**RESEARCH PAPER**

# A Clinical Evaluation of the Correlation Between Eye Scleral Color and Tooth Shade in Natural Dentition

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**ABSTRACT**
Background: Selecting the right tooth shade is crucial for excellent esthetic results in prosthodontic rehabilitation. Traditional shade selection techniques are not generally reliable in totally edentulous patients or in patients without pre-extraction records. Alternative anatomical landmarks could be identified to enhance clinical shade selection. The present study assessed the correlation between the natural tooth shade and eye scleral shade in young individuals.
Materials and Methods: A cross-sectional observational clinical investigation was undertaken in 140 healthy persons (age 20-30 years). The natural tooth shade of the left maxillary central incisor was measured with the VITA Easyshade® spectrophotometer . The scleral shade was established by visual comparison with the VITA Classical Shade Guide under standardized daylight illumination. The data were analyzed using IBM SPSS Statistics version 25.0. Descriptive statistics summarized the distributions of shade, and the correlation between tooth shade and scleral shade was assessed using the chi-square test. Statistical significance was accepted at $p<0.05$.
Results: Natural tooth shade was most frequently A1 (57.1%) and scleral shade was most frequently B1 (58.6%). There was an exact connection between tooth shade and scleral shade in 65 subjects (46.4%), with the highest agreement for B1 (77.1%) followed by A1 (43.8%). Cross tabulation showed considerable agreement between the two variables. Chi square analysis ($\chi$ 2 = 95.35, p = 0.001) showed that there was a statistically significant connection between natural tooth shade and scleral shade.
Conclusion: The shade of the sclera of the eye was significantly correlated with the natural tooth shade and may be a useful supplemental reference during prosthodontic shade selection, especially for patients without traditional shade data. Further multicentric research with objective measurement of scleral colour are necessary to confirm these results..
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## INTRODUCTION

Esthetic rehabilitation is a fundamental objective of modern prosthodontic treatment, aiming to restore oral function while achieving optimal facial harmony and patient satisfaction. One of the major elements affecting dental esthetics is correct tooth shade selection, being important to produce restorations that closely resemble the appearance of natural dentition. Incorrect shade selection can

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jeopardize the aesthetic result and impair the patient acceptance and confidence. Traditionally, shade selection has relied on pre-extraction information, existing prostheses, clinical images or patient preferences. However, these references are often not available or not reliable in completely edentulous patients or patients undergoing full mouth rehabilitation or requiring extensive esthetic restorations. Thus, the need for alternative and reliable anatomical landmarks for shade determination is emphasized.[1-3]

The association between tooth colour and face traits has been investigated by several researchers in order to help with objective shade choosing. The skin complexion, hair colour, age, gender and eye characteristics have been studied as potential determinants of natural tooth shade. Lagouvardos et al. noted substantial interrelationships between tooth, skin, hair and eye colour in young adults and suggested that face traits may be effective adjuncts in the planning of esthetic treatments.[4] Pustina-Krasniqi et al. also found a favorable connection between tooth colour and eye colour, which reinforces the idea that ocular traits may be of use to physicians when selecting a shade.[5] Similarly, Seth et al. suggested that eye colour and skin complexion could help in the choice of harmonious tooth hues in young Indian adults, but the intensity of these connections differed with gender.[6]

While the studies have been mostly concentrated on iris color, nothing is known about the utilization of the sclera as a possible reference for tooth shade selection. The sclera has several attributes which make it an attractive anatomical landmark. These include its relative uniformity, low physiological pigmentation and color stability throughout adult life. Unlike the iris, which exhibits large inter-individual variability, the sclera usually appears uniformly white under normal physiological conditions. In addition, studies on facial aesthetics have indicated that scleral traits are important for facial attractiveness and visual perception, contributing to the overall harmony of the face.[7] The exact replication of scleral colour is of exceptional importance in maxillofacial prosthodontics during the manufacturing of orbital prostheses, especially in patients with bilateral orbital abnormalities when there is no natural scleral reference.

Recent breakthroughs in digital colour science have greatly improved the precision and reproducibility of the assessment of tooth shade. The use of spectrophotometers for instrumental colour analysis has reduced the subjectivity involved with conventional visual shade matching by decreasing the effects of operator experience, ambient illumination and observer tiredness. The VITA Easyshade spectrophotometer has been widely regarded as one of the most accurate devices for objective tooth colour measurement and has shown better repeatability compared to the standard shade guidelines.[2,8-10]

There has been considerable progress in the digital assessment of shade, however evidence about the link between scleral colour and natural tooth shade is still lacking, especially in the Indian population. Most of the existing studies have addressed the skin or iris colour, and the possible relevance of scleral colour as a reliable anatomical reference has been poorly scientifically addressed. This association may give doctors with an extra objective guide to determine tooth shade in patients missing reference information.

