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Visual Assessment of Dental Filling Shades as Performed by Students of Dentistry and Dental Technology

Ocena wizualna odcieni wypełnień zębów przeprowadzona przez studentów stomatologii i techniki dentystycznej

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Abstract

Background. In the course of their training, students of dentistry and dental technology learn the structure of teeth and their shades. These are important parts of preclinical education.

Objectives. The aim of this study was to evaluate if the ability to identify the shades of composite fillings depends on the field of study (dentistry and dental technology) or on the sex of participants, and indirectly assess whether dental students need support during this procedure.

Material and Methods. The study involved a group of 74 students of the second year of dentistry (33 women and 19 men) and dental technology (20 women and 2 men). The students identified the shades of A1, A2, A3, C1 and C2 Herculite XR^V® fillings in 5 extracted teeth.

Results. There was no statistically significant difference in the ability to identify the filling shade between the students of dentistry and the students of dental technology ($p = 0.303$). A difference was found in the correct identification of filling shades between men and women ($p = 0.04996$). The ability to correctly determine shades changed depending on the filling shade in a tooth and ranged between 13% and 82%.

Conclusions. The ability of dentistry and dental technology students to match a shade of a restoration to a shade of a tooth is affected by sex but not by the students' field of study. (**Dent. Med. Probl. 2016, 53, 3, 394–400**).

Key words: restorative dentistry, shade tabs, dental education.

Słowa kluczowe: stomatologia zachowawcza, kolornik, edukacja stomatologiczna.

The everyday work of a dentist requires the skill to properly select a filling or a prosthesis shade. Moreover, the development of adhesive techniques and the increasingly wide range of composite materials available expand the array of procedures where these abilities prove useful. Students of dentistry and dental technology are trained in the structure of teeth, the properties of materials and their shades. They are all important parts of preclinical education. New devices help dentists choose shades in their dental prac-

tice, but the selection of a filling shade is still almost always based on visual perception; and it is the result of cooperation between a doctor and a dental technician. Such cooperation brings about the best aesthetic results. However, practical verification of these skills takes place at a dental chair with a patient sitting in it.

The choice of a shade is affected by several factors, among others by the individual predispositions of the doctor. This includes the red-green vision disorder (color blindness). As candidates for

dentistry and dental technology studies are not screened for such vision defects, it seems they may further on practice their profession with this kind of disability, not even being aware of their shortcoming. Natural lighting, indicated by some researchers as being the most appropriate for a correct shade assessment, to a large extent remains dependent on the time of year and day, and thus are often beyond the clinician's control [1]. However, they usually make decisions on shade selection in such lighting conditions. The studies published have been unable to conclusively determine whether the examiner's experience is important for the efficacy of shade assessment. Given the conflicting reports in this respect, this topic requires further research [2–4]. Independent work and the patient's aesthetic requirements are therefore a great challenge for students and, then, doctors.

The objective of this study was to evaluate the predisposition and the ability to identify the shades of composite fillings by students of dentistry and dental technology during preclinical education. An assumption was made that there would be no differences in the ability to verify filling shades between sexes and the field of study the students represent.

Material and Methods

The study was reviewed and approved by the local ethics committee at the Poznan University of Medical Sciences (No. 932/13) and has been conducted in full accordance with the World Medical Association Declaration of Helsinki. Written consent was obtained from all participants involved in the study. The study covered a group of 74 second-year students of dentistry (33 women and 19 men) and dental technology (20 women and 2 men), aged 20 to 24 years (mean age: 21.2 years). The structure of the test groups in terms of sex and the number of participants was a consequence of the number of students in groups receiving education in a given field and year of study. Dentistry students had no previous clinical experience in shade selection. Students of dental technology, on the other hand, due to the nature of the laboratory classes they had attended (which cover shades assessment) and due to their declared professional experience (1–2 years), were a reference group “with some experience”. Students were qualified for the tests having been evaluated for vision deficiencies using the Ishihara color plates (24 plates, 1998 edition, Kanehara Trading Inc., Tokyo, Japan) to exclude participants with color vision deficiency. The test confirmed all the participants to identify colors correctly.

