

Application of Advanced Technologies in Shade Matching – A Spectrophotometer

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SUMMARY

One of many challenges in cosmetic dentistry is to accomplish appropriate and satisfactory reproduction of natural shade of teeth and in that way to make successful restoration. The procedure of choosing a shade can be performed using visual method or by an instrument. The kind of shade guide, individual ability to choose shades and conditions the choice is made under, all have influence on reliability and accuracy of the procedure. Therefore, it is necessary to introduce instrumental color determination in everyday work. The instrumental color determination method considers use of a spectrophotometer, a colorimeter and a digital camera or even the combination of all three in shade matching. The purpose of this article was to present all amenities and advantages of the instrumental color determination in shade matching through the demonstration of the clinical performances of an intraoral spectrophotometer VITA Easyshade Compact device. VITA Easyshade Compact device provides fast and reliable measuring and gives results that are not influenced by the conditions under which the shade was chosen or by the person who made choice. Shade matching using a spectrophotometer meets all the requirements for choosing the shade by vision, therefore it is recommended for clinical work.

Keywords: tooth color; shade guide; spectrophotometer

INTRODUCTION

Continuous technological improvements of dental materials and consequent aesthetic enhancement of direct and indirect restorations require trained practitioner able to choose the right shade. However, the path to the appropriate choice of shade for future restoration is not simple. Achieving the satisfying morphological, optical and biological form of a restoration is one of the most important goals of esthetic dentistry and dentistry in general [1].

By definition, color is subjective perception of the quality of light and colorimetry is a scientific discipline which enables measuring and specifying the color [2, 3]. Basic knowledge about shades is prerequisite to make the right choice. In 1900, American painter and teacher of art Albert Henry Munsell wrote about tri-dimensional property of color and parameters such as: hue, chrome and value or lightness [4].

The procedure of selecting shade in cosmetic dentistry can be done by visual or instrumental color determination. Visual color determination considers comparing the shade with already known physical standard accepted as a reference. Basically, it is the use of color atlas or shade guide in more or less controlled conditions. [3, 5, 6, 7]. The most common and widely accepted way to choose shade is by the shade guide. The shade guide is a collection of shade samples offered by a manufacturer or shades that he provides components for. The sample from the shade guide should match the shade one would get using

appropriate materials to make the restoration [2]. The first shade guide “Tooth Color Indicator”, made by Clark, contained 60 porcelain samples of shades. By 1950, there were numerous guides for choosing shades on the market [8, 9]. Years back “Vitapan Classic Shade Guide” was the gold standard in choosing shades. Although still in use today, it shows various shortcomings successfully overcome in new guides [8, 9]. The first person to point out the necessity to include all three parameters of color when choosing a shade was Hall in 1991. His work was base for the development of “Vitapan 3D-Master Shade Guide” which was the first commercial system for determining and reproduction the shades based on the principles of colorimeter classification. It is highly improved compared to the classic shade guides with better organization, wider range and uniform distribution of shades [8, 10]. A new version of VITA Toothguide 3D-Master called “Linearguide 3D Master” is also available. It has a practical linear structure of shades more suitable for dentists who use Vitapan Classic shade guide which also has a linear structure of shades [8].

The instrumental color determination requires devices such as spectrophotometers, tri-stimuli colorimeters, spectroradiometers as well as digital cameras [3, 5, 11, 12].

The purpose of this article was to present all amenities and advantages of instrumental color determination in shade matching through demonstration of the clinical performances of an intraoral spectrophotometer VITA Easyshade Compact device.

