

INSTRUMENTI ZA ODREĐIVANJE BOJE

COLOR MEASURING INSTRUMENTS

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Sažetak

Cilj: Cilj ovog rada bio je da prikaže pregled najnovijih instrumenata za određivanje boje u stomatologiji, kao i onih koji se više ne proizvode, ali se još uvek mogu videti u stomatološkoj praksi.

Metod rada: Pregled literature i „Medline“ baze za period od 2000. god. do današnjeg dana.

Zaključak: Opisani su tipovi instrumenata za određivanje boje u stomatologiji. Znanje o boji i znanje o instrumentima za određivanje boje može pomoći lekarima da bolje odrede boju zuba u stomatološkoj praksi.

Ključne reči: određivanje boje, tristimulus kolorimetar, spektrofotometar

Abstract

Objectives: The goal of this paper was to review color measuring instruments in dentistry.

Methods: Literature review, „Medline“ database for the period 2000 to the present day, and the information provided by manufacturers.

Conclusions: Different types of color measuring instruments used in dentistry were described. Color measuring instruments can help dental professionals in achieving enhanced esthetic outcome thus increasing patient satisfaction.

Key words: color, color measuring instruments, tristimulus colorimeters, spectrophotometers

Uvod

Određivanje boje zuba je kompleksan fenomen. Mnogi faktori kao što su uslovi osvetljenja, providnost, rasejanje svetlosti, sjaj, ljudsko oko i ljudski mozak utiču na ukupnu percepciju boje zuba.¹ Određivanje boje u stomatologiji može biti podeljeno u dve kategorije: vizuelno i instrumentalno. Najčešća metoda određivanja boje u kliničkoj stomatologiji je vizuelno upoređivanje boje zuba pacijenta sa kolor standardom.² Međutim, vizuelno određivanje boje je nepouzdan i nedosledan način i to je stalni problem u stomatološkoj praksi.³

Instrumentalne analiza boje su objektivne, mogu se izmeriti i rezultati se mogu brže dobiti. U prednosti su u odnosu na vizuelno

Introduction

Color appearance of teeth is a complex phenomenon. Many factors such as lighting conditions, translucency, opacity, light scattering, gloss and the human eye and brain influence the overall perception of tooth color.¹ Color matching/measurement in dentistry is performed using two methods: visual and instrumental. Visual color matching is a comparison of a patient's tooth/teeth with shade guide tabs, and is by far predominant in clinical dentistry.² However, visual shade selection has been found to be unreliable and inconsistent to certain extent.³

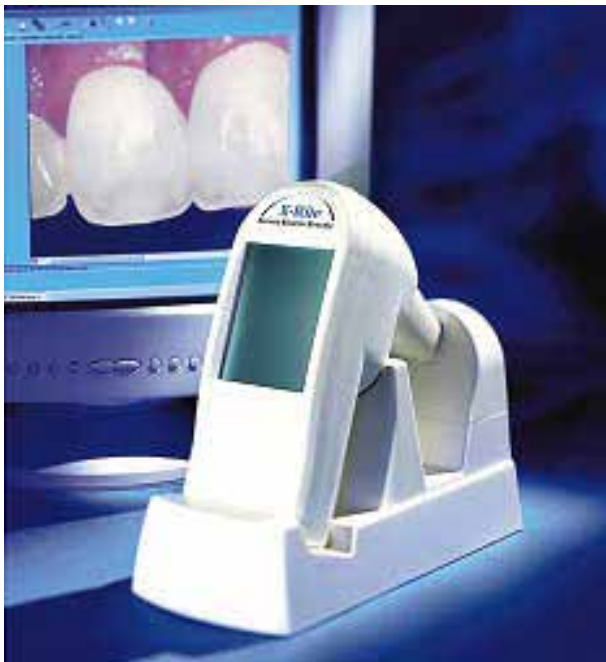
Instrumental color analysis are objective, can be quantified, and they are more rapidly obtained. They have a potential advantage over visual shade matching.⁴ Different technologies and methods are used for color measurement

određivanje boje zuba.⁴ Za određivanje boje u stomatologiji se koriste brojne metode, a broj signala varira od minimum tri (po jedan za svaki stimulus) za *kolorimetre*, do maksimalnog 471 (po jedan za svaki nanometar između 360nm i 830nm talasne dužine) za *spektrometre*. Kolorimetri direktno mere kolorimertiske vrednosti dok spektrometri kalkulišu kolorimertiske vrednosti koristeći spektralne podatke.⁵ Kada se vrši merenje materijala spektrometar se zove *spektrofotometar*, a kada se vrši merenje izvora koristi se izraz *spektoradiometar*.⁵ Digitalne kamere postaju sve popularnije u određivanju boje zuba. Tehnologija se može podeliti u dva pristupa: kolorimetrski i multispektralni.⁶

