



# Study of the most frequent natural tooth colors in the Spanish population using spectrophotometry

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**PURPOSE.** To identify the most frequent natural tooth colors using the Easyshade Compact (Vita -Zahnfabrik) spectrophotometer on a sample of the Spanish 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 Easyshade Compact spectrophotometer (Vita Zahnfabrik) in 1361 Caucasian Spanish participants aged between 16 and 89 years. Natural tooth color was recorded using the 3D Master System nomenclature. The program used for the present descriptive statistical analysis of the results was SAS 9.1.3. **RESULTS.** The results show that the most frequent dental color in the total sample studied is 3M1 (7.05%), followed by the intermediate shade 1M1.5 (6.91%) and 2L1.5 (6.02%). **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 Spanish population is 3M1; the most common lightness group is 2; the most frequent hue group according to the 3D Master System is M and the most frequent chroma group is 1.5. [*J Adv Prosthodont 2015;7:413-22*]

**KEY WORDS:** Tooth; Color; Spectrophotometry; Population; Age; Gender

## INTRODUCTION

The study of color is a fundamental part of aesthetic dentistry. To fabricate an aesthetically pleasing prosthesis, information regarding the polychromatic color distribution, translucency, intricate contours, and textures of the adjacent or opposing structures must be provided for technicians.<sup>1</sup> Color is undoubtedly one of the parameters with the greatest weight when patients judge the quality of their restoration, above all in the anterior region.<sup>2</sup>

An adequate definition for color is the one published in 2001 by the Commission Internationale de l'Éclairage (C.I.E.):

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Received April 27, 2015 / Last Revision July 29, 2015 / Accepted  
October 29, 2015

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“Characteristic of the visual perception that can be described by the attributes of hue, value and chroma”.<sup>3</sup> Hue is the first dimension of color, and is related to perceived light wavelengths. It is the characteristic that differentiates colors from each other. Value is probably the most important dimension in terms of dentistry. A color's value is defined by the amount of black and white within the scale, which is related to lightness/darkness, and chroma represents the degree of saturation of a color.

Currently, the method of tooth color choice most widely used in dentistry is subjective, based on toothguides,<sup>1,4</sup> although objective methods are available with spectrophotometers, digital devices, or digital image analysis techniques.<sup>5</sup> Objective methods usually express the results in the CIE L\*, a\* and b\* systems,<sup>6</sup> as well as in one or more of the conventional toothguide systems.<sup>7</sup>

Toothguides usually comprise a series of shades that are compared successively with the tooth color until the one that appears to be the closest match is found.<sup>8</sup> However, the use of toothguides is a subjective procedure, and the results may be affected by ambient illumination, professional experience, age, the surrounding colors, the angle of view of the tooth and the shade tab, the clothes and makeup of the patient, and the chromatic perception of the den-

tist.<sup>9,10</sup> As if these limitations were not enough, some minor chromatic changes in toothguides from the same manufacturer have been detected.<sup>11,12</sup> Thus, shade matching with toothguides consists of a subjective visual comparison that is neither reliable nor consistent.<sup>13</sup> Moreover, most commercial toothguides do not provide a complete representation of the color variation present in natural dentition.<sup>14,15</sup> Lemire and Burk<sup>16</sup> investigated the distribution and frequency of the natural tooth color space in 1974 using a spectrophotometer and they concluded that the color space occupied by natural teeth was broader than that measured by toothguides.

