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Research / Araştırma Makalesi

Comparison of CIE94 and CIEDE2000 Color Difference Formulas Using Visual Shade-Matching

Görsel Renk Eşleştirmede CIE94 ve CIEDE2000 Renk Farkı Formüllerinin Karşılaştırılması

Mehmet GÜVEN[1] (ORCID-0000-0001-9531-5520), **Erdal EROGLU**[1] (ORCID-0000-0003-1446-0166), **Zeynep DEMİREKİN**[1] (ORCID-0000-0001-6717-8370)

[1]Süleyman Demirel Üniversitesi Diş Hekimliği Fakültesi Protetik Diş Tedavisi ABD, Isparta, Türkiye

[1]Süleyman Demirel University Faculty of Dentistry, Department of Prosthodontics, Isparta, Turkey

ÖZ

Amaç: Son yıllarda renk eşleştirme çalışmalarında temel referans olarak kabul edilen ΔE değerinin tespiti için kullanılan CIELab değerlerine dayalı formülasyon yerine insan gözünün renk algısını daha iyi yansıttığı düşünülen CIEDE2000 formülasyonunun kullanılması önerilmektedir. Bu çalışmanın amacı, görsel renk eşleştirmesinde CIE94 ve CIEDE2000 formülasyonlarının karşılaştırmalı olarak tekrarlanabilirlik ve güvenilirlik açısından incelenmesidir.

Gereç ve Yöntem: Araştırmaya yetmiş (70) diş hekimliği öğrencisi dahil edildi. Renk eşleştirme için 26 renk tablasından oluşan iki adet 3D-Master Diş Kılavuzu kullanıldı. Çalışma öncesinde, Vita EasyShade V spektrofotometre kullanılarak tüm tablaların orta 1/3 lük alanlarından ölçüm yapıldı. Tablaların L, a, b, c, H renk değerleri temel veri olarak kaydedildi. Tüm renk tablalarının birbirlerine yönelik ΔE değerleri tespit edildi. Çalışma için altı hedef renk (1M2, 2M2, 2R2.5, 3M3, 3L1.5, 4R1.5) belirlendi ve katılımcılardan hedef renk tablalarını örnek skaladaki tablalarla eşleştirmesi istendi. İşlem, standart ışık ortamı sağlayan bir renk kabininde gerçekleştirildi. Katılımcıların yaptığı eşleştirmelerin ΔE değerleri, tablaların önceden tespit edilen renk değerleri doğrultusunda CIE94 ve CIEDE2000 formülasyonlarına göre ayrı ayrı belirlendi. Bu yöntemlerin tekrarlanabilirliğini test etmek amacıyla bir ay sonra tüm katılımcılar için aynı renk eşleştirme protokolü tekrarlandı.

Bulgular: Yapılan çalışmada 1 ay sonra tekrarlanan ölçümlerde her iki yöntemde de (CIE94, CIEDE2000) kendi içlerinde hedef renklerin hiçbirinde anlamlı farklılık bulunamadı (p>0,05). CIE94 ve CIEDE2000 formülasyonları arasında ise ölçüm sonuçları ortalamalarında anlamlı farklılık görüldü (p<0,05).

Sonuç: CIE94 ve CIEDE2000 formülasyonları arasında anlamlı farklılık bulunmaktadır (p<0,05). İncelenen tüm metotlar tekrarlanabilir ve güvenilir bulunmuştur.

Anahtar kelimeler: Güvenilirlik, Tekrarlanabilirlik, Görsel renk seçimi, Renk kılavuzu.

ABSTRACT

Background: Today, the frequency of seeking an aesthetic smile in patients who apply to dentistry clinics has increased compared to the past. This expectation is fundamental in restorations in the anterior region, as well as shape, size, and proportion, as well as color harmony. One of the most challenging stages in prosthetic dental treatment is to find the natural and correct color for the planned restorations. This study aims to examine the most commonly used visual color matching and color matching using Vita 3D Master color guide in terms of CIE94 and CIEDE2000 formulations in comparison and to examine the repeatability and reliability of the methods.

