RESEARCH ARTICLE

COLOR NATURAL TEETH DETERMINATION AMONG A POPULATION OF MOROCCAN PATIENTS

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ARTICLE INFO

ABSTRACT

Purpose: To identify the most frequent natural tooth color using the Easy shade Micro spectrophotometer on a sample of the Moroccan population according to the 3D Master System. **Materials and Methods:** The middle third of the facial surface of natural maxillary central incisors was measured with an Easy shade Micro spectrophotometer in 1100 Moroccan participants aged between 16 and 89 years. Natural tooth color was recorded using the 3D Master System nomenclature. The program used for the results descriptive statistical analysis was SPSS. **Results:** The results show that the most frequent dental color in the total sample studied is 2R2.5 (25.7%), followed by the shade 1M2 (23.2%) and 2M2 (14.1%). **Conclusion:** According to the research methodology used, and taking into account the limitations of this study, it can be proposed that the most frequent color among the Moroccan population is 2R2.5; the most common value group is 2; the most frequent hue group according to the 3D Master System is M and the most frequent chroma group is 2.

INTRODUCTION

In fixed prosthesis, a tooth restoration is successful when the shape, the position and the visual perception that are emitted inhale harmony, integration and aesthetic. The visual perception remains one of the most complicated parameters to manage because of its multiple interdependencies. Thus, the color determination for natural dentition restorations continues to be one of the most puzzling challenges among fixed prosthesis (Todorović, 2013; Bahannan, 2014). To carry out this work, we drew upon related study realized at the Faculty of Dentistry at the University of Madrid, Spain (Gómez-Polo *et al.*, 2015). Due to the complexity of the tooth color determination, the human eye reliability and the low performances of the shade guides, measuring tooth color especially in a subjective way remains a real challenge for dental practitioners. As a matter of fact, the use of Vita-Classic shade guide, which is regarded as obsolete and had produced unreliable color determination results if not inaccurate, did

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lead to the introduction into the market of a more efficient shade guide, taking into account the three dimensions of color, later called Vita 3D Master shade guide. The Vita 3D Master manufacturing was based on a Vita company survey of a European sample, in order to identify the tooth color chromatic range, thereby identifyied as a banana shape (Fig.1) within the CIE LAB color space. This methodological approach has ensured that the Vita 3D Master shade guide was much more efficient than the Vita-Classic (Hassel, 2005). However, a wide performance gap couldn't be shown in comparison with the old shade guide in spite of its design including the value factor and the HBS (Hue, Brightness, Saturation) color values derived from clinical research (Paravina, 2009). Given these observations, our presumption was to hypothesize that the low performance of the 3D Master shade guide may have been partially related to the fact that its manufacturing was based on European sample clinical studies, a population with chromatic range probably different or representing a wide gap in comparison with other populations genetically diverse, in this case the north African population. The aim of the present work is to identify first the chromatic data related to a north African population (Moroccan) and to compare it to other ethnical groups. The main use of it, in second phase, will be the manufacture of a personalized shade guide entirely suited to this population. Once the new shade guide is put into use, a

comparative work will be realized with regard to the 3D Master performance in order to give a clear answer to our initial hypothesis.

MATERIALS AND METHODS

We conducted a cross-sectional descriptive study, based on the measurement of the natural tooth color of 1100 maxillary central incisors of Moroccan participants (727 women and 373 men). Were included all the patients aged between 16 and 89 years who was examined during consultation or a follow-up at the Dental Treatment and Consultation Center (DTCC) of Casablanca and having a straight and healthy natural maxillary central incisor, with no substance loss, nor previous whitening. Three types of variable parameters were used in this survey: Male, Female, and Color. The gender; where the sample was divided to M(male) and F(female) and age which both are qualitative variables related to the sample identification.

In order to define the most frequent colors in different age groups, the participants were recruited into three groups according to age: between 16 and 30 (young group), between 31 and 59 (middle-aged group), and above the age of 60 and up to a maximum of 89 (elderly group). Those groups were further subdivided by gender (Gómez-Polo, 2015). The color; a qualitative variable defined by the hue, value and chroma. The value (or the brightness which represents the amount of light returned from an object.