The 3D Master System was introduced into the market in 1998 with the purpose, according to its manufacturer Vita-Zahnfabrik, of covering the natural tooth color space. It is based on the three-dimensional color model and is currently the only commercialized toothguide able to scientifically determine shades by selecting each of the three dimensions of color individually, following the order of value or lightness, chroma and hue. One of its advantages is that it represents color within a three-dimensional space based on the perception of individual color. This color system is the one used by the American Dental Association, and is also the basis for current tooth guides and electronic spectrophotometers. The 3D Master System has color samples featuring equidistant distribution in the color space in accordance with scientific principles, which according to the manufacturer adds greater precision to shade matching if properly handled. However, the 3D Master System has advantages regarding spatial distribution, affording less coverage error in comparison with the Vita Classical toothguide.<sup>17,18</sup> The system comprises the 26 physical colors of the 3D Master Toothguide plus the so-called intermediate shades, which are not represented physically. With these intermediate shades, the system comprises more than 75 colors. By mixing the 26 colors of the 3D Master Toothguide, some intermediate shades can be obtained, for example 4.5M3, 3R2, 1.5M1.5, 2.5L2.5. These intermediate shades can only be obtained through spectrophotometric measurements, since there is no physical representation of them in the 3D Master Toothguide (Fig. 1).<sup>5</sup> Five different levels of lightness are used to create 5 groups of shade tabs, from 1 (the lightest) to 5 (the darkest). There are 3 chroma levels, from 1 (the least chromatic) to 3 (the most chromatic) in each group. Chroma levels (1.5 and 2.5) in groups 2, 3 and 4 are associated with hue variations-L (yellow) and R (redder). By using this toothguide, the dentist first selects the lightness, then the chroma, and finally the hue.<sup>19</sup> Consequently, each color is determined by a number (value), a letter (hue), and a number (chroma), such as 2M3, where 2 represents lightness, M represents hue, and 3 represents chroma.

Most authors have studied the natural dentition in different populations by means of the L\*, a\* and b\* coordinates<sup>20-26</sup> but without reporting their results in a nomenclature that is more familiar to dentists: the shade tabs of toothguides.

Other authors have studied the 3D Master Toothguide



Fig. 1. 3D Master Toothguide.

via its color coordinates<sup>5,8,27-32</sup> but few studies have used toothguides to focus on the most frequent natural tooth colors in different age and gender groups.<sup>17,30-32</sup>

It has been reported that the color of natural teeth becomes darker over time<sup>22,33,34</sup> and that men generally have darker teeth as compared to women,<sup>35-37</sup> although the degree of relation and change with the shade tabs systems has not yet been assessed.

Subjective choice of natural tooth color may be made more systematic and ordered by performing a visual comparison with the most frequent shade tabs according to age and gender group. Knowledge of the objective distribution of natural tooth shades according to age group and gender may be a useful method in shade selection, particularly for inexperienced operators.

Unfortunately, only limited scientific information is available concerning the frequency of natural tooth color according to the shades tabs of 3D Master Systems. The present study was designed to identify the most frequent tooth colors from among a sample of Spanish participants using the Easyshade Compact (Vita-Zahnfabrik) spectrophotometer, analyzing different age and gender groups, according 3D Master System.

## MATERIALS AND METHODS

The study was based on the measurement of the natural tooth color of 1361 maxillary central incisors of Caucasian Spanish participants (671 men and 690 women) aged between 16 and 89 years and distributed homogeneously according to gender and age. All participants were asked to read and sign an informed consent form for participation in the study, which was approved by the Research Ethics Committee of the San Carlos Clinic (Madrid). The Research Ethics Committee of the San Carlos Clinic (Madrid) gave a

positive evaluation of the protocol used in this study; that is, it met the standards of good clinical practice. All participants were asked to read and sign an informed consent form for participation in the present study. One clinician (a woman of 30 with 8 years of experience, initials CGP) made the measurements with the same spectrophotometer (Easyshade Compact; Vita Zahnfabrik) with a standardized protocol for color evaluation. The examiner was instructed in the theory and practice of the use of the Easyshade compact over two days. Thus, the clinician collected data from different places and indeed a large part of the Spanish territory was covered. All the participants were evaluated at the Department of Prosthodontics, School of Odontology, Complutense University of Madrid, Spain.

The spectrophotometer had previously been subjected to reliability and validation tests to evaluate its temporary stability and inter-examiner reliability. All recordings were made in the same room under D65 daylight fluorescent tubes with a luminescence intensity of between 1200 and 1500 lux. The upper central incisor has frequently been used to assess tooth color, as a representative of an individual's natural tooth color.<sup>36,38</sup> The natural maxillary central incisors of the participants were healthy, with no restoration and no artificial whitening, and were cleaned before their color was measured. Before the recordings were made, a hygienic protector was placed on the probe tip (5 mm in diameter), and the lamp was calibrated according to the manufacturer's instructions. After calibration, the probe tip was placed in contact with and perpendicular to the middle third of the facial surface of the tooth.