Methods: 70 3rd-grade students who did not have color education clinically or theoretically as a curriculum were included in the study. The 3D-Master Tooth Guide with 26 tabs was used for color matching. Six target colors (1M2, 2M2, 2R2.5, 3M3, 3L1.5, 4R1.5) were determined, and an intraoral spectrophotometer was used for color measurements of the target tabs and all color guide tabs. CIE L*a*b* color coordinates were recorded to evaluate color differences for CIE94 and CIEDE2000. To test the reproducibility of this method, the same color-matching protocol was repeated for all participants after one month.

Results: In the study, no significant difference was found in any of the colors in both methods (CIE94 and CIEDE2000) in the measurements repeated one month later (p>0.05). There was a significant difference in the mean measurement results between CIE94 and CIEDE2000 formulations (p<0.05).

Conclusion: There is a significant difference between CIE94 and CIEDE2000 formulations (p<0.05). All the methods examined were found to be reproducible and reliable.

Keywords: Reliability, Repeatability, Visual color selection, Color Guide.

Introduction

Visual shade matching with today's color scales in dentistry consists of 3 basic steps. This; is the ability to determine the lightness, hue, and saturation accurately. VITA Classical and 3D MASTER shade guides are frequently used for visual shade matching in dental clinics.

Visual shade matching is entirely subjective (according to age, gender, eye condition, education, and experience), and the opinions of the same individual may change even for the same tooth over time.([1]) In addition to visual shade matching, today's technology allows us to match shade instrumentally. Thus, it is aimed at preventing errors and inconsistencies in shade matching. It will also be easier to clarify the information to be shared with third parties (other dentists, dental laboratory technicians, and dental assistants) in this way.

Color difference formulations are basic equations created to reveal the perceived color difference and quantitative color differences between two objects. The purpose of color difference formulas is to provide a better correlation between visual judgments (perceptibility and acceptability) and instrumental color difference values. Improved correlation is vital to provide essential clinical interpretation of color differences in dentistry.([2]) The International Color Commission (Commission Internationale de l ¤Eclairage - CIE) has introduced CMC, CIE94, and CIE2000 formulas over time to ensure the ideal color formulation.([3]) Each of these formulas attempts to improve the perceptual uniformity of the calculated color differences by decomposing the Euclidean distance in the CIELa*b* color space into components corresponding to lightness, hue, and color differences. These values are then recombined as a square of their weighted mean values. The color values depend on the position of the samples in the color space. The primary focus of research on improved color difference formulas is to improve perceptual uniformity.([4,5]) The primary color systems in color science define lighting patterns and color difference (ΔE) concepts.

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Sorumlu yazar/Corresponding Outhor: Mehmet GÜVEN
E-mail: dtmehmetguven@gmail.com
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Given the CIELa*b* color space (L: value axis; a*: red-green axis; b*: yellow-blue axis), ΔE_{ab} has been classically the standard parameter for the total color difference between two objects. The total color difference can be calculated by the formula ΔE. ΔE is a single value that considers the differences between the target color and the standardized L, a*, and b* values. If ΔE is outside the ideal range, it does not indicate which parameter causes it. It can also be misleading in cases where ΔL, Δa, or Δb is out of tolerance but ΔE is still within tolerance. The larger the value in the CIELa*b* metric, the more significant the color difference, and as a result, the more the difference can be perceived by the human eye.([6]) To minimize the differences between calculated and perceived colors, CIE recommends using the CIEDE2000 color difference formula so that the CIELa*b* color space is not uniform.([7]) CIE has proposed two CIELa*b*-based color difference formulas to reduce the difference between calculated and perceived color differences: CIE94 and CIEDE2000. Both include special corrections for non-uniformity of the CIELa*b* area (the weighting functions SL, SC, SH) and parameters (called parametric) that consider lighting and viewing conditions in evaluating color difference. In summary, five fixes for CIELa*b* were made in CIEDE2000: lightness (SL), color (SC), and tone (SH) weighting functions; added fixes for rotation and neutral colors.([8])

In their 2010 study, Paravina et al. reported that they found CIEDE2000 color difference formulations more successful than CIE94 color difference formulations regarding both acceptability and perceptibility. The researchers have proposed using the CIEDE2000 formulation in dental research and in vivo instrumental studies. They reported that the CIEDE2000 formula statistically improved performance against visual data.([3])

Lee conducted a study examining the effects of color difference formulations on dental composites used in restorative dentistry. In this study, ΔEab and ΔE00 value ranges were determined similarly. Therefore, he stated that with this new color difference formula, the problem of inconsistency between visual perception and instrumental techniques and color difference values could continue. The researcher states that the formula CIEDE2000 can be used to evaluate the color difference, as it has proven to be more compatible with validated data and observer pairings.([9]) Although these advantages of the CIEDE2000 formula have been reported in visual shade-matching studies, it is also observed that the CIE94 formula is still used in some recent studies.([10])

This study aimed to compare the ΔE values obtained by CIE94 and CIEDE2000 color difference formulations and to evaluate these formulations in terms of reliability and repeatability.

