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Research Article

Contralateral shade comparison in anterior teeth

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Abstract

Digital shade determination was used to evaluate shade distribution and contralateral shade matching in the maxillary anterior teeth of 120 patients aged 18–30 years. Teeth 13, 12, 11, 21, 22 and 23 were scanned with 3Shape TRIOS 4 Wireless and classified according to VITA 3D-Master and VITA Classical. Of 720 planned tooth-level observations, 709 were valid; 11 were excluded because of scanning artifacts. The most frequent 3D-Master shades were 1M2 (51.6%), 2M3 (24.7%) and 0M3 (6.6%). The most frequent Classical shades were A1 (45.4%), A2 (30.3%) and A3 (8.6%). Confirmed contralateral matching was higher with VITA 3D-Master than with VITA Classical, reaching 65.0% for teeth 11–21. Complete matching in all three pairs occurred in 26.7% and 5.8% of patients, respectively. These findings show that contralateral teeth can support esthetic planning, but individual digital shade assessment remains necessary for predictable anterior restorations. This supports cautious use of contralateral reference teeth clinically.

Keywords

tooth shade, VITA Classical, VITA 3D-Master, intraoral scanner, 3Shape, digital dental medicine

Introduction

Determination of the shade of natural teeth is one of the key stages in esthetic restorative dental medicine. An incorrect shade selection can lead to visible disharmony between a restoration and adjacent natural teeth, particularly in the maxillary anterior region, where even small differences may be clinically perceptible. Shade selection has traditionally been performed visually using standardized shade guides. However, visual determination is subjective and can be influenced by illumination, operator experience, eye fatigue, surrounding soft tissues and individual differences in color perception. For this reason, instrumental and digital approaches to shade determination have become increasingly important in contemporary dental practice (1,2) VITA Classical A1-D4 is a widely used clinical shade guide that classifies tooth color into 16 shade tabs grouped in the A, B, C and D families. VITA 3D-Master is organized more systematically and describes shade through the dimensions of value, chroma and hue. This structure may allow a more differentiated description of the natural tooth-color space (3). Intraoral scanners were initially introduced mainly for digital impressions, but modern systems also provide

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shade information from the scanned tooth surfaces. This enables shade determination to be incorporated into the digital workflow and supports communication between the clinician and the dental laboratory (4,5). Tooth color is a complex optical phenomenon and cannot be described by hue alone. It is influenced by several factors, including enamel thickness, dentin color, translucency, surface texture, hydration and light-scattering properties of the dental tissues. Moreover, natural teeth are not uniformly colored across the entire crown; shade variations may exist between the cervical, middle and incisal thirds. This complexity makes accurate shade determination particularly challenging in the anterior region, where esthetic demands are high (6,7)

Digital shade determination offers several potential advantages over purely visual methods, including standardized image acquisition, integration with computer-aided design and manufacturing workflows, and easier transfer of shade information to the dental laboratory. Nevertheless, shade data obtained from intraoral scanners may also be affected by scanning conditions, software algorithms, surface reflections, tooth hydration and the quality of the captured image. Therefore, the clinical interpretation of digitally recorded shade values requires an understanding of both the advantages and the limitations of the technology used (8). The assessment of shade symmetry between contralateral teeth is clinically relevant because restorative treatment in the maxillary anterior region often aims to reproduce the appearance of the corresponding natural tooth. However, physiological and acquired differences between left and right teeth may occur as a result of variations in enamel thickness, dentin saturation, tooth position, wear, pigmentation or previous minor structural changes. For this reason, evaluation of contralateral shade matching may provide useful information for treatment planning and may help determine whether the contralateral tooth can be considered a reliable shade reference (9). In clinical practice, the contralateral tooth is frequently used as a reference when restoring a missing or damaged anterior tooth. However, shade symmetry between left and right maxillary anterior teeth should not be assumed to be absolute. The present study evaluates the shade distribution of maxillary anterior teeth and the degree of matching between contralateral tooth pairs after digital shade determination using the VITA Classical and VITA 3D-Master systems. Aim The aim of the present study was to perform a comparative analysis of the shade of left and right maxillary anterior teeth in patients aged 18 to 30 years, with shade values determined through intraoral scanning with 3Shape TRIOS 4 Wireless and classified according to VITA Classical and VITA 3D-Master.