Color was determined on the middle third of the tooth, which is the area that best illustrates tooth shade.<sup>39,40</sup> Measurements were made in Single Tooth mode with Easyshade compact spectrophotometer (Fig. 2). The color of the patient's clothes was neutralized with a gray cloth.<sup>41</sup> Following the manufacturer's instructions, the first result that matched twice was recorded in the 3D Master System as one of the 26 physical shade tabs (for example, 2M3, 4L2.5) or as an intermediate shade (for example 4.5M3, 3R2). As can be observed in Fig. 2, the resulting color in this case was 4.5M3. The CIELCH coordinates for the anterior teeth measurements have been published in a previous study that used the same color measurement protocol



**Fig. 2.** Screen of Easyshade compact for the 4.5M3 intermediate shade tab.

and total sample as in this study.<sup>8</sup> Accordingly, all the results obtained were objective and collected exclusively via the spectrophotometer. A personalized tooth positioner was not used because the total number of the teeth was too large (1361 teeth) and their shape was too varied. In order to determine the most frequent colors in the 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).<sup>42</sup> These groups were subdivided according to gender. Descriptive statistics were generated from the data with an analysis package (SAS 9.1.3 Institute Inc., Cary, NC, USA).

## RESULTS

To check the homogeneity of the sample in the age groups in both genders, the sample was divided according to the three different age groups addressed in this study (Table 1). The Chi-square test for homogeneity, with  $P > .05$ , revealed that there were no statistically significant differences in age

**Table 1.** Sampling distribution of the three age groups according to gender

Age groups	Distribution of the total sample			Total
	16 - 30 years	31 - 59 years	60 - 89 years	
Men	206	237	228	671
Women	217	249	224	690
Total	423	486	452	1361

groups or gender ( $\chi^2=0.353$ ; 2gl;  $n=1361$ ;  $P = .838$ ).

The color of 40% of the participants of this study had a match within the 26 colors of the 3D Master Toothguide, while 60% presented intermediate shade colors that were not physically represented in the toothguide. The spectrophotometer recorded a total variety of 75 colors, including so-called intermediate ones. The 3D Master Toothguide has a total of 26 physical shade tabs for natural teeth and 3 bleached tabs (0M1, 0M2, 0M3).

Table 2 summarizes the most frequent colors revealed by an analysis of the data for the total sample and for the three age groups in both genders. The most frequent color among all the participants was 3M1 (7.05%), followed by the intermediate shades 1M1.5 (6.91%), 2L1.5 (6.02%) and finally 2.5L1.5 (5.22%). When the sample was divided into age and gender groups, the most frequent color in men and women between the ages 16 and 30 years was 1M1.5; in older (60-89 years group) women it was 3M1, and in older men it was 4.5M1.5 (Table 2).

In the group of men young individuals with ages between 16 and 30, the most frequent color was 1M1.5 (14.56%), followed by 1M2 (13.59%), with 1.5M1.5 (9.71%) in third place. For the group of young women, the most frequent color was 1M1.5 (21.66%), followed by 1M1 (13.82%) and then 2L1.5 (10.14%). Likewise, the intermediate age group and the older age group were analyzed. For the intermediate age group of men, the most frequent color was 3M1 (10.13%), followed by 2.5L1.5 (5.91%) and finally 3L1.5 (5.06). For the intermediate age group of women, the most frequent color was 2M1 (10.84%), followed 2L1.5 (10.04%), and finally by 3M1 (10.04%), the latter two with the same frequency. For the elderly age group of men, 4.5M1.5 was the most frequent color in 8.77%, followed by 4.5M2.5 in 7.89%, while the percentage corresponding to third position, 3M1, was 4.82%. In the group of women between 60-89 years, 9.82% had 3M1 as the most frequent color, followed by 2.5L1.5 (5.80%) and finally 3.5M1 (5.36%).

In Table 3, which shows the group of participants between 16 and 30 years, the most frequent value was 1 for both men (33.01%) and women (44.70%). In both genders, the most frequent hue was M, which was observed in 73.30% of men and 75.58% of women. The most frequent chroma for both genders was 1.5, which appeared in 37.38% of men and in 46.08% of women. Four participants (0.29%) had a natural tooth color with a lightness or value group of 0 or 0.5, which is outside the color range of natural teeth, although they had not undergone any bleaching treatment.