Material and Methods

This research was carried out at Süleyman Demirel University Faculty of Dentistry, Isparta, Turkey. The Ishihara Color Vision Test was administered to volunteer students (Colblindor. Retrieved 11/11/2022. https://www.color-blindness.com/ishihara-38-plates-cvd-test/#prettyPhoto, 2019). The volunteers were then evaluated for drugs that affected visual perception, and 70 people were included in the study. This research was approved by Süleyman Demirel University Isparta Faculty of Medicine – Turkey Ethics Committee with the decision numbered 171 on 11/07/2018.

1)Shade-Matching Protocol

To standardize environmental conditions in the shade-matching protocol, a shade-matching cabinet (LR-F009, Dongguan Lonroy Equipment Co. Ltd, China) with a color temperature of 6500K and a neutral gray background to standardize environmental conditions in the shade-matching protocol Equipment Co. Ltd, China) with a temperature of 6500K, a neutral gray background was used. Optical geometry (illuminator/imaging geometry) was 0/45. Luminous efficiency was assessed with a colorimeter (Sekonic colorimeter C-500 Prodigi Colo, Nerima-Ku, Tokyo, Japan) and a light meter (LX-1308 Light Meter, China) before each shade matching process.([11]) Visual shade matching was done between 10 - 12 am when the participants were not tired and nervous.([12]) Participants were admitted to the color selection booth a few minutes before the procedure to enable them to adapt to environmental lighting conditions.([13]) The research used two commercial shade guides (VITA Toothguide 3D-Master, VITA Zahnfabrik, Bad Sackingen, Germany).([2]) All participants were asked to match six target colors (1M2, 2M2, 2R2.5, 3M3, 3L1.5, 4R1.5) taken from a 3D Master Toothguide, with the shade tabs on the other 3D Master Toothguide. During operation, each carrier bar was placed in a plastic cap with the color code closed to hide the color codes found on the carrier bars of the target shade tabs. A total of 26 shade tabs were used for shade-matching, including a 3D-Master Dental Guide. There was no time limit for the shade-matching protocol.

The participants comprised 37 male and 33 female dentistry students aged between 20-22 (n=70). Before the study, participants were subjected to verbal and practical training on shade matching protocol. This group of participants performed the shade matching procedure in three steps as recommended by the manufacturer: a) determining the lightness value, b) choosing the chroma, c) determining the hue (http://firstchoicelab.com/wp-content/uploads/3d-shade-guide-instructions.pdf). The same shade-matching protocol was repeated for all participants one month later for repeatability evaluation.([14])

2)Determination of ΔE Values

An intraoral spectrophotometer (Vita EasyShade V, Vita Zahnfabrik, Bad Säckingen, Germany) was used for color value measurements of target tabs and shade guide tabs. The measurements were carried out so that all shade tabs in the shade guide were in the middle 1/3 area. A particular mold was produced so the measurements could be carried out in the same area each time (Figure). On this mold, which is compatible with the buccal face of the shade tabs, a hole large enough for the spectrophotometer measuring tip to enter (5mm diameter and depth) was prepared. This way, measurements were made from the same area of the shade tabs each time.

With the measurements made with the spectrophotometer, the CIE La*b*, C*, and h° color coordinates of each shade tab were determined. The same experienced researcher carried out all instrumental color measurements. The measurement processes were repeated three times, and each measurement result was recorded as primary data. These data calculated different color values for CIE94 and CIEDE2000 color difference formulations. After the shade-matching process, the ΔE values, the color difference values between the shade tabs and the target shade tabs matched by the participants, were calculated separately for the CIE94 and CIEDE2000 formulations. Two different ΔE values were obtained.

