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Original Article

Dentistry Section

Prevalence of Colour Vision Anomalies Amongst Dental Professionals and its Effect on Shade Matching of Teeth

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ABSTRACT

Introduction: The success of a restoration is dependent on accurate shade matching of teeth leading to studies evaluating the factors affecting the perception of shades. Colour vision anomalies including colour blindness have been found to exist in the population and it has been thought to be a potential factor affecting the colour perception ability.

Aim: The present study was done to evaluate the prevalence of colour vision anomalies and its effect on matching of shades of teeth.

Materials and Methods: A total of 147 dental professionals were randomly selected for the study and were first tested for visual acuity using the Snellen's Eye Chart so as to carry on the study with only those operators who had a vision of 6/6. Then, the Ishihara's colour charts were used to test the operators for colour vision handicap. In the last stage of the study, test for accuracy of shade selection was done using the Vitapan Classical shade guide. The shade guide tabs were covered to avoid bias. Percentage was used to calculate the prevalence of colour vision handicap and its effect on matching of shades of teeth as compared to normal vision, which was evaluated using Chi square test.

Results: Nineteen operators had colour vision anomalies out of hundred operators and only two operators presented with colour blindness. Colour vision anomaly was more prevalent than colour blindness and it was also found that it was more prevalent in males than females. The difference between the accuracy of shade matching between the operators with normal vision and colour vision defect and operators with normal vision and colour blindness was statistically not significant.

Conclusion: Colour blindness and colour vision handicap are rare conditions, with the latter being more common in the population. According to our study, it was concluded that no statistically significant difference existed amongst the operators with normal vision and colour vision anomaly or operators with normal vision and colour blindness during the matching of shades of teeth.

Keywords: Colour vision handicap, Colour blindness, Colour vision anomalies, Visual acuity, Shade matching

INTRODUCTION

In the past few decades demand for improved aesthetics in dentistry has increased considerably, which is mainly because of the advent of improved aesthetic materials, simplified techniques and increased patient-consumer alertness. The practicing dentists are constantly evaluating their colour matching skills as colour is a vital component of aesthetic dentistry [1,2]. Shades of restorations have definitely become a critical deciding factor when it comes to patient acceptance and satisfaction [3]. Colour is a 3D entity which is the result of interaction amongst the light, object and the observer [4]. Working with shades encompasses colour matching as well as shade reproduction hence; visual assessment of colour becomes an equally imperative factor for accurate shade matching.

Differences in colour perception have been observed to exist amongst different people and they also differ in their skill to perceive the small differences in colour of objects [5]. Colour matching is complicated by individual differences in colour perception and different ability of colour discrimination. It was found that the same dentist matched different shade for the same tooth in different ways [6]. Another study listed three factors upon which colour is dependent.

These are: (a) the observer, (b) the object and (c) the light source. Each one of these factor is a variable and when any one of these is altered the perception changes [7].

Colour vision is a critical component of prosthodontics, restorative and aesthetic dentistry as a defect in colour vision may lead to trouble in perceiving colour as compared to the normal colour vision dentists [8] but dentists as a group do not have their colour vision tested at any time during their career. Studies show that about 8% of the males and 0.5% of the females have colour vision deficiency [6].

According to a study, 9.3% of the population, all males, exhibited a colour vision defect [9]. Another study evaluated and compared the responses of the "normal" and "colour defective" operators at the various light intensities for both hue and chroma [10]. These observations have led to the evaluation of prevalence of colour vision anomalies amongst dental professionals and its effects on the shade selection.

Colour blindness is defined as a condition in which the operators fail to accurately identify all the plates of the Ishihara colour chart series [6]. According to a study, it was found that the hue range of the teeth was limited to the yellow/yellow-red zone and teeth of high chroma tended to be more reddish while those of lower chroma were more yellow [11]. As all the shades of teeth have traces of red, a study was done to verify the effect of colour vision handicap on shade matching. The aims of this study were to find the colour vision deficiency amongst dental professionals and to evaluate the effect of colour vision handicap on the accuracy of shade selection of natural teeth.

MATERIALS AND METHODS

A survey based cross-sectional study was designed and conducted to determine the effect of colour vision anomalies of the operators on the selection of shade of teeth and it was done in the Department

of Prosthodontics of M.R. Ambedkar Dental College, Bangalore, Karnataka, India in 2002.