It ranges from 1 to 5), the hue (specified as the dominant range of wavelengths in the visible spectrum that yields the perceived color. It varies between L, M and R) and the chroma (the saturation, intensity or strength of the Hue. It ranges between 1 and 3) (Sikri, 2010). The study was started after obtaining an appropriate authorization from the heads of Fixed Prosthesis and Emergency departments of the DTCC. All our participants were asked a formal verbal consent. Two examiners (female doctoral students) made the measurements with the same spectrophotometer (Easy shade Micro) and a standardized protocol for color evaluation. Before each use, the device was calibrated by performing measurements on pellets designed for that purpose according to the manufacturer's recommendations (Choi *et al.*, 2010). Color was determined on the middle third of the tooth, on the area that best illustrates tooth shade (Schwabacher *et al.*, 1990; Eiffler, 2010; Dozić, 2005). The result is then stored in a digital format as "TSL" chromaticity coordinates, and the software generates the equivalent of the dominant color at the center point of the resulting survey as a 3D master tab (Figure 2). Descriptive statistics were generated from the data via SPSS software, within the biostatistics and epidemiology laboratory of the Faculty of dentistry of Casablanca.

RESULTS

A total of 1100 patients were examined, which corresponds to 1100 maxillary central incisors have been carefully analyzed. Up to 66.1% of ours ample were females and 33.9% were males (Table 1). Respondents were divided according to their age into three groups. The results showed that 84.7% were aged between 16 and 30, 10.8% between 31 and 59, and only 1.8% were aged between 60 and 89 (Table 2). The color survey among our sample had a match within 27 colors variation. The Table 3 summarizes the most frequent colors for the three age groups in both gender.

Table 1. Sampling distribution by gender.

Gender	Population	Ratio
Female	727	66.1
Male	373	33.9
Total	1100	100.0

Table 2. Sampling distribution by age group.

Age	Population	Ratio
16 – 30 years	961	87.4
31 – 59 years	119	10.8
60 – 89 years	20	1.8
Total	1100	100.0

Table 3. Sample distribution by color

Color	Population	Ratio
2R2.5	283	25.7
1M2	255	23.2
2M2	155	14.1
3M2	75	6.8
3M1	61	5.5
2M3	52	4.7
2L1.5	48	4.4
2R1.5	43	3.9
3R2.5	32	2.9
3M3	18	1.6
3R1.5	12	1.1
2R2	11	1.0
2M1	11	1.0
3L2.5	8	0.7
3M1	7	0.6
4M2	4	0.4
3L1.5	4	0.4
3R3	3	0.3
2L2	3	0.3
4M1	2	0.2
5M1	2	0.2
4M3	2	0.2
4L1.5	1	0.1
3L3	1	0.1
5M2	1	0.1
5M5	1	0.1
Total	1100	100.0

The most frequent color among all the patients was 2R2.5 (25.7%), followed by 1M2 (23.2%) and finally 2M2 (14.1%). (Table3). When the sample was divided into age and gender groups, the most frequent color among men and women aged between 16 and 30 was 2R2.5. In older women (60 to 89 years) the color was 2R1.5 and 2R2.5, in older men we observed three colors: 4M2, 2M2 and 1M2 (Table 4). In the men group aged between 16 and 30 years, the most frequent color was 2R2.5 (25.37%), followed by 1M2 (19.40%), with 2M2 (17.31%) in third position. For the young women group, 26.43% had 1M2 as a frequent color, followed by 2R2.5 and finally 2M2 (12.73%).

Likewise, the intermediate age group and the older age group were analyzed. For the intermediate age men group, the most frequent color was 2R2.5 (23.52%), followed by 1M2 and 2M3 (11.76%), the two last colors having the same frequency. For the intermediate age women group, the most frequent color was 2R2.5 (25.30%), followed by 1M2 (21.68%) and finally by 2M2 (14.45%). For the elderly aged men group, we have noticed 4M2, 2M2 and 1M2 with the same frequency (33.3%). In the women group aged between 60 and 89 years, 17.64% was the percentage of the two most frequent colors: 2R1.5 and 2R2.5, while 11.76% was the percentage of the 3M1 (Table 4).