CIE recommends calculating ΔE value with CIE94 color difference formulation as follows;

$$\Delta E94 = \sqrt{\left(\frac{\Delta L'}{K_L S_L}\right)^2 + \left(\frac{\Delta C'}{K_C S_c}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2}$$

CIE recommends calculating ΔE value with CIEDE2000 color difference formulation as follows;

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{K_L S_L}\right)^2 + \left(\frac{\Delta C'}{K_C S_C}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2}$$

3)Statistical Analysis

The ΔE values were evaluated in terms of their groups' first-day and 30th-day results to determine the repeatability and reliability of the CIE94 and CIEDE2000 formulations, A comparison was made separately for each target shade tab to examine the difference levels of ΔE values according to CIE94 and CIEDE2000 formulation parameters. For statistical analysis, T-test, one-way, Anova, and post hoc tests were used.

Results

The ΔE values obtained using CIE94 and CIEDE2000 formulations according to repeated measurements (1st vs. 30th) are given in **Table 1**. The results indicate that the ΔE values calculated by CIEDE2000 color difference formulation after the shade matchings on the first day, there was no significant difference among the ΔE values in the target shade tabs 1M2-2M2, 2M2-4L1.5, 3L1.5-3M3, 3L1.5-4L1.5, 3M3-4L1.5. According to the ΔE value results calculated by CIE94 color difference formulation after the shade matching on the first day, there was no significant difference in terms of ΔE values among the comparisons between the target shade tabs 1M2-2M2, 2M2-3L1,5, 3L1,5-3M3, 3L1,5-4L1-5, 3M3-4L1,5 (**Table1**).

According to the results of the ΔE value calculated by CIEDE2000 color difference formulation after the visual shade-matchings made on the 30th day, no significant difference was found among the ΔE values in the target shade tabs 1M2-2M2, 2M2-3L1.5, 2M2-3M3, 2M2-4L1.5, 3L1.5-3M3, 3L1.5-4L1.5, 3M3-4L1.5. The ΔE value results calculated by CIE94 color difference formulation after shade matching on day 30 exhibit no significant difference in ΔE values among the target shade tabs 1M2-2M2, 2M2-3L1.5, 3L1.5-3M3, 3L1.5-4L1-5, 3M3-4L1.5 (**Table1**).

Table1. The ΔE values obtained using CIE94 and CIEDE2000 formulations according to repeated measurements (1st vs. 30th).

Color Difference Formulation		1st Day Measurement ΔE Values			30th Day Measurement ΔE Values		
		Mean.	Std. Deviation	P	Mean	Std. Deviation	P
CIE94	1M2	2.65^{d}	2.16	<0.001	2.59^{d}	2.31	<0.001
	2M2	2.93^{cd}	1.68		3.09^{cd}	1.57	
	2R2,5	5.89^{a}	2.45		5.71^{a}	2.83	
	3L1,5	3.80^{bc}	2.23		3.88^{bc}	2.41	
	3M3	4.40^{b}	3.59		4.14^{b}	3.68	
	4L1,5	4.66^{b}	3.61		4.06^{b}	3.36	
CIEDE2000	1M2	1.27^{d}	0.96	<0.001	1.31^{c}	1.08	<0.001
	2M2	1.47^{cd}	0.61		1.67^{bc}	0.75	
	2R2,5	2.75^{a}	1.10		2.73^{a}	1.23	
	3L1,5	1.90^{b}	1.10		2.01^{b}	1.24	
	3M3	2.14^{b}	1.82		1.96^{b}	1.83	
	4L1,5	1.86^{bc}	1.27		1.74^{b}	1.20	

*a,b,c,d; cells with the same letter value did not differ significantly in terms of ΔE value.

Of the ΔE values calculated using the color difference formulations used on the first and 30th day, the 2R2.5 shade tab showed significantly different ΔE values in each color difference formulation and repeated shade-matching evaluations in the other target shade tabs (**Table1**).

Both color difference formulations were evaluated internally between the 1st and 30th-day measurements of the ΔE values obtained by CIE94 and CIEDE2000 color difference formulations. There was no significant difference between the results obtained with these formulations and the measurement results repeated after one month. ($p>0.05$). Therefore, using both formulations was determined to be repeatable and reliable (**Fig.1**).

