Review Article

Assessment of the Relationship Between Anterior Teeth Colour and Skin Colour by assessing different measurement tools in Adult Patients: A Systematic Review

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Abstract: Background: Previous research conducted since 1968 have extensively examined the correlation between tooth color and skin color. The purpose of these studies was to determine whether skin color could effectively influence dentists in choosing tooth color. The objective of this systematic review was to examine the methodologies employed in assessing the relationship between tooth and skin color, and to identify the most precise and dependable approaches for modeling and evaluating this relationship. The systematic review was registered in the PROSPERO (CRD42022356022). This systematic review was done on four databases using PRISMA 2009 search strategy, and selected studies were chosen according to PICO model. JBI Critical Appraisal Checklist was used for quality assessment. Out of 1611 articles that were found in the databases, 10 articles matched the criteria and were selected for this systematic review study. Three main methods were found in the 10 studies: conventional methods, digital methods, conventional-digital (mixed) methods. Digital methods were found to be the more reliable methods for color evaluation. Specific settings should be applied during digital color measuring methods. Conventional and digital assessment methods showed either a negative or a positive significant association between the color of teeth and skin. However, the combined method (digital for tooth and visual for skin) did not show any such relation. It is imperative to conduct and apply research in Artificial Intelligence to forecast tooth color based on knowledge of skin color.

Keywords: Tooth color, Skin color, Color measurement, Relationship modelling, Digital shade assessment.

Introduction

As one study stated, tooth color is a part of a picture in which the face is the frame, therefore, the tooth color should harmonize with the face color [1]. The association between the colour of teeth and skin has been the focus

of several scientific research. The first study that tested this relationship was done in Japan on 1968 [2]. After then, a plethora of studies utilizing various methodologies and materials looked at the connection between skin tone and tooth shade. Researchers have observed that the colour of a persons' teeth is inversely related to the colour of their skin. Furthermore, people who have darker skin tones may have teeth that are lighter than their facial complexion [3, 4].

A research conducted using the L*a*b* colour system, established by the Commission Internationale de l'Eclairage (CIE), has identified positive and significant correlations in colour spaces L* and a* between skin and teeth colour. Additionally, a significant inverted relationship has been observed in colour space b* between skin and teeth colour [5]. Despite this, there is still a paucity of information about the connection between tooth shade and skin colour [5].

Three different techniques have been used previously to assess tooth and skin colour. These approaches might be entirely conventional, fully digital, or a hybrid of the two. One of the methods that can be used for color selection is color matching using the naked eye. However, the studies showed that conventional shade matching is subjected to bias and less accurate compared to digital shade measurement [6]. Previous studies also showed that color is a result of light, therefore, the light condition can affect the quality and temperature of color [3]. Hence, light condition using different materials and methods while measuring skin and tooth color should be extremely considered and highlighted to achieve more precise and dependable outcomes. Several additional variables can influence the color measurements. such as calibration of eye/instrument, patient position during color assessment, and background condition [5]. For accurate color measurements, it is necessary to identify and manage these variables. Many studies failed to account for this, leading to flawed findings and unreproducible methods [5].

The knowledge of the connection between the colour of one's teeth and their skin can be useful in many different contexts. When it comes to the treatment planning of complicated aesthetically demanding cases, understanding the ideal match between the patient's skin tone and tooth colour might be beneficial [7, 8]. Researching the correlation between the colour of a persons' teeth and the colour of their skin may also help in the creation of innovative dental materials and technologies that enhance both the aesthetics and the practicality of dental restorations [5]. The objective of this systematic review is to present the parameters and methodologies employed in prior studies to assess the link between skin and tooth color, as well as the outcomes of this relationship. Furthermore, its objective is to address the most precise and dependable techniques employed to assess the association between skin and tooth color.

Review

Materials and Methods

Protocol registration

The present systematic review was registered in the PROSPERO International Prospective Register of Systematic Reviews (CRD42022356022).

Research Questions

- To investigate/ dissect what are the material and methods that have been used to investigate the relation between tooth color and skin color by previous researchers in adult patients?

- To investigate/ dissect what is the association between skin and tooth color by previous researchers?

Inclusion Criteria

This systematic review included all English, full text, in-vivo, and cross-sectional studies that were done on adults (18 years and above) to measure the association between skin and anterior teeth color.

Exclusion Criteria

Studies on patients 17 years old and below. Studies on dental material color evaluation or changes such as: composite, restorations, resin, acryl, cement, zirconia, porcelain, implants, ceramic, gingival color, blood, and silicon. Studies on the effect of orthodontics or endodontics treatments on tooth color, posterior teeth, and bleaching and tooth whitening articles. Studies on face detection using digital cameras. Studies on animals/plants/insects. In-Vitro studies and case reports and clinical notes. Non-English and non-full text articles

Search Strategy

The literature search strategy PRISMA 2009 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist was performed on all previous investigations that reported the association between skin and tooth color. Excel sheets (Microsoft® Excel® for Microsoft 365 MSO V. 2209) were used to record data, and Endnote X8.2 (Clarivate Analytics, Toronto, ON, Canada) was used to manage data. After receiving all search results, duplicates were eliminated using Endnote. After that, title screening was done using Microsoft Excel. This was followed by abstract screening and full paper review. The reviewers consulted after reading each article to preserve consensus. Papers have been reviewed for full analysis by both reviewers, and the reason(s) for exclusion has been reported.

Searching Databases and words

Four databases were used in this systematic review study: EBSCO (Articles on USM Library Collection (KRISALIS Discovery)), Scopus, MEDLINE/PubMed, and Web of Science® ISI Thomson Reuters databases. A literature search of publications from 1940 to September 2022 was carried out by two reviewers on the 19th of September 2022. The search results were evaluated separately by two authors and then were evaluated together. A systematic search of the available published literature was made possible by the search strategy as follows:

EBSCO: AB ("tooth" OR "teeth") AND AB "skin" AND AB ("color" OR "colour" OR "colors" OR "colours" OR "shade" OR "shades" OR "tone" OR "value")

SCOPUS: (TITLE-ABS-KEY ("tooth" OR "teeth") AND TITLE-ABS-KEY ("skin") AND TITLE-ABS-KEY ("color" OR "colour" OR "colors" OR "colours" OR "shade" OR "shades" OR "tone" OR "value"))

PubMed: (("tooth"[Title/Abstract] OR "teeth"[Title/Abstract]) AND ("skin"[Title/Abstract])) AND ("color"[Title/Abstract] OR "colour"[Title/Abstract] OR "colors"[Title/Abstract] OR "colours"[Title/Abstract] OR "shade"[Title/Abstract] OR "shades"[Title/Abstract] OR "tone"[Title/Abstract] OR "value"[Title/Abstract])

ISI/WOS: "tooth" OR "teeth" (Abstract) and "skin" (Abstract) and "color" OR "colour" OR "colors" OR "colours" OR "shade" OR "shades" OR "tone" OR "value" (Abstract)

Study selection

Two reviewers screened the records for inclusion independently and disagreements were resolved by a third reviewer. PICO model was used in review and selection of all studies that were reported on the association between skin and tooth color as follows:

P= adults above 18 years old.