Tristimulus kolorimetar

Tristimulus kolorimetri su instrumenti za određivanje boje koji su opremljeni sa tri (ili četiri) specijalna filtra. Filtri sadrže RGB (crveno, zeleno, plavo) vrednosti. Tristimulus kolorimetar koristi transmisioni tip silikonskog detektora. Oni su često manje precizni od spektrofotometara, ali su traženiji jer manje koštaju i lakši su za korišćenje.⁷

ShadeVision (X-Rite Inc., Grandville, USA) je kolorimetar koji omogućava kompletnu sliku zuba. *Shade Vision* ima tri odvojene baze za svaki deo sa različitom nijansom – gingivalni, srednji/dentinski i incizalni.⁸ U laboratoriji,



Sl. 1. *ShadeVision* (X-Rite Inc., Grandville, USA)

Fig. 1. *ShadeVision* (X-Rite Inc., Grandville, USA)

in dentistry, and the number of signals ranges from the minimum of three (one for each tristimulus values) for *colorimeters*, to a maximum of 471 (one for every nanometer between 360 nm and 830 nm) for *spectrometers*. Colorimeters directly measure colorimetric quantities whereas spectrometers calculate colorimetric quantities from spectral data.⁵ When measuring materials, the spectrometer is termed *spectrophotometer*, while the term *spectroradiometer* is used when sources are measured.⁵ Digital cameras are becoming increasingly popular for color measurement in dentistry. The technology can be divided into two approaches: colorimetric and multispectral.⁶

Tristimulus colorimeters

Tristimulus colorimeters are instruments for color measurement which are equipped with three (or four) special filters. Filters obtain RGB (red, green and blue) values. Tristimulus colorimeters use a transmission-type silicon trap detector. They are usually less accurate than spectrophotometers, but tristimulus colorimeters are often preferred because of their low cost and user-friendliness.⁷

ShadeVision (X-Rite, Grandville, MI, USA) is an imaging colorimeter that enables complete tooth image. *ShadeVision* has three separate databases for each shade tab – gingival, middle/dentin, and incisal.⁸ In lab, technician can virtually test the color accuracy of the restoration during fabrication, because this colorimeter has virtual try-in feature.⁹ (Fig. 1)¹⁰

Spectrophotometers

Spectroradiometer is a device that measure reflectance from materials or transmittance trough materials: irradiation (W/m^2) and irradiance (W/m^2Sr). Spectral irradiance and irradiation are presented as a function of luminance (cd/m^2) and illuminance (lux). Radiometric energy is measured in the visible light spectrum in the intervals between 380 and 780 nm. The main parts of this apparatus are: a telescope, a monochromator and a photoreceptor.¹¹ Several intra-oral spectrophotometers are currently available. They all consist of a cordless hand-piece and a base unit.

tehničar može virtualno proveriti tačnost boje restauracije za vreme izrade, jer ovaj uređaj poseduje virtual try-in funkciju.⁹ (Sl. 1)¹⁰

Spektrofotometri

Spektroradiometar je uređaj kojim se mere radiometričke osobine: iradijacija (W/m^2) i zračenje (W/m^2Sr). Spektralna iradijacija i zračenje se mogu predstaviti kao osvetljenje (cd/m^2) i kao osvetljenost (lux). Radiometrička energija se meri u vidljivom delu spektra u intervalu između 380 i 780 nm. Glavni delovi ovog aparata su: teleskop, monohromator i fotoreceptor.¹¹ Oni se sastoje od bežičnog uređaja i baze.