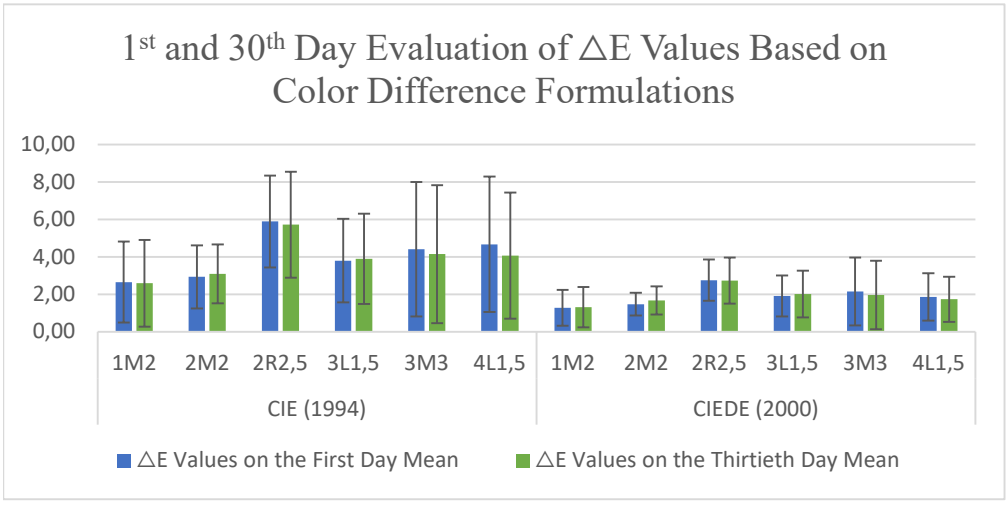

Figure 1. Evaluation of ΔE values on the 1st and 30th day depending on the color difference formulations.

Data comparing the color difference formulations used for the 1st and 30th day ΔE values according to the target color tables are given in **Table2**. The results show a statistically significant difference between the ΔE values obtained by CIE94 and CIEDE2000 color difference formulation in the visual shade-matching of the participants for the target shade tabs.

As shown in **Figure2** and **Figure3**, there was no significant difference between the CIE94 and CIEDE2000 color difference formulations and the ΔE values calculated on days 1 and 30 within the formulations themselves.

When the ΔE values obtained with CIE94 and CIEDE2000 color difference formulations were evaluated comparatively, a statistically significant difference was observed in the ΔE values determined for all shade tabs targeted for visual shade matching($p<0.05$).

Table2. Comparison of the differences in the color difference formulations used on the first day and the ΔE values on the 30th day according to the target shade tabs.

Target Color	Day	Color Difference Formulation		Mean Differences	Std. Deviation	Sig.
1M2	1st Day Measurement ΔE Values Difference	CIE94	CIEDE2000	1.3742*	0.3130	0.000
	30th Day Measurement ΔE Values Difference	CIE94	CIEDE2000	1.27338*	0.33935	0.000
2M2	1st Day Measurement ΔE Values Difference	CIE94	CIEDE2000	1.4587*	0.3532	0.000
	30th Day Measurement ΔE Values Difference	CIE94	CIEDE2000	1.41652*	0.31949	0.000
2R2,5	1st Day Measurement ΔE Values Difference	CIE94	CIEDE2000	3.1339*	0.4116	0.000
	30th Day Measurement ΔE Values Difference	CIE94	CIEDE2000	2.97758*	0.44759	0.000
3L1,5	1st Day Measurement ΔE Values Difference	CIE94	CIEDE2000	1.8906*	0.4900	0.000
	30th Day Measurement ΔE Values Difference	CIE94	CIEDE2000	1.87391*	0.48691	0.000
3M3	1st Day Measurement ΔE Values Difference	CIE94	CIEDE2000	2.2574*	0.5362	0.000
	30th Day Measurement ΔE Values Difference	CIE94	CIEDE2000	2.18117*	0.52999	0.000
4L1,5	1st Day Measurement ΔE Values Difference	CIE94	CIEDE2000	2.8084*	0.4560	0.000
	30th Day Measurement ΔE Values Difference	CIE94	CIEDE2000	2.32434*	0.44471	0.000

*. The mean difference is significant at the 0.05 level.

