ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 7, Issue – 2, March – 2024, Page No. : 188 - 202

To comparatively evaluate digital versus visual tooth shade selection: A Systematic Review

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Citation of this Article: Dr. Shikha Yadav, Dr. Punit R S Khurana, Dr Aditya Chaudhary, Dr Anju Aggarwal, "To comparatively evaluate digital versus visual tooth shade selection: A Systematic Review", IJDSIR- March – 2024, Volume –7, Issue - 2, P. No. 188 – 202.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

Accurate determination of the tooth shade is a crucial factor in restorative and prosthetic procedures. Selecting the correct shade of the natural teeth is an ongoing challenge in restorative dentistry. Many restorations fail because of poor color selection.

Visual shade matching owing to its subjectivity is a concern for the dental clinicians so different devices have been introduced to aid the colour selection for achieving optimum aesthetics.

Shade matching of teeth in dentistry is traditionally done by visually comparing the color of the tooth/teeth to standard shade reference tabs, with the operator selecting the best or closest match.

Digital photographs are a common interaction tool in dental workplaces. Digital photographs can capture clear images of the tooth and have been progressively used to document the whole clinical procedure.

Keywords: Digital, Virtual, Spectrophotometer, Vitapan.

Introduction

Patients seeking dental prosthetic treatments are concerned with their appearance. According to Young, the major aspects of aesthetics are beauty, harmony, naturalness, and individuality. There are many factors which govern the esthetics of a patient, tooth color being one of them. Extrinsic and intrinsic elements work together to determine the color of teeth.[1] Extrinsic

variables are linked to the deposition of food or beverage stains on the enamel, as well as the pellicle layer which forms on the tooth surface. Intrinsic variables are related to the reflection, and light dispersion properties of enamel and dentin. Dentin characteristics have a profound impact on tooth colour.[2]

Selecting the correct shade of the natural teeth is an ongoing challenge in restorative dentistry. Many restorations fail because of poor color selection. The ability of a dentist to choose and convey an appropriate shade match is critical to treatment success, particularly when it comes to satisfying patient expectations and demands for precision in cosmetic dentistry.[3]The two main methods for shade matching are the conventional visualand the instrumentation method, using color-measuring devices. Shade matching of teeth in dentistry is traditionally done by visually comparing the color of the tooth/teeth to standard shade reference tabs, with the operator selecting the best or closest match.[4] Human physiological factors impacting visual tooth matching include differences in color perception (operator subjectivity), operator experience and color blindness.

Visual shade guides act as a standard reference, when performing shade selection using visual method. The most prevalent shade guides are VITAPAN Classical SHADE Guide and Vita 3D Master Shade Guide (Vita Zahnfabrik, Bad Erlangen, Germany).

The instrumental methods include spectrophotometers, colorimeter, digital cameras, and intraoral scanners.[5] These devices consist of a detector, signal conditioner, and software, which processes the signal to make the data usable in a clinic or laboratory. Spectrophotometric color measurements are capable of reliably quantifying the color of natural teeth as well as restorative dental materials. Also, they have been found to be most accurate when compared to other methods of shade selection.[6]

Digital photographs are a common interaction tool in dental workplaces. Digital photographs can capture clear images of the tooth and have been progressively used to document the whole clinical procedure. Recently it has also been used to select shade in the form of various mobile applications. However, digital photographs of natural teeth can show noteworthy color modifications when the optimal conditions of light illumination are not used.[7]Although, computational photography has improved the prediction of accurate shade, further research is still required. One of the latest technologies in shade selection has been intraoral scanners. These, digital scanners have their own light source with an added advantage of being in proximity with the tooth. However, further research is warranted to prove their accuracy.[8]

Thus, the purpose of this systematic review was to review the accuracy of shade selection when done using visual and instrumental method.

Review of Literature

1. S. Rodrigues. S. R. Shetty. D. R. Prithviraj (2012)[9]conducted a studyto evaluate the shade differences of the natural anterior teeth in different age groups and gender, within the cross sectional Bangalore, Karnataka population, using commercially available shade guides. The shade of a cross section of the population comprising of 400 subjects of both the sexes (800 incisors; 400 maxillary central incisors; 400 mandibular central incisors) visiting the outpatient Department of Government Dental College was selected randomly and evaluated visually by a single observer using three commonly used shade guides i.e. Vita Lumin, Chromascope and the Vita 3D Master. The incidence of the most common shades in the different

age groups and gender using these shade guides was obtained and this data was subjected to the v^2 test (p \ 0.05—significant). The most common shade for the maxillary and mandibular incisors in the younger age group is A2/2R1.5/140 and A1/1M2/120 for the males and females using Vita Lumin, Vita 3D Master and Chromascop shade guides respectively. In the advanced age group the most common shade for the maxillary and mandibular incisors is A2/2R2.5/140 using the same order of shade guides. However the results showed no statistical significance in shade variation in males and females in different age groups using different shade guides. Although, the incidence of males with darker teeth as compared to females was higher, the study showed no statistical significant correlation between shade differences in both the sexes. They concluded that there is a significant darkening of teeth as the age advances.

