Dentistry Section

Effect of Formal Training on Tooth Shade Matching Ability among Indian Dental Students in Diverse Clinical Settings: A Quasi-experimental Study

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ABSTRACT

Introduction: Selecting a correct shade is the key to success of any prosthesis, especially in the aesthetic zone. Variations of shade in a single tooth or the polychromatic nature of a tooth can impose greater challenges in shade matching. Therefore, it would be best if it is taught during the undergraduate course in dental schools.

Aim: To evaluate the knowledge and shade matching skills among dental undergraduate students with and without training in three different clinical conditions.

Materials and Methods: This post-test only quasi-experimental study was conducted with 377 undergraduate students of Indian origin studying in a dental teaching institute. The students were divided into two groups based upon their clinical training in shade matching: Group I (trained, n=197) and Group II (untrained, n=180). Three different patients, in terms of their shade complexity, were presented to both the groups and their shade matching ability was assessed. The results were subjected to statistical analysis using the Chi-square test and one-way Analysis of Variance (ANOVA).

Results: Statistical analysis showed that the mean correct scores of the trained students were significantly higher than those of the untrained students (p=0.0001) in all three patients. There was a statistically significant difference (p=0.0001), as the trained group was better able to identify the correct or clinically acceptable shade compared to the untrained group in all three cases.

Conclusion: The study concluded that training significantly improved the shade matching ability of dental undergraduate students in clinical conditions presenting varied complexities.

INTRODUCTION

Currently, high aesthetic demands laid out by the patients and the increased use of tooth-coloured materials have made accurate shade matching critical to the success of a dental restoration [1,2]. Understanding colour is the most important aspect of shade selection, which is a challenging step as no tooth is of uniform shade [3,4]. Selecting a shade in the traditional sense is a very subjective practice, even among the most experienced clinicians [1,5,6]. Selected shades can vary from individual to individual and also from time to time; for instance, if the same individual matches the shade on two different occasions, the results may still vary [7]. Since shade matching is inherently subjective, this skill can only be acquired through practical training and clinical experience [8-10]. This process is best done in collaboration with the patient; however, the deciding figure will ultimately rest with the operator, who can properly guide the patient in appropriate shade selection. During their undergraduate years, a lack of awareness and specialised training among students, leading to inappropriate use of shade matching tools, can be responsible for diminished aesthetics in dental restorations.

Many factors influence the accuracy of shade-matching results, including subjectivity, lighting conditions, the surrounding environment, tooth condition, and the shade-matching tools and methods used [11]. There is still no common consensus on the effects of ethnicity, age, and sex on shade matching ability [12-14]. Studies have shown that instrumental methods of shade matching, such as spectrophotometers and colourimeters, are repeatable and accurate tools for shade matching [15,16]. Despite the re-emerging colour matching instruments, such as spectrophotometer and colourimeter, visual method using a shade guide remains the most popular and commonly used method, especially in dental schools

[17,18]. Using a shade guide also requires adequate knowledge of colour and colour perception for precise assessment [6].

This is especially important for students who have just entered the field of dentistry. Most dental students, although exposed to theoretical knowledge, lack previous experience and practical knowledge which makes it extremely difficult for them to completely understand the concept of colour and use it to their advantage during their progressive years in clinical education [19]. Hence, it is important to understand the lacunae in the basic colour science knowledge imparted to students in dental institutes. Several studies have been carried out to assess the effect of formal training to improving students' practical skill sets [9,20-23].

However, there is still a paucity of available literature on special education aimed at developing analytical skills for identifying tooth shades in complex cases. It is imperative to address the comparison of visual shade selection in clinical situations of varying complexities, as this can provide a different perspective for the clinical training curriculum in dental schools. The present study was carried out to compare the shade-matching ability in dental undergraduate students with and without training in an Indian setting. The null hypothesis was that formal training would not have any effect on tooth shade matching ability among dental students under varying clinical conditions.

MATERIALS AND METHODS

This post-test only quasi-experimental study was carried out in Manav Rachna Dental College, Faridabad, Haryana, India, from January to March 2023, on 380 dental students of Indian origin, after taking approval from the Institutional Ethical Committee (IEC No. MRDC/2023/IEC/11). The significance and nature of the

research study were explained to the selected individuals in their own language, and they were made to sign an informed consent form before the procedure began.

Inclusion criteria: Undergraduate students from all five years who were willing to participate were included in the study.

Exclusion criteria: Participants who did not pass the Ishihara test and those having less than 2/3rd correct answers on the three days of training were excluded from the study.

Procedure

Participant Selection and Grouping: Based on the results of a pilot study conducted on 50 participants and using nMaster 2.0 software, with a 95% confidence interval, 80% power, and a 5% marginal error, the minimum sample size was calculated as 173 per group.

Undergraduate students from all five years who were willing to participate in the study were divided into two groups:

- Group 1 (calibrated/trained, n=200, to account for potential dropouts and eliminations after training tests).
- Group 2 (non-calibrated/untrained, n=180).