In Table 4, which shows the dimensions of color for middle-aged participants, the most frequent value was 3.5 for men (21.52%) and 2.5 for women (20.08%). In both genders, the most frequent hue was M, which was observed in 55.70% of men and 60.24% of women. The most frequent chroma in men was 1.5 (35.86%) whereas in women was 1 (38.96%), indicating that women teeth are less chromatic .

Table 5 shows the dimensions of color for elderly group participants. The most frequent value was 4.5 for men (23.68%) and 3.5 for women (22.32%), these values suggest that women have greater lightness than men. The hue that stood out above the rest was M, as in the other groups, with a percentage of 70.61% for men and 58.04% for women. The chroma 1.5 and 2.5 appeared with the same frequency in the men group (24.56%) and in the women group, the most frequent was 1.5 representing the 32.59% of the results.

Regarding hue in the total sample, the least frequent R group had 114 representatives (8.3% of the total sample). The most frequent hue was the M hue group, with 888 individuals: (65.3% of the total sample) followed by hue L, with 359 individuals and an associated percentage of 26.3%. Also, the chroma group 1.5 in the total sample was the most frequent with 482 participants (35.42%).

**Table 2.** Most frequent colors in 3D Master System, according gender and age group

Gender	Most frequent colors in 3D master system					
	Men (n = 671)			Women (n = 690)		
Age groups	16 - 30 years	31 - 59 years	60 - 89 years	16 - 30 years	31 - 59 years	60 - 89 years
Shade tab (Percentage)	1M1.5 (14.56%)	3M1 (10.13%)	4.5M1.5 (8.77%)	1M1.5 (21.66%)	2M1 (10.84%)	3M1 (9.82%)
Shade tab (Percentage)	1M2 (13.59%)	2.5L1.5 (5.91%)	4.5M2.5 (7.89%)	1M1 (13.82%)	2L1.5 (10.04%)	2.5L1.5 (5.80%)
Shade tab (Percentage)	1.5M1.5 (9.71%)	3.5L1.5 (5.06%)	3M1 (4.82%)	2L1.5 (10.14%)	3M1 (10.04%)	3.5M1 (5.36%)

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

		Value, hue and chroma groups according 3D Master system							
		Men 16 - 30 years				Women 16 - 30 years			
		F	P	AF	AP	F	P	AF	AP
Value	0	2	0.97	2	0.97	1	0.46	1	0.46
	0.5					1	0.46	2	0.92
	1	68	33.01	70	33.98	97	44.70	99	45.62
	1.5	38	18.45	108	52.43	33	15.21	132	60.83
	2	54	26.21	162	78.64	53	24.42	185	85.25
	2.5	28	13.59	190	92.23	19	8.76	204	94.01
	3	12	5.83	202	98.06	11	5.07	215	99.08
	3.5	4	1.94	206	100	2	0.92	217	100
Hue	L	39	18.93	39	18.93	51	23.50	51	23.50
	M	151	73.30	190	92.23	164	75.58	215	99.08
	R	16	7.77	206	100	2	0.92	217	100
Chroma	1	43	20.87	43	20.87	62	28.57	62	28.57
	1.5	77	37.38	120	58.25	100	46.08	162	74.65
	2	64	31.07	184	89.32	44	20.28	206	94.93
	2.5	10	4.85	194	94.17	8	3.69	214	98.62
	3	12	5.83	206	100	3	1.38	217	100

F=frequency, number of participants, P=percentage of frequency, AF=accumulate frequency, AP=accumulate percentage

**Table 4.** Distribution of value, hue and chroma groups according 3D Master system, in middle-aged group participants

		Value, hue and chroma groups according 3D master system							
		Men 31 - 59 years				Women 31 - 59 years			
		F	P	AF	AP	F	P	AF	AP
Value	1	5	2.11	5	2.11	19	7.63	19	7.63
	1.5	6	2.53	11	4.64	19	7.63	38	15.26
	2	33	13.92	44	18.57	71	28.51	109	43.78
	2.5	45	18.99	89	37.55	50	20.08	159	63.86
	3	46	19.41	135	56.96	41	16.47	200	80.32
	3.5	51	21.52	186	78.48	34	13.65	234	93.98
	4	28	11.81	214	90.30	9	3.61	243	97.59
	4.5	20	8.44	234	98.73	6	2.41	249	100
	5	3	1.27	237	100				
Hue	L	73	30.80	73	30.80	74	29.72	74	29.72
	M	132	55.70	205	86.50	150	60.24	224	89.96
	R	32	13.50	237	100	25	10.04	249	100
Chroma	1	64	27.00	64	27.00	97	38.96	97	38.96
	1.5	85	35.86	149	62.87	91	36.55	188	75.50
	2	49	20.68	198	83.54	38	15.26	226	90.76
	2.5	28	11.81	226	95.36	18	7.23	244	97.99
	3	11	4.64	237	100	5	2.01	249	100

