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Utjecaj kliničkog iskustva na točnost u procjeni boje različitih stomatoloških profesionalnih skupina

Effect of Clinical Experience on the Shade Matching Accuracy in Different Dental Occupational Groups

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Sažetak

Svrha: Istraživanjem se nastojalo procijeniti utjecaj razine kliničkog iskustva na točnost u procjeni boje u različitim stomatološkim profesionalnim skupinama. **Materijali i postupci:** U istraživanju je ukupno sudjelovalo 80 ispitanika te su, ovisno o razini njihova kliničkog iskustva u određivanju boje, raspoređeni u četiri skupine: dentalni tehničari (DT), specijalizanti stomatološke protetike (RP), specijalisti stomatološke protetike (SP) i studenti dentalne medicine – dentalni studenti (DS). Ispitanici su se koristili *Toothguide Training Boxom* (TTB) i odredili 15 standardnih boja iz ključa *VITA 3D-Master*. U završnom testu zabilježen je broj pogrešaka svakog ispitanika te je izračunata njegova točnost. Razlika u procjeni (ĆE) za svaku odabranu boju izračunata je s pomoću L*, a* i b* vrijednosti. Ispitane su razlike u točnosti srednjih ĆE vrijednosti i srednjih vrijednosti pogreške ĆE-a u četirima skupinama. **Rezultati:** Statistički značajna razlika u točnosti i srednjim ĆE vrijednostima unutar četiriju skupina nije pronađena ($p > 0,05$). Točnost u njima iznosila je 0,51 ± 0,20 (DT), 0,54 ± 0,18 (RP), 0,49 ± 0,16 (SP) i 0,55 ±0,14 (DS). Srednje ΔE vrijednosti iznosile su 2,10 ± 0,98 (DT), 2,18 ± 0,97 (RP), 2,51 ± 0,97 (SP) i 2,08 ± 0,86 (DS). S obzirom na srednje vrijednosti pogreške ΔE-a, pronađena je statistički značajna razlika s DT skupinom koja je imala znatno manja odstupanja u usporedbi s ostalima ($p < 0,05$). **Zaključci:** Rezultati ovog istraživanja dokazali su da kliničko iskustvo nije značajan čimbenik točnosti u određivanju boje. No ispitujući srednje vrijednosti pogreške ΔE-a ustanovljeno je da su DT-i uspješniji u određivanju od ostalih ispitanika.

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Uvod

Jedna od najvažnijih komponenti estetskoga stomatološkog zahvata svakako je postupak određivanja boje zuba.

Različiti su subjektivni i objektivni načini određivanja boje koji uključuju uporabu ključeva boja i spektrofotometra. Iako se instrumentalno određivanje pokazalo pouzdanim, i dalje se najčešće upotrebljavaju komercijalni ključevi boja (1).

Na vizualno određivanje boja utječu razni čimbenici, poput dobi promatrača, njegova/njezina iskustva, tu su i mogući problemi s percepcijom boje, stanja promatranih zuba i izvor svjetlosti (2 – 4).

Znanje o fizikalnoj pojavi boje također je jedan od važnih čimbenika pri njezinu određivanju. Dobro poznata Munsellova teorija opisuje boju kao trodimenzionalni fenomen koji se sastoji od nijanse, svjetline i zasićenosti, obilježja važnih za procjenu boje zuba (5, 6).

Zato je u novom ključu boja *Vita 3D Master* korištena gore navedena Munsellova terminologija (Vita Zahnfabrik, Bad Sackingen, Njemačka), a temelji se na konceptu percep-

Introduction

Correct tooth shade assessment is one of the most important components of esthetic dental treatment.

There are a number of different subjective and objective ways for choosing shades, including various shade guides as well as spectrophotometers. Although the instrumental color matching has already been proved more reliable, the selection of matching shade tabs from commercially available shade guides is still the most common method of tooth color assessment (1).

Visual color matching is affected by many variables, such as age of the observer, his/her experience, possible color deficiency, condition of the teeth observed and light source (2-4).

Knowledge about the physical appearance of color is also one of the important factors for visual shade selection. The well-known Munsell's theory is describing color as a three-dimensional phenomenon consisting of hue, value and chroma, color characteristics necessary to observe while assessing tooth shade (5, 6).