2. D. Ongul et al (2012)[10]conducted a study to evaluate the influence of two shade guides on color match and to evaluate the relationship between color difference ΔE value in ceramic crowns. The results revealed that the color difference values between the teeth and crown fabricated with the shade selected from vita 3-D master shade guide were significantly smaller than those of the VitapanClassic Shade Guide. Thus, the color replication ability of vita 3-D master shade guide was found to be better than that of the vita classic shade guide. However, the ceramic crowns that were fabricated with both shade guide had acceptable color match.

3. Safura A Baharin et al (2013)[11]conducted a study to determine the optimum lighting condition and preferable patient position that may influence the anterior tooth shade selection. 100 students were selected to perform the shade selection for two selected subjects. The shade of the tooth was predetermined using an intraoral spectrophotometer and the result was used as reference for the visual shade selection procedure done by the students. Four different clinical environment were selected, and the shade selected by the students was compared with the predetermined shade, Result of this study concluded that 56%of students selected most accurate tooth shade when patient is in upright position with dental chair light switched off followed by least result produced when patient was in supine position with the dental light switched off i.e., 35.5%.

4. C.G.mez-Polo et al (2013)[12] conducted a study to assess the agreement between instrumental and visual colourmatching. Shade selection with the 3DMaster shade guide (Vita-Zahnfabrik) was performed on 1361 maxillary central incisors and compared with the shade obtained with the Easy- Shade Compact (Vita-Zahnfabrik) spectrophotometer and observed a greater correlation between the objective method and the subjective one in the color dimension of lightness (Kappa 0.6587), followed by hue (Kappa 0.4337) and finally chroma (Kappa 0.3578). They concluded that the color dimension in which the greatest agreement is seen between the operator and the spectrophotometer is value or lightness.

5. Suganya S.P et al (2013)[8]conducted a study to learn the possible shade differences between human eye and the digital method with spectrophotometric methods. Fifty dental students of age groups 18–25 with maxillary right central incisor after undergoing oral prophylaxis were included in this study. Before undergoing shade selection, standardization protocol was followed. The shade of the right maxillary central incisor was determined by using the following methods: visual, spectrophotometer, and digital photography. The shades obtained by spectrophotometric, digital and visual methodswere compared and L*, a*, and b* values were

obtained and subjected to statistical analysis. They concluded that the digital photography can be used as one of the reliable methods for shade selection in a clinical setup.

6. Ozat, P. B et al (2013)[6]conducted a study to evaluate the repeatability and reliability of human eye in visual shade selection. 54 dentists participated in the study matched the shade of upper right central incisor tooth of single subject. TheVita 3D Master Shade Guide was used for this study. Before each shade matching procedure the identification of the shade tab was hidden by opaque strip and shade tabs were placed randomly. Theprocedure was repeated one month later to ensure that visual memory did not affect the result. The baseline data and one month follow up records was evaluated. The study found that dentists were able to performed poorly wrt repeatability in visual shade matching.

7. IF Alshiddi,Richards LC(2014)[9]conducted a study to compare the accuracy of shade selection using a spectrophotometer and a conventional method in 'trained' and 'untrained' students. The 'trained' group were given a presentation and training exercise on colour science and shade selection and the 'untrained' group were not given any information or training. Each student matched the shade of maxillary right central incisor for eight test subjects using both methods. Differences in colour (ΔE) and value (ΔL) between the natural teeth and the shade determined by each method were calculated for both trained and untrained students. However, knowledge and training on colour science and shade selection significantly affected the results.

8.Moodley DS (2015)[5]conducted a study toevaluate thedifference in tooth shades determined using visual and spectrophotometric methods. Twenty five patients were selected between the age groups of 20 and 25 withcomplete set of maxillary anterior teeth and vital right upper central incisor. For visualmethod Vita pan Classical and Vita 3D-Master shade guideswere selected and for spectrophotometric method SpectroShade (company name)were selected. They concluded that combination of both methods provide best shade determination.

9. Veeraganta, et al. (2015)[14]conducted a study to investigate the corelate in tooth shade valueaccording to age, gender and skin color among a sample of the local population in Bengaluru. They included 100 subjects comprising of both male and female population with age groupsranges from 16years to 55 years. Tooth shade of permanent maxillary central incisors were recordedusing Vita3DMaster Shade Guide, skin color was matched using radiance compact makeup shades.