All participants in both groups were asked to fill a questionnaire. The questionnaire comprised of two sections: the first section included patient's personal data, and the second section consisted of a 24-plate Ishihara [24] test to rule out defective colour vision. One participant from Group 1 was unable to pass the Ishihara test and was excluded from the study.

Group-1 (Trained)

The training on Day 1 began with a 20-minute presentation lecture on tooth shade and its components, namely value, hue, and chroma. The 199 trainees were familiarised with the concept of colour and tooth shade, and how to use a shade guide in detail. It ended with participants taking a tab test, which comprised of matching three shade tabs from one Vita Classical shade guide (Vita Zahnfabrik, Germany) with another.

On Day 2, the participants were trained using interactive CD-ROM exercises focused on aesthetic shade matching in dentistry, developed by Rade Paravina and John Powers [25]. The training session ended with another round of the tab test.

On Day 3, more complex exercises from the same program were used to further train the participants, and the session ended with a tab test taken by all participants. Only those participants who scored at least two-third correct answers over the three days were included in the study. A total of 197 students were finally selected out of all participants based on their training test results.

Group-2 (Untrained)

A total of 180 participants in this group did not receive any prior training in shade matching.

Shade selection by students: The participating students were asked to do shade matching for the natural maxillary central incisors of three patients using the Vita Classical Shade Guide to maintain the standardisation of the study. The three patients were selected according to the complexity of their tooth shades. The first patient selected had a fairly monotonous shade of the maxillary central incisor, and was the simple case. The second patient had a polychromatic maxillary central incisor, representing a moderate case. The third patient, or the complex case, had a polychromatic tooth with intrinsic staining or a line of hypocalcification.

Assessment

Based on the number of correct shade matches, the colour-matching ability of the participants was categorised into four categories:

- Excellent (score 3): all three correct matches;
- Good (score 2): two correct matches;

- Fair (score 1): one correct match;
- Poor (score 0): no correct matches. Colour matches were verified using a spectrophotometer and were accepted only if the colour difference (ΔE) was less than 0.5 [26]. The data on clinically acceptable/correct answers was drawn and compared for both trained and untrained participants.

STATISTICAL ANALYSIS

The data entry and analysis were done using Excel and Statistical Package for Social Sciences (SPSS Inc, Chicago, version 21.0) software packages. Descriptive statistical analysis was performed on all data records, and significance was determined at a p-value of <0.05. The Chi-square test was used to test association between the proportions of various parameters, such as the percentage of correct answers in a clinical setting among the trained and untrained groups. The correct responses were dichotomised into "correct/clinically acceptable" (1) and "incorrect" (0). Since this variable was ordinal in nature, the Mann-Whitney U test was used to compare the means of correct responses to three different clinical cases in terms of complexity among both groups.

RESULTS

After the exclusion of 3 students from the trained category following Ishihara test and tab training test, a total of 377 students aged 20-24 years were selected for the study. The trained group comprised of 197 participants, of which 23.3% (N=46) were males and 73.7% (N=151) were females. The untrained group comprised of 180 participants, out of which 25 were males and 155 females. There were no dropouts in either group.

The percentage of correct or acceptable answers for shade matching in patients with simple (Patient A), moderate (Patient B), and complex (Patient C) tooth shades among the two study groups can be seen in [Table/Fig-1]. There was a statistically significant difference (p=0.0001) as the trained group was better able to identify the correct shade compared to the untrained group in all three cases.

Group	Simple case	Moderate case	Complex case
Trained	192 (97.5%)	168 (85.3%)	46 (23.3%)
Untrained	150 (83.3%)	79 (43.9%)	07 (3.9%)
Chi-square	22.294	71.324	23.227
p-value	**0.0001**	**0.0001**	**0.0001**

[Table/Fig-1]: Comparison of percentage of correct/acceptable answers for the three patients among the two study groups.

The majority of students in the trained group scored 2, indicating a moderate category, whereas the majority of untrained students scored 1, indicating a fair category. The difference was statistically significant (p=0.0001). Both groups showed the lowest percentage of correct answers for complex cases and the highest for simple cases, as shown in [Table/Fig-2].

Group	Score 0 (Poor)	Score 1 (Fair)	Score 2 (Moderate)	Score 3 (Excellent)	Total	Chi-square	p-value
Trained	4 (2.0%)	22 (11.2%)	137 (69.5%)	34 (17.3%)	197 (100%)	106.729	**0.0001**
Untrained	14 (7.8%)	100 (55.6%)	62 (34.4%)	4 (2.2%)	180 (100%)		

[Table/Fig-2]: Comparison of percentage of correct/clinically acceptable answers in both the groups across all categories of colour matching ability.