SpectroShade Micro (MHT Optic Research AG, Niederhasli, Switzerland) je spektrofotometar koji koristi digitalnu kameru povezanu sa LED spektrofotometrom. Poseduje interni kompjuter koji u svom računaru sadrži Linux softversko okruženje i može da analizira više od dva miliona slika na referentnim tačkama po celoj površini zuba. Posle toga program određuje i izračunava brojčane razlike između prirodnih zuba i izabrane baze boje na postojećim standardima, obezbeđujući laboratoriji podatke o svetlini, zasićenosti i vrsti boje (lightness, chroma and hue).¹² Svaka slika poseduje sve neophodne podatke koji su potrebni analitičkom softveru. Tačno određivanje boje zuba se postiže korišćenjem sistema vodjenog pozicioniranja zuba koji se prikazuje na LCD displeju. LCD takođe može biti korišćen da se pristupi svim operacijama uređaja korišćenjem touch screen tehnologije. Slike i podaci o boji mogu biti memorisani i prenešeni u računar.¹³ Sl.2.¹⁴

Easyshade Compact (Vita Zahnfabrik, Bad Säckingen, Germany) je bežični spektrofotometar koji određuje boju zuba, baziran na VITA Classical ili Vitapan 3D-Master ključu za određivanje boje. To je uređaj kontaktnog tipa koji koristi digitalni spektrometar i LED fiber optički svetlosni izvor.¹⁵ Oblast koju meri ovaj uređaj iznosi oko 5 mm u prečniku i ne generiše digitalnu sliku. Međutim, poseduje program koji obezbeđuje informacije dentalnoj laboratoriji u elektronskom ili štampanom obliku.¹⁶ Easyshade Compact je dizajniran da meri boju celog zuba ili da napravi izdelfjenu mapu zuba u cerviko-incizalnom smeru.

SpectroShade Micro (MHT Optic Research, Niederhasli, Switzerland) is an imaging spectrophotometer that uses a digital camera connected to a LED spectrophotometer. It has an internal computer with Linux operating system that analyzes more than 2 million image capture reference points over the entire tooth surface. After that, the program matches and calculates numerical differences between the natural tooth and selected color based on existing standards, providing laboratory information about lightness, chroma and hue.¹² Every image gathers all the necessary data to fully utilize the analytical software. Correct measurement of color of the tooth is achieved by using the tooth positioning guidance system that is shown on the LCD screen. LCD can be also used to access all the instrument operations by touch screen technology. Images and spectral data can be saved on the internal memory and transferred to a PC.¹³ (Fig. 2.¹⁴).

Easyshade Compact (Vita Zahnfabrik, Bad Säckingen, Germany) is a cordless spectrophotometer that determines a tooth shade based on



Sl. 2. *SpectroShade Micro* (MHT Optic Research, Niederhasli, Switzerland)

Fig. 2. *SpectroShade Micro* (MHT Optic Research, Niederhasli, Switzerland)

Određivanje boje je upoređivanje sa standardima pomoću kojih je uređaj kalibrisan. Kalibracija ovog uređaja se može izvršiti na dva načina. Prvi je korišćenjem keramičkog bloka poznate boje. Blok se nalazi u prekidaču koji se koristi za detektovanje kada je instrument u modu kalibracije. Drugi način je kada je baza povezana sa osnovnim uređajem; procedura kalibracije se obavlja automatski. Kalibracija se može izvršiti i kada baza nije dostupna glavnom uređaju. U tom slučaju, instrument se kalibriše manuelno.¹⁷ (Sl. 3)¹⁵



Sl. 3. Vita Easyshade (Vident, Brea, USA)

Fig. 3. Vita Easyshade (Vident, Brea, USA)

Easyshade Compact poseduje četiri različita tipa podešavanja merenja: mod merenja boje celog zuba, mod merenja boje pojedinih oblasti zuba (boja cervikalne, srednje i incizalne trećine zuba), verifikacija boje restauracije (uključujući svetlinu, intezitet boje i upoređivanje boje) i mod ključa za određivanje boja (trening mod).¹⁸

Crystaleye (Olympus America, Center Valley, PA, USA) je dentalni ručni spektrofotometar koji kombinuje digitalne slike sa podacima o boji zuba baziranim na spktrofotometrskim merenjima.¹⁹ Spektrometar koristi sedam dioda koje emituju svetlo (LEDs) kao svetlosni izvor sa 45/8 geometijom. Trajanje snimka je 0,2 s. Vrednosti refleksije se kreću od 400 do 700 nm sa 1nm intervalom za svaki pixel. Slika se može prebaciti sa spektrofotometra u računar.²⁰