10. Clary JA et al (2016)[16]conducted an invitro study to compare results of shade matching using hand held shade matching device with or without polarising filter with results obtained using professional viewing booth. For the study a total of 96 third year students participated and were randomly allocated into 4 groups, with each group having 1 of 2 handheld shade matching device with or without polarising filter.

11. Dhruv Anand et al (2016)[17]conducted a study to ascertain if digitally acquired images with an SLR camera can be used as an alternative to the VITA easy shade spectrophotometer for obtaining the shade of the teeth. Twenty extracted anterior tooth samples were analysed to determine the L*, a*, b* values with a spectrophotometer. The same samples were imaged with a digital camera, and same colour parameters were determined on the digital images with a software. Statistical analysis was performed using Pearson coefficient of correlation. It was observed that the L* and b* values obtained by both the methods were highly significant ($r \geq 0.7$, $p \leq 0.05$) with r = 0.798 (p=0), r =

0.858 (p=0) whereas 'a' value was not significant with r=0.246 (p=0.377). It was concluded that an SLR camera with Adobe photoshop CS5.1 as an adjunct can be used as an alternative to spectrophotometer in obtaining 'l' and 'b' values accurately.

12. J. S. Miyajiwala, M. G. Kheur, (2017)[1] conducted a study to compare three different methods used for shade selection, i.e., visual method, spectrophotometer, and digital photography method. Fifty participants were selected from the out-patient department of prosthodontics. Presence of the maxillary right central incisor with no history of any restorative or endodontic procedures was the primary inclusion criterion. The shade of the right maxillary central incisor was determined using all the three shade selection proceduresnamely visual, spectrophotometric, and digital photography method for all the selected participants. The agreement between the readings obtained by the three different methods was compared and subjected to appropriate statistical analysis. They concluded that the digital photography method emerged as a reliable method for shade selection in a clinical setup.

13. C.Igiel et al (2017)[3]conducted a study to evaluate intra-rater and inter-rater reliability of visual and instrumental shade matching. Forty individuals with normal color perception participated in this study. The right maxillary central incisor of a teaching model was prepared and restored with 10 feldspathic all-ceramic crowns of different shades. A shade matching session to provide the time interval that consisted of the observer (rater) visually selecting the best match by using VITA classical A1-D4 (VC) and VITA shade guide 3D Master (3D) shade guides and the VITA Easy Shade Advance intraoral spectrophotometer (ES) to obtain both VC and 3D matches. Three shade matching sessions were held with 4 to 6 weeks between sessions. Intra-rater reliability was assessed based on the percentage of agreement for the three sessions for the same observer, whereas the inter-rater reliability was calculated as mean percentage of agreement between different observers. The Fleiss' Kappa statistical analysis was used to evaluate visual inter-rater reliability.

14.N.Sirintawat,T.Leelaratrungruang(2017)[4] conducted a study to investigate and compare the reliability and accuracy of tooth shade selection in the model using 30 milled crowns via five methods: (1) digital single-lens reflex (DSLR) camera with twin flash (TF) and polarized filter (DSLR + TF), (2) DSLR camera with a ring flash (RF) and polarized filter (DSLR + RF), (3) smartphone camera with light corrector and polarized filter (SMART), (4) intraoral scanner (IOS), and (5) spectrophotometer (SPEC). These methods were compared with the control group or manufacturer's shade. The CIE Lab values (L, a, and b values) were obtained from five of the methods to indicate the colour of the tooth. Adobe Photoshop was used to generate CIE Lab values from the digital photographs. The reliability was calculated from the intraclass correlation based on two repetitions. The accuracy was calculated from; (a) ΔE calculated by the formula comparing each method to the control group, (b) study and control groups were analysed by using the Kruskal–Wallis test, and (c) the relationship between study and control groups were calculated using Spearman's correlation. The reliability of the intraclass correlation of L, a, and b values obtained from the five methods showed satisfactory correlations ranging from 0.732–0.996, 0.887–0.994, and 0.884–0.999, respectively. The ΔE from all groups had statistically significant differences when compared to the border of clinical acceptance (ΔE = 6.8). The ΔE from DSLR + TF, DSLR + RF, SMART, and SPEC

were higher than clinical acceptance (ΔE > 6.8), whereas the ΔE from IOS was 5.96 and all of the L, a, and b values were not statistically significantly different from the manufacturer's shade ($p < 0.01$). The ΔE of the DSLR + RF group showed the least accuracy (ΔE = 19.98), whereas the ΔE of DSLR + TF, SMART, and SPEC showed similar accuracy ΔE (ΔE = 10.90, 10.57, and 11.57, respectively). The DSLR camera combined with a ring flash system and polarized filter provided the least accuracy. The intraoral scanner provided the highest accuracy. However, tooth shade selection deserves the combination of various techniques and a professional learning curve to establish the most accurate outcome.