During the *in vitro* studies, Herculite XRV[®] composite material (Kerr, Orange, USA) was used along with a VITAPAN[®] Classical Shade Guide (Vita Zahnfabrik, Bad Säckingen, Germany). The VITAPAN shade guide and the composite material were selected for tests as they are very commonly used in clinical practice in Poland. The study was performed using extracted human teeth placed in a plaster model. A filling was placed in molars and premolars which were free of caries, with no other fillings and discolorations, extracted for orthodontic reasons or as a result of advanced periodontal disease. Tooth preparation involved occlusal surfaces, of uniform depth and similar surface area. Teeth were then filled with the Herculite XRV composite material using shades A1, A2, A3, C1 and C2, according to the VITAPAN shade guide. Identical exposure time of 40 s was applied in each case (Elipar TriLight[®], ESPE, 3M, Maplewood, USA). The color of the filling was confirmed by the Shadepilot TM[®] (Dentsply Sirona, York, USA).

The study was conducted in natural lighting, in daylight hours from 10 am to 2 pm, on an autumn, slightly-cloudy day. All the students made their assessments in similar lighting and participated in the study in the same offices which faced one geographical direction [5].

During the first part of the study, the participants were asked to arrange the tooth shades B1, B2, B3 and B4 from the VITAPAN Classical Shade Guide, from the lightest to the darkest. The shade marking was covered with an opaque tape. In this part of the study there were no time limits. In the following part of the study, the students identified the shades of Herculite XRV fillings in 5 extracted teeth using the VITAPAN Shade Guide. The decision time was limited to one minute for each filling [3, 5]. The students made a total of 370 choices.

The results are shown for all test participants as well as with their division into sex and field of study. Statistical significance level was $\alpha = 0.05$. Fisher's exact test was used to verify the relationship between the correctness of tooth arrangement as to their brightness and the test participants' sex and field of study. The relationship between sex and field of study and the ability to identify filling shades was evaluated with the χ^2 and Fisher-Freeman-Halton tests. To perform statistical analysis, STATISTICA 10.0 and 10.0 CytelStudio software packages were used.

Results

The results of the tooth arrangement according to their decreasing brightness, with the students divided into specific groups, are present-

ed in Table 1. No significant relationship was found between sex and arrangement of B1, B2, B3 and B4 shades in the group of women and men (Fischer's exact test, $p = 1.000$) and in the dentistry student group itself (Fischer's exact test, $p = 0.521$). Neither was the correct tooth arrangement affected by the field of study (Fischer's exact test, $p = 1.000$). Among the female students of dentistry, 94% arranged the B shades from the VITAPAN Shade Guide properly, while the remaining 6% failed to do it correctly. Among the males, all of them arranged the shades correctly (100%). In the group of dental technicians, 100% of the test participants arranged the shades successfully.

The division of the test participants into sexes and fields of study as well as the results of the filling shade identification are shown in Table 2. Of the 74 test participants, 5 students (4 women: 2 dentistry students and two dental technology students, and 1 male student of dentistry) correctly identified all fillings, which represents 6.6% of the test participants (this data is not included in the table). Male dentistry students succeeded in giving correct answers in 42% of restorations, female dentistry students did so in 45%. The result for dental technology students was 48%.

The relationship between sex and the field of study and the ability to identify the shades of

all fillings was evaluated using the χ^2 test (this data is not included in the table). There was no statistically significant difference in the correct determination of the filling shade between the students of dentistry and dental technology (χ^2 test, $p = 0.303$). A difference was found in the correct identification of the filling shade between men and women (χ^2 test, $p = 0.04996$), irrespective of their field of study. Women identified filling shades correctly in 46% of the teeth while men in 35%. However, the test carried out in the group of female and male dentistry students showed no statistically significant differences in their evaluation of filling shades (χ^2 test, $p = 0.151$).

Table 3 shows the results of filling shade identification in the whole study group, with respect to specific filling shades. For all the test participants, the correct shade identification varied depending on the filling shade in the tooth and ranged between 13 and 82%. The greatest number of correct responses was obtained for the C2 shade, then A3, while the smallest was for C1. The detailed data showing the most incorrectly indicated filling shade in the entire test group is given in Table 3.

