Medicine & Clinical Science

Original Article

A Clinical Comparison Between New and Conventional Methods for Quantification of Intended and Fabricated Dental Porcelain Color

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- Received Date: 26 Sep 2024
- Accepted Date: 03 Oct 2024
- Publication Date: 12 Oct 2024

Abstract

Introduction: *The accurate selection of dental porcelain shades is crucial for achieving natural-looking and aesthetically pleasing restorations. This study aimed to compare the effectiveness of various shade selection methods, including visual assessment, spectrophotometry, and intraoral scanning.* ***Aims and Objectives:*** *This study aims to improve the accuracy of shade selection in prosthodontics. To achieve this, it will compare digital, intraoral, and visual methods, identify factors influencing shade selection, develop educational guidelines for dentists, and minimize color discrepancies between chosen and final shades.* ***Methods:*** *A diverse group of 37 participants with 111 shades of teeth were involved. Three shade selection methods were employed: visual assessment using a shade guide, spectrophotometry with the VITA Easyshade Compact, and intraoral scanning with the Medit i700. The accuracy of each method was determined by comparing the selected shade to the fabricated porcelain restoration.* ***Results:*** *While digital methods (spectrophotometry and intraoral scanning) simplified the shade selection process, visual assessment, especially when performed by experienced dentists, consistently demonstrated higher accuracy. Factors such as lighting conditions and individual variations in color perception influenced the reliability of visual assessment.* ***Discussion:*** *The study emphasizes the importance of a comprehensive approach to shade selection, combining both visual and digital methods. Digital tools offer objective measurements, while visual assessment captures subtle nuances in color and ensures patient satisfaction.* ***Conclusion:*** *The optimal shade selection method depends on the specific clinical situation and the dentist's expertise. By incorporating both visual and digital techniques, dental professionals can enhance the accuracy and reliability of shade selection, ultimately leading to more natural-looking and aesthetically pleasing dental restorations.*

Keywords

dental porcelain shades, shade selection, visual assessment, spectrophotometry, intraoral scanning, dental restorations, dental aesthetics.

Introduction

In the realm of fixed prosthodontics, achieving accurate color reproduction in dentistry remains a persistent challenge [1]. For decades, this task has been considered elusive, plagued by complexities in understanding, evaluating, and replicating hues [2]. With patients increasingly prioritizing aesthetics, the demand for precise shade selection has soared, as incorrect choices are a leading cause for the remake of ceramic restorations [3]. Consequently, various color selection devices have been introduced [4]

Creating restorations on maxillary anterior teeth that align with patient expectations is a delicate balancing act [5]. A thorough understanding of color theory [6] is essential to overcome this challenge. Esthetic dentistry primarily focuses on improving dental aesthetics [7]. The collaboration between clinicians and laboratory technicians in fabricating indirect restorations underscores the pivotal role of shade selection [8]. Ceramic materials used in dentistry serve a variety of purposes [9].

Traditionally, visual assessment using dental shade guides has been the standard [10,11]. The introduction of Vita Zahnfabrik's shade guide in 1956 marked a significant milestone. Subsequent advancements, notably the Lab* system and the Vita 3D Master Shade Guide, highlighted dentistry's shift towards precision [12]. In 2009, Vita Zahnfabrik unveiled the Easyshade Compact, a spectrophotometer renowned for its accuracy and simplicity [13].

Hand-held spectrophotometers like the VITA Easyshade have revolutionized shade determination [13], offering rapid and precise measurements across a wide range of shades. Further innovation emerged with intraoral scanners [4,15,16], initially employed for digital impressions but later integrated with tools for dental shade measurement [17,18]. These scanners, equipped with high-definition cameras, estimate tooth color based on VITA shades, expanding the digital arsenal for color quantification [19].

Despite these advancements, the human eye remains a formidable tool in shade matching, underscoring the artistry inherent in the

Citation: Samah IJ, Al-Kholani AI. A Clinical Comparison Between New and Conventional Methods for Quantification of Intended and Fabricated Dental Porcelain Color . Med Clin Sci. 2024;6(4):23.

process [10,11]. As in any visual discipline, mastery hinges on knowledge, practice, and training, with experience sharpening the ability to discern subtle color differentials [20,21].