Prvi korak je izrada i snimanje fotografije. Na ovaj način se stvara mapa zuba koja je podeljena na horizontalne trećine. Svaki deo

either the VITA Classical or Vitapan 3D-Master shade guide. This is a contact-type device that uses a digital spectrometer and a LED fiber optic light source.¹⁵ The measurement area of this device is 5-mm in diameter and no digital images are generated. However, the software that produces electronic or hard copy “prescriptions” for dental laboratory technicians is included.¹⁶ Easyshade Compact is designed to measure an overall tooth shade or provide a sectioned map of the tooth from cervical to incisal.

Color measurement is a comparison with standards to which a device is calibrated. Calibration of this unit can be done in two ways. The first way is with a ceramic block of known color. The block is located over a switch which is used to detect when the instrument is in the calibration mode. The second way is when the base unit is connected to the mains supply; the calibration procedure is carried out automatically. The instrument can also be calibrated when a power source is not available for the base unit. For this purpose, the instrument can also be calibrated manually.¹⁷ (Fig. 3.¹⁵)

Four different measurement settings are possible with Easyshade Compact: tooth single mode, tooth areas mode (cervical, middle and incisal shades), restoration color verification (includes lightness, chroma and hue comparison), and shade tab mode (practice/training mode).¹⁸

Crystaleye (Olympus America, Center Valley, PA, USA) is a handheld dental spectrophotometer which combines digital images with tooth shade data based on spectrophotometric measurements.¹⁹ The spectrophotometer uses seven Light Emitting Diode (LEDs) as an illumination source with 45/8 geometry. The capture time is 0.2 s. The reflectance values from 400 to 700 nm with 1 nm intervals for each pixel. Image can be transferred from the spectrophotometer to a personal computer.²⁰

The first step is to take and download a photo. This produces a map of the tooth that is divided into horizontal thirds. Each section has a different shade, and the chart shows how close it is to the actual shade. A graph showing the tooth and a shade tab is displayed in a split-screen view. A combination of detailed tooth anatomy and color information gives to technician enough information about color of the tooth.²¹ There are other features as well, such as the tooth response to bleaching and documentation for before-and-after restorative treatments.²²(Fig. 4.²³)



Sl. 5. Shade-X (X-Rite Inc., Grandville, USA)
Fig. 5. Shade-X (X-Rite Inc., Grandville, USA)

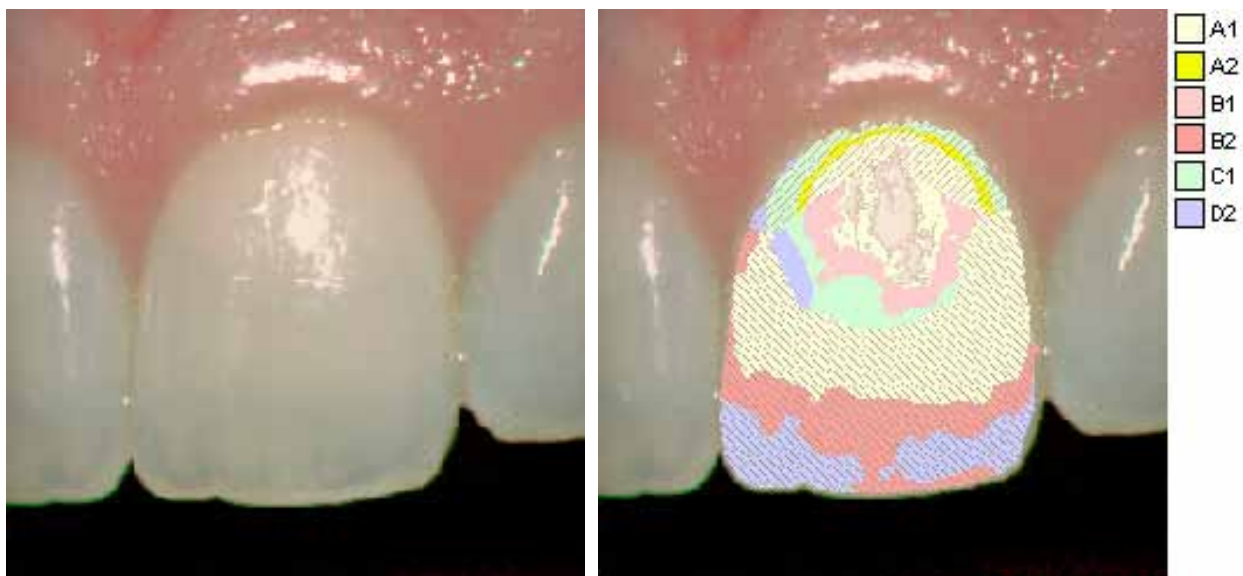
ima različitu boju, i na grafikonu se može videti koja je to tačno boja. Grafikon pokazuje zub i boje prikazane u split-screen formi (na „podeljenom“ ekranu). Kombinacija detaljne anatomije zuba i informacija o boji pruža tehničaru dovoljno informacija o boji zuba.²¹ Postoje i druge opcije, kao što su provera uspešnosti beljenja zuba i dokumentacija pre i posle restorativnog zahvata.²² (Sl.4.²³).

