In Vivo Evaluation of the Color of Anterior Primary Teeth

R. Meera, BDS Joshua Shieh, BDS
M.S. Muthu, MDS, PhD

ABSTRACT

Purpose: The purpose of this study was to evaluate the color of anterior primary teeth.
Methods: A total of 449 teeth (including central and lateral incisors) belonging to 78 3- to 6-year-olds were evaluated. A spectroscope was used to determine tooth color. Each tooth's overall shade and the respective shades in the cervical, middle, and incisal thirds were measured, and data collected was subjected to statistical analysis.
Results: D2 was found to be the most common shade of primary teeth. Comparing B1, D2, and C1 shades using a chi-square test showed statistically significant (P<.001) differences among children.
Conclusions: D2 was the most common shade of primary anterior teeth in children.
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The phenomenon of color is a combination of the psychophysiological response to the physical interaction of light energy with an object and the subjective experience of an individual observer.[1] Three factors influence the perception of color: (1) the light source; (2) object being viewed; and (3) observer viewing the object.[2] Color also can be described in terms of: hue (attribute of a color that enables one to distinguish between different families of color); value (which indicates the lightness of a color); and chroma (which describes the strength, intensity, or vividness of a color).[3] Although a color range of natural teeth has been reported by several investigators,[4-6] a reliable database of tooth color of the primary dentition does not currently exist.

The color of primary anterior teeth plays a vital role in the facial esthetics of children. Both adults and children evaluate children differently based on physical attractiveness.[7,8] In fact, children as young as 3-years-old are able to distinguish between attractive and unattractive peers.[9] Attractiveness of the dentofacial area contributes to the face's total attractiveness.[10] In a young child, primary anterior teeth—particularly the maxillary anterior teeth—are said to have a key impact on facial esthetics.[11]

Hosoya evaluated the color of primary anterior teeth of 60 Japanese children via various measuring devices and found them to be very light.[12] A comparison of 4 shades from 4 different shade guides with primary teeth color of African American, Caucasian, and Hispanic children has revealed significant differences among the shades of teeth among different ethnic groups.[13] Kim et al., evaluated primary anterior teeth using an intraoral spectrophotometer and observed color variations among different tooth types.[14] Various studies have evaluated parental satisfaction regarding the bonded resin strip crowns,[15] esthetic anterior primary crowns,[16] and anterior stainless steel crowns.[11] The results of these studies have revealed that they are esthetically unacceptable in spite of being effective restorations[14].

Various efforts have been made to find an effective method (either subjective or objective) to measure the color of a tooth to provide the best possible shade match of the restorative material. Many anterior restorations in clinical practice are regularly carried out with the help of a shade guide to select the matching color. A manual shade guide is composed of a set of shade tabs intended to cover the range of colors present in the human

Dr. Meera is junior lecturer, Department of Orthodontics, Dr. Shieh is postgraduate student, Department of Periodontology, all at Meenakshi Ammal Dental College, Chennai, India and Dr. M.S Muthu is professor and head, Department of Pediatric Dentistry, Saveetha Dental College and Hospital, Chennai. Correspond with Dr. Meera at drmeeraramaswamy@gmail.com

dentition. The successful achievement of a clinically acceptable color match between a given tooth and a shade tab is closely related to the spectral coverage of the shade guide, clinician's experience,[17] and viewing conditions.[18-20]

Numerous reports have indicated that common shade guides do not provide sufficient spectral coverage of the colors present in teeth.[21-25] Generally, the shade tabs do not appear to have enough yellow-red hue and are also not sufficiently dark or saturated. This inability to represent the color spectrum of teeth, coupled with non-ideal viewing conditions,[26] could lead to a significant mismatch between tooth color and restoration color. Hence, color measurements taken directly in the mouth and subjective comparisons between paper tabs and porcelain and acrylic tooth color guides may have limitations. Objective evaluation of the tooth color independent of viewing conditions and examiner experience has been carried out with spectrophotometers,[27-29] colorimeters,[30-32] film-based photography,[33] digital photography,[34] and intraoral spectrophotometers.[14]