Materials and methods

Methods

This study was designed as a clinical observational comparative study. Written informed consent was obtained from all participants prior to their inclusion in the study. A total of 120 patients aged 18 to 30 years were included. For each patient, the maxillary anterior teeth 13, 12, 11, 21, 22 and 23 were assessed according to the FDI World Dental Federation tooth-numbering system. Shade determination was performed after intraoral scanning with 3Shape TRIOS 4 Wireless (3Shape A/S, Copenhagen, Denmark). For each examined tooth, shade values were recorded according to two shade systems: VITA 3D-Master and VITA Classical (VITA Zahnfabrik, Bad Säckingen, Germany) (Fig.1). The initially planned sample comprised 720 tooth-level observations, corresponding to 120 patients with six maxillary anterior teeth each. After scan-quality assessment, 11 teeth were excluded because of scanning artifacts that did not allow reliable shade determination. Therefore, the final descriptive analysis of shade distribution was performed on 709 valid tooth-level observations. For the comparative analysis between symmetric left and right maxillary anterior teeth, the contralateral pairs 13-23, 12-22 and 11-21 were evaluated at patient level in the full clinical cohort of 120 patients. A pair was classified as matching only when both contralateral teeth had reliable and identical shade codes within the respective shade system. If one or both teeth in a pair had an artifact-affected or unreliable shade record, the pair was classified as non-matching for the purpose of the patient-level agreement analysis. This conservative approach preserved the full patient cohort as the denominator while avoiding the assumption of shade agreement in cases where reliable bilateral comparison could not be confirmed.

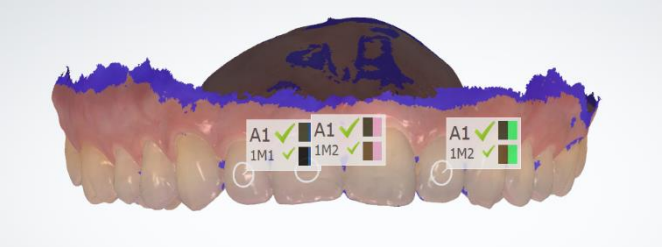

Fig. 1 Digital shade analysis

The data were processed using descriptive statistical analysis. Absolute frequencies and relative percentages were calculated for each shade category. For the contralateral tooth pairs, the percentage of complete agreement of the shade code between the left and right sides was calculated separately for VITA 3D-Master and VITA Classical. Matching was treated as a binary patient-level outcome. Only confirmed identical shade codes were

counted as matching. Non-identical shade codes and artifact-affected comparisons without reliable bilateral shade confirmation were counted as non-matching.

Results

The final descriptive analysis included 709 maxillary anterior teeth. According to VITA 3D-Master, the shade distribution showed a marked concentration in the range of medium value and moderate chroma. The most frequently recorded shade was 1M2 (n=366; 51.6%), which clearly predominated over all other shade categories. The next most frequent shades were 2M3 (n=175; 24.7%) and 0M3 (n=47; 6.6%). Other relatively common categories included 3M3, 2R2.5 and 1M1, while all remaining shades with an individual relative frequency below 2% were grouped as Other for clearer presentation (Tab.1).

Table 1. Distribution of tooth shades according to VITA 3D-Master

VITA 3D-Master shade	Number of teeth	Percentage
1M2	366	51.6%
2M3	175	24.7%
0M3	47	6.6%
3M3	35	4.9%
2R2.5	33	4.7%
1M1	18	2.5%
Other shades	35	4.9%
Total	**709**	**100.0%**

According to VITA Classical, the shade distribution showed a clear predominance of shades from group A. The most frequent shade was A1 (n=322; 45.4%), followed by A2 (n=215; 30.3%) and A3 (n=61; 8.6%). These three shades represented the majority of all observations and formed the main shade profile of the studied group. Shades B1, B3 and A3.5 were less frequent, while the remaining shades were grouped as Other (Tab.2).

Table 2. Distribution of tooth shades according to VITA Classical

VITA Classical shade	Number of teeth	Percentage
A1	322	45.4%
A2	215	30.3%
A3	61	8.6%
B1	37	5.2%
B3	31	4.4%
A3.5	28	3.9%
Other shades	15	2.1%
Total	**709**	**100.0%**

The contralateral comparison was performed at patient level in the full clinical cohort of 120 patients. In this patient-level analysis, the denominator was the full cohort of 120 patients. Only confirmed identical contralateral shade codes were counted as matching, while non-identical and artifact-affected comparisons were counted as non-matching. According to VITA 3D-Master, the highest shade agreement was observed between the central incisors 11-21 (78/120; 65.0%). The agreement between the canines 13-23 was 68/120 (56.7%), while the agreement between the lateral incisors 12-22 was 59/120 (49.2%). According to VITA Classical, contralateral matching rates were lower. The highest agreement was found between the canines 13-23 (52/120; 43.3%), followed by the central incisors 11-21 (40/120; 33.3%) and the lateral incisors 12-22 (28/120; 23.3%) (Tab.3).