Table 4. The most frequent color in 3D Master System, according to gender and age group

Gender	Women			Men		
Age	**16 – 30**	**31 – 59**	**60 – 89**	**16 – 30**	**31 – 59**	**60 – 89**
	1M2	2R2.5	2R1.5	2R2.5	2R2.5	4M2
	26.43%	25.30%	17.64%	25.37%	23.52%	33.33%
	2R2.5	1M2	2R2.5	1M2	1M2	2M2
	26.43%	21.68%	17.64%	19.40%	19.40%	33.33%
	2M2	2M2	3M1	2M2	2M3	1M2
	12.73%	14.45%	11.76%	17.31%	11.76%	33.33%

Table 5. Distribution of value, hue and chroma groups according to 3D Master system, in young group participants

	Women (16 – 30 years)		Men (16 – 30 years)	
VALUE	Frequency	Percentage	Frequency	Percentage
1	214	34.07%	85	25.37%
2	338	53.82%	195	58.20%
3	73	11.62%	50	14.92%
4	1	0.15%	4	1.19%
5	2	0.13%	1	0.29%
HUE				
L	37	5.89%	20	5.97%
M	375	59.71%	191	57.01%
R	216	34.39%	124	37.01%
CHROMA				
1	46	7.32%	22	6.56%
1.5	57	9.07%	36	10.74%
2	291	46.33%	145	43.28%
2.5	196	31.21%	107	31.94%
3	38	6.05%	25	7.46%

Table 6. Distribution of value, hue and chroma groups according to 3D Master system, in middle-aged group participants

	Women (31- 59 years)		**Men (31 – 59 years)**	
VALUE	**Frequency**	**Percentage**	**Frequency**	**Percentage**
1	23	27.71%	7	20.58%
2	41	49.39%	20	58.82%
3	13	15.66%	4	11.76%
4	6	7.22%	2	5.88%
5	0	0%	1	2.94%
HUE				
L	5	6.02%	1	2.94%
M	48	57.83%	21	61.76%
R	30	36.14%	12	35.29%
CHROMA				
1	7	8.43%	4	11.76%
1.5	13	13.66%	4	11.76%
2	36	43.37%	12	35.29%
2.5	22	26.50%	9	26.47%
3	5	6.02%	5	14.70%

Table 7. Distribution of value, hue and chroma groups according to 3D Master system, in elderly group participants

	Women (60 – 89 years)		Men (60 – 89years)	
VALUE	**Frequency**	**Percentage**	**Frequency**	**Percentage**
1	2	11.76%	0	0%
2	10	58.82%	2	66.66%
3	5	29.41%	0	0%
4	0	0%	1	33.33%
5	0	0%	0	0%
HUE				
L	2	11.76%	0	0%
M	8	47.05%	3	100%
R	7	41.17%	0	0%
CHROMA				
1	3	17.64%	1	33.33%
1.5	5	29.41%	0	0%
2	5	29.41%	2	66.66%
2.5	4	23.52%	0	0%
3	0	0%	0	0%

Table 8. Comparison of the most frequent color between the Moroccan and the Spanish population by age and gender

