example, causes color changes (39), while increasing of the number of firings, contrary to the omnipresent

opinion, does not (40,41). Different condensation methods can also influence the restoration (40,42). The surface texture can also influence the color: the smoother one increases, while the rougher one decreases the value of the restoration (43).

### Conclusions

1. Shade matching is much more complicated task than it may look like.
2. Final judgment about tooth shade should be made by a dentist, who could eventually consult a dental technician. Dentists should be educated about basic of color science.
3. Dentists, dental technicians and dental students should go through some of the color vision tests.
4. Variability of the factors which influence shade matching procedure should be minimalised.

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5. There is a need for new, better, logically and scientifically arranged shade guides which would cover complete color range of natural teeth. They should be made in the same way the PFM restoration is being made, with metal alloys and opaque layer. Until they are not made, it is advisable to use shade guides and materials of a few different manufacturers. Thus, the possibility of matching the proper shade increases.
6. The communication with laboratory should be improved, by sending more precise and clear information to dental technician.
7. It is essential for dental technicians to follow strictly both manufacturers' instructions concerning working technology and dentists' instructions concerning the chosen shade.
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## NEDOSTATCI STANDARDNOG METODA ZA ODREĐIVANJE I REPRODUKCIJU BOJE ZUBA: PREGLEDNI ČLANAK

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*Kratak sadržaj:* Određivanje boje zuba je mnogo složeniji zadatak nego što se na prvi pogled može učiniti. Pri određivanju boje zuba odlučujuću reč treba da ima stomatolog, uz eventualno konsultovanje zubnog tehničara. Stomatolozi treba da poznaju osnove nauke o boji. Bilo bi poželjno da stomatolozi, zubni tehničari i studenti stomatologije provere svoj kolorni vid.

Promenljivost faktora koji utiču na određivanje boje zuba treba svesti na minimum. Postoji objektivna potreba za novim, boljim, logično i naučno aranžiranim ključevima za određivanje boje zuba, koji bi pokrili ukupan opseg boja prirodne denticije. Ti ključevi bi trebalo da budu izrađeni na isti način na koji se izrađuje metalo–keramička (MK) restauracija, sa metalnom podlogom i opakerom. Dok se ovakvi ključevi za određivanje boje zuba ne pojave na tržištu, savetuje se primena ključeva i materijala različitih proizvođača. Na taj način se povećava mogućnost za određivanje odgovarajuće boje.

Komunikaciju sa zubnom tehnikom takođe treba popraviti, šaljući preciznije i jasnije informacije zubnom tehničaru. Od najvećeg je značaja da se zubni tehničar striktno pridržava uputstava proizvođača o tehnologiji izrade metalo–keramičke nadoknade i uputstava stomatologa u pogledu boje koja je određena.

*Ključne reči:* Određivanje boje, zub, ključ za boju, nauka o boji

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