The study aimed to determine the effect of colour vision anomalies on the matching of shades by dental professionals therefore the sampling frame included dental students who had a prior theoretical knowledge of the concept of colour. A total of 147 subjects were selected using purposive sampling technique.

Test for Visual Acuity

A total of 147 dental professionals including dentists and dental students who had a theoretical knowledge of colour were randomly selected as operators. Since it was imperative that the operators should have a normal vision, they were asked to fill up a performa which had questions pertaining to their past medical history, family history of cataract and glaucoma with the aim to find any factor that could impair the vision of the operators. All the operators were then tested for visual acuity because vision below 6/6 might itself impair the ability of the operator to accurately assess the shade of the tooth and could affect the final outcome of the study leading to confounding bias. Therefore, a standard Snellen's Eye Chart was used to check the vision of the operators under supervision of an ophthalmologist. Visual acuity was tested for each eye separately, and both eyes together.

Test for Colour Vision Handicap

After the evaluation of visual acuity, only 100 out of 147 operators with a 6/6 vision were allowed to participate in the next part of the study which involved checking for colour vision handicap. A total of hundred operators with a (normal) 6/6 vision and no medical history, that could affect the vision, were selected to undergo test for colour vision anomalies. Ishihara colour charts were used to check the colour vision anomalies. There were a total of 38 plates and the operator was asked to identify the number seen on each plate in not more than three seconds. A neutral background and a natural light source were used to conduct this test so as to maintain standard conditions [12,13] for shade matching and avoid bias due to any external factors. The operators who could not identify all the plates were designated as colour blind and those who could not accurately read up to three plates were categorized to have a colour vision deficiency.

Test for Accuracy of Shade Selection

All the operators who participated in the test for colour vision handicap were then asked to undergo the test for shade selection. Although there are many standard shade guides available like Vitapan Classical, Vintage Halo and Vitapan 3D Master, Vitapan Classical shade guide was used for this purpose as the arrangement of shades is simple in this shade guide. A complete set of the shade guide was used along with few randomly selected shade tabs from a second shade guide with the same make. The shade tab numbers were covered in both the shade guides to avoid bias. The operators were then asked to determine the shade of the tab and select the corresponding matching tab from the complete shade guide. The prevalence of colour vision handicap and colour blindness was calculated as percentage and the effects of colour vision handicap on the selection of shade were evaluated against the normal vision using the Chi-square test in Microsoft Excel 2000.

RESULTS

Out of one hundred operators eighty one had no colour vision anomaly and nineteen reported as having colour vision deficiency. Thus, the percentage of people with colour vision anomaly as found in this study is 19%. Out of the nineteen operators who had colour vision deficiency only two operators were found to have colour blindness (those who could not identify all the plates of the Ishihara colour charts). Colour vision anomaly was more prevalent than colour blindness as per the results of the study [Table/Fig-1].

Colour vision defects were found to be more common in males than females. Out of 19 operators exhibiting colour vision anomalies 17 were males. The two female operators having colour vision deficiency gave an underlying medical history of being on systemic steroids [Table/Fig-1].

The percentage of dentists who had a normal vision and could identify the shades accurately was 72.839%. Only 52.941% of the individuals with colour vision handicap and 50% of colour blind individuals could match the shade teeth accurately. The difference in accuracy of shade matching between the operators with the normal vision and colour vision deficiency was statistically not significant (p=0.075) [Table/Fig-2].

The difference in accuracy of shade matching between operators with normal vision and colour blindness was statistically not significant (p=0.058) [Table/Fig-2].

Defects in colour vision did not seem to have significant effect on the accuracy of shade matching.