Table 4 shows the differences in the correct and incorrect determination of the specific filling shades, with regard to sex of the test participants. Both men and women made the most correct

Table 1. Arrangement depending on the field of study and sex

Field of study	Sex	n	Correct answers n (%)	Incorrect answers n (%)	p-value
Dentistry	female	33	31 (94)	2 (6)	0.521 ^a
	male	19	19 (100)	0 (0)	
Dentistry Technology		52	50 (96)	2 (4)	1.000 ^a
		22	22 (100)	0 (0)	
Dentistry and D. technology	female	53	51 (96)	2 (4)	1.000 ^a
	male	21	21 (100)	0 (0)	

^a Fisher's exact test.

Table 2. Identification of filling shades in groups divided into field of study and sex

Field of study	Sex	n (%)	Correct answers n (%)	Incorrect answers n (%)
Dentistry	female	33 (63)	75 (69)	90 (60)
	male	19 (37)	34 (31)	61 (40)
In total		52 (100)	109 (100)	151 (100)
D. technology	female	20 (91)	49 (92)	51 (89)
	male	2 (7)	4 (8)	6 (11)
In total		22 (100)	53 (100)	57 (100)
In total (dentistry and d. technology)		74 (100)	370 (100)	

Table 3. Identification of particular filling shades in test group

Shade	Responses			
	correct (%)	incorrect (%)	most often incorrect	n (% of all the incorrect)
A2	32 (43)	42 (57)	A3	25 (60)
C1	9 (13)	65 (87)	A2, A1	24 (37)
A3	43 (58)	31 (42)	A2	13 (42)
A1	17 (23)	57 (77)	C1	33 (58)
C2	61 (82)	13 (18)	A3	5 (38)

Table 4. Filling shade identification in group of women and men

Shade	Women				Men			
	correct (%)	incorrect (%)	most often incorrect	n (%)*	correct (%)	incorrect (%)	most often incorrect	n (%)*
a2	26 (49)	27 (51)	A3	17 (31)	6 (29)	15 (71)	A3	8 (53)
C1	7 (13)	46 (87)	A1	21 (46)	2 (10)	19 (90)	A2	7 (37)
A3	33 (62)	20 (38)	A2	7 (33)	11 (52)	10 (48)	A2	6 (60)
A1	12 (23)	41 (77)	C1	25 (61)	5 (24)	16 (76)	C1	8 (50)
C2	47 (89)	6 (11)	A3	3 (50)	14 (67)	7 (33)	C1	3 (43)

* (% of all the incorrect ones).

Table 5. Results of filling shade assessment in group of dental students divided into women and men

Correct shade	Women				Men			
	correct (%)	incorrect (%)	most often incorrect	n (%)*	correct (%)	incorrect (%)	most often incorrect	n (%)*
a2	15 (45)	18 (55)	A3	11 (61)	6 (32)	13 (68)	A3	8 (62)
C1	5 (15)	28 (85)	A1	13 (46)	2 (11)	17 (89)	A2, C2	5 (9)
A3	17 (52)	16 (48)	C1	5 (31)	9 (47)	10 (53)	A2	6 (60)
A1	10 (30)	23 (70)	C1	16 (70)	5 (26)	14 (74)	C1	6 (43)
C2	28 (85)	5 (15)	A3	3 (60)	12 (63)	7 (37)	C1	3 (43)

* (% of all the incorrect ones).

Table 6. Filling shade matching in group of dental students and dental technology students

Shade	Dental technicians				Dentists			
	responses							
	correct (%)	incorrect (%)	most often incorrect	n (%)*	correct (%)	incorrect (%)	most often incorrect	n (%)*
a2	11 (50)	11 (50)	A3	6 (55)	21 (40)	31 (60)	A3	19 (61)
C1	2 (9)	20 (91)	A2	9 (45)	7 (13)	45 (87)	A1	16 (36)
A3	17 (77)	5 (23)	A2	3 (60)	26 (50)	26 (50)	A2	10 (38)
A1	2 (9)	20 (91)	C1	11 (55)	15 (29)	37 (71)	C1	22 (59)
C2	21 (95)	1 (5)	A1	1 (100)	40 (77)	12 (23)	A3	5 (42)

* (% of all the incorrect ones).

matches for the C2 shade (89% and 67% respectively), followed by A3 and A2. The fewest correct matches in both groups were made with respect to the C1 and A1 shades. The most common incor-

rectly matched filling shades in the group of men and women were A1, A2 and A3. In both groups, the same wrong shade was most often indicated. A statistically significant difference in matching

the filling shade was found between women and men for the C2 shade (Fisher Freeman Halton test, $p = 0.015$). There were no significant differences for the A2 shade (Fisher Freeman Halton test, $p = 0.318$), C1 (χ^2 test, $p = 0.224$), A3 (χ^2 test, $p = 0.446$) or A1 (χ^2 test, $p = 0.446$).