	Spanish Population			Moroccan Population		
	16-30 years	31-59 years	60-89 years	16-30 years	31-59 years	60-89 years
Women	1M1.5	2M1	3M1	1M2	2R2.5	2R1.5
Men	1M1.5	3M1	4.5M1.5	2R2.5	2R2.5	4M2
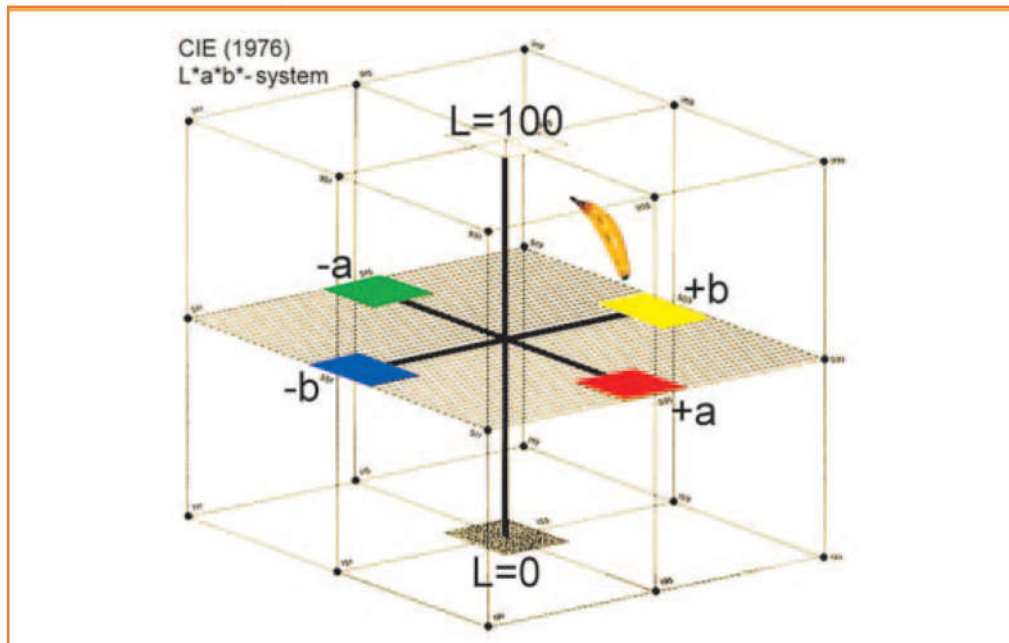
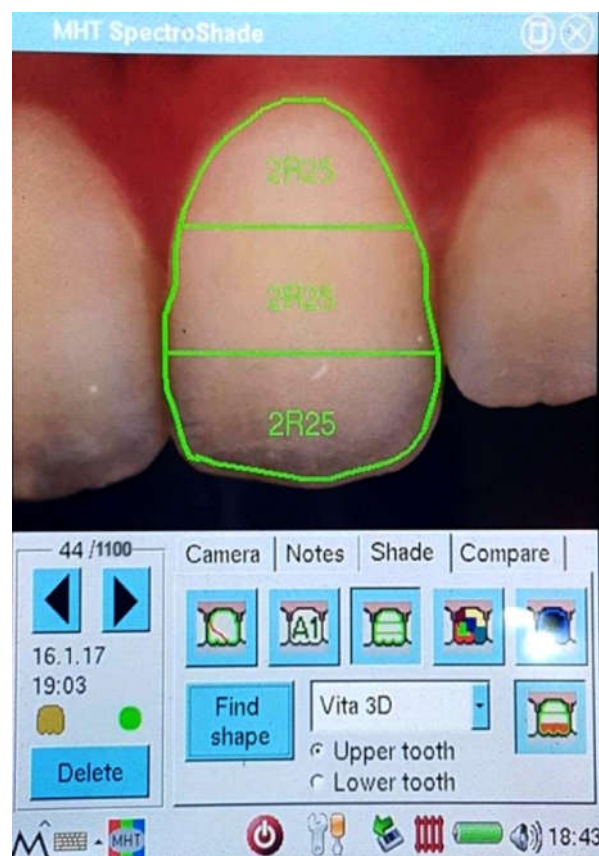**Figure 1. Tooth color chromatic range within the CIE-L*a*b* color space**

Figure 2. Color determination of natural maxillary central incisor

In Table 5, which shows the group of participants between 16 and 30 years, the most frequent value was 2 for both men (58.20%) and women (53.82%). In both genders, the most frequent hue was M, which was observed in 57.01% of men and in 59.1% of women. The most frequent chroma for both genders was 2, with 43.28% among men and 46.33% among women (Table 5). In table 6, which shows the color dimensions for the middle-aged participants, the most frequent value was 2 for both men (58.82%) and women (49.39%). In both genders, the most frequent hue was M, which was noticed among 61.67% of men and 57.82 of women. The most frequent chroma was 2 in 35.29% of men and 43.37% of women (Table 6). The table 7 shows the color dimensions among elder participants. The most frequent value was 2 for both men (66.66%) and women (58.82%). The hue the most noticed was M, as in the previous groups, with 100% among men and 47.05% among women. The chroma 1 and 2 appeared with the same frequency in both gender groups (29.41%); the most frequent was 2 representing with 66.66% of the results. (Table 7)