The color of human teeth is generally not uniform throughout the crown, but shows a gradation from the gingival to the incisal region. No study has so far reported the gradations from gingival to incisal region in primary teeth. Lack of understanding and research in these gradations of color of primary teeth has resulted in the availability of few shades of restorative materials for primary teeth. Hence, the present investigation was undertaken to measure the color of natural primary maxillary and mandibular incisors in vivo using a SpectroShade (MHT International, Newton, Pa). The SpectroShade is a comprehensive optic shade communication system that can accurately and consistently measure shades of teeth. The most common shade of the primary incisors and the variations in shade in different regions—namely the cervical, middle, and incisal—were documented.

METHODS

STUDY DESIGN

This investigation was approved by the Review Board of Meenakshi Ammal Dental College and Hospital. Upon verbal consent from the school and parents, 2- to 5-year-old boys and girls were recruited for the study, which was conducted at Meenakshi Matriculation School, Maduravoyal, Chennai, India. A total of 160 children were screened, and 78 children were recruited for the study.

Excluded from the study were any children who had: no healthy anterior teeth to complete the assessment; restored anterior teeth; anterior teeth near exfoliation; white spot lesions on the labial surfaces of anterior teeth; anterior teeth discolored due to trauma; any single tooth that was obviously discolored for any other reason.

All children considered for the study were of Indian origin. After the exclusion, the teeth considered for the study were 449 primary incisors. The teeth were divided into 4 groups: (1) maxillary central incisors; (2) maxillary lateral incisors; (3) mandibular central incisors; (4) and mandibular lateral incisors.

IMAGE ACQUISITION

Each tooth's facial surface was cleaned with wet gauze before measurement. The MHT Spectroshade was used to capture the teeth images. This device consists of a base and a handpiece with a mouthpiece and a digital screen. The mouthpiece was required to be placed at a 90° angle to the teeth and the gingiva. Barrier strips were used on the mouthpiece for every patient. After retracting the lips, the images were captured. Before the next image was captured, the device had to be calibrated on a white and green tile by placing it on the base of the device to capture the surrounding light. This minimized the chances of mismatch and errors due to environmental light affecting the shade determination. The images were captured and shade analysis was done.

SHADE ANALYSIS

The overall shade of a particular tooth and the shade of the incisal/middle/cervical region were determined by selecting that particular tooth/or a specific region of the tooth (incisal/middle/cervical) on the screen of the spectroscope. The shade reading obtained was captured against the VITA classic shade guide system chosen from the options available on the spectroscope. The recordings were tabulated into 2 categories: (1) overall shade of anterior primary teeth; and (2) shades at the incisal, middle, and cervical thirds of the teeth.

DATA ANALYSIS

The data were analyzed and the chi-square test was performed to compare the overall shade of anterior primary teeth among the 4 groups and shade differences at the incisal, middle, and cervical thirds of the teeth. A *P*-value of <.05 was considered to be statistically significant.

RESULTS

Tables 1 to 3 present the readings of all 449 teeth that were categorized into 4 groups following the assessment for eligibility. The mean age of the 78 participating children was 4.5-years-old.

Table 1 shows D2 to be the most common shade among maxillary central incisors (~47%), maxillary lateral incisors (~86%), and mandibular lateral incisors (~68%). B1, however, was found to be the most common shade among mandibular central incisors (~62%). The chi-square test showed a statistical significance (P<.001) among shades D2, B1, and C1 between the 4 groups of teeth.

ASSESSMENT OF SHADE AT CERVICAL, MIDDLE, AND INCISAL SITES

Tables 2 and 3 show the reading at the cervical, middle, and incisal sites of the 4 groups of teeth. D2 was found to be the most common shade in the cervical, middle, and incisal thirds of teeth. The maxillary central incisor group,

TABLE – 1 Overall Shade of the Anterior Primary Teeth

GROUPS	A1		A2		B1*		B2		C1*		C2		C3		D1		D2*	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Maxillary Central Incisor	4	1.9	2	0.9	80	38.6	0	0	23	11.1	0	0	0	0	0	0	98	47.3
Maxillary Lateral Incisor	0	0	0	0	3	10.3	0	0	0	0	0	0	1	3.4	0	0	25	86.2
Mandibular Central Incisor	0	0	0	0	74	61.7	0	0	4	3.3	0	0	0	0	0	0	42	35
Mandibular Lateral Incisor	0	0	0	0	24	25.8	0	0	2	2.2	0	0	4	4.3	0	0	63	67.7

*Statistically significant difference was observed P = 0.000 (P<0.001 – 99.9% Sig).