I= (Measurement materials and methods) digital photography, spectrophotometer, categories of colors, or shade guide used for shade measurement of anterior teeth and skin color, patients' preparation and position, calibration, lights, background, and general settings (in vivo studies).

C= tooth and skin color.

O= the association between skin and tooth color.

PICO score was given for all studies in Excel sheets. Score of 0 and 1 were excluded from the review, and score 2 and 3 were carried out for abstract screening, and full text screening.

Data Extraction

One reviewer extracted the data, and another reviewer checked the extracted data. Disagreement was resolved by a third reviewer. The extracted data were as follows:

Authors and year of study, type of study, materials and methods (Age and population, type of measurement method (digital/conventional/mix), color measurement materials, and color measurement settings), reliability of instruments, reliability of method and categories, results and outcomes (Tooth color category or value (L*a*b* values, Lch values), and skin color category or value (L*a*b* values, Lch values), p-value/R2 result of relationship, relationship modelling and clinical significance.

Quality assessment

Two researchers performed the Quality assessment using the JBI Critical Appraisal Checklist for Quality Assessment of Analytical Cross-Sectional Studies for the selected studies in the present systematic review. The checklist had 8 questions. Out of the 8 questions, two questions were not applicable for this type of studies: 1. Have confounding variables been identified? 2. Were approaches to address confounding variables explicitly outlined? Hence, there were 6 quality questions were used. Any study had less than 4 Yeses were excluded from the systematic review. The reasons of excluding these studies were addressed in table 1.

Results

The search of EBSCO, Scopus, MEDLINE/PubMed, and Web of Science® ISI Thomson Reuters databases have resulted in 1611 articles. Duplication removal has been done on these articles and followed the process of title and abstract screening, and ultimately full text screening to end up with 12 selected articles that match the eligibility criteria (Figure 1).

Most of the excluded studies were non-dental studies, or not relevant to the present review topic, or not available in English language. After duplication removal and title screening, 37 studies were selected for abstract screening. However, 18 articles were excluded after abstract screening because the samples included participants younger than 18 years old, or the studies studied the prospection of aesthetic among participants. Finally, 7 more articles were excluded in full-text screening because either full text was not available, or samples included participants <18 years old. This led to the selection of twelve different articles.

An assessment of the studies' quality was provided in Table 1 for the 12 selected articles. Out of the 12 articles, two articles had less than 4 yeses therefore they were excluded [4, 9]. This systematic review eventually included 10 articles that met the selection criteria and passed the quality assessment (Table 1).

Table 1. JBI Critical Appraisal Checklist for Quality Assessment of Analytical Cross-Sectional Studies

Questions	Jahangiri, et al., 2002[10]	Hassel, et al., 2008[11]	Dosumu Oluwole, et al., 2010[12]	Nourbakhsh, et. al., 2013[4]	Lagouvardos, et al., 2013[13]	Al-Dwairi, et al., 2014[14]	Haralur, et al., 2014[15]	Vadavadagi, et al., 2016[16]	Susanty, et al., 2018[17]	Pustina-Krasniqi, et al., 2018[9]	Turker, et al., 2020[18]	Moazam, et al., 2022[5]
Were the criteria for inclusion in the sample clearly defined?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were the study subjects and the setting described in detail?	Y	Y	Y	UC	Y	Y	Y	UC	Y	Y	Y	Y
Was the exposure measured in a valid and reliable way?	Y	UC	Y	UC	Y	Y	Y	Y	UC	N	Y	Y
Were objective, standard criteria used for measurement of the condition?	UC	N	N	UC	Y	N	Y	UC	UC	N	Y	Y
Were confounding factors identified?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Were strategies to deal with confounding factors stated?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Were the outcomes measured in a valid and reliable way?	Y	Y	UC	UC	Y	Y	Y	Y	Y	UC	Y	Y
Was appropriate statistical analysis used?	Y	Y	Y	Y	Y	UC	Y	Y	Y	Y	Y	Y
Overall appraisal:	I	I	I	E	I	I	I	I	I	E	I	I
Comments (Including reason for exclusion)	-	-	-	Color measurements were described briefly with on details on categorization, measurement method, reliability, and there was a lack of important details.	-	-	-	-	-	There was no explanation on the method used to categorize and measure skin color.	-	-

Y: Yes, **N**: No
UC: Unclear, **N/A**: Not applicable
I: Included, **E**: Excluded
SFI: Seek Further Information.

EBSCO: n = 463
SCOPUS: n = 847
PubMed: n = 134
WOS: n = 167

Total search result: n = 1611

Total duplicated articles: n = 701

Results after duplication removal: n = 910

Deleting irrelevant titles: n = 873
Reasons: Articles on:
Dental material color evaluation or changing such as: composite, restorations, resin, acryl, cements, zirconia, porcelain, implants, ceramic, gingival colour, blood, and silicon.
Studies on the effect of orthodontics or endodontics treatments on tooth color and bleaching and tooth whitening articles. Studies on face detection using digital camera. Studies on animals/plants/insects. In-Vitro studies, review studies, non-English studies, and case report, clinical notes, and non-dental studies.

Results after Title Screening: n = 37

Deleting irrelevant Abstracts: n = 18
Reasons:
Included participants who are less than 18 years old. Study on patient's prospection of esthetic smile. Studies on plastic surgery. Studies on the association between ginigival and tooth color only. Studies on posterior teeth colour.

Results after Abstract Screening: n = 19

Deleting irrelevant Full texts: n = 7
Reasons:
Full-text not available (conference abstracts). The study included participants less than 18 years old.