DISCUSSION

The present survey is a cross-sectional descriptive study, and the sample size seems to be sufficient even though not all the groups have had equal size due to the sampling system used. The current sample size n (1100) fits the minimum required to meet the statistical standards in order to represent the DTCC population. It is worth noting that the DTCC receives patients from Casablanca and surrounding cities, as well as the south region of Morocco. The limitation, however, is the sample composition as it did not represent all the variability among the Moroccan population. Despite this, the obtained results suggest that the approach taken was sound. Previous published works have used a similar or smaller sample size to draw conclusions for different populations: The south Asian population (n=162) (11), the Buffalo population (n=501) (12), the Japanese population (n=87) (13); (n=195) (14), and the Spanish population (n=1360) (3). The current sample is limited to a particular ethnicity group and the results cannot be extrapolated to other ethnicities (Nourbakhsh *et al.*, 2013). Furthermore, this study did not follow up each patient to track individual changes over time. This would probably have been an improvement with controlling and evaluating different variables such as smoking, the ingestion of different drugs types, food hygiene, water quality, teeth surface and brushing frequency. Today, the tooth color determination in dentistry is still subjective and based on shade guides, even though that the objective methods are disposable, such as spectrophotometers, digital cameras and computer image analysis. In 1998, the 3D Master System shades was introduced to the market, according to its manufacturer Vita-Zahnfabrik, in order to cover the color space in natural teeth. It is based on a tridimensional color scheme and currently remains the only marketed shade guide which is able to determine the nuances scientifically by selecting individually each of the three-color dimensions in this order; the value, the chroma and the hue. This color system is the one used by the American Dental Association as well as the current shade guides and the electronic spectrophotometers. The color samples of the 3D Master system have an equal distribution in the color space, in accordance with the scientific principles, which, according to the manufacturer, adds higher accuracy to the color matching if handled correctly. Moreover, the 3D Master System offers clear advantages in terms of the spatial pattern, with less coverage errors in comparison with the classic Vita shade guide. The system consists of 26 colors of the 3D Master shade guide and the so-called intermediates colors that are not physically represented. With these intermediate colors, the system consists of more than 75 colors. For example: 2R2, 5.1L1.5. These intermediate colors can be obtained only by spectrophotometric measurements as they have no physical representation within the 3D Master shade guide (Figure 1). Five value levels and five chroma levels are used, in each group, the hue varies between L(Yellow), M (Middle) and R (more Reddish). By using this shade guide, the practitioner selects first the value, then the chroma and finally the hue. Consequently, each color is determined by a number (Value), a letter (Chroma) and a number (Hue), such as 2M3, where 2 refers to the Value, M represents the Chroma and 3 stands for the Hue. This « in vivo » investigation offers the advantage of sample analyzing by age groups, which is very effective to establish comparison indicators with other populations. Many authors have divided the sample by age groups, while others have divided it by age groups and ethnic categories in order to extrapolate their results. Good outcomes have been reported in previous « in vivo » and « in vitro » studies concerning Easy shade spectrophotometer measurements in term of precision (Gozalo-Diaz *et al.*, 2008).