15. Liberato et. Al (2018) [18] conducted a study to compare the reliability of different visual and instrumental methods for dental shade matching. Visual shade matching was performed by 3 experienced clinicians using 2 different shade guides (VITA Classical A1-D4 and VITA Tooth guide 3D-MASTER with 29 tabs; VITA Zahnfabrik) with and without the aid of a light-correcting device (Smile Lite; Smile Line). An intraoral scanner (TRIOS; 3Shape A/S) and a spectrophotometer (VITA Easy shade Advance 4.0; VITA Zahnfabrik) were also used for color shade matching. The instrumental methods were repeated 3 times to determine repeatability. Shade-matching sessions for each method were performed under controlled lighting on the middle third of the maxillary right central incisor of 28 participants and concluded that instrumental methods for color shade matching were more reliable than the visual methods tested.

16. BegümYılmaz,Özgür Irmak (2018)[7]conducted a study to evaluate the effect of professional experience and lighting conditions on visual shade selection on natural teeth and comparing the visual-shade-selection results with those of instrumental methods. The different materials and methods shade selection were performed on five maxillary central incisors. The 25 observers were divided into five groups according to their professional experience. Observers performed visual-shade-selection using shade guide (Vita 3D Master, Vita Zahnfabrik, Bad Säckingen, Germany) under two lighting conditions (4000 and 6500 K) from the cervical, middle and incisal thirds of the teeth. Same teeth were measured using an intraoral scanner (Trios 3Shape, Copenhagen, Denmark) and spectrophotometer (Vita Easy shade Compact, Vita Zahnfabrik, Bad Säckingen, Germany), under the same two lighting conditions. They concluded that shade measurement outcomes were not affected by the lighting conditions (4000 and 6500 K). The shade measurement feature of the T-3S could be an alternative to VES and VSS.

17. Demirel M G et al (2019)[19]conducted a study to determine the effect of age, gender, and educational background on the color coordinates of maxillary central incisors. Forthis studythe shade of 302 individual and shade of their tooth were recorded using spectrophotometer. The study concluded that as the individual age increase the shade gets darkerand also women have lighter tooth shade color as compared to men and also color of tooth.

18. Ratzmann et al. (2020)[2]conducted a study to compare a 2D and 3D color system concerning a variety of statistical and graphical methods to assess validity and reliability of color measurements, and provide guidance on when to use which system and how to interpret color distance measures, including ΔE and d(0M1). They included 14 to 24 teeth of 35 patients undergoing regular bleaching treatment that was visually assessed and electronically measured with the spectrophotometer Shade Inspector. Tooth color was recorded before

bleaching treatment, after 14 days, and again after 6 months. VITAPAN Classical (2D) and VITA-3D-Master(3D) served as reference systems and they concluded that the 3D system may confuse human raters and even electronic devices. The 2D system is the simple and best choice.

19. Sabrin Abu-Hossin et al (2023)[21]conducted a study to compare visual and digital shade selection to assess the repeatability of the utilized intraoral scanners. In 31 probands, tooth color was determined on teeth 11, 13, and 16. Shade selection was performed visually by a dentist and digitally using Trios 3 and CerecOmnicam. Three measurements were performed to determine the repeatability of intraoral scanners. Fleiss' κ test was used for statistical evaluation of the repeatability and Cohen's κ test was used for comparison of methods. They concluded that Intraoral scanners can facilitate the workflow in clinical practice. They are a good supplement for color determination but should additionally be confirmed by the visual method.

Methodology

Eligibility criteria

The inclusion criteria for admittance in the systematic review were selected clinical studies on humans, literature reviews, systematic reviews to assess the following:

1. Studies including peer review articles published from January 2012 to December 2022.
2. Studies including the comparative evaluation of shade matching using various conventional methods.
3. Studies including the comparative evaluation of shade matching using various digital instruments.
4. Studies that discuss a comparative evaluation of a visual shade method and digital shade method.

The exclusion criteria were based on the following:

1. Age group less than 18.
2. Interventional studies, laboratory research, abstracts, case reports, protocols, personal opinions, letters and posters, review of literature
3. Full text not available
4. Non-English language.

Information Sources

A systematic search in the National Library of Medicine's PubMed Database, Google Scholar, web of science, Cochrane EBSCO and ProQuest was performed to identify all peer-reviewed articles in the English literature related to conventional as well as digital tooth shade selection, in accordance with the search strategy described in the following sections. The studies included in review were assessed independently by two authors, based on the approach of reading structured articles, which is described in the following sections.