Hence, the objective of the present study was to assess the association of the eye scleral color with the natural tooth shade in young adults using the VITA Easyshade spectrophotometer and VITA Classical shade guide. The demonstration of a significant association between these anatomical structures may provide a practical adjunct for tooth shade selection in prosthodontic rehabilitation in the absence of conventional procedures.

## METHODOLOGY

The Department of Prosthodontics, Crown and Bridge and Implantology undertook a cross-sectional observational clinical study to assess the association between the natural tooth shade and the scleral shade of the eye in young individuals. The study was carried out with clearance from the Institutional Ethics Committee and written informed consent from all the subjects prior to participation. The study was conducted on 140 healthy adults in the age group of 20-30 years. The sample size was computed using G*Power software version 3.1.9.2 with an effect size of 0.38, an alpha error probability of 0.05 and a statistical power of 95% to yield a final sample size of 140 participants.

Participants were selected from patients with natural maxillary anterior teeth and with the appropriate age range. Exclusion criteria were the presence of anterior teeth that had been restored or bleached, developmental defects affecting the shape or colour of the teeth, intrinsic or extrinsic staining of the teeth, the use of contact lenses and ocular disorders that may impact the appearance of the sclera . The clinical armamentarium included a mouth mirror, explorer, periodontal probe, kidney tray, surgical gloves, surgical mask, cheek retractor, VITA Easyshade® digital spectrophotometer (VITA Zahnfabrik, Bad Säckingen, Germany) and the VITA Classical Shade Guide. All tests were carried out under uniform daytime conditions so as to minimize the change in colour perception. Before shade assessment, the maxillary anterior teeth were cleaned to remove superficial dirt and plaque. Each participant was comfortably seated with the Frankfort horizontal plane parallel to the floor. The left maxillary central incisor was shade matched using the VITA Easyshade® digital spectrophotometer per manufacturer's instructions. In order to have an objective colour measurement, the measuring point of the device was placed perpendicular to the middle third of the labial surface of the tooth and the matching VITA Classical shade was recorded.

Following the tooth shade evaluation, the matching shade tab of the VITA Classical Shade Guide was placed adjacent to the left sclera. Participants were told to look to the right, thus fully exposing the left sclera for visual comparison under identical standardized lighting circumstances. The

scleral shade was measured by comparing the sclera with the selected shade tab and recording the closest matching shade. All clinical assessments were performed by a single, calibrated assessor using the same standardized technique for all participants, to ensure uniformity and avoid observer bias.

The main outcome measure was the connection between the color of the natural tooth and the color of the sclera. Secondary outcome measures were the frequency distribution of tooth and scleral shades, the proportion of exact shade matches between the two variables and distribution of individual shade combinations.

The collected data was entered into Microsoft Excel and analyzed by Statistical Package for the Social Sciences (SPSS) software (IBM SPSS Statistics, Version 25.0, IBM Corp., Armonk, NY, USA). Demographic characteristics and shade distributions were summarized using descriptive statistics and presented as frequencies and percentages. Chi-square test was used to analyze the relation of tooth shade with the scleral shade. A 95% confidence interval and p value $< 0.05$ were recognized as statistically significant. Results were provided in an appropriate tabular form to aid interpretation of the association between natural tooth shade and scleral colour.

## RESULTS

A total of 140 healthy young adults (aged 20-30 years) were included in the study. The average age of the participants was 21.76 ± 1.99 years, indicating a highly homogeneous study population in terms of age. Table 1 shows the distribution of natural tooth tints and scleral shades. The investigation of exact shade agreement between the natural tooth shade and the scleral shade revealed variable levels of concordance among the different shade groups (Table 2). The most agreement was seen in B1 where 27 of 35 (77.1%) subjects had the same dental and scleral colors. This was followed by A1, where 35 of 80 participants (43.8%) had an exact match. Lower agreement rates were found for A2 (16.7%) and B2 (14.3%). No exact matching was found for A3, B3 or C1. Overall, 65 of the 140 participants (46.4%) showed an exact correspondence between tooth shade and scleral shade, while 75 participants (53.6%) displayed discrepancies between the two parameters, demonstrating that although scleral shade cannot reliably predict tooth shade in every individual, a significant percentage presented with similar colour characteristics.