Results after Full-text Screening: n = 12

Deleting low quality Full texts: n = 2
Reasons:
Full-text had low quality assessment

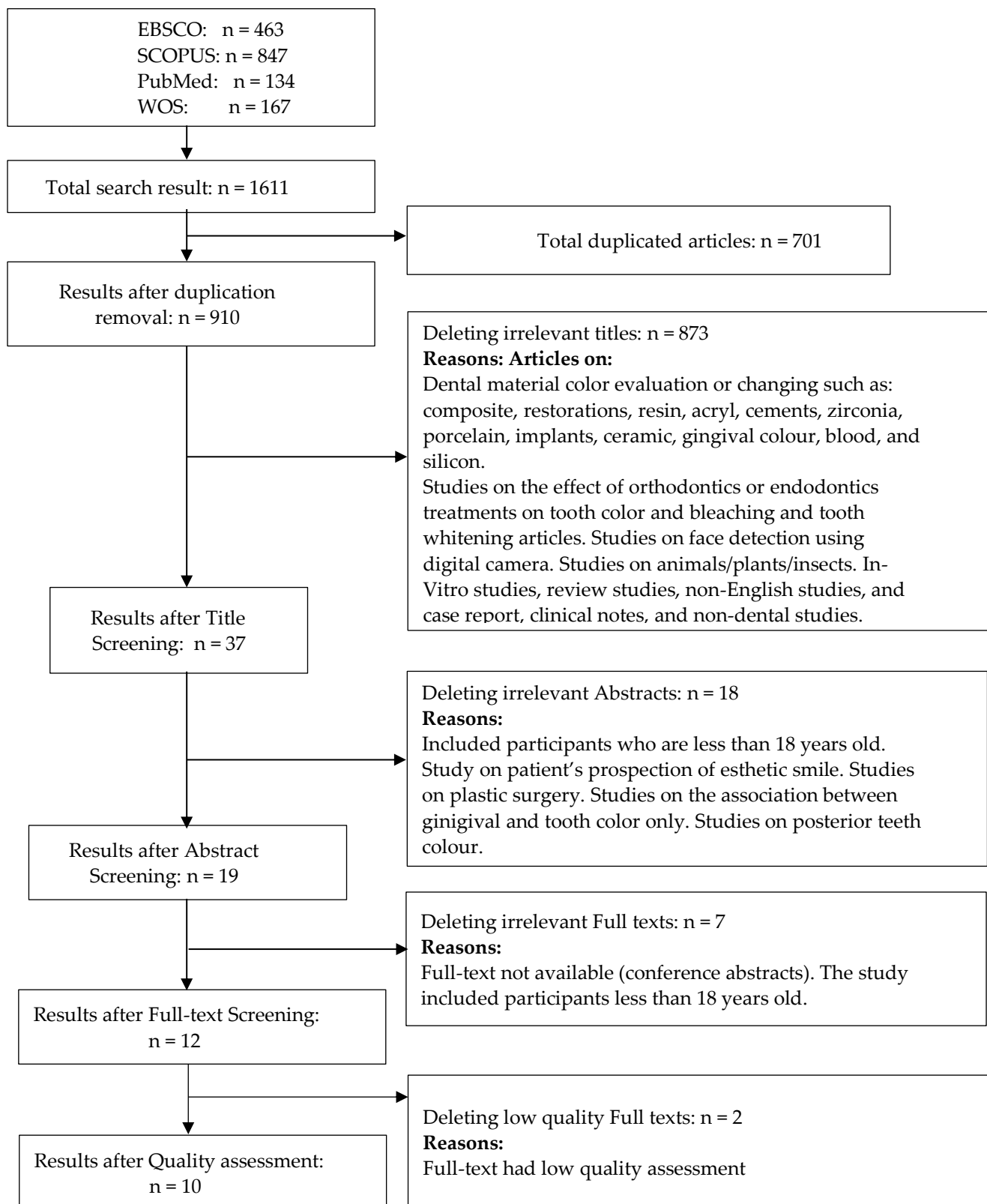Results after Quality assessment: n = 10

Figure 1. PRISMA Flow Diagram

Samples preparation

The patients were prepared for tooth color measurement before data collection in three ways: 1. Clinical tooth cleaning by low-speed brush and paste (tooth prophylaxis) [12, 15, 17, 18], 2. Cottons/ gauze/ dry sterile gauge to swipe teeth [11, 13], 3. Participants were instructed to diligently brush their teeth using a toothbrush and toothpaste for a duration of two to three minutes [5]. Some studies indicated tooth cleaning before color measurements with one day to two weeks [12, 18], others did the tooth cleaning just before the measurements [5, 11, 15, 17].

Participants were also asked to remove and wash gently any makeup including lipstick and sunscreen or accessories on the face like glasses [5, 12, 13, 15] before skin color measurements and selection. Some studies had their patients to stay in a normal room temperature between 23±2 C° [13, 15, 18]. The other studies did not consider the room temperature [5, 10-12, 17, 16, 18].

Inclusion and exclusion criteria

For inclusion criteria, all of the studies included maxillary anterior teeth with no fillings, caries, cavitations, restorations, braces, or bleaching on the measured teeth. On the other hand, smokers, systematically unhealthy participants, irritated/ inflamed skin, scared skin, tanned skin were the exclusion criteria.

Considerations and general settings

Agreement between examiners and reliability of measurements

The agreement between the examiners was used in visual shade matching which ranged between 92% and 96% [10]. That was done by using two examiners to select color and then find the agreement between the two examiners selections. On the other hand, digital shade measurement methods used Intraclass correlation test (ICC) to test the reliability of the measurements [5, 13]. That was done by measuring the color twice in each measuring sight and find the correlation between the measurement in each sight. The correlation in these selected studies ranged between 0.93 to 0.99 which indicates excellent reliability.

Light condition and background

The second factor was light condition during color selection/measurement and the color of the background. Natural daylight (sunlight) [10, 12, 14, 16] was used mostly in visual shade matching studies and the measurement was done after 30 minutes of noon time [14]. Two studies that used digital methods used soft boxes [5, 18] with light strobes that have color temperature of 5000K to 6500K [5]. The lights were positioned in a standard setting [5, 18] in a dark room [5]. Another study also used two light sources with diffusers, but without any information about the type of lights and diffusers used [15]. A 45-degree angle was taken to position them in front of the patients, one on tope and one down in a sagittal plane. The last study used both natural light and artificial ceiling light during the color measurement [13].

For background, natural background was used [10, 12] with no explanation of natural meaning or settings. There are several colors were also used as background such as blue color [12, 15], and grey color [5]. The rest of the studies did not mention the background they used [11, 13, 14, 16, 17].

Calibration

For visual shade matching, the examiners had eye calibration [10] by viewing a light blue color between each color matching process. They also had a check for color blindness and color deficiency test [14]. On the other hand, digital

color calibration was done for the instruments used for measurements following the manufacture instructions [5, 11, 13, 15, 18].

Patient's position

Patients were seated in an upright position on a chair during color measurement/ selection [5, 12, 14, 15, 17, 18].