The most frequent color among the sample was 2R2.5, followed by 1M2. The sample allocation interests mainly a young population which makes the results suited to the fixed prosthesis. In 2015, Gomez-polo *et al.* (2015) have determined with a spectrophotometer the color of 1360 natural maxillary central incisors in Spanish population divided into three age groups (16-30 years), (31-59 years) and (60-89 years) and they have found that the most frequent color was 3M1 while it only represents 0.6% among the Moroccan population (Table 8). In 2007, Bayindir *et al.* (2007) have measured with spectrophotometer 120 central and lateral maxillary incisors of a north American population aged between 18 and 85 years in 4 ethnic groups and have shown that the most common color was 3R1.5. It may be related to some fundamental differences in the dental color within the sample groups. By contrast, the current outcomes for a Moroccan population show that 3R1.5 was only represented by 1.1%. They have recruited their sample into 5 age groups, 18-29 years, 30-39 years, 40-49 years, 50-59 years and 60-85 years. Even though the inclusion criteria of the present work and those used in Bayindir *et al.* protocol were similar, the main differences lie in that those authors have measured three teeth, have used a spectroradiometer (PR 705; Photo Research Inc, Chatsworth, Calif) with a smaller sample size. The current results are inconsistent with Gomez-Polo *et al.* outcomes (Gómez-Polo, 2015). This is probably due to the fundamental differences in color teeth among the population groups, the different measurement instruments and the different age groups studied. The most frequent color among the sample analyzed in our study was 2R2.5 in 283 participants with a percentage of 25.7%, followed by 1M2 in 225 participants with a percentage of 23.2%. According to Gomez-polo, the group with the most frequent value is 2, represented by 17.93% of the Spanish population, followed by the group of value 2.5 with 14.77% and finally the group of the value 1 with 14.55%. Those results are inconsistent with the present study in percentage terms. The present study has shown that the most frequent value is 2, represented by 55.1%, followed by the group of value 1 represented by 30.1% and, thereafter, the group of value 3 represented by 13.2%. In 2012, Rodrigues *et al.* (2012) have

studied in India the color of natural maxillary central incisors in both male and female divided in four age groups (the total sample n=400): 15-25, 25-35, 35-45, and a last group more than 45 years. Although the inclusion criteria are similar in our study, the main difference is that the color selection is based on a subjective comparison and the other authors have not used electronic devices. They noticed that in all age groups, regardless of whether the participants are male or female, the most common color for maxillary central incisors using the 3D Master shade guide was 2R2.5. Thus, the study have not shown any statistically significant correlation between the different colors in both gender. The above outcomes in all age groups are similar to the ones reported by Smith and Wilson (Smith, 1998) and by the present study.

The disparity in the results can be explained by the fact that the color perception is an individual phenomenon and it varies depending on the quality and the quantity of the light environment, the observer and the object. The hue R seems to be the most frequent in all age groups (Rodrigues *et al*., 2012). In 2017, another Indian study based on measuring the shade of right maxillary central incisor of 117 volunteers aged between 18 and 24, using a VITA Easy shade® Advance 4.0, has found that the most prevalent shade in cervical region was 1M2. It accounted for 31.62%. This was followed by 1M1 which was 15.8%. Dominant hue was M with lighter value. Only 3% of specimens were found to be of higher value (Harinder *et al*., 2017). According to a Turkish study published in 2018, where the tooth color was measured using the VITA Easy shade V spectrophotometer with a total of 202 volunteers (89 men, 113 women). aged between 15 and 70 years old, the tooth color distribution of the central and lateral incisors showed a maximum of A2, with a maximum of B3 for the canine teeth. (Karaman *et al*., 2018). In contrast, in the present study the hue M is the most common with a percentage of 58.6% (n=645). By analyzing the most frequent colors in men and women among the three age groups, we find that the value 2, the chroma 2 and the hue M of the color remain unchanged.

Conclusion

In spite of the limitations of the present work, it can be stated that the most frequent color in the Moroccan population 2R2.5; the most common value group is 2; the most frequent hue group according to the 3D Master System is M and the most frequent chroma group is 2. Our survey focused on the determination of the most frequent color natural teeth associated to age-gender groups, in order to develop a shade guide which will be customized to the North-African population and notably the Moroccan one. It would have been desirable to conduct longitudinal studies and spectral measurements on representative samples at different times, with several ethnic categories and similar age groups, as well as to take into consideration the behavioral variables of the participants in order to obtain more revealing data. However, an objective knowledge of natural tooth colors by gender and different age groups may be a useful and much easier way to choose a tooth color during various dental restorations and prosthesis, especially in the hands of novice practitioners.

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