Table 5 shows the results of particular filling shade identifications in the group of dentistry students, with regard to their sex. In the group of dentistry students, both men and women most frequently identified the C2 shade correctly (85% and 63%, respectively), followed by A3 and A2. Women were more likely to correctly indicate a given filling. The fewest correct matches in both groups were made with respect to the C1 and A1 shades. The table also indicates the filling shade that was most commonly matched incorrectly in the group of dentistry students, both women and men. In cases of teeth filled with the A1 and A2 shades, in both groups, the same wrong shade was indicated most often, though at a different percentage. There was no statistically significant difference in filling shade matching between men and women studying dentistry (shade A2 Fisher Freeman Halton test, $p = 0.682$, C1 χ^2 test, $p = 0.116$, A3 χ^2 test, $p = 0.438$, A1 Fisher Freeman Halton test, $p = 0.263$, C2 Fisher Freeman Halton test, $p = 0.079$).

Table 6 shows the results of filling shade matching divided into the field of study and particular teeth assessed. In the group of dentists and dental technicians, the greatest number of correct matches were made with respect to the C2 shade (77% and 95%, respectively), followed by the A3 and A2 shades. In this case, the dental technicians were more likely to match the shades accurately. The fewest correct matches in both groups occurred with respect to the C1 and A1 shades. The table shows the most frequently chosen wrong filling shade in the group of dentists and technicians. In the teeth filled with the A1, A2 and A3 shades in both groups, most often the same wrong shade was indicated, though at a different percentage. There was no statistically significant difference in filling shade matching between the students of dentistry and the students of dental technology (A2 χ^2 test, $p = 0.786$, C1 χ^2 test, $p = 0.651$, A3 Fisher Freeman Halton, $p = 0.366$, A1 χ^2 test, $p = 0.060$, C2 Fisher Freeman Halton test, $p = 0.273$).

Discussion

It has been observed that slight differences in saturation (chroma) and hue are less effectively captured by the human eye than mistakes in the correct determination of brightness [3]. Brightness is a critical component which ultimately af-

fects the proper selection of the filling [6]. Considering the above, in the process of shade selection, brightness should be determined as the first component [7].

We found a major regularity in tooth arrangement according to decreasing brightness, regardless of the test group. Initial tooth arrangement was done on purpose, which was to make the test participants familiar with shade guides, as a prelude to a more demanding task – determining filling shades *in vitro*.

The study did not demonstrate statistically significant differences in the identification of filling shades between the students of dentistry and dental technology, or between men and women studying dentistry. Still, a difference was found in the correct identification of filling shades between men and women of both groups together. The research hypotheses were therefore partly confirmed.

In previous studies on shade matching, a number of factors were analyzed in how they affect the processes of color perception and color matching. Color perception was found to be affected by: lighting conditions, eye strain and psycho-emotional state [8]. None of the people willing to participate in our study suffered from color vision disorders. Impaired color vision affects shade assessment done by medical personnel, which was confirmed in the study by Gokce et al. [9].

It should be noted that confusion or difficulty in the selection of shades is often caused by the shade guides available on the market, hardly representing all naturally occurring colors of teeth. Instead, they only show approximate values which often do not correspond to an existing clinical situation [10, 11]. Moreover, shades present in a shade guide do not truly reflect the composite materials color range [12] and, if placed in a tooth, the perception of their shade is affected by the tooth shade itself. Still, despite these limitations, using shade guides facilitates the clinical procedure and can reduce the amount of material used in a filling insertion. Therefore, such a solution was applied in this study [13].

In some studies, no statistically significant differences in distinguishing shades were demonstrated between subjects representing various ages, sexes, and occupations [2, 3, 14].