Conventional shade matching methods

In this review study, there were three selected studies that used conventional (visual) shade matching for skin and tooth color. The three studies used tooth shade categories and makeup skin tone categories to evaluate the association between skin and tooth color. Among these three studies, two studies [10, 12] used almost the same materials, settings, and methods. The first study was done on the US population [10], the second study was on the Nigerian population [12], and the third study was on the Indian population [16] (Table 2).

Visual tooth color matching

For visual tooth color matching, Vita-Lumin shade guide [10, 12] and Cosmopolitan shade guide [12] were used to select tooth color from the middle 1/3 of the maxillary central incisors [10, 12]. Vitapan Classical shade guide was also used [16] to match anterior teeth color. After selecting tooth color, the colors were grouped into categories. Some studies categorized the color according to the color chroma [16]. Others grouped them according to the color values [10, 12] (Table 2).

Visual skin color selection

For skin color matching, L'Oréal (Paris, France) make up [10, 12], and Lakme liquid foundation make up [16] were used for skin shade matching. One of the studies [16] used patients' hands to select skin color. The other studies were not specified on the examined sight of the face during skin color matching [12, 16] (Table 2).

After matching skin color, the colors were grouped in different categories. L'Oréal (Paris, France) True Illusion compact makeup shades were grouped in four categories: 1. Fair (light and medium L'Oréal shades), 2. Fair/Medium (deep L'Oréal shade), 3. Medium (deeper L'Oréal shade), and 4. Dark (shades darker than the L'Oréal deeper shade) [10, 12]. Lakme liquid foundation make up shades were grouped in three categories: 1. Fair (pearl, marble), 2. Medium (shell, coral), and 3. Dark (rosewood) [16] (Table 2).

Results of relationship

Even though the three studies used conventional shade matching using almost the same materials and methods, they had different results. Two analyses established a correlation between the color of teeth and skin [10, 16]. Nevertheless, a study revealed a notable inverse relationship between tooth and skin color, with lighter skin color being associated with darker teeth and medium to dark skin color being associated with lighter teeth [10]. A separate study revealed a direct relationship between the color of the skin and the color of the teeth [16]. The third study did not find any significant correlation between them [12] (Table 2).

Table 2. Overview of the research incorporated in this review according to the conventional color measurement methods.

Ref	Sample size and population	Method of measurement	Measuring sight:	Reliability (instruments/ method/ categories):	Results and general information:
Jahangiri, et al., 2002[10]	**Population:** US population **Size:** 119 participants **Age:** 18-80	**Tooth color measurement:**	Middle 1/3 of the crown of either maxillary left or right central incisors	Two examiners examined the participants and tooth color selection agreement between the examiners was 92%, and 96% for skin color agreement.	Medium to darker skin color have lighter teeth. Lighter skin color had darker teeth
		Skin color measurement:	Patients' hands.		
Dosumu Oluwole, et al., 2010[12]	**Population:** Nigeria **Size:** 127 participants **Age:** 18-60	**Tooth color measurement:**	Maxillary incisal 1/3 of right and left central incisors.	Not mentioned	No significant relationship between tooth color and skin color. Artificial tooth color selection may not be confidently made according to patients' skin color.
		Skin color measurement:			
Vadavadagi, et al., 2016[16]	**Population:** India **Size:** 300 participants **Age:** 18-20	**Tooth color measurement:**	Anterior teeth.	Intra examiner reliability was found to be good with kappa value of 0.82. .	Positive correlation was found between tooth shades and skin shades. Lighter skin color had lighter teeth. Skin color may be a reliable method to select tooth color as there was a significant correlation between them

Digital color measurement methods

There are two digital techniques employed for the measurement of skin color: colorimetry and digital photography. Three digital techniques for quantifying tooth color are present: colorimeter, digital photography, and spectrophotometer (Table 3).

Four selected studies matched the criteria of this review study and used digital shade matching [5, 13, 15, 18]. Two of them [15, 18] employed a methodology for determining tooth shade and another methodology to evaluate skin color. A spectrophotometer was used to determine tooth shade, while digital photography was used for skin color measurements. [15, 18]. On the other hand, the other two studies used the same device in measuring skin and tooth color. They either used colorimeter [13] for determining skin and tooth color, or used digital photography [5] for determining skin and tooth color. All of the four studies used the CIELab color system to describe and compare colors.

Digital skin color measurement

Colorimeter (ShadeEye NCC chromameter/Shofu Dental Corp) [13] was used to measure skin color. The device has a 3mm measuring tip that is placed with a direct contact with the measuring surface. The device was calibrated after each measurement.

Digital photography (Nikon DSLR, Nikon D5200, and Nikon D90 DSLR) [5, 15, 18], with camera's lens (Nikon DX, F-S NIKKOR 18-135 MM 1:3.5-56 G ED)[5] were also used to measure skin color. The camera settings were: shutter speed 1/125, and 1/50, Aperature f 5, f 10, and f 16 [5, 15, 18], and ISO 200 with auto white/black balance [5]. The studies that used digital photography, used artificial light sources as the only light sources during digital photography [5, 15, 18]. On the other hand, the study that used colorimeter included both artificial and natural light (daylight) sources during the color measurements [13].

The color measurements were done in four zones, the forehead [5, 13, 15, 18], the malar area [5, 13, 15, 18], the ear lobe [13, 15], and the chin [5]. A study [18] used a special software that does the measurement of skin color automatically from the patient's picture in the selected arias of the face. It also excluded the arias with any excessive changes in skin color due to rashes, moles, etc [18]. The other studies that used digital photography, used Adobe Photoshop to measure the colors from the patients' pictures [5, 15] after calibration using a calibration board (ColorChecker Digital SG semi-gloss, X-Rite PANTONE) [5]. The recorded measurements of the areas were averaged to obtain a single skin color reading (L*, a*, b*) for each participant in the studies investigating the correlation between tooth color and overall skin lightness [5, 18] (Table 3).

Table 3. Overview of the research incorporated in this review according to the digital color measurement methods.