Therefore, a new shade guide Vita 3D Master has been developed, using the above mentioned Munsell's terminology

cije boje s pet različitih svjetlina i trima razinama zasićenosti i nijanse, što se pokazalo mnogo točnijim (7 – 9). Kako bi se boja zuba mogla uvježbati i što preciznije procijeniti možda uporabom ključa boja *3D Master*, 2007. godine razvijen je sustav poznat kao *Toothguide Training Box Mark II* (TTB) (Vita Zahnfabrik, Bad Sackingen, Njemačka), oblikovan tako da stomatolozima približi novi postupak (10 – 13). Taj sustav omogućuje korisniku sustavno određivanje svih triju karakteristika boje zuba prema percepciji ljudskoga oka pod standardiziranim umjetnim dnevnim svjetlom temperature svjetlosti od 5500 K (14, 15).

Svrha ovog istraživanja bila je procijeniti utjecaj razine kliničkog iskustva na točnost procjene boje u četirima različitim stomatološkim profesionalnim skupinama – dentalnih tehničara (DT), specijalizanata stomatološke protetike (RP), specijalista stomatološke protetike (SP) i dentalnih studenata (DS).

Prva nulta hipoteza bila je da će postojati razlika u točnosti određivanja boje TTB sustavom između različitih skupina, ovisno o razini njihova kliničkog iskustva (u procjeni boje zuba). Druga nulta hipoteza glasila je da će postojati razlike u ΔE vrijednostima izračunatima kao odstupanja od točnih odgovora između različitih skupina. Treća nulta hipoteza bila je da će postojati razlike u pogreškama ΔE vrijednosti onih koji su odabrali pogrešnu boju između različitih skupina i unutar njih, ovisno o razini njihova kliničkog iskustva u procjeni boje zuba.

Materijali i postupci

Ovo istraživanje odobrilo je Etičko povjerenstvo Stomatološkog fakulteta Sveučilišta u Zagrebu.

Veličina uzorka

Ukupno su odabrana 84 ispitanika koji su, ovisno o razini kliničkog iskustva u procjeni boje zuba, podijeljeni u četiri skupine:

- 20 dentalnih tehničara (DT) – 5 muškaraca, 15 žena; prosječna dob 30,4 ± 1,5,
- 21 specijalizant stomatološke protetike (RP) – 8 muškaraca, 13 žena; prosječna dob 31,1 ± 2,1,
- 23 specijalista stomatološke protetike (SP) – 10 muškaraca, 13 žena; prosječna dob 43,2 ± 3,4 i najmanje 10 godina specijalističkog iskustva
- 20 dentalnih studenata (DS) – 7 muškaraca, 13 žena; prosječna dob 22,1 ± 1,5,

Svi su se ispitanici do trenutka istraživanja koristili Chromascopovim ključem boja (Ivoclar Vivadent, Schaan, Lihtenštajn) za procjenu boje zuba i prije testiranja nisu bili na predavanju o korištenju sustava *3D Master* ili o njemu nisu dobili detaljne upute.

Kriteriji za isključivanje iz istraživanja

Ispitanici koji su već sudjelovali u sličnom istraživanju, prakticirali su određivanje boje, koji su imali nešto iskustva ili su uvježbavali korištenje ključa boja *3D Master*, isključeni su iz istraživanja. To su bili jedna specijalizantica i tri specijalista.

(Vita Zahnfabrik, Bad Sackingen, Germany). It utilizes the color perception concept with five levels of values and three levels of chroma and hue and has been proved to be more accurate than other theories (7-9). In 2007, in order to assess tooth color using 3D Master shade guide as precise as possible and practice the procedure, a system known as the Toothguide Training Box Mark II (TTB)(Vita Zahnfabrik, Bad Sackingen, Germany) was introduced, designed to familiarize the dentists with tooth shade selection (10-13). It enables the user to systematically select tooth shades by determining all three color characteristics in accordance with human color perception under the standardized artificial daylight with color temperature of 5500 K (14,15).

The aim of this study was to evaluate the effect of clinical experience level on the shade matching accuracy in four different dental occupational groups - dental technicians (DTs), residents in prosthodontics (RPs), specialists in prosthodontics (SPs) and dental students (DSs).

The first null hypothesis was that there will be differences in accuracy of the shade tabs selection using TTB between different groups depending on their level of clinical experience in tooth shade assessment. The second null hypothesis was that there will be differences in ΔE values, calculated as a deviation from the correct answers, between four different groups. The third null hypothesis was that there will be differences in error ΔE values in those who selected wrong shades between different groups depending on their level of clinical experience in tooth shade assessment.

Materials and methods

The design of the study was approved by the Ethics Committee of the School of Dental Medicine, University of Zagreb, Croatia.