Selection process

For article selection or first approach, two researchers independently selected potentially eligible articles using title and abstract. Articles that meet PICO and inclusion criteria are included in the review for the final analysis.

Data collection process

Data was collected from studies that determined the digital vs visual tooth shade selection, The publishing year, natural tooth shade, traditional shade selection, digital shade selection, all-ceramic crowns, metal-ceramic crowns, and spectrophotometer were all specifically significant pieces of information.

Shade assessment tools, such as the natural tooth shade, conventional shade matching, and digital shade matching, comparative evaluation tools, such as conventional and digital shade matching, and matching instruments, such as spectrophotometers, colorimeters, scanners, and computer software, were all used to measure the results.

Figure 1: Prisma Flowchart

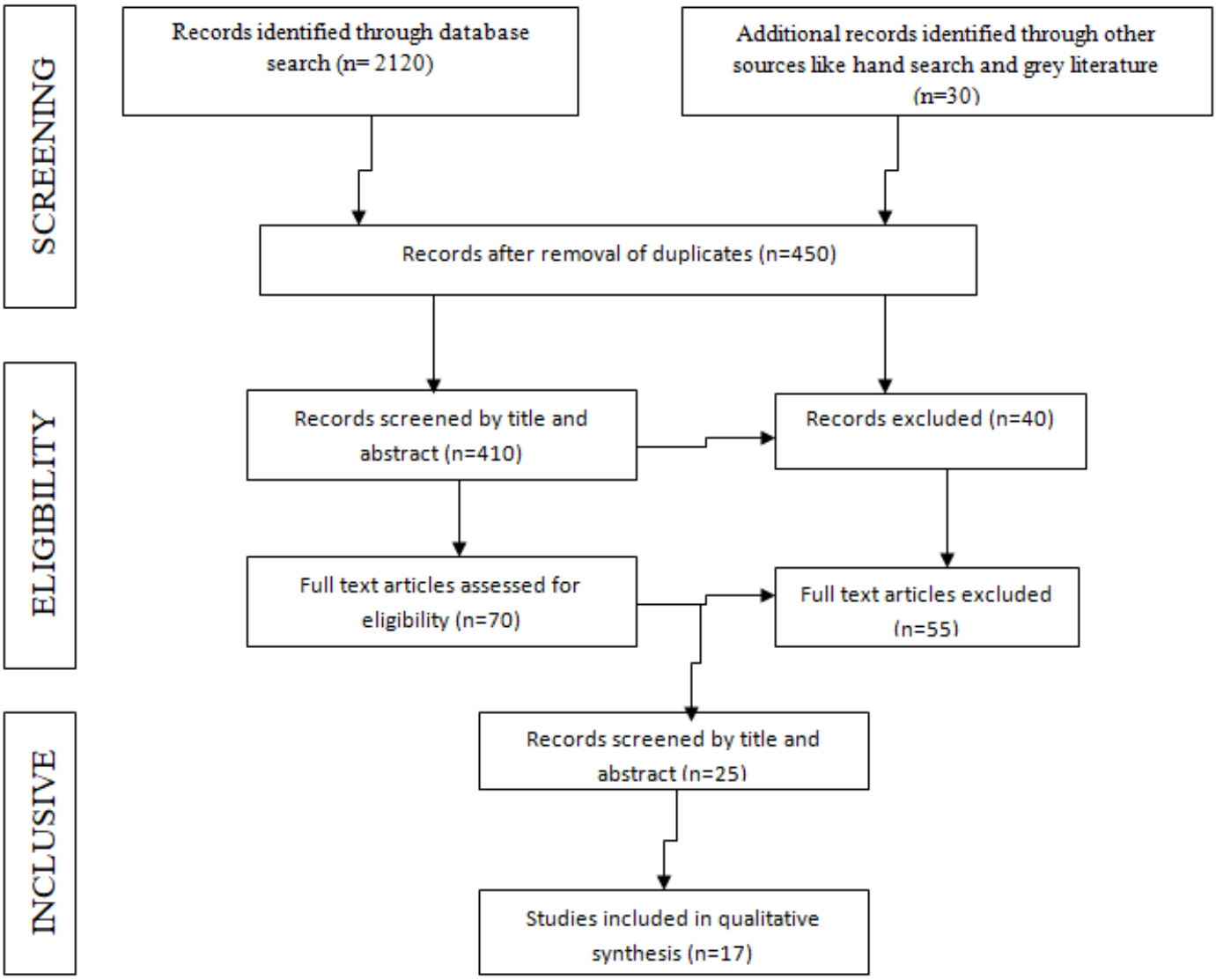

Table 1: Comparative Analysis

Author/year	Type of study	Population	Intervention	Control or comparison	Outcome	Conclusion
Rodrigues et. Al (2012)	Cross-sectional	400(M/F)800 CI (400- Upper, 400-lower)	Shade selection	Shade difference in different age group	Shade appear different in different age groups	In younger age group shade is-A2/2R1.5/140 and A1 / 1 M2 / 120. In advanced age A2 / 2 R2.5 /140 For both F and M.
Ozat.et all(2013)	Randomized control trial	Not applicable	Shade of right central incisor using the Vita 3D-Master shade guide and the Vita easy shade.	NO comparison	To get clinically acceptable shade, knowledge and training is essential.	Dentist performs insufficiently regarding repeatability, but the shades were clinically acceptable.
SafuraBaharinet.al(2013)	Cross-sectional	100 Students	Influence of light source and patient position on	Shade selection by	Different shade appears in	Shade appears more reliable in upright dental

			shade selection.	visual and intraoral spectrophoto meter under different light and patient position.	different light and different position	chair position with lights off (56%) and the least when patient is in supine with dental lights off.
Bahannan SA et .al(2014)	Comparative study	Not applicable	Visual vs. spectrophotometer tooth shade selection.	Spectrophoto meter improves the quality of shade matching.	Dental students recorded 36.3% accurately using visual shade and 80.4% using Easy shade.	Spectrophotometer records more accurate shade than visual methods.
Alshiddi IFetal. (2015)	Comparative study	Not applicable	Visual and spectrophotometer tooth shade evaluation by untrained and trained dental students.	Trained and untrained dentist	Spectrophotomete r showed better result, but the knowledge of the shade selection is more important than the device.	There is a significant color difference between spectrophotometer(E-3.63)and visual method (e-4.22)
DS .Mooddley et al.(2015)	cross-sectional	25 patients	Extent of agreement between the digital and human assessment methods	visual vs spectrophoto meter	Significant difference were recorded between the systems	use both human assessment and digital evaluation to ensure that acceptable esthetics are achieved.
Parameshwaran et al.(2016)	Comparative study	360 readings (270for visual 90 for spectrophotometric	To determine the accuracies in visual and intraoral spectrophotometer.	Visual vs spectrophoto meter	Accuracies were more in visual but spectrophotometer shows better interrater agreement.	visual methods were more accurate than spectrophotometry