Tooth shade and scleral shade cross-tabulation further demonstrated the distribution of specific shade combinations and their association (Table 3). The most prevalent scleral tint for subjects with A1 tooth shade was B1 (n=41) followed by A1 (n=35). Similarly, 27 subjects with the B1 tooth shade had a comparable B1 scleral shade, but fewer were spread throughout the B2, A1, and B4 scleral shades. Similar distributions were reported for the other tooth shade groups but with relatively fewer observations because of their lower prevalence. The statistical study using Chi-square test showed the extremely significant correlation between natural tooth shade and scleral shade ($\chi 2$= 95.35, p= 0.001) which means that the observed distribution was not likely due to chance. Thus, the null hypothesis was rejected and the two variables are statistically significantly related. The results indicate that scleral shade may serve as a useful auxiliary clinical reference for tooth shade selection, particularly when conventional shade selection aids like as pre-extraction data, prior prosthesis, or clinical pictures are not accessible. Although there was no total agreement between tooth and scleral shades for all the individuals, the high statistical correlation warrants the possible use of scleral colour as an additional anatomical reference in prosthodontic rehabilitation and esthetic treatment planning.

**Table 1. Demographic Characteristics and Distribution of Tooth and Scleral Shades (n = 140)**

| Category | Tooth Shade, n (%) | Scleral Shade, n (%) |
|---|---|---|
| A1 | 80 (57.1) | 41 (29.3) |
| A2 | 12 (8.6) | 3 (2.1) |
| A3 | 4 (2.9) | 1 (0.7) |
| B1 | 35 (25.0) | 82 (58.6) |
| B2 | 7 (5.0) | 11 (7.9) |
| B3 | 1 (0.7) | 0 (0.0) |
| B4 | 0 (0.0) | 1 (0.7) |
| C1 | 1 (0.7) | 1 (0.7) |
| **Total** | **140 (100.0)** | **140 (100.0)** |

**Table 2. Exact Shade Matching Between Tooth Shade and Scleral Shade**

| Tooth Shade | Matched/Total, n | Agreement (%) |
|---|---|---|
| A1 | 35/80 | 43.8 |
| A2 | 2/12 | 16.7 |
| A3 | 0/4 | 0.0 |
| B1 | 27/35 | 77.1 |
| B2 | 1/7 | 14.3 |
| B3 | 0/1 | 0.0 |
| C1 | 0/1 | 0.0 |
| **Overall** | **65/140** | **46.4** |

**Table 3: Cross-tabulation of Tooth Shade and Scleral Shade**

| Tooth Shade VS Scleral shade | A1 | A2 | A3 | B1 | B2 | B4 | C1 | Total | $X^2$ VALUE | P VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 35 | 0 | 1 | 41 | 2 | 0 | 1 | 80 | 95.35 | **0.001** |
| A2 | 4 | 2 | 0 | 4 | 2 | 0 | 0 | 12 | | |
| A3 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 4 | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| B1 | 1 | 0 | 0 | 27 | 6 | 1 | 0 | 35 | | |
| B2 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 7 | | |
| B3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | | |
| C1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | | |
| **Total** | **41** | **3** | **1** | **82** | **11** | **1** | **1** | **140** | | |

## DISCUSSION

The present cross-sectional observational study assessed the link between natural tooth shade and scleral eye shade among young adults and found a statistically significant association between the two variables ($\chi 2 = 95.35$, $p = 0.001$). The results indicate that scleral colour may be a valuable supplemental anatomical reference for tooth shade selection, especially in clinical scenarios when traditional records such as pre-extraction pictures, current prostheses or past dental restorations are unavailable. One of the most difficult parts of esthetic prosthodontics is to obtain an accurate shade match. The success of a restoration depends not only on function but also on the reproducibility of the optical qualities of the natural dentition.[1,3,11]

The distribution of tooth colors in the present investigation showed that the most frequent natural tooth shade was A1 (57.1%) and the most frequent scleral shade was B1 (58.6%). These data suggest that lighter shade categories are more frequently found in young individuals. Observations in agreement with the present study were made by Gómez-Polo et al. who revealed that younger persons tend to exhibit lighter hues due to less influence of dentin chromaticity and less age-related changes in enamel.[10] Paravina similarly described that tooth colour increasingly darkens with age due to secondary dentin deposition and changes in enamel translucency; thus younger populations are more likely to have lighter tints.[12]