Sample size

A total of 84 participants, assigned to one of four groups depending on the level of their clinical experience in shade matching:

- 20 dental technicians (DTs): 5 men, 15 women; average age 30.4±1.5,
- 21 residents in prosthodontics (RPs); 8 men, 13 women; average age 31.1±2.1,
- 23 specialists in prosthodontics (SPs) and 10 men, 13 women; average age 43.2±3.4, minimum 10 years of service as the specialist, and
- 20 dental students (DSs); 7 men, 13 women; average age 22.1±1.5, took part in the study. All of the participants used the Chromascop shade guide (Ivoclar Vivadent, Schaan, Liechtenstein) for the tooth color assessment and did not receive any type of lecture or training about the 3D Master system.

Exclusion criteria

The respondents who have previously participated in similar research or have been practicing color determination had some previous shade selection experience or training using 3D Master shade guide were excluded from this study. One

S obzirom na to da TTB protokol uključuje i testiranje raspoznatljivosti boja, svi su ispitanici testirani Ishiharinim testom s 24 slike i oni s više od dvije pogreške trebali su biti isključeni (16). No tim testom nisu ustanovljena odstupanja ni kod jednog ispitanika.

Zato se uzorak ovog istraživanja sastojao od 80 ispitanika – po 20 u svakoj od četiriju ispitivanih skupina.

TTB

U ovom istraživanju primijenjen je TTB. Svaki ispitanik uspravno je sjeo ispred uređaja i dobio upute kako aparat radi te o fazama uvježbavanja određivanja boje.

Elektro-mehanički uređaj bio je spojen s programskim sustavom koji se sastojao od 52 radijalno složena zuba iz ključa boja *3D Master*. Vizualizacija testiranog i odabranog uzorka boje zuba obavljala se kroz otvor u sredini uređaja. Biralo se uporabom gumba označenih strjelicama (slika 1.).

TTB je osigurao uvjete dnevnog svjetla (Dialite Color Sxstem) s difuznim svjetlom dviju svjetiljaka od 5 W postavljenih pod kutom te s karakteristikama od 5500 K i 1000 luksa. Prosječna udaljenost ispitanikova oka tijekom promatranja iznosila je 25 cm.

TTB protokol sastojao se od triju vježbi i završnog testa kojim se mjerilo znanje i kapacitet u procjeni boje. U trima vježbama ispitanik je morao točno odrediti svjetlinu, svjetlinu i zasićenost te svjetlinu, zasićenost i nijansu testiranih zuba. Nakon završenog uvježbavanja ispitanik je morao pristupiti i završnom testu u kojemu je istodobno određivao sva tri parametra na 15 testiranih zuba.

female resident and 3 female specialists in prosthodontics were therefore excluded.

Since the TTB curriculum includes a color vision test all the participants were given the Ishihara test of 24 plates and those participants who had more than two errors are excluded (16). The evaluation of the Ishihara test did not reveal color vision deficiency in participants.

Therefore, the sample group finally consisted of 80 participants, 20 in each of the four investigated groups.

TTB

The TTB was used for the purpose of the study. Each participant was asked to sit in front of the device, in the upright position and received instructions regarding the functioning of the device and training steps.

The electro mechanic device was connected to a software system and consisted of 52 teeth from the 3D Master shade guide, radially arranged. The visualization of the tested teeth and the selected group from the color key was performed trough an opening in the center of the device. The selection was performed using arrow buttons positioning the key in accordance with the ones assortment (Figure 1).

The TTB worked under daylight lamp conditions (Dialite Color System) with diffused light from two angled 5 W lamps of 5500 K and 1000 lux. The approximate distance of the participants' eye during the observation was 25 cm.

The TTB training was structured in three exercises and a final test that measured knowledge and color assessment capacity in shade matching. During the period of three exercises the participants had to correctly select the lightness, lightness and chroma and lightness, chroma and hue of the tested teeth, respectively. After completion of exercises, the participants had to undergo a final test in which all three parameters needed to be assessed for 15 tested teeth.

Slika 1. TTB sustav
Figure 1 TTB system

Ispitivani parametri

Točnost

Prikupljeni su podatci o broju točnih odgovora svakog ispitanika u završnom testu te je izračunata točnost kao omjer točnih odgovora prema ukupnom broju pokušaja (x : 15).

Observed parameters

Accuracy

The number of correct answers from the final test of each participant was collected and accuracy calculated as the ratio of correct and total number of attempts (x: 15).