Anand et al.(2016)	Comparative study	20 anterior extracted	SLR as an alternative to the spectrophotometer in shade selection	spectrophoto meter vs digital	SLR with adobe Photoshop as an adjunct can be used as an alternative to the spectrophotometer	DSLR can be used as an alternative to spectrophotometer.
Juzeret al.(2017	comparative study	50 participants	shade selection by visual,spectrophotometer and digital methods.	photographic vs conventional methods .	Digital photographymeth od emerged as a reliable method for shade selection.	The visual and the spectrophotometric method show higher percentage of agreement forA1 shade, Digital photography can emerge as a variable alternative to the use of spectrophotometer
Christopher Igiel et at.(2017	Cross-sectional	Model evaluation of shade matching by forty observers	to evaluate intrarater and inter-rater reliability of visual and instrumental shade matching.	visual and instrumental shade matching.	The intrarater and inter-rater reliability of visual and	visual shade matching exhibited a high to moderate level of incon-sistency for both intrarater

					instrumental tooth color matching strongly suggest the use of color matching instruments as a supplementary tool to enhance the esthetic outcome.	and inter-rater compared to the VITA Easy shade.
MG Dimirel et al.(2018)	Cross-sectional	302(119-Male,183-Female	influence of age, gender and educational background on tooth color	NO comparison	Significant difference among all three parameters of color and age was observed.	As individual ages, tooth color darkens; women have lighter teeth than men. The tooth color of high school group was found to be lighter than of the other groups.
WalleskaFeijó Liberato et.al (2018	Comparative study	28 participants	compare the reliability of different visual and instrumental methods for dental shade matching.	2 different shade guides with and without the aid of a light-correcting device and an intraoral scanner and a spectrophoto meter	Instrumental methods were more accurate than visual methods.	Instrumental methods for color shade matching were more reliable than the visual methods tested.
Samehet al.(2019)	randomized control trial	26(13-VITA SUPINITY, 13-IPS EMAX CAD	Patient satisfaction combined with shade matching of VITA SUPRINITY VSIPS e-max CAD	Vita supinity vs ips e-max CAD	Both materials are clinically accepted to be used as full coverage restoration	100% patient were satisfied by restorations in both the groups
Begum et al.(2019)	Cross-sectional	5 volunteers and 25 observer	outcomes of VSS differ as performed by operator with different experience and light condition	Shade differs with different experience and different light conditions.	Professional experience has no effect on VSS outcomes under both light conditions	Shade measure outcomes were not affected by the light conditions. The shade measurement feature of the t-3S could be an alternative to VES and VSS.
Suganya et.al (2020)	Comparative study	50 dental students (18-25). Age group	Shade difference between human eye and digital method with spectrophotometer	Digital vs conventional.	Professional experience has no effect on VSS outcomes under both light conditions.	Digital shade evaluation is more precise than conventional method
Ratzman et.al(2020	comparative study	35 patients	validity and reliability of color measurements, of 2D and 3D color system concerning a variety of	2D versus 3D color system.	The 3D system may confuse both human raters and electronic devices.	2D system was superior to the 3D system, both visually and electronically .