Research by Miranda [4] showed that professional long-time experience gained while working in dentistry is a key factor in correct shade assessment. Hammad [15] in his studies pointed out the differences in the choice of shades among doctors of different specialties. The study involved men only as it was difficult to find a group of female prosthetists in this occupational group. The test

participants with extensive experience in shade assessment were far more accurate when selecting shades than general dental practitioners. Other authors found no relationship between experience and accuracy of shade matching [2, 3]. Although the difference in clinical experience among our students was not extensive, a detailed analysis of the obtained data showed that the students of dental technology would more often assess filling shades in the correct way, thereby producing fewer incorrect answers. This suggests, therefore, that with time the observer tends to become more accurate in their analysis. Still, this is a difficult skill to learn [14, 15].

Poljak-Guberina et al. [14] studied color perception by male and female dentists and technicians (free from visual color deficiency) and found no differences between the representatives of these two professions. Also Klemetti et al. [16], when studying groups of students of dentistry and dental technology, did not find any statistically significant differences in the choice of color tones. They also found that students with relatively low experience at the time of study, having gained some relevant experience over time, improved their competence in shade assessment and matching. In our study, the absence of statistically significant differences between students of dentistry and dental technology could confirm the findings that accuracy of shade assessment does not result from what a student presently studies. Therefore, it may be concluded that prospective students do not decide on their field of study because they have an inborn skill to differentiate colors. The results of our study indicate differences in the choice of shades depending on the sex of participants, although in the group of dentists itself, the difference was not significant. This is a meaningful conclusion as worldwide sex distribution in dental professions is unequal. In Poland it is mainly women who practice dentistry, while in the United States it is men [17]. So, from the patient's point of view, it is important to note that, irrespective of their dentist's sex, color perception will be undistorted, provided they have no vision color defects. Interestingly enough, in our study, female students of dentistry were more likely to correctly evaluate filling shades than men (not statistically significant data), although both women and men most commonly gave correct answers in the same shade groups (C2, A3, A2). In other studies, no relationship was found between sex and the choice of shade [3, 14, 18], although there are some publications indicating that men's results were better [4].

Still, doubt remains whether the difference in color match showed in our study derives from

a better color perception attributed to women, only, or is it a derivative of female sex combined with short-time professional experience, as was the case with female technology students, who received better color match results.

The greatest number of correct evaluations was obtained in this test for the C2 shade (82%) and then A3 (58%). Accurate matching, depending on the filling shade, was in the range of 13% (the brightest shades) to 82% (the darkest shades). For all shades, correct matches made 42% of the time in dental students, and slightly more frequently (48%) in the group of dental technicians. In the studies by Gokce et al. [9] the total number of correct matches made in standard daylight was 63.02%, but the participants had at least 2 years of clinical experience. Moreover, the range of correct evaluations in the studies by Klemetti et al. [16] ranged from 5% to 63% depending on the tested tooth and the shade guide used. The test participants in Klemetti's case were students, hence a broad range of correct evaluations, which was also confirmed in the present study.

Our analysis attempted to determine which filling shade was the most troublesome for the students and which was the easiest to evaluate. In the case of the tests in question, fillings were made in teeth with necrotic pulp, the color of which was not assessed. The contrast between the teeth and the filling could be difficult to find, even for experienced observers. The C2 shade was correctly indicated most frequently, regardless of sex or the participants' field of study. Seemingly, it is primarily due to the fact that C2 is a relatively dark and distinctive color. Other shades which tended to be selected correctly were A3 and A2; still, there were many errors in this group of shades as well. The shades A2 and A3 are similar to each other and for less experienced students the difference between them was not significant. Similar results were obtained in the study by Curd et al. [3]. Generally, the students frequently confused bright shades in groups A and C (A1 and C1), often treating them interchangeably. This is confirmed by the results obtained by Curd et al. [3] in his study of students. In our study, similar shades were often indicated wrongly in all groups, and the sequence of the most frequent correct shades was similar in all groups as well.

Conclusions

The results suggest that, firstly, there is a difference in the ability to select filling shades, depending on the sex of test participants. Secondly, more extensive dental practice combined with

the sex of students of dental technology, although not statistically significant, results in a more pronounced regularity in perceiving differences in fillings shades, than in the group of dentistry stu-

dents. It seems, however, that the students of dentistry and the students of dental technology can deal equally efficiently with the task of shade matching.

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