Srednja vrijednost ΔE-a

Udaljenost u prostoru boja (ΔE) između zadane i odabrane boje izračunata je formulom

$\Delta E = ((\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2)^{1/2}$ (17). Na temelju L*a*b* vrijednosti proizvođača mogle su se izračunati razlike u ΔL-u*, Δa-u* i Δb-u*. U izračunu su točni odgovori označeni kao ΔE = 0.

Srednja vrijednost pogreške ΔE-a

Kako bi se dobila informacija o rasponu ΔE vrijednosti kod netočno određenih boja, izračunata je srednja vrijednost pogreške ΔE-a.

Svi su parametri izračunati za sve četiri ispitivane skupine.

Statistička analiza

Prikupljeni podatci uneseni su u Excelovu bazu podataka i statistički su analizirani programom SPSS 19.0 (SPSS, Chicago, IL, SAD).

Razlike u točnosti, srednjim vrijednostima i pogreškama ΔE-a unutar četiriju skupina analizirane su jednosmjernim testom ANOVA, uz Bonferonijevu korekciju.

Rezultati

Od ukupno 84 ispitanika, u istraživanju je sudjelovalo njih 80 (96 %). Četiri su isključena jer su prije toga uvježbavali određivanje boje ključem *3D Master* i imali su iskustva s njegovim korištenjem (1 RP i 3 SP).

Testiranje Ishiharinim testom pokazalo je da ni jedan ispitanik nema problema s raspoznavanjem boja.

Srednje vrijednosti točnosti, ΔE vrijednosti i pogreške izračunate iz rezultata završnog testa na TTB sustavu nalaze se na slikama 2. – 4.

Srednja vrijednost točnosti iznosila je od 0,49 do 0,55 – u skupini dentalnih tehničara bila je najviša, a u onoj specijalista najniža (slika 2.). Statistički značajna razlika u točnosti unutar četiri skupine nije zabilježena ($p > 0,05$; tablica 1.).

Srednje ΔE vrijednosti iznosile su od 2,08 do 2,51 – u skupini dentalnih tehničara bile su najviše, a u onoj specijalista najniže (slika 3). Statistički značajna razlika u srednjim ΔE vrijednostima u četirima ispitivanim skupinama nije zabilježena ($p > 0,05$; tablica 1.).

Srednje vrijednosti pogreške ΔE-a iznosile su od 4,05 do 4,84 – u skupini dentalnih tehničara bile su najviše, a u onoj specijalista najniže (slika 4.). Srednje vrijednosti pogreške ΔE-a kod dentalnih tehničara statistički su se razlikovale od onih u ostalim trima ispitivanim skupinama ($p < 0,05$; tablica 1.).

Mean ΔE

The distance in the color space (ΔE) was determined for each shade tab and color difference between the task tab and selected tab was calculated using equation

$\Delta E=((\Delta L)^2+(\Delta a)^2+(\Delta b)^2)^{1/2}$ (17). On the basis of L*a*b* values provided by the manufacturer it was possible to calculate the differences in ΔL*, Δa* and Δb*. In calculation, the correct answers were recorded as ΔE=0.

Mean error ΔE

In order to get information about the range of ΔE values when wrong shade tab was selected, mean error ΔE only for wrong answers was calculated as mentioned above.

All the observed parameters were calculated in the four aforementioned study groups.

Statistical analysis

The collected data were entered into Excel database and statically analyzed, imported into statistical program SPSS 19.0 (SPSS, Chicago, IL, USA).

The differences in accuracy, ΔE and error ΔE values between the four study groups were analyzed using the one-way ANOVA and Bonferoni corrections.

Results

Out of a total of 84 participants, 80 participated in the study (96%). Four participants were excluded because they had previous training and shade selection experience with the 3D Master shade guide (1 RP and 3 SPs).

The evaluation of the Ishihara test did not reveal any color perception deficiencies in participants.

Mean accuracy, ΔE and error ΔE values from the results of the final test with the TTB system were calculated in all groups (Figures 2-4).

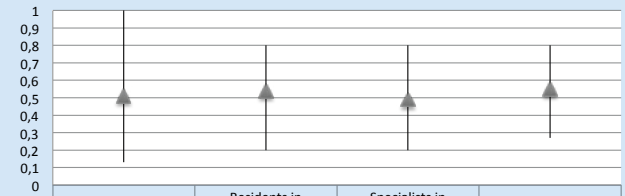
Mean accuracy ranged from 0.49 to 0.55, of which DSs have reached the highest, and SPs the lowest values (Figure 2). A statistically significant difference in accuracy between four groups was not recorded ($p>0.05$; Table 1).