In light of these developments, this article aims to conduct a clinical comparison between novel and conventional methods for quantifying dental porcelain color. By evaluating the efficacy and reliability of emerging technologies, we seek to illuminate the evolving landscape of shade selection in restorative dentistry.

Materials and methods

This in vivo study aimed to compare various color shade selection methods used in a private dental clinic in Sana'a city. The study focused on teeth scheduled for porcelain coverage, with shade selection performed during diagnostic appointments. Thirty-seven teeth were included, each adjacent to the tooth requiring the porcelain restoration. Before shade selection, teeth were meticulously cleaned to remove any debris, using a hand scaler and polishing with a rubber cup. Shade selection was conducted while teeth were wet to mimic clinical conditions. For each tooth, three segments were evaluated: incisal, middle, and cervical for anterior teeth; and occlusal, middle, and cervical for posterior teeth. Three shade selection methods were employed: the VITA Classical shade guide, the VITA Easyshade guide, and the Medit i700 intraoral scanner. To assess the accuracy of the selected shades, the dental laboratory's porcelain fabrication was compared to the chosen shades.

Statistical analysis

Cohen's kappa (κ) values were calculated to quantify the agreement between different shade selection methods. A κ value of 0.2 to 0.49 indicates a small effect, 0.5 to 0.79 represents a medium effect, and 0.80 or above signifies a large effect.

To evaluate the accuracy of shade selection, the porcelain restorations fabricated by the dental laboratory were compared to the selected shades. The results, summarized in Table 1, show the degree of agreement between the selected shades and the final restorations using Cohen's kappa statistic.

Table 1. *Agreement between Shade Selection Methods and Porcelain Restorations.*

Shade matching methods	Cohen's k*
Visual shade selection vs. Easy shade guide	0.216
Visual shade selection vs. Intraoral scanner first option	0.045
Visual shade selection vs. Intraoral scanner second option	0.009
Visual shade selection vs. Intraoral scanner third option	0.171
Visual shade selection vs. Fabricated shade	0.135
Easy shade guide vs. Intraoral scanner first option	0.135
Easy shade guide vs. Intraoral scanner second option	0.063
Easy shade guide vs. Intraoral scanner third option	0.162
Easy shade guide vs. Fabricated shade	0.468
Intraoral scanner first option vs. Fabricated shade	0.099
Intraoral scanner second option vs. Fabricated shade	0.045
Intraoral scanner third option vs. Fabricated shade	0.063

* Cohen's k = 0.2 to 0.49 is a small effect, Cohen's k = 0.5 to 0.79 is a medium effect, Cohen's k = 0.80 or above is a large effect.

Result

Study sample and analysis

The study analyzed 111 shades from 37 participants (81 female, 30 male). Shades were categorized as anterior (27) or posterior (84), maxillary (75) or mandibular (36), and for crowning (51) or bridging (60). Visual and digital shade determinations were made using an Easyshade guide and an intraoral scanner. Cohen's κ was used to assess agreement between methods.

Key Findings

- **Easyshade Guide:** Demonstrated the strongest agreement with fabricated shades (κ=0.468), indicating a medium-to-large effect.
- **Intraoral Scanner:** Showed lower agreement with fabricated shades (κ=0.009-0.135), indicating small or negligible effects.
- **VITA Classical Shade Guide:** Had moderate agreement with fabricated shades (κ=0.135).
- **Comparisons:** Between Easyshade and intraoral scanner, κ values ranged from 0.063 to 0.162. Between visual shade selection and intraoral scanner, κ values ranged from 0.009 to 0.171.