F=frequency, number of participants, P=percentage of frequency, AF=accumulate frequency, AP=accumulate percentage

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

		Value, hue and chroma groups according 3D master system							
		Men 60 - 89 years				Women 60 - 89 years			
		F	P	AF	AP	F	P	AF	AP
Value	1	5	2.19	5	2.19	4	1.79	4	1.79
	1.5	1	0.44	6	2.63	3	1.34	7	3.13
	2	8	3.51	14	6.14	25	11.16	32	14.29
	2.5	20	8.77	34	14.91	39	17.41	71	31.70
	3	32	14.04	66	28.95	49	21.88	120	53.57
	3.5	51	22.37	117	51.32	50	22.32	170	75.89
	4	32	14.04	149	65.35	18	8.04	188	83.93
	4.5	54	23.68	203	89.04	28	12.50	216	96.43
	5	25	10.96	228	100	8	3.57	224	100
Hue	L	51	22.37	51	22.37	71	31.70	71	31.70
	M	161	70.61	212	92.98	130	58.04	201	89.73
	R	16	7.02	228	100	23	10.27	224	100
Chroma	1	38	16.67	38	16.67	60	26.79	60	26.79
	1.5	56	24.56	94	41.23	73	32.59	133	59.38
	2	40	17.54	134	58.77	41	18.30	174	77.68
	2.5	56	24.56	190	83.33	36	16.07	210	93.75
	3	38	16.67	228	100	14	6.25	224	100

F=frequency, number of participants, P=percentage of frequency, AF=accumulate frequency, AP=accumulate percentage

## DISCUSSION

The limitations of this cross-sectional study may derive from the spectrophotometer used as well as from the populations selected. The present work is cross-sectional and descriptive, and the size of the sample is sufficient even though not all groups were of equal size owing to the population sampling system employed. The size of the present sample matches the minimum  $n$  required to meet the statistical conditions established in order to represent the Spanish population (confidence level 95.5%; accuracy 3% and  $p=q=0.50$ ). The deficiency lies not in the number of individuals included in the study, but in the actual composition of the sample, which does not represent the whole variability of the Spanish territory. Despite this, the results obtained do suggest that the approach used is sound. The works published on this issue have used a sample similar in size or even smaller than the present one to draw conclusions for different populations: the Southern-Eastern Asia population ( $n=162$ ),<sup>20</sup> the Buffalo population ( $n=501$ ),<sup>21</sup> the Japanese population ( $n=87$ )<sup>22</sup>; other works related to natural tooth color ( $n=195$ ),<sup>40</sup> ( $n=195$ )<sup>43</sup> and the Spanish population ( $n=600$ ).<sup>23</sup> The present sample is limited to a particular eth-

nicity group and as such our results cannot be generalized to other ethnicities.<sup>44</sup> Furthermore, this study did not follow each patient over time to observe the individual changes. Perhaps this would have been an improvement, especially if different variables were controlled and evaluated, i.e. smoking, the ingestion of different types of drugs, coffee or wine.

This “*in vivo*” investigation offers the advantage of capturing all possible 3D Master System shades based on objective spectrophotometric measurements. Shade matching by clinicians using the instrumental method affords greater consensus and is more effective than shade matching by clinicians using the visual method.<sup>45</sup> The 3D Master Toothguide afforded the lowest coverage errors as compared to the Vita Lumin Classical or Chromascop toothguide systems.<sup>17</sup>

Detailed analysis of the most frequent colors for each year of age seems to be unnecessary and not very informative, although with some exceptions, such that it is usual to use intervals of class or age groups, relating these to the gender of the individuals. The analysis by age groups is highly operational for the establishment of indicators and comparisons with other populations. Several authors have

divided the sample studied into different age groups,<sup>46</sup> while others have combined age groups and ethnic categories to report their results on tooth color.<sup>1</sup>