Mean ΔE ranged from 2.08 to 2.51, with DSs who reached the lowest, and SPs the highest values (Figure 3). A statistically significant difference in ΔE between four groups was not recorded ($p>0.05$; Table 1).

Mean error ΔE ranged from 4.05 to 4.84, with DTs reaching the lowest, and SPs the highest values (Figure 4). DTs' mean error ΔE statistically differed from the other three groups ($p<0.05$; Table 1).

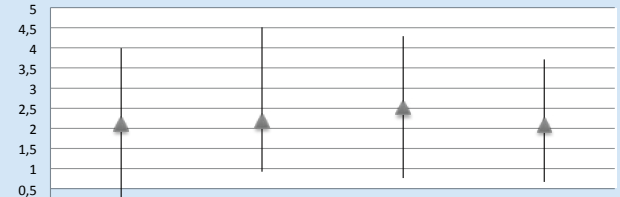
Tablica 1. Razlike u točnosti, srednjim ΔE vrijednostima i srednjim vrijednostima pogreške ΔE-a unutar četiriju stomatoloških profesionalnih skupina
Table 1 Difference in accuracy, mean ΔE and mean error ΔE among four dental occupational groups

	F	df	p
Točnost • Accuracy	0,48	3	0,70
Srednja ΔE vrijednost • Mean ΔE	0,88	3	0,45
Srednja vrijednost pogreške ΔE-a • Mean errof ΔE	3,15	3	0,03



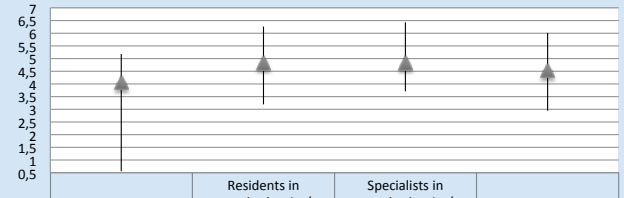
	Dental technicians/ Dentalni tehničari	Residents in prosthodontics/ Specijalizanti stomatološke protetike	Specialists in prosthodontics/ Specijalisti stomatološke protetike	Dental students/ Dentalni studenti
x	0,51	0,54	0,49	0,55
min	0,13	0,2	0,2	0,27
max	1	0,8	0,8	0,8

Slika 2. Srednje vrijednosti (x), minimalna (min.) i maksimalna (maks.) točnost unutar četiriju stomatoloških profesionalnih skupina
Figure 2 Mean (x), minimum (min) and maximum (max) accuracy among four dental occupational groups



	Dental technicians/ Dentalni tehničari	Residents in prosthodontics/ Specijalizanti stomatološke protetike	Specialists in prosthodontics/ Specijalisti stomatološke protetike	Dental students/ Dentalni studenti
x	2,1	2,18	2,51	2,08
min	0	0,92	0,76	0,67
max	3,99	4,51	4,29	3,71

Slika 3. Srednje vrijednosti (x), minimalne (min.) i maksimalne (maks.) ΔE vrijednosti unutar četiriju stomatoloških profesionalnih skupina
Figure 3 Mean (x), minimum (min) and maximum (max) ΔE values among four dental occupational groups



	Dental technicians/ Dentalni tehničari	Residents in prosthodontics/ Specijalizanti stomatološke protetike	Specialists in prosthodontics/ Specijalisti stomatološke protetike	Dental students/ Dentalni studenti
x	4,05	4,82	4,84	4,53
min	0,55	3,2	3,71	2,95
max	5,18	6,27	6,43	6,02

Slika 4. Srednje vrijednosti (x), minimalne (min.) i maksimalne (maks.) pogreške ΔE-a unutar četiriju stomatoloških profesionalnih skupina
Figure 4 Mean (x), minimum (min) and maximum (max) error ΔE values among four dental occupational groups

Rasprava

Svrha ovog istraživanja bila je procijeniti utjecaj razine kliničkog iskustva na točnost u procjeni boje u različitim stomatološkim profesionalnim skupinama s pomoću TTB sustava i primjene protokola *3D Master*.

Ovaj sustav primarno je oblikovan za studente koji uče određivati boju zuba i u nekoliko se studija istraživao utjecaj TTB-a na njihovo uvježbavanje (10,12,13).