Shade-X (X-Rite, Grandville, MI, USA) je kompaktni, bežični spektrofotometar, sa sondom prečnika 3 mm, sa unešenim, najčešće korišćenim, ključevima za određivanje boje. Shade-X sadrži dve baze podataka za merenje boje dentina i incizalnog regiona zuba. Dentinski region je više neprozirna, a incizalni region više prozirna regija.²⁴ (Sl. 5.²⁵, Sl. 6.²⁴)



Sl. 4. Crystaleye (Olympus America, Center Valley, PA, USA)
Fig. 4. Crystaleye (Olympus America, Center Valley, PA, USA)

Shade-X (X-Rite, Grandville, MI, USA) is a compact and cordless spectrophotometer with 3-mm probe diameter, keyed to the most widely used shade guides. Shade-X operates with two databases to match the dentin and the incisal regions of patient's tooth. Dentin region is more opaque and incisal region is more translucent area.²⁴ (Fig. 5.²⁵, Fig. 6.²⁴)



Sl. 6. Computer mapping of shifts in color on tooth
Fig. 6. Computer mapping of shifts in color on tooth

Analiza digitalne kolor slike

Fotografski film, televizijske kamere, digitalne kamere i skeneri se mogu koristiti za snimanje informacija o boji. Kao foto uređaji, oni mogu snimiti boju i predstavljaju buduću generaciju instrumenata za merenje boje.²⁶ Kombinacija digitalne fotografije i preciznog kolorimeriskog ispitivanja dovodi do razvoja procesa merenja boje u stomatologiji. Ovi tipovi uređaja obezbeđuju i detaljnu sliku površine zuba i korisno mapiranje boja.²⁷

ClearMatch (Smart Technology, Hood River, OR, USA) softverski sistem koristi slike sa digitalnih kamera visoke rezolucije i upoređuje boje sa površine zuba sa poznatim referentnim bojama. Sistem koristi tri osnovne kolor reference (crnu, belu i ključ za određivanje boja) da kalibriše i determiniše boju. Opremljen je industrijski-standardnim ključevima za određivanje boje.²⁸

Instrumenti sa ograničenom upotrebom

Chromascan (Sterngold, Stamford, CT, USA) je bio prvi instrument dizajniran specijalno za određivanje boje u stomatologiji. Predstavljen je ranih osamdesetih, ali je postigao minimalni uspeh zbog komplikovanog korisničkog interfejsa i donekle ograničene preciznosti.²⁹

Dental Color Analyzer (Wolf Industries, Vancouver, Canada) je bio dizajniran da omogućiti određivanje najpribližnije boje pacijenta, sa opcijom slanja podataka o boji pacijenta u računar, za elektronsko arhiviranje sa podacima drugih pacijenata.³⁰

Identacolor II (Identa, Holbaek, Denmark) obezbeđuje informacije o boji dentina i o boji prebojenih i translucenčnih regija, korišćenjem mikro-spektrometra.³¹ Kalibriše se automatski kod promena vlažnosti i temperature.^{32,33}