Ref	Sample size and population	Method of measurement	Measuring sight:	Reliability (instruments/ method/ categories):	Results and general information:
Lagouvardos, *et al.*, 2013 [13]	**Population:** Greece **Size:** 150 participants **Age: 20**	**Tooth color measurement:**	2/3 of Maxillary right central and lateral incisors.	25 participants were selected randomly for Intra-examiner reliability (ICC) using the same method of measurement. Results showed excellent reliability (ICC ≥ 0.93).	Skin was darker, redder, and yellower than incisors. Lighter teeth were associated with lighter skin color of malar and forehead.
		Skin color measurement:	Forehead (3cm above nasal bridge), middle of the outer surface of the right earlobe, and the right malar area.		
Haralur, *et al.*, 2014 [15]	**Population:** East Asian (Philippines, Indonesia), Indian region (India, Pakistan, Bangladesh), Saudi Arabian, and African. **Size:** 300 participants **Age: 20-50**	**Tooth color measurement:**	2/3 of Central incisors.	Not mentioned.	Skin color is a reliable guide that can be used for maxillofacial prosthesis color selection when there is no natural tooth.
		Skin color measurement:	Forehead (nasal bridge /5mm above it), Earlobe (right), and Malar area (left).		
Turker, *et al.*, 2020 [18]	**Population:** Kosovo and Albanian **Size:** 149 participants **Age: 18-23**	**Tooth color measurement:**	2/3 of Maxillary right central incisors.	Not mentioned.	Some skin color parameters (CIELab) can be used in selecting tooth color.
		Skin color measurement:	Face: Malar area (frontal, right, and left areas).		
Moazam, *et al.*, 2022 [5]	**Population:** Malaysians **Size:** 150 participants **Age: N/A**	**Tooth color measurement:**	Maxillary centrals and laterals incisors (incisal, middle, and gingival thirds).	Reliability test was used to test the reliability of the equations that were predicted in the study on 30% of data (ICC intraclass correlation test). The reliability test was 0.993 and 0.985.	Three excellent reliable equations can be used to predict tooth color from skin color (CIELab).
		Skin color measurement:	Chin, right cheek, and forehead.		

Digital tooth color measurement

Tooth color measurement was done on the middle third of right maxillary central and lateral incisors [5, 13, 15, 18]. The same settings that were used in skin digital color measurements were also used in tooth color measurements by using the Colorimeter [13], and digital photography [5]. However, in digital photography, only one type of camera was recorded: (Nikon D90 DSLR) with a camera lens (Nikon N AF-S MICRO NIKKOR 105 MM 1:2.8 G ED) [5]. The camera settings were ISO 200, Shutter speed 1/125, and Aperature f 20 [5]. Spectrophotometer (VITA Easyshade spectrophotometer) was also used [13, 18] in tooth color measurement and was calibrated following the manufacture instructions (Table 3).

Results of relationship

Most of the digital modality's studies employed correlation tests to compare skin and tooth color [13, 15, 18]. Regardless of whether the measuring instruments were the same or different, the correlation test revealed a weak correlation between tooth and skin color.

For regression, the statical tests in a study [18] showed that when using two different digital measuring methods, only the skin b* color parameter was significant in describing the tooth b* parameter. On the other hand, the other study [5] that used regression, when using the same digital measuring device, found that tooth color could be described when using sex and tooth type with skin color. Consequently, they derived three equations to forecast tooth color based on the knowing of sex, tooth type, and skin color [5]. Table 4 presents the findings of the correlation and regression [5, 18] between tooth color and skin color obtained by digital measurement techniques.

Table 4. Results of Digital Color Measurement Methods

Study	Measuring tools		Relationship between skin and tooth color
Turker, *et al.,* 2020 [18]	**Tooth:** Spectrophotometer **Skin:** Digital Photography	Correlation	1. Significant (-) weak correlation between lightness (L*) and tooth a* and b* parameters in both genders. 2. Significant (+) weak correlation between skin b* value and tooth b* value in both genders. 3. Significant (-) weak correlation in males between skin L* parameter and tooth a* and b* parameters. 4. Significant (+) weak correlation in males between skin b* parameter and tooth a* and b* parameters. 5. Significant (-) weak correlation in females skin lightness (L*) and tooth yellowness (b*). 6. Significant (+) weak correlation in females skin yellowness (b*) and tooth yellowness (b*).
		Regression	Skin b* parameter was statically significant in describing the b* parameter of tooth.
Moazam, *et al.,* 2022 [5]	**Tooth:** Digital Photography **Skin:** Digital Photography	Correlation	None
		Regression	1. Skin L* parameter along with sex type and tooth type were statically significant in describing the L* parameter of tooth. 2. Skin a* parameter along with sex type and tooth type were statically significant in describing a* parameter of tooth. 3. Skin b* parameter along with sex type and tooth type were statically significant in describing the b* parameter of tooth. Results in three equations: • Tooth color L* = 70.22 + (0.02 skin color L) + (0.69 sex) + (-5.35 tooth type) • Tooth color a* = 3.46 + (-0.195 sex) + (1.57 tooth type) • Tooth color b* = 15.11 + (-0.08 skin color b) + (-0.31 sex) + (0.74 tooth type)

Mixed color selection methods

There were three studies in this systematic review that used mixed measurement methods (conventional and digital) to evaluate the association between teeth and skin color [11, 14, 17] as shown in table 5. These studies used digital shade matching method for selecting tooth color. On the other hand, visual shade matching method was used for skin color selection.

Mixed skin color measurement

Skin color matching was done using makeup shades in two studies: Revlon and L'Oreal makeup foundation shades [14], and Wardah makeup compact shade guide [17]. The third study did not use any shade guide, instead, they used general skin color classification as: very light skin, light skin, middle skin, and dark skin [11]. There was no information on how the classification of skin color was done [11].

Mixed tooth color measurement

All of the three studies used Vita Easyshade spectrophotometer. However, one study used L*c*h* color parameter to measure tooth color [11], the second study used the vita classical shades [17], and the third study categorized the vita classical shades into four categories: highest value, high value, medium value, and low value [14].

Results of relationship

These three studies collectively found no statistically significant correlation between skin and tooth color, as shown in table 5.

Table 5. Overview of the research incorporated in this review according to the mixed color measurement methods

Ref	Sample size and population	Method of measurement	Measuring sight:	Reliability (instruments/ method/ categories):	Results and general information:
Hassel, *et al.*, 2008 [11]	**Population:** Germany **Size: 94** participants (541 teeth) **Age:** 75-77	**Tooth color measurement:**	2mm away from gingiva, maxillary incisors, canines, and premolars evaluated bilaterally.	Not mentioned	No significant association between tooth color and skin color.
		Skin color measurement:	Facial complex (no specified).		
Al-Dwairi, *et al.*, 2014 [14]	**Population:** Jordan **Size:** 400 participants **Age: 20-50**	**Tooth color measurement:**	2/3 of Central incisors.	Intra-examiner reliability was tested by measuring three consecutive times the color of teeth, skin, hair and eyes at the predefined areas, on 25 persons randomly selected from a population outside the sample.	The agreement between tooth color and skin color in both dental devices were 50±1% with no significant agreement.
		Skin color measurement:	Patients' inner aspect of the wrist.		
Susanty, *et al.*, 2018 [17]	**Population:** Indonesia **Size: 84** participants **Age: 18**	**Tooth color measurement:**	Anterior teeth.	Not mentioned.	Skin color does not affect tooth color with no significant difference between tooth and skin color.
		Skin color measurement:	Back of the patient's hand.		