Poslije se uporaba TTB-a proširila i na ostale skupine – od stomatologa, tehničara, dentalnog osoblja do laika (18 – 20). U ovom istraživanju željela se procijeniti sposobnost točne procjene boje prema ključu *3D Master* u stomatološkim profesionalnim skupinama koje taj postupak provode gotovo svakodnevno, ali prema drukčijem protokolu i uz uporabu drukčijih ključeva boja, pa su zato bili isključeni laici. Capa i suradnici već su dokazali da stomatološki profesionalci koji rutinski izrađuju restaurativne nadomjestke odlično određuju boju, mnogo bolje od ostalih profesionalnih skupina i laika (21). To su dokazali i De la Bona i suradnici u čijem su istraživanju klinički iskusniji stomatolozi postigli značajno bolju usklađenost od uspoređivanih promatrača koji nisu bili stomatološke struke (23). No u literaturi još nema odgovora na pitanje utjecaja već stečenoga znanja i iskustva na točnost u

Discussion

The purpose of this study was to evaluate the effect of clinical experience level on the shade matching accuracy in different dental occupational groups using the TTB and applying the 3D Master protocol.

This system was primarily designed to introduce university students to tooth shade selection and several studies investigated the effect of the TTB on training dental students in color identification (10, 12, 13). Later on its use was extended to other groups - from dentists, technicians, dental staff members and laypeople (18-20). In this study, we have decided to assess the ability to accurately assess shade tabs according to the 3D Master shade guide in dental occupational groups, who assess the color mostly on their everyday basis but in different protocols using different shade guides, therefore, we decided to exclude laypeople. Capa et al. have already shown that dental care professionals who routinely performed restorative procedures matched the shades better than other dental occupational groups together with laypeople (21). Similar results were obtained by Della Bona et al. who also shown significantly higher visual-instrumental shade agreement where both the VITA Classical and 3D Master shade guides were used

određivanju boje. Neki ističu potrebu za uvježbavanjem, učenjem i iskustvom jer to utječe na sposobnost određivanja boje (13, 18, 21, 22). Drugi, pak, tvrde da stečeno iskustvo ne poboljšava sposobnost određivanja boje ili samo minimalno utječe na postupak (19, 23, 24).

S obzirom na to da je svrha rada bila istražiti utjecaj protokola *3D Master* temeljenog na određivanju svjetline na sposobnost točnog određivanja boje ispitanika koji su se do tada koristili ključevima boja temeljenih na nijansi, isključeni su svi ispitanici s prijašnjim iskustvom u radu s ključem boja *3D Master* i oni koji su već uvježbavali TTB. To je bio razlog zbog kojeg ispitanici prije testiranja nisu bili ni na kakvom uvježbavanju i nisu slušali predavanja o protokolu *3D Master*, čak nisu dobili ni osnovne informacije o parametrima boja ili metodama korištenja ključeva. Prvi kontakt s novim protokolom temeljenim na određivanju svjetline bile su tri vježbe prije završnog testa na TTB-u.

Također je bilo bitno isključiti one ispitanike koji su imali bilo kakve probleme s prepoznavanjem boja jer je već dokazano da oni mogu rezultirati znatno lošijom kvalitetom određivanja boje od ispitanika s normalnim prepoznavanjem boja (25). Ni jedan ispitanik u ovom istraživanju nije imao probleme s prepoznavanjem boja.

Rezultati ovog istraživanja pokazali su da su dentalni tehničari dosegnuli najvišu razinu točnosti, a specijalisti najnižu – 0,55 i 0,49 ($p > 0,05$; slika 22.). Ti rezultati vrlo su zanimljivi jer se očekivalo da će specijalisti stomatološke protetike, oni koji boju zuba u ustima određuju svakodnevno, biti najtočnija skupina, a dentalni tehničari s najmanje iskustva u tom postupku najmanje točni. No moramo uzeti u obzir da su se ispitanici u istraživanju u svojoj praksi koristili Chromascopovim ključem boja (temeljen na nijansi) i da nitko nije znao protokol ključa boja *3D Master*. Zato su rezultati ovog istraživanja dokazali da oni koji su se dulje koristili ključem temeljenim na nijansi (specijalisti u ovom istraživanju koristili su se njime dulje od 10 godina) imaju poteškoća s uporabom ključeva boja složenih prema svjetlini. Istodobno, dentalni su studenti tek početnici u usvajanju procesa određivanja boje zuba i vrlo je jednostavno procjenjuju prema svjetlini.

Sinmazisik sa suradnicima koristio se omjerom pogrešaka i bodova u završnom testu za procjenu sposobnosti određivanja boje zuba učenika budućih dentalnih tehničara i stomatologa i rezultati su pokazali da su učenici bili uspješniji, što se slaže s našim rezultatima.