Good results of the Easyshade measurements in terms of the repeatability and accuracy have been reported in previous *in vitro* and *in vivo* studies.<sup>2,47</sup> Nevertheless, in 2002 Tung *et al.* reported that the widespread use of spectrophotometers in dentistry has been hampered by their complexity, their high price and, above all, the difficulty in measuring tooth color *in vivo*.<sup>48</sup> These devices are designed to measure flat surfaces, a necessary requirement for reliable measurements to be made. Spectrophotometers are designed for use on smooth surfaces, an essential condition for reliable measurements. In this sense, their use in dentistry is hindered by the convex surface of teeth, which complicates the correct placement of the spectrophotometer's probe tip. The probe tip of the Easyshade compact spectrophotometer captures roughly 25% of the color reflected back from the tooth surface measured.<sup>21</sup> It must be taken into account that the position of the spectrophotometer probe tip on the tooth surface is important when obtaining shade tab colors. Since no positioners were used for the participants, it was not possible to guarantee that the probe tip would always be repositioned in exactly the same place. The position of the probe tip of the spectrophotometer on the tooth surface is important when obtaining color shade. Here, only one person was responsible for data collection in order to minimize the inherent variability that arises when data are collected by several different people.

In 1998 Smith and Wilson reported that the most frequently chosen color was A3, followed closely by A2, C2, B2 and B3 according to the Classical Vita Toothguide<sup>32</sup>; data on the visual selection of shade for 2,500 metal ceramic crown were registered. These results match the brown-reddish hues A3 and A2. Furthermore, shades in the reddish-grey range of hue were rarely chosen (D group in Vita Classical Toothguide).<sup>32</sup> The results of the present study are not completely the same, since we used spectrophotometry and 3D Master Toothguide. The most frequent natural color was 3M1 in the overall sample studied. Moreover, 3M1 was the most frequent tooth color in middle-aged men and in women from the elderly group. Recent research has attempted to relate the 16 colors of the Vita Classical Toothguide and the 26 colors of the 3D Master Toothguide by means of conversion tables without adding a clinically significant error,<sup>49,50</sup> although these tables for conversions between the two guides have not been ratified by the manufacturer, Vita Zahnfabrik. Coding the present results to the Vita Classical toothguide has the advantage of using a chromatic code that corresponds to the gold standard of toothguides. Although the 3D Master Toothguide offers improved shade-matching performance, many dental materials are only available in Vita Classical shades. Nevertheless, it is preferable to perform direct measurements on the surface of the tooth and not to use conversion tables, which involve an associated error.

In 2007, Bayindir *et al.*<sup>17</sup> measured the maxillary central

and lateral incisors and canines of 120 North-American subjects between 18 and 85 years of age with a spectroradiometer in 4 ethnic groups, and revealed that the most common colors were D3 (Vitapan Clasica), 410 (Cromascope) and 3R1.5 (3D Master Toothguide). This may be related to basic differences in tooth shade among the different population groups. By contrast, the present results for a Spanish population indicate that 3R1.5 was represented by only 0.22%. In addition, for all toothguide systems together, the most common color was 4R1.5.<sup>17</sup> They recruited their sample into 5 age groups, 18-29 years, 30-39 years, 40-49 years, 50-59 years, and 60-85 years, and found an interaction between age and the toothguide systems, which shows that each age group might not be weighted the same. Although the criteria for inclusion in the trial of Bayindir *et al.*<sup>17</sup> and those of the present study are similar, the main differences lie in the fact that those authors measured three teeth, used a spectroradiometer, and used a smaller sample size.<sup>17</sup>

The present results are not in agreement with those of Smith and Wilson<sup>32</sup> nor with those of Bayindir *et al.*<sup>17</sup> This may be due to basic differences in the hue of teeth among different population groups,<sup>17</sup> the different measuring devices and different age groups studied. The most frequent color in the sample analyzed here was 3M1 in 96 participants and a percentage of 7.05%, followed by 1M1.5 in 94 participants and a percentage of 6.91%. If natural tooth color frequency is studied based on gender only in the total sample, the results are 1M1.5 (8.84%) for women, and 3M1 (6.26%) for men.