An exact match between tooth shade and scleral shade was observed in around half of the subjects (46.4%). Highest agreement was observed with B1 (77.1%) followed by A1 (43.8%). Although not all participants fully agreed, the statistically significant connection shows that scleral colour may have clinical implications in shade choosing. Likewise, studies that have assessed facial characteristics have also revealed that ocular and facial features have quantifiable associations with tooth colour. Lagouvardos et al. found strong connections between tooth, skin, hair and eye colour, suggesting that facial features may provide crucial adjunctive information during esthetic rehabilitation.[4] Similarly, Pustina-Krasniqi et al. reported a positive correlation between tooth colour and eye colour stating that ocular features could help doctors when traditional shade selection references are not accessible.[7] In a study carried out on young Indian individuals, Seth et al. noticed that skin tone and eye colour might affect the selection of optimal teeth tints, although the intensity of relationship differed by gender.[6] The results of the current study support these observations but go further by applying the idea specifically to the sclera, which has not received much attention in the dentistry literature.

Unlike the iris, which shows considerable variance across people and ethnic groups, the sclera usually retains a rather constant appearance throughout adult life. This stability makes it potentially a more reliable anatomical reference for colour comparison. Cosmetic elements also have less effect on the sclera than on other face features such as skin colour or hair colour. Thus, the present work proposes a new approach by assessing scleral colour instead of iris colour, thus enhancing the current knowledge on alternate anatomical references for prosthodontic shade selection.

The objective colour assessment by the VITA Easyshade® spectrophotometer significantly increased the credibility of the present experiment. Instrumental colour determination reduces the subjective nature of conventional visual shade matching . It decreases the effect of ambient illumination, observer experience, colour weariness and individual perception. Spectrophotometric shadow analysis has been shown in several studies to provide increased accuracy and repeatability compared to conventional shade guides.[13] Chu et al. identified the spectrophotometers as one of the most accurate clinical techniques for determining tooth colour.[2] Excellent repeatability and inter-examiner dependability of digital colour-measuring instruments in restorative and prosthodontic practice have also been demonstrated in recent investigations by Nayak et al. and Alshiddi et al.[14,15] Therefore, the current study incorporated a digital shade evaluation to minimize the measurement bias and increase the validity of the recorded tooth shades.

The results were statistically significant, but the present study also showed that there was no exact shade correspondence in more than half of the participants. This shows that eye traits are not the only effect on tooth colour and that other biological and environmental factors also play a role. Tooth colour has been observed to be influenced by age, enamel thickness, dentin chromaticity, hydration status, dietary choices, tobacco exposure, genetic diversity and lighting conditions.[16-19] Scleral shade should not be considered a replacement for existing shade selection approaches but rather as a supplementary clinical aid that can enhance decision making when standard reference methods are not accessible.

The findings may be of particular therapeutic significance in complete denture manufacturing, implant-supported prostheses and full mouth rehabilitation where doctors often face patients lacking pre-extraction records. Similarly, other methods are often needed to estimate the true tooth colour in individuals with significant dental discolouration, widespread restorations, developmental defects or substantial prosthetic rehabilitation.[20] In these difficult clinical conditions, the inclusion of scleral shade as an extra

anatomical landmark can improve esthetic harmony and provide personalized treatment planning.

A key advantage of the present study is the use of an objective digital spectrophotometer to quantify tooth shade, in conjunction with consistent daylight illumination and a uniform clinical process for all participants. The use of healthy young adults decreased confounding factors associated with age-related colour changes, and strengthened the internal consistency of the results. Nevertheless, some limits need to be admitted. The study was conducted at a single institution with a very homogeneous age group, which limits the generalizability of the findings to other age groups and ethnic groupings. Furthermore, the evaluation of tooth shade was performed objectively, but the evaluation of scleral colour was based on visual comparison with the VITA Classical Shade Guide, which may introduce variability dependent on the observer, even after calibration of the examiners.

Future studies should include bigger multicentric populations with different ethnic backgrounds and greater age ranges, and objective digital imaging or spectrophotometric examination of scleral color to increase the precision of measurements. The predictability of shade selection could be enhanced further by incorporating scleral features together with other facial parameters through integration of artificial intelligence-based colour analysis and machine learning algorithms. Such approaches may finally lead to the creation of full computerized esthetic planning systems for prosthodontic rehabilitation. In conclusion, the current results offer preliminary evidence that scleral colour may represent a useful adjunctive reference in tooth shade selection and further studies are warranted to establish standardized clinical guidelines for its frequent use.

## CONCLUSION

A significant association was observed between natural tooth shade and eye scleral shade among young adults. Although scleral colour cannot replace conventional shade selection methods, it may serve as a valuable adjunctive reference during esthetic rehabilitation, particularly in patients lacking pre-extraction records. Further multicentric studies are needed to validate these findings.

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