Digital Shade Guide DSG4 (A. Reith, Schorndorf, Germany) Uređaj karakteriše kompaktan radni deo koji obezbeđuje merenje jedne, tri, šest ili devet tačaka na zubu, kao i na susednim zubima. Vednosti boja mogu biti prikazane kao jedna boja ili kao mešavina dve boje u jednoj tački.³⁴

Ikam (Metalor Technologies, Attleboro, MA, USA) je razvijen sa ciljem da obezbedi preciznu analizu i komunikaciju o nijansi, obliku i konturi prirodnih zuba između stomatologa

Digital Color Image Analysis

Photographic film, broadcast television cameras, digital cameras and scanners can all be used to record color information. As imaging devices, they can record color and they represent the next generation of color measurement instruments.²⁶ Combining digital color imaging with very precise colorimetric assessments stands for improvement in the development of dental color management. These types of devices provide both a detailed image of the tooth surface and useful color mapping.²⁷

ClearMatch (Smart Technology, Hood River, OR, USA) software system uses high-resolution digital camera images and compares shades over the entire tooth with known reference colors. The system uses three basic color references (black, white and shade tab) to calibrate and determine the shade. For color matching, the unit is equipped with industry-standard shade guides.²⁸

Instruments with limited availability

Chromascan (Sterngold, Stamford, CT, USA) was the first instrument designed specifically for color evaluation in dentistry. It was introduced in early 1980s, but had minimal success because of the difficult user interface and somewhat limited accuracy.²⁹

Dental Color Analyzer (Wolf Industries, Vancouver, Canada) was designed to facilitate determining the best color match for patient, with an option of transferring patient's color data to a personal computer for electronic filing with other patient records.³⁰

Identacolor II (Identa, Holbaek, Denmark) provides information on the base dentine color and color of discolored and translucent areas by means of micro-spectrometer.³¹ It self-calibrates automatically to changes in humidity and temperature.^{32,33}

Digital Shade Guide DSG4 (A. Reith, Schorndorf, Germany) features a compact handpiece that allows shade measurement from one, three, six, or nine points on the tooth and adjacent teeth. The color values can either be displayed as a single shade or as a mixture of two shades at a single point.³⁴

Ikam (Metalor Technologies, Attleboro, MA, USA) has been developed to accurately analyze and communicate the shade, shape and

i tehničara.³⁵ Stomatolog bira nivo detalja za svaki slučaj ponaosob – grubo, srednje ili fino i izabrani nivo slike stvara mapu nijanse zuba. Digitalna kamera slika dve fotografije zuba – sjajnu i mat. Program pruža smernice za izbor boje.³⁶

The ShadeEye NCC (Natural Color Concept) Chroma Meter (Shofu Dental, Menlo Park, CA, USA) je druga generacija dentalnog tristimulus kolorimetra. Uređaj koristi 0/0 mer-nu geometriju sa pulsniim ksenon blicem.³⁷

Beyond Insight Shade Taking Device (Beyond Dental & Health, Beijing, China). Ovaj uređaj uvodi vodedeće ključeve za određivanje boje.³⁸ Trenutno se nalazi u fazi velikog redizajniranja.

Shadescan (Cynovad, Montreal, Canada) determiniše boju i providnost zuba. On takođe može mapirati boje i katakteristike cele površine zuba, komunicirati sa laboratorijom i omogućiti snimanje glasovnih komentara. Takođe omogućava vizuelne smernice za proceduru beljenja zuba. Slika se izrađuje pomoću nastavka i može se videti na 1.5" x 2" LCD monitoru, ili snimiti u računaru.³⁹

Vita Easyshade (Vita Zahnfabrik, Bad Säckingen, Germany) je intraoralni dentalni spektrofotometar sa karakteristikama sličnim *Easyshade Compact-u*. On prezentuje CIE L*a*b* vrednosti u četiri merna moda: mod merenja boje celog zuba, mod merenja boje pojedinih oblasti zuba, verifikacija boje restoracije i trening mod. Odgovarajući mod mora biti odabran pre merenja. Dobijeni podaci se prezentuju u odgovarajućem modu. Podaci o boji se takođe prezentuju kao najbliža boja iz Classical ili 3D Master ključa.⁴⁰ Uređaj može upamtiti 25 uzastopnih merenja gde se svaki komplet merenja zona zuba pamti kao jedan rezultat.⁴¹