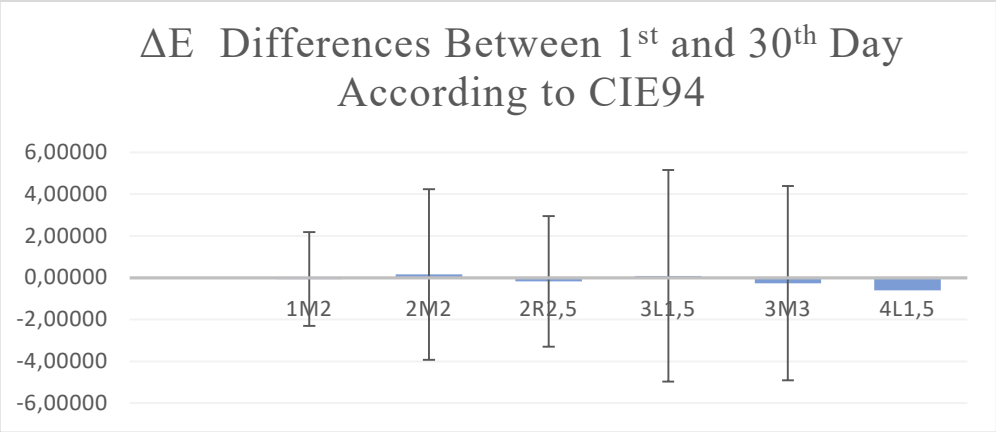

Figure2. Evaluation of the 1st day and 30th-day differences of ΔE values calculated with CIE94 color difference formulations.

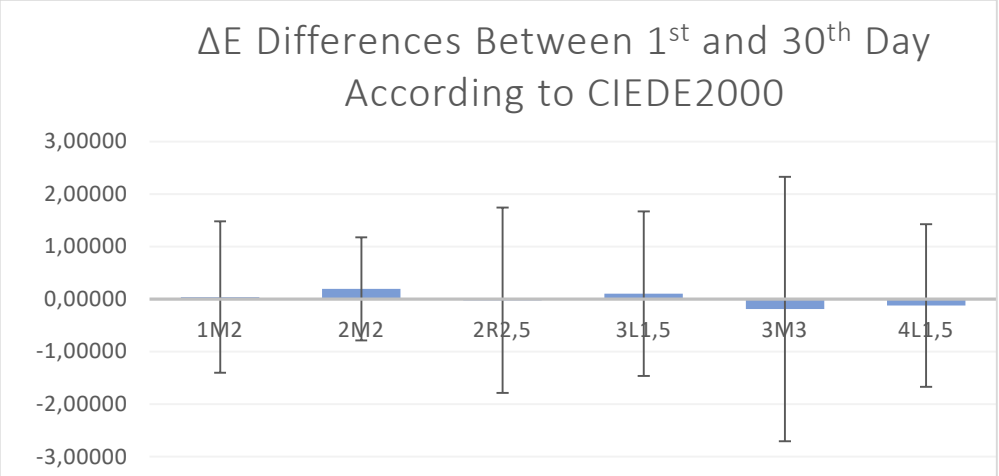

Figure3. Evaluation of the 1st and 30th-day differences of ΔE values calculated with CIEDE2000 color difference formulations.

Discussion

The primary purpose of color difference formulation development is to minimize the difference between the color perceived by the human eye from an object and the instrumentally determined color coordinates. The closer the ΔE value calculated by the color difference formulation is to 0, the more successful the color harmonies will be regardless of the area in which it is used (textile, industry, dentistry). The CIEDE2000 formula developed for this purpose has been the subject of many studies.

Thirty-seven women and thirty-three male women participated in this study. A previous study showed that gender, age, or ethnicity did not affect color choice or perception. However, our study aimed to keep the number of men and women and the ages of the participants (20-22) close to each other and to prevent the differences that may arise from gender and age differences. The 6500K is standardized to allow the color booth to be completely isolated and simulated so that light reaches the human eye at 11 o'clock. The neutral gray floor of the cabin interior prevents environmental eye illusions and eye fatigue.

Similarly, in studies where color difference formulations were examined, the color coordinate values of the target shade tabs were measured two times and recorded.([6]) In our study, each color tab in the color guide was measured three times, and the color coordinates were recorded. Thus, data loss, which is one of the biggest problems caused by instrumental color measuring instruments, has been tried to be prevented.([15]) The accuracy of the data obtained has been increased by producing an adaptation spacer to avoid edge losses that may occur due to the end of the spectrophotometer being round and flat surface and the teeth being oval. Thus, it is aimed at preventing color errors caused by data loss.