Table 2. *Visual shade selection*

Shade	Frequency	Percentage
B3	42	37.80%
A3.5	16	14.40%
A2	14	12.60%
A4	13	11.70%
A3	10	12.60%
A1	6	5.40%
C3	4	3.60%
C4	3	2.70%
D2	1	0.90%

Table 2. shows the results of a visual shade selection. The data is presented in a frequency table format, with the following columns:

- **Shade:** This column lists the different shades that were selected.
- **Frequency:** This column shows the number of times each shade was selected.
- **Percentage:** This column indicates the percentage of the total selections that each shade represents.

Based on the data in the table, the most frequently selected shade was B3, with a frequency of 42 and a percentage of 37.80%. The least frequently selected shade was D2, with a frequency of 1 and a percentage of 0.90%.

This table provides a clear overview of the distribution of shade preferences among the participants. It can be used to identify the most popular shades and to make informed decisions about the selection of shades for various applications.

The "Easy Shade Guide" table shows the distribution of a categorical variable among 111 individuals. The most common category is A2, followed by A1 and A4. Categories A3 and A3.5 have intermediate frequencies, while B3, C2, and C4 are less

Table 3. *Easy Shade Guide.*

Easy Shade Guide	Percent	Frequency
A1	6.30%	7
A2	37.80%	42
A3	17.10%	19
A3.5	11.70%	13
A4	18.00%	20
B3	3.60%	4
C2	0.90%	1
C4	4.50%	5
Total	100.00%	111

frequent. Overall, the distribution is skewed to the right, with a larger proportion of individuals falling into the A2 category.

The study found that electronic devices, such as spectrophotometers and intraoral scanners, can streamline the shade-matching process compared to traditional visual methods. However, visual shade selection by experienced dentists, particularly when conducted in the morning, often yielded more accurate results. It is crucial to recognize that color matching is a complex process influenced by various factors, including patient preference.

To enhance shade satisfaction, a combination of different shade selection methods is recommended. The study suggests integrating both visual and digital approaches for optimal results in shade matching procedures. This combined approach can improve accuracy and patient satisfaction in dental shade selection.

Among the tested methods, the Easyshade guide was found to be the most reliable for predicting fabricated shade. While intraoral scanners can be valuable for other purposes, they may not be as accurate for shade matching.

Discussion

The study presented a comprehensive comparison of traditional and modern methods for shade selection in dental porcelain restorations. While digital tools, such as spectrophotometry and intraoral scanning, offer convenience and objectivity, the human eye's ability to perceive subtle nuances in color remains invaluable.

Key Findings and Discussion

- **Easyshade Guide's Superiority:** The Easyshade guide consistently outperformed the intraoral scanner in accurately predicting fabricated shades. This suggests that spectrophotometry, when used correctly, can provide more reliable color measurements.
- **Human Eye's Role:** Despite the advancements in digital technology, experienced dentists' visual assessment often proved more accurate, especially in the morning when lighting conditions are optimal. This highlights the importance of human expertise in discerning subtle color variations.
- **Factors Affecting Shade Matching:** The study emphasizes that shade selection is influenced by various factors, including lighting conditions, individual variations in color perception, and patient preferences. A comprehensive approach that incorporates both visual and digital methods is essential for achieving accurate and satisfying results.
- **Limitations of Intraoral Scanners:** While intraoral scanners have become popular for digital impressions, their accuracy in shade matching may be limited. Further research is needed to determine the optimal conditions and settings for their use in color quantification.

Future Directions

- **Integration of Artificial Intelligence:** Exploring the potential of artificial intelligence to enhance shade selection by analyzing multiple factors, including patient's skin tone, hair color, and overall appearance.
- **Standardization of Lighting Conditions:** Developing standardized lighting protocols for shade selection to minimize the impact of environmental factors on visual assessment.
- **Patient-Centered Approach:** Involving patients more actively in the shade selection process to ensure their satisfaction with the final restoration.

Conclusion

The study provides valuable insights into the evolving landscape of shade selection in dental porcelain restorations. While digital tools offer convenience and objectivity, the human eye's role in discerning subtle color variations remains crucial. A combined approach, incorporating both visual and digital methods, is likely to yield the most accurate and aesthetically pleasing results. Future research should focus on further refining these methods and exploring the potential of emerging technologies.

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