In 2004 Baltzer and Kaufmann-Jinoian<sup>30</sup> reported that the most frequent value group was 3, in 50%, followed by value group 2, in 26%, and value group 4, in 20%. The results of this study do not confirm these findings either in terms of percentage or order. According to this study, the most frequent value or lightness group is 2, represented by 17.93% of the population, followed by value group 2.5 in 14.77%, and finally value group 1, in 14.55%. The most noticeable difference is in value group 1, since Baltzer and Kaufmann-Jinoian<sup>30</sup> reported that the percentage associated with it was 2%, while in this study it was 14.55%.

In 2012, Rodrigues *et al.*<sup>31</sup> studied the natural tooth color of maxillary central incisors with male and female subjects categorized in four age groups (total sample n=400): 15-25, 25-35, 35-45 and above 45 years. Although the inclusion criteria were similar to those employed here, the main difference is that the choice of color was based on a subjective comparison and those authors did not use electronic devices. Rodrigues *et al.*<sup>31</sup> found that in nearly all age groups, regardless of whether the individuals were men or women, the most common shade for the maxillary central incisors using the 3D Master Toothguide was 2R2.5. Thus, the study failed to reveal a statistically significant correlation between shade differences in both genders. The findings in all the above age groups are similar to those reported by Smith and Wilson.<sup>32</sup> The variation in both results can be explained by the fact that color perception is an individual phenomenon, and it varies with the quality and quantity

of light, the color of the surroundings, the observer and the object. Hue R appears as the most frequent in all age groups.<sup>31</sup> By contrast, here, hue R was the least common, with a percentage of 8.3% (n=114).

Men generally have darker teeth than women.<sup>15,35,37</sup> This study revealed that 1M1.5 was the most frequent natural tooth color in both men and women in young group. By contrast, in the intermediate and elderly age groups value or lightness in the most frequent natural color was higher in women than in men. It is also known that teeth become significantly darker with age. In the present study, it was noted that the 3D Master system had the greatest variety of colors, the variations in colors between adjacent shade tabs being highly suitable.

Upon analyzing the most frequent colors in men in the three age groups it may be seen that a decrease occurs in the lightness of the color, changing from 1M1.5 (young group) to 3M1 (middle-aged group) and to 4.5M1.5 (elderly group). It is also seen that hue M persists and that chroma is similar. On analyzing the group of women, the most frequent color changes from 1M1.5 (young group), to 2M1 (middle-aged group) and to 3M1 (elderly group). As in the case of men, hue and chroma remain almost unmodified. It may be deduced that both the men and women in the younger age group share the initial color (1M1.5) but in the older age group the most frequent colors in men are less luminous than those corresponding to women. Here, caution must be exercised because the present study was a cross-sectional one.

Cross-sectional studies are useful for investigating large population groups at a given moment in time without the risk of the sample population falling off over time. They also offer the advantage of being able to generate working hypotheses that can be checked in later studies. Cross-sectional studies are widely used since they are cheaper than longitudinal studies, which require follow-up over time. However, one of their disadvantages is that they do not allow a temporal relationship of either cause or effect to be established. Despite this, they do represent a valid methodology to gain an approximate idea of the natural change in tooth color. This preliminary cross-sectional work aimed at exploring the most frequent natural tooth color associated with age-gender groups, and offers some working hypotheses for future work. In order to identify the most revealing data, it would be advisable to carry out longitudinal studies and spectral measurements on representative samples at different moments, with different ethnic categories and similar age groups, as well as to include the behavioral variables associated with the participants. Subjective choice of natural tooth color may be made more systematic and ordered by performing a visual comparison with the most frequent shade tabs according to age and gender group. Knowledge of the objective distribution of natural tooth shades according to age group and gender may be a useful method in shade selection, particularly for inexperienced operators.

## CONCLUSION

According to the methodology followed, and in spite of the limitations of this study, it can be stated that the most frequent color in Spanish population is 3M1. The most frequent hue according to the 3D Master Toothguide is M. The most frequent chroma is 1.5 and the most frequent value is 2.

## ACKNOWLEDGEMENTS

The authors wish to thank José Manuel García de Cecilia and Carmen Bravo, for his support and professional assistance with the statistical analysis. We thank to Prof. Dr. Nic Skinner for editing English.

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