During the shade-matching process, it was seen that the participants had difficulty determining the lightness value, which is one of the basic steps of the shade-matching process. In later studies, an examination of lightness value pairings may be meaningful.

In their study, Paravina et al. found that the Linearguide 3DMaster shade guide provided significantly better shade-matching results than the Toothguide 3D-Master. They observed that both 3D-Masters shade guides exhibited significantly smaller ΔE values for the first ten matches than the Vitapan shade guide.([2]) Their study, which compares the shade guide tabs, clearly shows us the importance of ΔE value. In this present study, we used the Vita 3D-Master shade guide to evaluate the ΔE value among CIEDE2000 and CIE94 color difference formulations. Statistical findings suggest that both color difference formulations are repeatable and reliable. In the ΔE average values obtained from the pairings made on the 1st and 30th days, it was seen that the color difference formulations did not differ significantly within themselves. Even if there was no significant difference between the first day and the 30th day in themselves, the results closer to 0 were obtained in all target shade tabs from the ΔE values obtained with CIEDE2000 for all target shade tabs than the ΔE values obtained with CIE94 for all target shade tabs.

In a similar study using four extracted upper-middle-incisor teeth, CIELAB and CIEDE2000 were used to calculate color differences. The study reported that neither formulation was 100% efficient, but the matches made with the CIEDE2000 formulation provided closer matching to visual perception([6]). In another study conducted with dental ceramics, a different material, it was seen that CIEDE2000 color difference formulation gave results closer to human color perception and was more harmonious.([3]) Our study was not conducted with dental ceramics. However, the results of our work are consistent with the results of the studies carried out by Ghinea et al. and Pecho et al.([3,6]) These current studies show that the use of CIEDE2000 color difference formulation can achieve results closer to the color perception of the human eye than the use of CIE94.

Adjustments to CIEDE2000 make a statistically significant difference. Corrections for chroma and tonal differences have improved the CIEDE2000 color difference formulation performance.([9]) In our study, in the matches and repetitive matching processes performed on all target shade tabs, the value calculated with CIEDE2000 color difference formulation was lower and closer to 0 than the value calculated by CIE94 color difference formulation. The CIEDE2000 color difference formulation showed statistically significant results that were closer to the color perception of the human eye than the CIE94 color difference formulation.

Conclusion

The study results show that the tested CIE94 and CIEDE2000 color difference formulations are repeatable and reliable in themselves but also support the use of CIEDE2000 color difference formulation in shade-matching protocols, which shows results closer to the color perception of the human eye.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu çalışma Selçuk Üniversitesi 3. Uluslararası Yenilikçi Diş Hekimliği Kongresi'nde (25-27 Kasım 2022, Konya, Türkiye) sözlü bildiri olarak sunuldu.

Çalışma herhangi bir tez çalışması değildir.

Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

This study was presented as an oral presentation at Selcuk University 3rd International Congress of Innovative Dentistry (25-27 November 2022, Konya, Turkey).

The study is not any thesis work.

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

ethic.selcukdentaljournal@hotmail.com

Finansman / Grant Support

Bu çalışma sırasında, yapılan araştırma konusu ile ilgili doğrudan bağlantısı bulunan herhangi bir ilaç firmasından, tıbbi alet, gereç ve malzeme sağlayan ve/veya üreten bir firma veya herhangi bir ticari firmadan, çalışmanın değerlendirme sürecinde, çalışma ile ilgili verilecek kararı olumsuz etkileyebilecek maddi ve/veya manevi herhangi bir destek alınmamıştır. | The authors declared that this study has received no financial support.

Çıkar Çatışması / Conflict of Interest

Bu çalışma ile ilgili olarak yazarların ve/veya aile bireylerinin çıkar çatışması potansiyeli olabilecek bilimsel ve tıbbi komite üyeliği veya üyeleri ile ilişkisi, danışmanlık, bilirkişilik, herhangi bir firmada çalışma durumu, hissedarlık ve benzer durumları yoktur.| The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: EE %40, MG %30, ZDB %30
Veri Toplanması | Data Acquisition: EE %40, MG %30, ZDB %30.
Veri Analizi | Data Analysis: EE %40, MG %30, ZDB %30
Makalenin Yazımı | Writing up: EE %40, MG %30, ZDB %30
Makale Gönderimi ve Revizyonu | Submission and Revision: EE %40, MG %30, ZDB %30

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