CHOOSING SHADES

VITA Easyshade Compact is the device that meets the greatest number of requirements for choosing the shades in clinical settings (Figure 1). The device can be used to determine an overall tooth shade, the shade of each third of the tooth- cervical, middle and incisal, as well as to confirm the shade of the restoration (Figure 2). VITA Easyshade Compact is able to measure a wide range of colors which include VITA Linerguide 3D-Master, VITA Toothguide 3D-Master and VITAPAN A1-D4 classic shades. There is a possibility to adjust the device to measure interpolar 3D shades, i.e. shades obtained by mixing one or more porcelain materials. During the procedure of confirming a shade of restoration, a user receives thorough and precise data about any inconsistency with wanted shade. To choose a shade using this spectrophotometer, one needs to perform an automatic or manual calibration with protective foil and to choose the appropriate functions from the menu (overall tooth shade or shade by thirds – cervical, middle or incisal third of the restoration). The tip of the machine is set perpendicularly and uniformly on the surface of the tooth, at least 2 mm away from the incisal edge and 2 mm from the gingiva (Figure 3). It is necessary to avoid contact with existing restorations. VITAPAN Classic and VITA 3D-Master shade appears as a result of measuring (Figure 4).

DISCUSSION

Considering that the kind of a shade guide, individual ability and the conditions under which the shade is chosen can influence the reliability and accuracy of the procedure, it is necessary to introduce instrumental color determination in everyday work [13]. The conditions such as lighting, time of the day, weather conditions, surroundings and factors

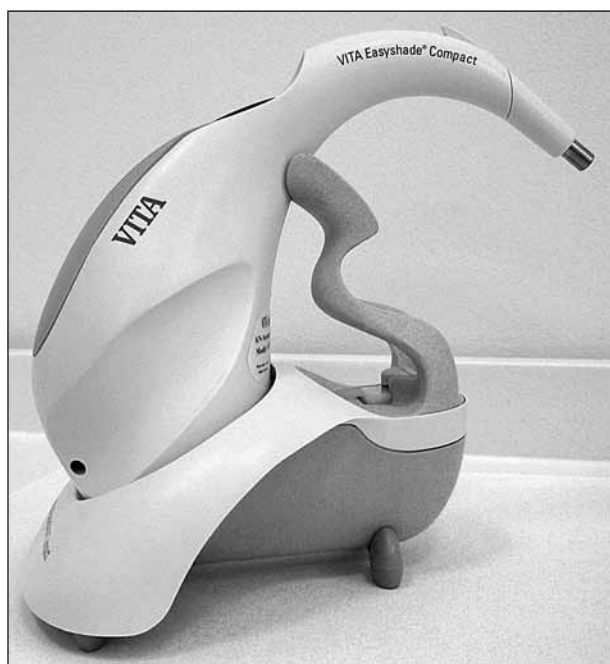


Figure 1. VITA Easyshade Compact device
Slika 1. Aparat VITA Easyshade Compact



Figure 2. The device features: overall tooth shade determination, determination of the tooth shade for each third and verification of the shade of restoration

Slika 2. Funkcije aparata: određivanje boje celog zuba, određivanje boje zuba po trećinama i provera boje restauracije



Figure 3. Clinical use of VITA Easyshade Compact device
Slika 3. Klinička primena aparata VITA Easyshade Compact



Figure 4. The result of shade determination: VITAPAN Classic and VITA 3D-Master shade

Slika 4. Rezultat merenja: VITAPAN klasična i VITA 3D-Master boja



Figure 5. The difference between determined shade for tooth area and approximate VITAPAN Classic A1-D4 shade in tri-dimensional color space

Slika 5. Razlika u boji između izmerenog područja zuba i približne VITAPAN klasične A1-D4 boje u trodimenzionalnom prostoru boja

related to age, work experience, tiredness and emotional state of the person who chooses the shade can have a great impact on the final result [1, 14]. Some chronic diseases as well as long-time use of certain medications can influence the perception of color [4, 11]. On the other hand, results of some clinical studies show that the gender of the person, eye color or whether the person has glasses or contact lenses do not influence the choice when using the shade guide [15, 16]. Taking these into consideration, it can be concluded that the choice of shade using the shade guide is highly subjective. VITA Easyshade Compact enables results not influenced by the conditions in which measuring was done or by the person who made the choice.