Discussion

This systematic review discussed ten studies. These studies discussed digital and/or conventional methods that were used in dentistry to measure anterior teeth and skin colors. Presenting these methods would shed the light on how to achieve the highest reliability possible when using conventional methods, digital methods, or both methods. This study discussed five main settings used in color measurements in the selected studies. These settings were: color measurement tools, patient preparation, light condition, background color, and calibration. It also discussed the association between skin and tooth color.

Color measurement tools

Among the three methods that were viewed in this review study, only digital methods (digital/digital) [5, 13, 15, 18] and conventional shade matching methods (conventional/conventional) [10, 16] showed significant association between skin and tooth color. On the other hand, mixed method (digital for teeth and visual for skin) showed no link between skin and tooth color [11, 14, 17]. Therefore, the association between skin and tooth color may be identified in a better way by utilizing the same method of measurement. In contrast, when using a measuring method for teeth and another different measuring method for skin, the relationship between teeth and skin color cannot be detected.

Mixed methods

Mixed methods use two different ways of reading colors; visual and digital shade selection. The visual shade matching is basically done due to a physical modification of light that is absorbed by the eye and illuminate by the brain [19]. The human eye can see colors due to light, in wave light between 400 to 800 nm along the electromagnetic spectrum [20]. Visual shade matching can be affected by many things such as eye fatigue, color blind, experience, light condition, and others [21-23].

On the other hand, digital methods work almost in the same way that human eyes work, as they translate the reflected light from an object into color. However, digital methods are not affected by eye fatigue, color blind, light condition as light source is stable, and these factors are limited when using digital instruments [21-25].

These differences make colors that are measured by human eye, and colors that are measured by digital methods incomparable to each other. This can be seen in the results of the several research that used mixed measuring methods [11, 14, 17] as no significant relationships were found between skin and tooth color. These results were in contrast with the studies that used the same measuring tool and method (digital/ digital, or, visual/ visual) to measure skin and tooth color. This could mean that doing the color measurement using the same materials and methods for skin and tooth color measurement is more accurate and reliable compared to mixed methods.

Digital methods vs. conventional methods

It was suggested by previous studies digital methods are more reliable and provide a more standardized measurement of color compared with conventional tooth color measurement methods [6, 26-28]. In this systematic review study, it was found that the control of the factors that can affect color measurement was firmed in digital methods more than conventional (visual) methods. Moreover, digital methods needed less time, and less efforts to manage these factors that can affected color measurement [5, 13, 15, 18].

Patient preparation

Before color measurement, patients were prepared for this process, to exclude any factor that can affect the color measurement. Most of the studies asked their patients to remove any makeup, glasses, lipstick, and sunblock before the color measurement was done [5, 13, 15, 18]. However, for tooth, some studies suggested to do tooth prophylaxis before the measurement [12, 15, 17, 18]. It was suggested by a previous study that professional tooth

prophylaxis would affect tooth color by decreasing the yellow color of the tooth [29]. That is because it removes all the staining and food debris from the tooth surface. By considering that result, swiping the tooth with cottons or improper way of brushing the teeth would affect tooth yellowness [29].

Light condition

Light condition can affect the quality of color [3]. Therefore, controlling the light condition, temperature, position, and type can increase the quality and reliability of colors. The studies in this systematic review used natural daylight (sunlight) [10, 12, 16], or used artificial light [5, 18]. Those who used natural daylight did not mention the weather condition, the season, the patient's position to the window, the window's position to the sun, and the size and number of windows in the room. Therefore, repeating the study would not give the same results. Dark places would show colors darker, and brighter places would show colors brighter and lighter. Hence, controlling natural daylight is a subjective matter that is difficult to control.

On the other hand, artificial lights can be used. According to a study [30], incandescent dental unit lights were utilized for color measurements. These lights emit light with a high intensity in the red-yellow spectrum (long wavelength), while emitting a low intensity at the blue end of the spectrum. With a higher chroma and a lower value than it already possesses, these lights make the enamel appears more translucent, revealing more dentine than it actually does. Hence, some studies that used artificial lights [5, 18] presented two ways to use the lights. The first way was using light settings of 45 degrees [18], and the second way was by using a standard setting [5]. The use of 45-degree technique can prevent shade formation which make it more effective than the standard settings [31]. However, the standard settings measured the length, destinations, and angles of lights and patients which make it more standard and able to be applied anywhere. Mixing the two methods, by applying the 45-degree technique with two strobe lights behind the participants and two in front of the participants with fixed 45-degree angulation between the lights and participants [31], and by using standard destinations, angulations and dimensions with grey background [5], would give a remarkable result.

Background color

The background of the measuring sight could affect the color temperature of the photos. Some studies used natural background with no explanation or details on how natural the background is [12]. Other studies used blue background [10, 31]. However, blue background considered as one of the colors that can affect the color temperature leading to falls results [32, 33]. Therefore, it is not an ideal choice to use blue color background when measuring the skin and tooth color. On the other hand, the blue background is effective when trying to capture the details of the face, as the contrast between the human skin color and the blue background color is high [31, 34]. A study used a grey background [5] which is considered as a neutral color and does not affect the color temperature of the photos [35]. Therefore, when the color of an object/ surface is needed, a grey background should be used, and when the details and shape of a s object/ surface is needed, a blue background should be used.

Calibration

To achieve accuracy in colour measurement using digital photography, it is suggested to use a calibration before colour evaluation [36]. The calibration process was found in digital methods: digital photography [5], spectrophotometer [15, 18], and colorimeter [15], and in conventional methods [16]. Therefore, it can be noted that most of the studies considered the calibration process as an important process in color measurement. Each method has its own calibration system. For example: the devices such as colorimeter and spectrophotometer have their own programmed calibration system and technique following the manufacturing instructions [13, 15, 18]. Digital photography can be celebrated using a calibrated board with different color patterns in the board [5]. Finally, for more accurate conventional shade matching, colour matching should be done using two individual examiners

with high agreement between them and eye calibration using a light blue colour to be viewed after each color matching process [10].

The association between skin and teeth color

The association between skin and teeth color was found in conventional shade matching [10, 16], and digital shade measurement [5, 13, 15, 18]. In conventional shade matching, two studies out of three studies found significant association between skin and teeth color [10, 16]. However, one of them found that darker skin had lighter teeth [10], and the other study found that lighter skin had lighter teeth [10]. These differences could be due to the difficulty of controlling the factors that can affect in visual shade matching [21-23]. That makes the results of the association between skin and teeth color using visual shade matching not conclusive.