(18). Učenici budući dentalni tehničari u njihovu istraživanju još su uvijek učili kako se procjenjuje boja i imali su više pogrešaka s parametrom nijanse, a stomatolozi više su griješili s parametrom svjetline (18).

Isto je bilo i s ΔE vrijednostima u našem istraživanju. Dentalni studenti imali su najniže, a specijalisti najviše vrijednosti – 2,08 i 2,51, ($p > 0,05$; slika 3.). Ovi se rezultati nalaze unutar granice vidljivosti razlike (PT) i granice prihvatljivosti razlike u boji (AT), iako nema konsenzusa o korištenju određenih vrijednosti. Khashayar i suradnici u svojem istraživanju istaknuli su da je u više od pola ispitivanih studija definirana granica vidljivosti razlike od ΔE = 1, a u jednoj trećini njih ΔE od 3,7 granica je na kojoj 50 % promatrača prihvaća razliku u boji (26).

by clinically experienced dentists compared to non-dental observers (23).

There is still no agreement in the literature about the role of previous knowledge and experience in dental shade matching. Some experts have emphasized the need for training, color teaching and experience proving their impact on color matching ability (13, 18, 21, 22). The others claim that previous experience does not improve ability in color selection or has a minimal impact on tooth-shade matching (19, 23, 24).

Since the main purpose of this study was to explore the impact of value-based protocol of the 3D Master shade guide on the ability to match shade tabs using the TTB on participants assessing the color previously using hue-based shade guides, we have excluded four participants who reported earlier training and shade selection experience with the 3D Master shade guide. Therefore, the participants in this study did not receive any type of lecture or training, not even basic information about dental color parameters or determination methods using color keys before they started. The first touch with the new value-based protocol was three exercises they had to pass before the final test on the TTB.

It was also important to exclude the participants with any types of color vision impairments because it had already been proved that color vision deficiency may result in significantly worse color matching quality compared to normal color vision (25). None of our participants discovered any color vision deficiencies.

The results of this study revealed that the DSs achieved the highest level of accuracy and the SPs the lowest one, 0.55 and 0.49 respectively ($p>0.05$; Figure 2). These results are very interesting because the SPs, who determine the tooth color on their daily basis were expected to be the most accurate group and the DSs with the least experience the least accurate. However, we have to take into account that all the participants in the study used Chromascop shade guide (hue-based) in their everyday practice and no one was familiar with the protocol of 3D Master shade guide. Therefore, the results of this study showed that those who used shade guides arranged according to hue over a longer period of time (SPs in this study had been using it for more than 10 years) found it more difficult to assess the color according to value. At the same time, DSs who were still novices in the process of learning how to accurately evaluate the color of the tooth found it easy to assess it according to value.

Sinmazisik et al. used the mistake ratio and scores from the final test to evaluate the ability to match tooth color between dental technician students and graduate dentists and they found students to be more successful in shade matching than dentists, which is in accordance with our results (18). In another study, dental technician students, those who still learn how to assess the color, made more mistakes in the h parameter, and dentists made more mistakes in the L parameter (18).

The same was with ΔE values in our study. The DSs revealed the lowest shade difference values in the assessment and SPs the highest one, 2.08 and 2.51, respectively ($p>0.05$; Figure 3). These results are within the accepted perceptibil-

U istraživanju Sinmazisika i suradnika učenici budući dentalni tehničari, imali su niže ΔE vrijednosti (1.72) i dokazali su da su bili bliži prihvaćenoj granici vidljivosti boje od naših dentalnih studenata, ali u njihovoj skupini stomatologa vrijednosti su bile čak i više od naših (2.92), no još uvijek u granicama prihvatljivosti (18).

Također je vrlo važno istaknuti da su u našem istraživanju dentalni tehničari bili drugi najtočniji, a jedan od ispitanika iz te skupine imao je 100 % točne rezultate testa (ΔE = 0; slika 3.). S obzirom na srednje vrijednosti pogreške ΔE-a, izračunate kao razlike u boji samo u slučaju da je pogrešno određena, dentalni tehničari imali su statistički čak značajno niže vrijednosti u usporedbi s ostalim trima ispitivanim skupinama. To znači da su u slučaju njihove pogreške odstupanja u boji bila značajno manja od ostalih ($p < 0.05$; slika 4.; tablica 1.).

To što su dentalni tehničari bili točniji u procjeni i u slučaju pogreške imali su manja odstupanja, može se objasniti činjenicom da je riječ o skupini koja svakodnevno proizvodi boju u dentalnom laboratoriju te, iako ne poznaju protokol određivanja boje prema svjetlini, zapravo rade manje pogreške od ostalih.