Spectrophotometers, instruments for determining tooth shade compare the light reflected from a sample and the light reflected from the white reference surface. Laboratory spectrophotometers measure diffuse reflectance by highlighting the sample with monochromatic light (380-700 nm wavelengths) at the angle of 45 degrees and detect diffuse light reflected from the sample surface at the angle of 0 degrees [3, 11, 17]. VITA Easyshade Compact follows very simple procedure. Being cordless, it gives the user mobility and freedom of movements. Its shape, light and round design make its use straightforward. One of the most important advantages of this device is that it can store successful shade measurement data. It enables viewing $L^*C^*h^*a^*b^*$ coordinates in $CIE\ L^*a^*b^*$ color space for the measured tooth area giving the additional information about the shade i.e. the difference between the color of the measured tooth area and approximate VITAPAN Classic A1-D4 shade in tri-dimensional color space (Figure 5).

Regardless of the way how the instrumental shade determination is done, reliability and accuracy of those devices are the most important. Several studies performed in this field in 2009 evaluated reliability and accuracy of four devices for instrumental shade determination: SpectroShade (spectrophotometer), Shade Vision (digital camera and colorimeter), VITA Easyshade (spectrophotometer) and Shade Scan (digital camera and colorimeter).

The results showed that only VITA Easyshade measurements were 90% reliable and accurate [11, 17]. Some studies point out the fact that Easyshade is the most reliable instrument for shade determination in in vitro and in vivo conditions [18].

CONCLUSION

Shade matching by using spectrophotometer meets all the requirements for successful choice of shade in accordance to the physiology of color vision and the science of color. That method for shade determination is recommended in everyday practice and surely characterizes the present and the future of restorative dentistry.

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Primena spektrofotometra u određivanju boje zuba

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KRATAK SADRŽAJ

Jedan od izazova estetske stomatologije je i odgovarajuća i zadovoljavajuća reprodukcija boje prirodnog zuba, što je značajan faktor uspeha buduće restauracije. Postupak izbora boje moguć je primenom vizuelne i instrumentalne metode. Vrsta primenjenog ključa boja, individualna sposobnost odabira boje i uslovi u kojima se izbor boje odvija mogu uticati na pouzdanost i preciznost postupka, pa je stoga neophodno uvođenje instrumentalne metode u svakodnevni rad. Radi objektivizacije terapijskog postupka, instrumentalna metoda određivanja boje zuba podrazumeva primenu spektrofotometra, tristimulusnih kolorimetara, digitalnog analizatora boja, kao i njihovu kombinaciju. U ovom radu prikazane su pogodnosti i prednosti primene instrumentalne metode u postupku određivanja boje zuba kroz prikaz kliničkih performansi intraoralnog spektrofotometra. Aparat *VITA Easysshade Compact* omogućava brzo i pouzdano merenje, pokazuje rezultate koji su potpuno nezavisni od uslova u kojima se izbor boje vrši i isključuje subjektivnost terapeuta. Određivanje boje zuba primenom spektrofotometra ispunjava sve predulove za izbor boje u skladu s fiziologijom kolornog vida i može se preporučiti u rutinskom kliničkom radu.

Ključne reči: boja zuba; ključ boja; spektrofotometar

UVOD

Stalna usavršavanja na polju tehnologije stomatoloških materijala i sledstveno poboljšanje estetskih odlika direktnih i indirektnih restauracija zahtevaju obučenosť terapeuta u procesu pravilnog izbora boje. Međutim, put do odgovarajućeg izbora boje buduće restauracije nije jednostavan. Postizanje morfološke, optičke i biološke estetike restauracije jedan je od važnih ciljeva i estetske i stomatologije uopšte [1].

Boja je subjektivni doživljaj kvaliteta svetlosti, a kolorimetrija naučna disciplina koja omogućava merenje i specifikaciju boje [2, 3]. Osnovno znanje o bojama važno je za pravilan postupak odabira boje u stomatološkoj ordinaciji, o čemu je još 1900. godine pisao američki slikar i profesor umetnosti Albert Henri Mansel (*Albert Henry Munsell*). On je pisao o trodimenzionalnosti boje, o parametrima kao što su osnovna boja (*hue*), zasićenost (*chroma*) i svetlina (*value* ili *lightness*) [4].