			statistical and graphical methods .		The 2D system is the simple and best choice.	
Sabrin Abu-Hossin et. Al (2023)	Cross-sectional study	31 probands	To compare visual and digital shade selection methods and to assess the repeatability of the utilized intraoral scanners.	Digital vs visual tooth shade selection	The use of digital instruments is increasingly being preferred over visual methods.	Intraoral scanners are a good supplement for color determination, but should additionally be confirmed by the visual method.

Discussion

The goal of the systematic review is to compare several approaches inselecting a tooth shade, weigh the benefits and drawbacks of different approaches, and identify a more effective and cost-effective approach. The review synthesised the following data from the results of 17 investigations.

According to the Bahannanhypothesis, the Vita Easy Shade spectrophotometer generates 80.4% more accurate shade matching than the 36.3% generated by the visual shade guide (VitaPan Classic).Compared to the VitaPan Classical shade guide, the instrumental shade matching performed by the Vita Easy Shade guide spectrophotometer was more accurate (Vita Zahnfabrik GmbH, Bad Sackingen, Germany). [2]

The result of the spectrophotometer for tooth shade selection by trained and untrained dentists revealed similar results, but the trained dentists had improved shade-matching skills and a significant impact on the final aesthetics (ΔE = 3.45 for a trained dentist compared to ΔE = 4.98 for an untrained dentist). A study conducted by Paul et al, where 14 male and 16 female patients in the age range of 17-44 years were compared, the spectrophotometer analysis delivered more accurate results than the visual approach. The significant findings of the study suggested that visual method observes the color difference of 3.7ΔEunder standardized laboratory conditions [4]. However, the standardisation of spectrophotometer is important as it observes a color difference upto1ΔE, when matched for the same tooth. The shade match between a tooth and the information from the colour library results in the shade determined by the spectrophotometer, along with depth-dependent translucency. According to Paul et al., spectrophotometer accuracy is 33% higher than that of the visual methods and rises to 93.3% when comparing closely to a tooth.[7] The Vitapan 3D-master shade guide system reported better shade-matching outcomes and a more accurate visual shade guide. The standardisation of spectrophotometer is important since the same observation in the oral cavity is 3.7ΔE when matched for the adjacent tooth. The 3D shade guide offers higher colour matching than previously available shade tabs, they have more ordered colour dispersion, and improved shade matching. The unbalanced distribution of colour space that is pertinent to human teeth was reported by the Vita classical shade tabs.[6]Evaluation of various shade guides using the cross-polarized photography of digital camera, A2 shade homogeneity among all shade tabs and A1, A3, and A3.5 of Vita classical exhibited the lowest value.[4]An evaluation of Spectro Shadescan, Vita Easy shade, were found to have dependability ranging from 87.4% to 99.0%, in a comparison of electronic shade-matching devices. After recording multiple measurements, all of the devices showed predictable shade values (variability 67%–93%). However, Shade vision recorded the lowest accuracy and Vita Easy shade recorded the highest.

The results of the investigations documented the differences between the visual and digital shade guides.