On the other hand, all studies that used digital methods proved that there is a significant association between skin and teeth color [5, 13, 15, 18], and they found that this relationship had poor correlation [13, 15, 18]. Regression tests showed that the skin yellowness can describe tooth yellowness (b* parameter) [18]. The study [18] used two different devices to measure skin color and tooth color, which could explain why only one color parameter of skin color was able to describe tooth color. The chances of having other color parameters to describe tooth color from skin color has increased when using the same measuring device to measure tooth and skin color with knowing sex and tooth type [5].

As a summary, among the studies that were selected for the systematic review, only one study suggested a model for the association between skin and teeth color. Moreover, there were no studies done on using artificial intelligence (AI) on modelling this association. The finding of this systematic review can be summarized in six points:

1. Digital methods are more reliable than conventional methods.

2. When measuring tooth and skin color, both surfaces should be measured using the same material and method.

3. Color calibration is a must, and a grey background should be used in color measurement studies.

4. Light condition can affect the quality and temperature of colors; therefore, they should be controlled and standardized.

5. The number of studies that have provided a model for the relationship between the color of the skin and the color of the teeth in order to predict tooth color is limited. Therefore, more research should be done to find a model for this relationship to be used in predicting tooth color.

6. There are no dental studies that used AI to assess the association between skin and teeth color and predict tooth color.

Conclusion

The present investigation on analyzing the link between anterior teeth and skin colour using various assessment techniques in adult patients has yielded some notable findings. Digital and traditional evaluation techniques demonstrated either a negative or a positive significant association between skin and teeth color, however, the mixed approach (digital for tooth and visual for skin) revealed no such relationship. The obvious conclusion that can be reached is that there are a variety of sample preparation and analysis techniques that may influence the results and final outcomes. More studies should be done using the findings of this systematic review to get more conclusive outcomes of the relationship between tooth and skin color.

Conflict of interest

The authors have no conflicts of interest to declare.

Author contributions

R.H.M and Z.A.G conceptualized and designed the study. R.H.M and M.A conducted the literature search and screening. Data extraction and quality assessment were performed by R.H.M, M.S.H and N.B.J. R.H.M and W.M.A.W.A conducted the data synthesis. The manuscript was written by R.H.M with contributions from all authors. R.H.M, M.A and J.Y.A provided critical revisions. R.H.M, M.A, Z.A.G and J.Y.A provided project management and oversight. All authors approved the final manuscript for submission.

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Informed consent

None

References

1.   Azad A, Salman A, Majid Z, Mubashir S. Relationship of age, gender and skin tone to shades of permanent maxillary central incisors. Pakistan Oral Dent J. 2007;27(1):119-125.

2.   Marui M. A relationship between tooth crown color and skin color. J Stomatological Soc. 1968;35(3):422-440. https://doi.org/10.5357/koubyou.35.422

3.   Sikri V. Color: Implications in dentistry. J Cons Dent. 2010;13(4):249. https://doi.org/10.4103/0972-0707.73381

4.   Nourbakhsh M, Mousavinejad N, Adli A, Harati M. Relationship between natural tooth shade and skin colour. Eur J Prosthodont Restor Dent. 2013;21(2):50-52.

5.   Moazam RM, Ab-Ghani Z, Ahmad WM, Halim MS, Jamayet NB, Matheel AR. Modeling the relationship between tooth color and skin color in equations to predict tooth color. Cureus. 2022;14(6).

6.   Bahannan S. Shade matching quality among dental students using visual and instrumental methods. J Dent. 2014;42(1):48-52. https://doi.org/10.1016/j.jdent.2013.11.001

7.   Agache P, Humbert P. Measuring the skin. Springer Science & Business Media; 2004 Jul 15. https://doi.org/10.1007/978-3-662-08585-1

8.   Pradhan D, Shrestha L, Lohani J. Tooth shade and skin colour: a descriptive cross-sectional study. J Nepal Med Assoc. 2020;58(223):144. https://doi.org/10.31729/jnma.4792

9.   Pustina-Krasniqi T, Xhajanka E, Ajeti N, Bicaj T, Linda D, Zana L. The relationship between tooth color, skin and eye color. Euro Oral Rese. 2018;52(1):45-49. https://doi.org/10.26650/eor.2018.05145

10. Jahangiri L, Reinhardt S, Mehra R, Matheson P. Relationship between tooth shade value and skin color: an observational study. J Prosthetic Dent. 2002;87(2):149-152. https://doi.org/10.1067/mpr.2002.121109

11. Hassel A, Nitschke I, Dreyhaupt J, Wegener I, Rammelsberg P, Hassel J. Predicting tooth color from facial features and gender: results from a white elderly cohort. J Prosth Dent. 2008;99(2):101-106. https://doi.org/10.1016/S0022-3913(08)60025-6

12. Dosumu O, Dosumu E. Relationship between tooth colour, skin colour and age: An observational study in patients at the Ibadan Dental School. African J Biomed Rese. 2010;13(1):9-14.

13. Lagouvardos P, Tsamali I, Papadopoulou C, Polyzois G. Tooth, skin, hair and eye colour interrelationships in Greek young adults. Odontology. 2013;101:75-83. https://doi.org/10.1007/s10266-012-0058-1

14. Al-Dwairi Z, Shaweesh A, Kamkarfar S, Kamkarfar S, Borzabadi-Farahani A, Lynch E. Tooth shade measurements under standard and nonstandard illumination and their agreement with skin color. Int J Prosthodont. 2014;27(5). https://doi.org/10.11607/ijp.3826

15. Haralur S, Dibas A, Almelhi N, Al-Qahtani D. The tooth and skin colour interrelationship across the different ethnic groups. Int J Dent. 2014. https://doi.org/10.1155/2014/146028

16. Vadavadagi S, Kumari K, Choudhury G, Vilekar A, Das S, Jena D, et al. Prevalence of tooth shade and its correlation with skin colour-A cross-sectional study. J Clin Diagn Res. 2016;10(2):ZC72. https://doi.org/10.7860/JCDR/2016/16918.7324

17. Susanty H, Gita F, Kusdhany L, Marito P. Relationship between the color of the maxillary central incisors and age, sex, and skin color: value analysis using a spectrophotometer. J Physics: Conference Series; 2018: IOP Publishing. https://doi.org/10.1088/1742-6596/1073/4/042009