Postupak izbora boje u restaurativnoj stomatologiji moguć je primenom vizuelne i instrumentalne metode. Vizuelna metoda podrazumeva upoređivanje s nekim poznatim fizičkim standardom koji je prihvaćen kao referentan, a u osnovi je to primena kolor atlasa ili ključa boja u manje ili više kontrolisanim uslovima [3, 5, 6, 7]. Najšire prihvaćen i najčešće primenjivan način izbora boje u praksi je primenom ključa boja. To je skup uzoraka koje proizvođač nudi ili za čiju izradu obezbeđuje potrebne komponente i specifikaciju. Uzorak iz ključa boja treba realno da predstavlja boju koja će se dobiti primenom odgovarajućih materijala za izradu restauracije [2]. Prvi ključ boja *Tooth Color Indicator*, koji je 1933. kreirao Klark (*Clark*), sa državao je ukupno 60 keramičkih uzoraka boje, a do 1950. godine na tržištu su predstavljeni razni sistemi za izbor boje [8, 9]. Godinama je *VITAPAN Classical Shade Guide* bio tzv. zlatni standard u izboru boje, koji, iako se i danas primenjuje, pokazuje niz nedostataka koji su razvojem novih sistema uglavnom prevaziđeni [8, 9]. Prvi koji je ukazao na potrebu da se u postupku izbora boje uključe sva tri parametra boje bio je Hol (*Hall*) 1991. godine. Njegov rad predstavljao je osnovu za

razvoj *Vitapan 3D-Master Shade Guide* ključa boja, prvog komercijalnog sistema za određivanje i reprodukciju boje zasnovanog na principima kolorimetrijske zakonitosti. Organizacijom, širim opsegom i uniformnom raspodelom boje pokazuje ogromne prednosti u odnosu na klasične ključeve [8, 10]. Radi dodatnog pojednostavljenja postupka izbora boje, dostupna je i nova verzija *VITA Toothguide 3D-Master* ključa pod nazivom *Linerguide 3D Master*. Zbog praktičnog linearnog rasporeda boja, pogodniji je za lekare koji su naviknuti na *VITAPAN Classical* ključ, sa takođe linearnom organizacijom boja [8].

U svrhu instrumentalnog određivanja boje svoju primenu pronašli su spektrofotometri, tristimulusni kolorimetri, spektroradiometri i digitalne kamere [3, 5, 11, 12].

Cilj ovog rada je bio da se na nekoliko slučajeva iz kliničke prakse prikažu sve pogodnosti i prednosti primene instrumentalne metode u postupku određivanja boje, kroz prikaz kliničkih performansi intraoralnog spektrofotometra.

IZBOR BOJE

Za određivanje boje u grupi ordinacijskih spektrofotometara nalazi se *VITA Easysshade Compact* (Slika 1), koji svojim kliničkim performansama zadovoljava najveći broj zahteva. Naime, ovaj aparat se može koristiti za određivanje boje celog zuba, određivanje boje zuba po trećinama i za proveru boje restauracija (Slika 2). Takođe ima mogućnost merenja širokog spektra boja koji uključuje *VITA Linerguide 3D-Master*, *VITA Toothguide 3D-Master* i *VITAPAN* klasične A1-D4 boje. Postoji mogućnost podešavanja aparata za merenje interpolarnih trodimenzionalnih boja, odnosno boja koje se dobijaju mešanjem više keramičkih masa. Pri proveru boje restauracije korisnik dobija detaljne i precizne podatke o eventualnim odstupanjima od željene boje. Postupak izbora boje primenom ovog spektrofotometra podrazumeva prethodnu automatsku ili ručnu kalibraciju uz primenu zaštitne folije, a nakon toga odabir odgovarajuće funkcije iz menija (proveru boje celog zuba, pojedinih trećina

ili restauracije). Merni vrh aparata se postavlja uspravno i ravnomerno na površinu zuba tako da bude udaljen najmanje 2 mm od incizalne ivice i 2 mm od ivice gingive (Slika 3). Neophodno je voditi računa i izbegavati kontakt s eventualno već postojećim restauracijama. Kao rezultat merenja prikazuju se VITAPAN klasična i VITA 3D-Master boja (Slika 4).