TABLE - 2: Shade of Maxillary Central and Lateral Incisors in the Cervical, Middle and Incisal Third Regions

GROUPS	A1			A2			A3			B1			B2			C1			C2			C3			C4			D1			D2			D3		
	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I
Maxillary Central Incisor	2	5	103	2	1	8	1	0	0	66	79	47	0	0	12	54	20	6	0	0	0	0	0	0	1	0	0	0	0	2	81	103	25	0	0	3
Percentage (%)	0.3	0.8	16.6	0.3	0.2	1.3	0.2	0	0	10.6	12.7	7.6	0	0	1.9	8.7	3.2	1	0	0	0	0	0	0	0.2	0	0	0	0	0.3	13	16.6	4	0	0	0.5
Maxillary Lateral Incisor	0	0	4	0	0	0	0	0	0	9	3	4	0	0	0	1	0	3	0	0	0	1	1	0	0	0	0	0	0	0	18	25	11	0	0	7
Percentage (%)	0	0	4.6	0	0	0	0	0	0	10.3	3.4	4.6	0	0	0	1.1	0	3.4	0	0	0	1.1	1.1	0	0	0	0	0	0	0	20.7	28.7	12.6	0	0	8

C - Cervical, M – Middle, I - Incisal

TABLE - 3: Shade of Mandibular Central and Lateral Incisors in the Cervical, Middle and Incisal Third Regions

GROUPS	A1			A2			A3			B1			B2			C1			C2			C3			C4			D1			D2			D3		
	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I	C	M	I
Mandibular Central Incisor	25	0	20	3	1	3	0	0	0	36	57	60	0	0	0	7	4	13	0	0	0	0	0	0	2	0	0	0	0	1	44	58	22	3	0	1
Percentage (%)	6.9	0	5.6	0.8	0.3	0.8	0	0	0	10	15.8	16.7	0	0	0	1.9	1.1	3.6	0	0	0	0	0	0	0.6	0	0	0	0	0.3	12.2	16.1	6.1	0.8	0	0.3
Mandibular Lateral Incisor	3	0	5	3	0	0	0	0	0	7	18	27	0	0	0	18	2	4	0	0	0	3	5	3	0	0	3	0	0	0	46	68	46	15	0	3
Percentage (%)	1.1	0	1.8	1.1	0	0	0	0	0	2.5	6.5	9.7	0	0	0	6.5	0.7	1.4	0	0	0	1.1	1.8	1.1	0	0	1.1	0	0	0	16.5	24.4	16.5	5.4	0	1.1

C - Cervical, M – Middle, I - Incisal

however, showed a greater percentage of A1 shade at the incisal site. The chi-square test showed no significant difference at the cervical, middle, and incisal sites of teeth between the 4 groups.

DISCUSSION

The color of primary teeth appears to have a greater significance than traditionally believed.[14] Despite the existing reports on color range and shade guides for permanent teeth,[4,5] there is a great need for an objective evaluation of tooth color in primary teeth. The greater percentage of D2 shade in the primary dentition vs other studies reported was an unexpected finding in this study. According to Kim et al., A1, A2, and B1 are the most common shades in the primary dentition.[14] This variation in results could be attributed to a difference in the instrument used in the study or the ethnicity of the study participants. In the study by Kim et al., shades were assessed by a Vita Easyshade (Vident, Brea, Calif), which uses a pseudocircular measuring geometry.[14]

In our study, however, we used a MHT micro Spectro-Shade. This is an optic shade communicating system using Windows-based software to read the shade of teeth.[35] Furthermore, several authors have reported a difference in the shades of teeth among races.[36,37] Although a statistically significant difference was not observed between the shades at the middle, cervical, and incisal sites in our study, D2 was found to be the most common shade at the cervical and middle thirds of teeth. The incisal sites, however, especially among the maxillary central incisors, had a greater percentage of A1 vs other sites. This shade difference at the incisal sites can be attributed to several factors explained in literature.