Zaključak

Opisani su različiti tipovi instrumenata za određivanje boje. Instrumenti za određivanje boje mogu pomoći lekarima da postignu bolji estetski ishod i da učine pacijente zadovoljnim.

contour of a natural tooth between the dentist and the technician.³⁵ Dentist selects the level of details for each specific case – coarse, medium or fine, and selected image level produces a shade map of the tooth. The digital camera captures two images of the tooth - glossy and matte. The software provides guideline for color selection.³⁶

The ShadeEye NCC (Natural Color Concept) Chroma Meter (Shofu Dental, Menlo Park, CA, USA) is the second generation of dental tristimulus colorimeters. The instrument uses a 0/0 measuring geometry with a pulse xenon flash.³⁷

Beyond Insight Shade Taking Device (Beyond Dental & Health, Beijing, China). This device is keyed to leading shade guides.³⁸ It currently undergoes major redesigning.

Shadescan (Cynovad, Montreal, Canada) determines the color and translucency of tooth. It can also map and communicate color and characterization of the entire surface of a tooth with laboratory and enable recording voice comments. It also permits visual guidelines for tooth-whitening procedures. The image is captured by a corded-handpiece and can be viewed on its 1.5" x 2" LCD screen, or downloaded onto a computer.³⁹

Vita Easyshade (Vita Zahnfabrik, Bad Säckingen, Germany) is an intraoral dental spectrophotometer with characteristics similar to *Easyshade Compact*. It provides CIE L*a*b* values in four measuring modes: single tooth mode, tooth areas mode, restoration mode and training mode. The appropriate mode must be selected prior to measuring. Obtained data are reported in specific mode. Shade tab data are also reported as the closest Classical and 3D Master shades.⁴⁰ The instrument can store 25 consecutive measurements where each set of tooth area measurement is stored as one result.⁴¹

Conclusions

Different types of color measuring instruments used in dentistry were described. Color measuring instruments can help dental professionals in achieving enhanced esthetic outcome thus increasing patient satisfaction.