DISKUSIJA

Budući da vrsta primenjenog ključa boja, individualna sposobnost odabira boje i uslovi u kojima se vrši određivanje boje mogu uticati na pouzdanost i preciznost postupka, sve više je neophodna primena instrumentalnog načina izbora boje u svakodnevnoj praksi [13]. U postupku određivanja boje primenom ključa važni su i uslovi u kojima se vrši određivanje boje (osvetljenje, doba dana, vremenske prilike, okruženje) i faktori u vezi sa starošću, radnim iskustvom, zamorom i emocionalnim stanjem onoga ko određuje boju [1, 14]. Neka hronična oboljenja, kao i dugotrajna primena određenih lekova takođe se dovode u vezu s kvalitetom percepcije boje [4, 11]. S druge strane, rezultati nekih kliničkih studija pokazuju da pol onoga koji vrši izbor boje, boja očiju i podatak da li nosi naočare ili sočiva za korekciju vida nemaju učinak na rezultat izbora boje primenom ključa boja [15, 16]. Imajući u vidu prethodno navedeno, može se zaključiti da je udeo subjektivnosti u izboru boje korišćenjem ključa boja veoma važan. Aparat VITA Easyshade Compact, osim što omogućava brzo i pouzdano merenje, obezbeđuje i potpuno nezavisne rezultate od uslova u kojima se izbor boje vrši, odnosno od onoga ko obavlja ovaj postupak.

Spektrofotometri, kao oblik instrumenta za određivanje boje zuba, svojom konstrukcijom omogućavaju merenje odnosa reflektovane svetlosti s uzorka i reflektovane svetlosti bele referentne površine. Laboratorijski spektrofotometri mere difuznu refleksiju tako što se uzorak obasja monohromatskom svetlošću talasne dužine 380-700 nm pod uglom od 45 stepeni, a

detektuje difuzno reflektovana svetlost pod uglom od 0 stepeni u odnosu na površinu uzorka [3, 11, 17]. Svojom inovativnom tehničkom koncepcijom način rada s aparatom VITA Easyshade Compact je maksimalno pojednostavljen. Činjenica da je bežičan pruža korisniku veću mobilnost i slobodu kretanja. Svojim praktičnim oblikom, tankim i zaobljenim dizajnom olakšava kliničku primenu. Još jedna od pogodnosti koju ovaj aparat pruža jeste mogućnost zapisa i memorisanja uspešno izmerenih rezultata. Pružaju se i mogućnost prikaza $L^*C^*h^*a^*b^*$ koordinata u CIEL $^*a^*b^*$ prostoru boja za izmereno područje zuba i dodatne informacije o boji u smislu razlika u boji između izmerenog područja zuba i približne VITAPAN klasične A1-D4 boje u trodimenzionalnom prostoru boja (Slika 5).

Nezavisno od toga koji način instrumentalnog određivanja boje zuba se primenjuje, pouzdanost i preciznost ovih aparata je najvažnija. S tim u vezi, neka od istraživanja iz ove oblasti izvedena tokom 2009. godine proverila su pouzdanost i preciznost četiri aparata za instrumentalno određivanje boje zuba: SpectroShade (spektrofotometar), ShadeVision (digitalna kamera i kolorimetar), VITA Easyshade (spektrofotometar) i ShadeScan (digitalna kamera i kolorimetar) [11, 17]. Rezultati su pokazali da je VITA Easyshade jedini aparat za instrumentalno određivanje boje zuba s vrednostima većim od 90% za pouzdanost i preciznost merenja. Pojedina istraživanja ukazuju na činjenicu da je ovaj aparat najpouzdaniji instrument za određivanje boje zuba u uslovima *in vitro* i *in vivo* [18].

ZAKLJUČAK

Određivanje boje zuba primenom spektrofotometra ispunjava sve predušlove za pravilan izbor boje u skladu s fiziološkim osobinama kolornog vida i naukom o boji. Ovaj način određivanja boje se može preporučiti za rutinsku kliničku primenu i sigurno čini sadašnjost i budućnost restaurativne stomatologije.