18. Turker N, Buyukkaplan U, Kurkcuoglu I, Yilmaz B. Use of a new skin colour measurement method for the investigation of relationship between skin and tooth colour. Euro Oral Res. 2020;54(2):81-85. https://doi.org/10.26650/eor.20200090

19. Billmeyer F, Saltzman M. Principles of color technology. Interscience Publishers; 1966.

20. Esan T, Olusile A, Akeredolu P. Factors influencing tooth shade selection for completely edentulous patients. J Contemp Dent Pract. 2006;7(5):80-87. https://doi.org/10.5005/jcdp-7-5-80

21. Veeraganta S, Savadi R, Baroudi K, Nassani M. Differences in tooth shade value according to age, gender and skin color: A pilot study. J Indian Prosthodont Soc. 2015;15(2):138-141. https://doi.org/10.4103/0972-4052.155035

22. Dewangan A, Dewangan D. Assessment of different shade value according to age, skin color and gender- A clinical study. J Adv Med Dent Sci Res. 2018;6(1):106-109.

23. Karaman T, Altintas E, Eser B, Yildirim T, Oztekin F, Bozoglan A. Spectrophotometric evaluation of anterior maxillary tooth color distribution according to age and gender. J Prosthodont. 2019;28(1): 96-102. https://doi.org/10.1111/jopr.12783

24. Dummett C, Sakumura J, Barens G. The relationship of facial skin complexion to oral mucosa pigmentation and tooth color. J Prosth Dent. 1980;43(4):392-296. https://doi.org/10.1016/0022-3913(80)90207-3

25. Dozić A, Kleverlaan C, El-Zohairy A, Feilzer A, Khashayar G. Performance of five commercially available tooth color-measuring devices. J Prosthodont. 2007;16(2):93-100. https://doi.org/10.1111/j.1532-849X.2007.00163.x

26. Chen H, Huang J, Dong X, Qian J, He J, Qu X, Lu E. A systematic review of visual and instrumental measurements for tooth shade matching. Quintessence Intern. 2012;43(8): 649-659.

27. Pimental W, Tiossi R. Comparison between visual and instrumental methods for natural tooth shade matching. Gen Dent. 2014;62(6):47-9.

28. Tuncdemir A, Polat S, Ozturk C, Tuncdemir M, Gungor A. Color differences between maxillar and mandibular incisors. Euro J Gen Dent. 2012;1(03):170-173. https://doi.org/10.4103/2278-9626.105381

29. Pereira R, Corado D, Silveira J, Alves R, Mata A, Marques D. Dental prophylaxis influence in tooth color assessment-Clinical study. J Esthet Rest Dent. 2020;32(6):586-592. https://doi.org/10.1111/jerd.12593

30. Vadher R, Parmar G, Kanodia S, Chaudhary A, Kaur M, Savadhariya T. Basics of color in dentistry: A review. IOSR-JDMS. 2014;13:78-85. https://doi.org/10.9790/0853-13917885

31. Swamy R, Most S. Pre-and postoperative portrait photography: standardized photos for various procedures. Faci Plas Surg Clin. 2010;18(2):245-252. https://doi.org/10.1016/j.fsc.2010.01.004

32. Dudea D, Gasparik C, Botos A, Alb F, Irimie A, Paravina R. Influence of background/surrounding area on accuracy of visual color matching. Clin Ora Inves. 2016;20:1167-1173. https://doi.org/10.1007/s00784-015-1620-3

33. Najafi-Abrandabadi S, Vahidi F, Janal M. Effects of a shade-matching light and background color on reliability in tooth shade selection. Int J Esthet Dent. 2018;13(2):198-206.

34. Khavkin J, Ellis D. Standardized photography for skin surface. Faci Plas Surg Clin. 2011;19(2):241-6. https://doi.org/10.1016/j.fsc.2011.04.001

35. Jaberi-Ansari Z. Evaluation of tooth color distribution in 20 to 30-year-old patients of Shahid Beheshti university related centers in 1389. J Iranian Dent Assoc. 2012;24(2):60-68.

36. Hong G, Luo M, Rhodes P. A study of digital camera colorimetric characterization based on polynomial modeling. Color Res & Applica: Color Sci Assoc Jap. 2001;26(1):76-84. https://doi.org/10.1002/1520-6378(200102)26:1<76::AID-COL8>3.0.CO;2-3

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مراجعة منهجية لتقنيات التقييم، وإعداد المريض، وحالة الإضاءة، ولون الخلفية، والمعايرة المستخدمة في التحقيق في العلاقة بين لون الأسنان الأمامية ولون الجلد لدى المرضى البالغين

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المستخلص:

تم تقييم العلاقة بين لون الأسنان ولون الجلد من خلال العديد من الدراسات منذ عام 1968. وقد أجريت هذه الدراسات لمعرفة ما إذا كان لون الجلد يمكن أن يرشد أطباء الأسنان لاختيار لون الأسنان. تهدف هذه المراجعة المنهجية إلى معالجة الطرق التي تم استخدامها لتقييم العلاقة بين لون الأسنان والجلد، وإيجاد الطرق الأكثر دقة وموثوقية لنمذجة العلاقة وتقييمها. المواد والطرق: تم تسجيل المراجعة المنهجية في PROSPERO (CRD42022356022). تم إجراء هذه المراجعة المنهجية على أربع قواعد بيانات باستخدام استراتيجية البحث PRISMA 2009، وتم اختيار دراسات مختارة وفقا لنموذج PICO. تم استخدام قائمة مراجعة التقييم النقدي لـ JBI لتقييم الجودة. النتائج والمناقشة: من أصل 1611 مقالة تم العثور عليها في قواعد البيانات، تطابقت 10 مقالات مع المعايير وتم اختيارها لهذه الدراسة المراجعة المنهجية. تم العثور على ثلاث طرق رئيسية في الدراسات العشر: الطرق التقليدية، والطرق الرقمية، والطرق التقليدية الرقمية (المختلطة). تم العثور على الطرق الرقمية لتكون الطرق الأكثر موثوقية لتقييم الألوان. يجب تطبيق إعدادات محددة أثناء طرق قياس الألوان الرقمية الاستنتاج: أظهرت تقنيات التقييم الرقمية والتقليدية وجود علاقة سلبية أو إيجابية بين لون الأسنان ولون الجلد، ومع ذلك، فإن النهج المختلط (الرقمي للأسنان والبصري للبشرة) لم يكشف عن أي شيء من هذا القبيل. علاقة. ينبغي إجراء دراسات باستخدام الذكاء الاصطناعي واستخدامها للتنبؤ بلون الأسنان من خلال معرفة لون البشرة.

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