LITERATURA / REFERENCES

1. Joiner A, Tooth color: a review of the literature. *Journal of Dentistry* 2004; 32, 3–12
2. Van der Burgt TP, Bosch JJ, Borsboom PC, Kortsmits WJ. A comparison of new and conventional methods for quantification of tooth color. *Journal of Prosthetic Dentistry* 1990;63:155-62.
3. McPhee ER. Light and color in dentistry. Part I—nature and perception. *Journal of Michigan Dental Association* 1978;60:565-72
4. Okubo SR, Kanawati A, Richards M, Childress S. Evaluation of visual and instrument shade matching. *The Journal of Prosthetic Dentistry*; 1998; 80: 6 642-648
5. Berns R. Billmeyer and Saltzman's Principles of Color Technology. John Wiley & Sons, INC. 2000; p. 82-83.
6. Paravina RD, Powers JM. Esthetic color training in dentistry. Elsevier Mosby, 2004; p.3
7. Eppeldauer G. Spectral Response Based Calibration Method of Tristimulus Colorimeters, JNIST 1998; 103:6 615-19.
8. X-rite – official website, accessed 06.10.2009. http://www.xrite.com/documents/apps/public/whitepapers/Interpreting_ShadeVision_Data.pdf
9. X-rite – official website, accessed 06.10.2009. http://www.xrite.com/product_overview.aspx?ID=339
10. Dental Product Report - Cristaleye, accessed 06.10.2009. http://www.dentalproductshopper.com/files/product/images/crystaleye_src_1.jpg
11. Paravina RD, Powers JM. Esthetic color training in dentistry. Elsevier Mosby, 2004; p.28-29
12. Clon 3D – SpectroShade Micro, accessed 06.10.2009. <http://www.clon3d.com/spectroshade-micro/>
13. Metalor Dental - SpectroShade Micro, accessed 06.10.2009. <http://www.metalordental.ch/index.php?id=885>
14. MHT Optic Research AG - SpectroShade Micro, accessed 06.10.2009. http://www.mht.ch/index.php?uri=micro_pictures.html
15. Vident – official website, accessed 06.10.2009. <http://www.vident.com/easyshadecompat/>
16. USAF Dental Evaluation & Consultation Service, accessed 06.10.2009. http://airforcemedicine.afms.mil/idc/groups/public/documents/afms/ctb_109492.pdf
17. Vita – official website, accessed 06.10.2009. http://www.vita-zahnfabrik.com/resourcesvita/shop/en/en_3050317.pdf
18. Vita – official website, accessed 06.10.2009. http://www.vita-zahnfabrik.com/resourcesvita/shop/en/en_3055212.pdf
19. Dental Product Report - Cristaleye, accessed 06.10.2009. <http://marketplace.dentalproductsreport.com/community/DisplayAd.asp?id=1201>
20. Ishikawa-Nagai S, Yoshida A, Sakai M, Kristiansen J, Da Silva J. Clinical evaluation of perceptibility of color differences between natural teeth and all-ceramic crowns. *Journal of Dentistry*; 2009; 37: 57-62.
21. D. Da Silva J, Weber H, Nagai S. Clinical performance of a newly developed spectrophotometric system on tooth color reproduction, *The Journal of Prosthetic Dentistry* 2008; 99:5; 361-68.
22. Dental Economics – Penn Well Dental Group, accessed 06.10.2009. http://www.dentaleconomics.com/display_article/357576/54/none/none/Dept/Color-My-World
23. Dental product shopper – official website, accessed 06.10.2009. http://www.dentalproductshopper.com/files/product/images/crystaleye_src_1.jpg
24. X-rite – official website, accessed 06.10.2009. http://www.xrite.com/product_overview.aspx?ID=815
25. Dental product shopper – official website, accessed 06.10.2009. http://www.dentalproductsreport.com/uploads/picture/upload/1697/Shade-X_34_left_1.jpg
26. Berns R. Billmeyer and Saltzman Principles Of Color Technology-3rd edition, John Wiley & Sons INC., 2000 p.92
27. USAF Dental Evaluation & Consultation Service, accessed 06.10.2009. http://airforcemedicine.afms.mil/idc/groups/public/documents/afms/ctb_109492.pdf
28. ClearMatch – official website, accessed 06.10.2009. <http://www.clearmatch.com/index.htm>
29. Paravina RD, Powers JM. Esthetic color training in dentistry. Elsevier Mosby, 2004; p.167
30. Helth Mantra – medical and dental website, accessed 06.10.2009. www.healthmantra.com/pdf%20files/yypb-apr99.pdf
31. GDS international – publishing company, accessed 06.10.2009. www.gdspublishing.com/ic_pdf/eeuhc/iden.pdf
32. ADI Association of Dental Implantology UK, accessed 06.10.2009. http://www.adi.org.uk/profession/pastevents/congress05/congress05_post.pdf
33. Boehringer-Ingelheim, accessed 06.10.2009. www.boehringer-ingelheim.de/service/serviceshop/pdf/BI_microoptics_en.pdf
34. Rieth-Dentalprodukte – official website, accessed 06.10.2009. <http://www.rieth-dentalprodukte.de/dsg-4-usb-p785.html?osCsId=3dec2332ecae8a0338c702841abf76e7>
35. Metalor – official website, accessed 06.10.2009. www.metalor.com/en/content/download/192/805/file/Metalor_annual_report_2000_en.pdf
36. Anand M, Shetty P, Bhat S. Shade matching in fixed prosthodontics using instrumental color measurements and computers, *The Journal of Indian Prosthodontic Society*; 2007; 7:4; 179-83
37. Shofu Dental – Shade Eye Quick Guide, accessed 06.10.2009. www.shofu.com/ShadeEyeGuide.pdf
38. Beyond - official website, accessed 06.10.2009. <http://www.beyonddent.com/>
39. USAF Dental Evaluation & Consultation Service, accessed 06.10.2009. http://airforcemedicine.afms.mil/idc/groups/public/documents/afms/ctb_109491.pdf
40. Yuan J, Brewer J, Monaco E, Davis E. Defining a natural tooth color space based on a 3-dimensional shade system, *The Journal of Prosthetic Dentistry* 2007; 98: 110-119.
41. Vita – official website, accessed 06.10.2009. http://www.vita-zahnfabrik.com/resourcesvita/shop/en/en_3055212.pdf

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