Haddad i suradnici također su objavili da su žene u njihovu istraživanju postigle značajno bolje rezultate u određivanju boje od muškaraca, dokazujući da je u tom postupku važan i spol (19). U našem istraživanju pokušali smo složiti homogene podskupine muškaraca i žena u svakoj ispitivanoj skupini, ali nismo uspjeli pa je u svima bilo više žena (55 % – 75 %), što je moglo utjecati na rezultate. U daljnjim istraživanjima, u svrhu poboljšanja rezultata, moramo postići podjednak broj muškaraca i žena, povećati uzorak ispitanika te uključiti vrijeme koje su ispitanici potrošili na uvježbavanje i bodove TTB sustava.

Zaključci

U ovom istraživanju studenti su bili najtočniji u procjeni i imali su najniže ΔE vrijednosti.

Uzimajući u obzir srednje vrijednosti pogreške ΔE vrijednosti, dentalni tehničari bili su uspješniji u procjeni boje od ostalih ispitanika.

Ovo istraživanje dokazuje da kliničko iskustvo nije jedan od značajnih čimbenika u točnosti pri određivanju boje zuba.

Sukob interesa

Nije bilo sukoba interesa.

ity (PT) and acceptability thresholds (AT), although there is no consensus regarding the values that should be used. Khashayar et al. found that more than half of the studies they investigated defined PT as ΔE=1, and one third of the studies referred to ΔE=3.7 as the threshold at which 50% of observers accepted the color difference (AT)(26).

In Sinmazisik et al. study, dental technician students revealed lower ΔE values (1.72) and proved to be even closer to accepted PT than our dental students, but in general dentists group the value was even higher (2.92), but still within AT(18).

What is also very important in this study is the fact that DTs were the second best in accuracy and shade difference with ΔE value of 2.1, and one of the participants from this study group even achieved the perfect matching with no errors (ΔE=0; Figure 3). Considering error ΔE, calculated as shade difference only in the case of errors, DTs even revealed significantly lower value in comparison to other three observed groups in the study, meaning that when they made a mistake, its discrepancy was lower ($p<0.05$; Picture 4; Table 1).These findings regarding more accurate assessment with less difference in shade matching can be attributed to the fact that DTs are focused on colors during their laboratory work even when they are not familiar with value-based protocol, thus having less chance of an error in tooth color assessment.

Haddad et al. also reported that females in their study achieved significantly better shade matching results than males, indicating that gender plays an important role in shade matching (19). In our study, we have tried to achieve homogenous subgroups of men and women in each investigated group but have not fully succeeded because we had more women (55%-75%) in all four groups and this probably affected our results. An equal number of men and women, larger number of participants as well as longer periods of training time and scores obtained from the TTB system are needed for pursuing further study.

Conclusions

The students achieved the highest accuracy and the lowest ΔE values in the study. With regard to the mean error ΔE values, DTs were more successful in shade matching than other participants.

This study shows clinical experience is not found to be a significant factor to the shade matching accuracy.

Conflict of interest

None declared

Abstract

Objectives: The aim of this study was to evaluate the effect of clinical experience level on the shade matching accuracy in different dental occupational groups. **Materials and methods:** A total of 80 participants, assigned to one of four groups depending on the level of their clinical experience in shade matching: dental technicians (DTs), residents in prosthodontics (RPs), specialists in prosthodontics (SPs) and dental students (DSs) took part in the study. They were asked to use Tooth guide Training Box (TTB) and determine 15 standardized shade tabs using VITA 3D-Master shade guide. The number of mistakes in final test for each participant was recorded and accuracy was calculated. Color difference (ĆE) values for each shade were calculated from L*, a* and b* values. Differences in accuracy, mean ĆE values and mean error ĆE values between four different groups were examined. **Results:** No statistically significant differences were found between the groups regarding accuracy and mean ĆE values ($p>0.05$). The accuracy rate in four groups was 0.51±0.20 (DTs), 0,54±0.18 (RPs), 0.49±0.16 (SPs) and 0.55±0.14 (DSs), respectively. Mean ĆE values were 2.10±0.98 (DTs), 2.18±0.97 (RPs), 2.51±0.97 (SPs) and 2.08±0.86 (DSs), respectively. Regarding mean error ĆE values, DTs made errors with significantly less deviations compared to other groups ($p<0.05$). **Conclusions:** This study has shown that clinical experience is not found to be a significant factor to the shade matching accuracy. With regard to the mean error ĆE values, DTs were more successful in shade matching than other participants.

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