Table 3. Shade matching between contralateral maxillary anterior teeth

Contralateral pair	VITA 3D-Master matching	VITA Classical matching
13–23	68/120 = 56.7%	52/120 = 43.3%
12–22	59/120 = 49.2%	28/120 = 23.3%
11–21	78/120 = 65.0%	40/120 = 33.3%

Complete shade agreement in all three contralateral pairs was observed in 32 of 120 patients (26.7%) according to VITA 3D-Master and in 7 of 120 patients (5.8%) according to VITA Classical (Tab.4).

Table 4. Complete shade matching in all three contralateral pairs

Indicator	VITA 3D-Master	VITA Classical
Complete matching in 13–23, 12–22 and 11–21	32/120 = 26.7%	7/120 = 5.8%

Discussion

The results show that in the examined age group of 18 to 30 years, the shade distribution of the maxillary anterior teeth was concentrated mainly in light to medium shade categories. This was confirmed by both shade systems: 1M2 predominated according to VITA 3D-Master, while A1 and A2 predominated according to VITA Classical. The prevalence of lighter shades is clinically plausible in young patients, in whom the hard dental tissues usually demonstrate higher value and less age-related darkening. The relatively narrow age range of the sample reduces the influence of age as a confounding factor, although it also limits direct extrapolation of the findings to older patient groups (10). The comparison between contralateral maxillary anterior teeth is clinically relevant because the contralateral tooth is often used as a reference when planning esthetic restorations. However, the present results demonstrate that complete shade identity between symmetric teeth is not universal. Even according to VITA 3D-Master, confirmed complete matching in all three contralateral pairs was present in only 26.7% of patients. The highest agreement according to VITA 3D-Master was observed for the central incisors 11-21. This finding is important because the maxillary central incisors are the most visible teeth during smiling and speech. Nevertheless, more than one third of the patients did not show confirmed identical VITA 3D-Master shade codes for the two central incisors. According to VITA Classical, the matching rate for 11-21 was even lower (11). The lower matching rates observed with VITA Classical may be related to the different organization of the two shade systems. VITA Classical is widely used in clinical practice but is less systematically structured. VITA 3D-Master classifies color according to value, chroma and hue, which may allow more differentiated grouping of similar shade characteristics (12). The findings support the clinical position that the shade of the contralateral tooth is useful as a reference but should not be used as the only determinant of shade selection. Individual shade assessment of each anterior tooth remains necessary, especially in esthetic treatments involving single crowns, veneers or direct restorations in the maxillary anterior region (13). The study has several limitations. First, the analysis was limited to patients aged 18 to 30 years. Second, shade determination was performed with one intraoral scanner model, and the results should not be generalized automatically to all digital systems. Third, the analysis was based on categorical shade codes rather than numerical colorimetric parameters such as L*, a* and b* (14).

Another methodological consideration is that artifact-affected contralateral comparisons were conservatively classified as non-matching in the patient-level analysis. Therefore, the reported matching rates should be interpreted as rates of confirmed shade agreement within the full clinical cohort, rather than as pairwise agreement rates after exclusion of all incomplete comparisons. Despite these limitations, the study provides clinically useful information on toothshade distribution and contralateral shade symmetry in young adults.

Conclusion

Within the limitations of the present study, the following conclusions can be made:

1. In patients aged 18 to 30 years, the most frequently recorded maxillary anterior tooth shade according to VITA 3D-Master was 1M2, followed by 2M3 and 0M3.
2. According to VITA Classical, the most common shades were A1, A2 and A3.
3. The observed proportion of confirmed contralateral shade matching was higher when shade was recorded using VITA 3D-Master than when recorded using VITA Classical.
4. The highest confirmed contralateral matching rate according to VITA 3D-Master was observed between the central incisors 11-21.
5. Confirmed complete matching in all three contralateral pairs was observed in 26.7% of patients according to VITA 3D-Master and in 5.8% according to VITA Classical.
6. In esthetic treatment planning, the contralateral tooth may be used as a clinical reference, but it should not be assumed to have an identical shade without individual shade determination.

Additional information

Funding statement

None.

Ethical compliance

Prior to participation, all participants were informed about the purpose of the study, and written informed consent was obtained.

Conflict of interest

The authors declare that they have no conflict of interest and no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

Author contributions

Conceptualization and study design - I.L, R.T
Data collection and spectrophotometric measurements - I.L
Data analysis and interpretation- I.L, T.U
Preparation of figures and visualization- I.L, R.T
Writing of draft- I.L
Revision, and final approval of the manuscript- T.U, R.T

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