The chromatic component of the optical properties can only compare areas of equal hues. While the same hues are frequently found in the middle and cervical thirds, distinct hues also can be identified at the incisal third due to the wavelength that is reflected, refracted, absorbed, or transmitted. Dentin and enamel have drastically different optical properties, and the relative contribution of each should be considered separately during shade determination. The incisal third of teeth has a greater amount of enamel than dentin. The degree of translucency or opacity is determined by the structure and thickness of enamel and dentin as well as the amount of light that penetrates the tooth. Although both enamel and dentine are translucent in natural dentition, the enamel layer is virtually transparent or colorless.

Opalescence occurs when visible light scatters. In the anterior teeth, this is observed in the incisal edges and the proximal incisal surfaces.[38] Goodkind et al., reported that a tooth has no single, uniform color.[5]

Though it's evident that teeth do not have a uniform color, the reasons for having no significant difference between the cervical, middle, and incisal sites could be attributed to 2 factors: (1) the decreased height of the primary teeth vs permanent teeth; and (2) the formation of secondary dentin in permanent teeth with advancing age. GoodKind et al., in fact, reported that the teeth get darker with advancing age.[5]

Despite the fact that the maxillary central incisors have a greater percentage of A1 shade compared to other teeth, it's evident from our study that mandibular central incisors have a greater value. Value is defined as the "brightness" of a color. In the Vita scale, a greater to lower value is seen with B1, A1, B2, D1, A2, through C4.[38] Goodkind et al., has also reported that maxillary anterior teeth are more yellow when compared to mandibular anterior teeth. In their study, however, the permanent maxillary central incisors have a greater value than permanent mandibular central incisors, which is in contrast to our study. There is no reliable database on the color of primary teeth with which to compare our results. This discrepancy in the overall shade when compared to the shade at the incisal sites can be attributed to the fact that the tooth's middle third best describes that tooth's color. The shades at the incisal and cervical thirds of the teeth are greatly affected by the background and neighboring tissues; hence, the middle third best represents the tooth color.[5]

A spectroscopic approach was chosen for the tooth color evaluation because it allows an objective assessment independent of viewing conditions and examiner experience. Spectroscopes measure 1 wavelength at a time from the reflectance or transmittance of an object and have been used to measure the visible spectra of extracted and vital teeth.[37] The subjective errors of manual shade guides are also eliminated by using a spectroscope. Although Clark introduced the concept of tooth color several decades ago, the exact restoration color is mismatched, even after evaluating the tooth color on the color scale. This leads researchers to adopt and perform more work on intraoral spectroscopes.[36]

Despite the fact that a spectroscopic approach was used for this study, a few potential concerns were identified. First, the size of primary teeth was not completely compatible with the frame size of the spectroscope; hence, 175 incisors were excluded from this study. Secondly, the shades were not recorded in our study, per the Commission Internationale de L' Eclairage (CIE) l*a*b* scale, which has been used in previous studies. Tooth-colored restorative materials available as of date for use, however, are not available in the CIE l*a*b* scale, but are available in shades like A1, B1, and A2.

Spectroscopes offer greater accuracy and precision than shade guides for color measurements. Yet, there are some practical limitations using these techniques. The common practical concerns are standardizations, cost, and ease of use in the clinical setting.[36] Hence, there is need for a specific, user-friendly, and objective method of evaluating the color of primary teeth to enhance esthetic restorations in children.

Several authors have reported dissatisfaction of parents and children with the color of bonded resin crowns. The only currently available material specific for primary teeth is P shade composite resin (3M ESPE, St. Paul, Minn). It is evident from the study, however, that one single shade will not satisfy the esthetic needs for all teeth. Hence, specific materials and shade guides for primary teeth of different races and groups are essential.

CONCLUSION

The most common shade for primary anterior teeth in children was found to be D2.

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