A comparison between correct and clinically acceptable answers among the two groups can be seen in [Table/Fig-3]. Statistically significant results (p<0.05) were observed, with trained students giving a higher percentage of correct answers compared to untrained students, who provided more clinically acceptable answers. The Mann-Whitney U Test was used to compare the

Cases	Trained		Untrained		p-value
	Correct shade Match	Clinically acceptable	Correct	Clinically acceptable	
Simple	117 (59.4%)	75 (38.1%)	56 (31.1%)	94 (62.6%)	**0.0001**
Moderate	94 (47.7%)	74 (37.6%)	27 (15%)	52 (28.9%)	**0.003**
Complex	13 (6.6%)	33 (16.8%)	01 (0.6%)	06 (3.4%)	**0.001**

[Table/Fig-3]: Percentages of correct and clinically acceptable answers given by the two groups according to the complexity of cases.

means of responses to the three different clinical cases in terms of complexity as drawn from the participants in both groups. A significant difference was observed in the correct answers for all three cases between the two groups, as seen in [Table/Fig-4].

Analytical parameters	Patient-A (Simple case)	Patient-B (Moderate case)	Patient-C (Complex case)
Mean (SD) for trained	0.97 (0.17)	0.85 (0.36)	0.23 (0.42)
Mean (SD) for untrained	0.83 (0.37)	0.44 (0.49)	0.04 (0.19)
Mann-Whitney U	15315.000	10481.50	14279.50
p-value	**0.0001**	**0.0001**	**0.0001**

[Table/Fig-4]: Mann Whitney U test for correct answer in three clinical cases.

DISCUSSION

This study was carried out to evaluate the role of training in shade-matching procedures performed by dental students in a clinical setting of varied complexities. The results showed a significant improvement in colour-matching ability in the trained group compared to the untrained group; hence, the null hypothesis was rejected.

The participants in the present study belonged to the age group of 20-24 years, which is usually associated with accurate colour perception and discrimination. With an increase in age, there can be a mild decrease in the response of the visual system to luminance [27]. Hence, the fear of the inability to choose the correct shade is reduced, along with other confounding factors such as systemic conditions.

Efforts were made to standardise the conditions of the study, especially the type of lighting, as it can affect shade matching [28]. Daylight was used in the present study because of its convenience, ready availability, and the absence of a requirement for additional equipment. The Vita Classical Shade Guide is claimed by the manufacturer to provide simple, consistent, and reproducible shade matching. It is also value-based, which is a more important aspect of colour than hue and chroma [27]. Considering these advantages, along with the availability of numerous shade options in the Vita Classical Shade Guide, the latter was selected for the study.

The translucency and colour variation from the incisal to cervical areas add complexity to the shade matching process. Doing the same in the patient's mouth makes the process even more challenging, especially in polychromatic cases with hypocalcification. Three cases of varying degrees of complexity were selected for the study to enhance the analytical skills of the students, enabling them to perform better in a clinical setting. The colour match was verified using a dental spectrophotometer only if the colour difference (ΔE^*) between the selected shade tab and the natural tooth was <0.5, a value that is barely perceptible [29]. This type of colour test was a first-of-its-kind experience for most of the participants.

The shade selected by the participant was also verified for the right hue and value as detected by the spectrophotometer. It was concluded that trained students found it more difficult to determine the correct hue group for all three patients, as evidenced by incorrect responses that belonged to the same value and chroma range but lied in a different hue group. Whereas the untrained students had a more difficult time identifying the correct value. This was in accordance with the results seen in studies by Winkler S et al.,

Alshiddi IF and Richards LC, and Wagner S et al., which concluded that a value-based dental colour training protocol significantly reduced the number of errors in colour selection, especially the value parameter (p=0.014) [30-32].

A study by Ellakany P et al., showed improvement in colour-matching skills by emphasising the relevance of teaching colour selection to students in dental schools [33]. Exposure to a multitude of comprehensive dental cases also improved dental aesthetic self-perception by enhancing knowledge and skills. Chowdary RB et al., highlighted that specialist practitioners have far better practical knowledge of shade selection compared to postgraduate students and general practitioners, indicating a need for Continuing Dental Education (CDE) programs on the principles of shade analysis to upgrade the knowledge of dental practitioners [11]. Kovacić I et al., recommended targeted academic education to sharpen clinical students' ability to better perceive tooth shade variations in dimensions and positions of the tooth [34].

The results of the current study point towards the fact that if students receive adequate training during their dental curriculum, it can enhance their sensibilities towards shade matching, even in complex clinical cases.

Limitation(s)

Some limitations of the study include non-uniform gradations on the shade guide and inherent variations in different manufactured lots of the shade guides, which can affect the outcome of the results. Additionally, subdividing dental students based on their academic and clinical experience would have made the results more relevant.

CONCLUSION(S)

The results clearly indicate that the trained participants demonstrated significantly better shade matching ability compared to the untrained students. As the complexity of cases increased, the trained students performed better as compared to untrained students. Also, sensitivity to correct value identification increases with training among the dental students. Keeping the limitations of the study, one cannot rule out the importance of practical training in developing better clinical skills for better aesthetic outcomes in restorative treatment.

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