Despite using different strategies, majority of the research had uniform findings. In a challenging situation where the clinician is unable to evaluate a single shade tab to match the tooth, Jarad et al.'s observation of computer-based shade matching revealed that it improves the clinician's ability to match the tooth colour. In comparison to the 41 % correct shade matching using visual approaches, the computer method reported 61.1% correct shade matching (P 0.001 and P 0.04 for the conventional and computer methods, respectively). The digital shade technique was created by Kim et al. by altering the intraoral camera. In order to block light from the outside, two linear polarizers were positioned in front of an intraoral cameras light source for cross-polarization.[8]These updated devices determine the shade using the Vita 3D shade guide. The author noted that this method aids in the highly accurate quantitative measurement of tooth colour, and stated that spectrophotometers and colorimeters do not accurately assess tooth colour as they do not provide actual picture . According to a cross-sectional research of 400 people, the most common shade of maxillary and mandibular incisors in younger age males is A2, 2R2.5, , and for females it is A1, 1M2. A2 for VitaPan classical, 2R2.5 for Vita 3D Master, and 140 for Chromascop shade guide[24].Since there are no similarities between the colour values (L*a*b*) obtained using two distinct spectrophotometers, the dentist and dental laboratory technician should choose their tooth shades using the same procedure or tool for improved tooth shade matching.[25]The shade quality using the conventional visual shade matching method, particularly the shade group of A 3.5, B3, B4, and D4, has been significantly impacted by the reported error produced by the blue background (U = 107.00, Z = 2.52, P = 0.01). The background/environment may account for a significant physical error in visual shade matching.[10] The observation of the Vitapan Classical visual shade guide in relation to hue, chroma, and value revealed 55.5% accuracy of shade selection, where 54.3% shade accuracy was strongly influenced by the value characteristic of the tooth colour.[3]The general public observation of the visual shade guide method revealed a significant percent visual instrumental shade agreement (PVIA = 38.5%) for the Vita classical shade guide compared to Vita 3D Master. Similarly, the dentists showed the highest PVIA (42%) for the same product, first-year dental students showed greater PVIA (35%) for Vita Pan classical than Vita 3D master. However, only a few dentists had a prior knowledge of the 3D shade guide. To obtain a correct shade for the dental colour, the practitioner needs to be familiar with the armamentarium as well as techniques for matching shade.[27]The comparative evaluation of the missing tooth colour revealed that, for a better shade comparison, the same type of tooth in the opposing arch can be considered for appropriate results. For example, if a maxillary lateral incisor is missing, the choice of the mandibular lateral incisor would be a better match, and if a maxillary canine was missing, the choice of the mandibular canine colour would be better. In another study, the importance of knowledge and competence in shade matching for precise shade selection was assessed by a randomized control trial, where the reliability of repeated visual shade matching was inconsistent. However, a clinician can select appropriate shades as long as they adhere to the manufacturer's recommended protocol.[29]The process of matching shade is greatly enhanced by colour matching education and training. Overall, the study findings revealed that the combination of knowledge regarding light and procedure training leads to an overall improvement in the shade-matching

process.[7]According to a study where shade evaluation was done in tooth preparation as well as cementation step, the shade selection using traditional method and a photo colorimetric method was same.[30] For clinicians who have trouble choosing shades, the photo colorimetric approach for shade selection can be a trustworthy substitute. Vita 3D-master shade guide provides a more accurate shade comparison than vita Pan classic shade guide. However, understanding the tooth colour concept is an important step for dental students.

Summary and Conclusion

The systemic analysis assessed twenty articles on tooth shade selection using both instrumental and visual methods. The instrumental method includes, photo colorimeter, digital imaging, intraoral scanner, and spectrophotometer. Comparing the instruments and the visual method, the Vita Easy shade spectrophotometer is more precise, dependable, and reproducible in evaluating shades. The Vita Easy shade reduces a visual method's subjective colour difference errors. The most significant advantage of the Vita Easy shade spectrophotometer is that it reduces the subjective error of the visual shade method because the Vita Easy shade Spectrophotometer detects colour differences of 1ΔE, whereas the visual method measures the colour differences of 3.7 ΔE.

The photo colorimeter produces better shade matching than the Vita Easy shade, but it is not superior. Additionally, the device is technique sensitive, so any error during the shade-matching procedure will affect the final result. Because there is no standardisation as it is inconvenient to chair side procedure, digital imaging, intraoral scanner, and cross-polarized photography require further evaluation regardless of an adequate result. The main issue with the instrumental method is the high cost of the device, which not every dentist can afford.

Most commonly method used as chair side for shade selection is visual. It is convenient, inexpensive, quick, and easily accessible. Significant subjective and physical errors in visual shade matching reduced the final shade's quality. However, Vita 3D master produces more consistent and reliable shade matching results than Vita pan Classical and other shade guides from different manufacturers. Clinical experience, knowledge, and training in the shade-matching protocol significantly improve a clinician's shade matching capability.

The review concludes that the visual shade guide may provide acceptable clinical shade matching if subjective errors are significantly reduced,. Shade-matching protocol knowledge and training, as well as continuing dental education, are required for clinicians to improve the quality of shade matching. The selected shade should be evaluated at various angles of the matched tooth because the presence of minute roughness on the tooth as these surface features determines the percentage of opacity (light reflection and amount of light that enters the tooth).

Finally, the clinician who is having difficulty with visual shade selection due to age, colour blindness, or any other eye problem can use the instrumental method, specifically the Vita Easy Shade spectrophotometer.

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