DISCUSSION

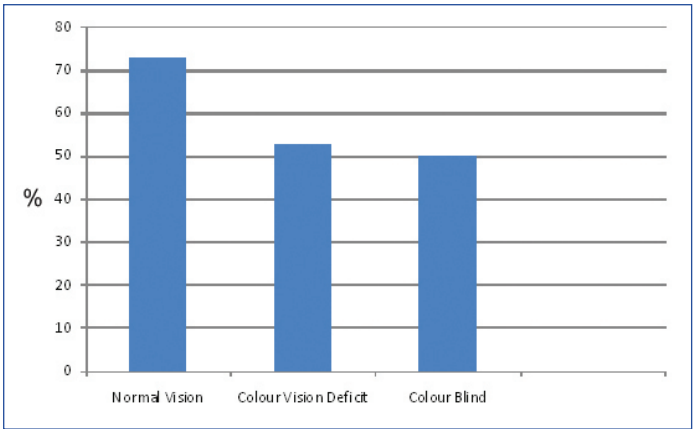
The younger professional colour matchers practising in the present era give greater preference to the role of the human observer, the effects of surrounding colour, difference in source of light and many other aspects of colour matching that determine the final colour estimation by the brain [14]. Dentists have little or no training in vision physiology or colour science. Although colour perception can be improved with the training in dental procedures [15], an understanding of how the eye perceives and the brain interpretes light as colour is important for successful aesthetic restorations [16].

The human eye-brain combination can detect very small differences in the colour between two objects. The cones of the eyes are the colour sensitive receptors which are responsible for encoding different colours. These cones contain visual pigments that are sensitive to red (560nm), green (530nm) or blue (430nm) wavelength of light. Absence of any of the three classes of cones i.e., red-sensitive cones/green-sensitive cones/blue-sensitive cones result in colour deficiency [1].

A study has proposed three alternative tracks for the individuals who tested positive for colour vision defect: (a) a formal course in colour education and training for dentists and dental assistants (b) the development of a staff trained in colour matching discrimination of teeth shades (c) development of colourimetric instruments. The alternative tracks are adjunctive measures that will provide a cohesive clinical practice environment for the dental clinician [17]. Shapiro suggested that the dentists should get their eyes checked for vision defects once in a year and should employ a team effort in case the practitioner is found to have colour vision anomalies [9].

Incorrect identification (No. of plates)	Number of operators (N=100)	Correct matching of shade tabs	Sex (M/F)	Past history	
0 (No colour vision anomaly)	81	59/81 (72.839%)	43M 38F	Not significant Not significant	Colour vision deficit
1 Plate	9	5/9 (55.556%)	8M 1F	Not significant Medication (steroids)	
2 Plates	5	2/5 (40%)	5M		
3 Plates	3	2/3 (66.667%)	2M 1F	Not significant Medication (steroids)	
All Plates (colour blind)	2	1/2 (50%)	2M	Not significant	Colour blindness

[Table/Fig-1]: Results of the test for colour vision anomalies and its effects on shade selection (shade guide used: Vitapan Classical).



[Table/Fig-2]: Comparison of accuracy of shade matching between the normal vision and the colour vision deficit operators.
Subjects who could accurately match the shade of teeth (as percentage)

Barghi N et al., compared the responses of the "normal" and "colour defective" operators at various light intensities for both hue and chroma [10]. It was found that operators with "normal vision" and "colour defective vision" showed no statistical difference.

Differences in various light intensities for both hue and chroma were not statistically significant for either the "normal" or the "colour defective".

A study was conducted by Barghi N et al., in which fifty people participated, seven were found to be "colour defective". Statistical comparisons between the responses of the "normal" and "colour defective" operators at various light intensities for both hue and chroma were made. It was found that for operators with normal vision and colour defective vision there was no difference [10] and the findings of our study are in agreement with this study.

According to Wasson W and Schuman N, 9.3% of the population, all males, exhibited a colour vision defect demonstrating the sex linked nature of this condition [17] and our study confirmed the findings. With regard to the race of the operators, no link was found. However, they also concluded that the incidence of colour vision defects varies amongst various ethnic and regional groups. Colour vision defect was also found to have no relationship with age [17]. The results of this study confirmed the finding that colour vision handicap is more common in men than in women as in a previous study [18]. It has been observed that the red and green cone pigments are encoded in the X chromosomes while the blue cone pigment are encoded on chromosome 7. Mutations of the blue cone pigments are exceedingly rare. Mutation of the red and green pigments cause congenital X linked colour blindness in 8% of the males. Affected individuals are not colour blind; rather they differ from normal operators in how they perceive colour and how they combine primary monochromatic lights to match a given colour [19].

The most popular colour vision tests are Ishihara charts [20] and 100 Hue Farnsworth Munsell test [6]. Ishihara colour plates are used to detect red-green colour blindness. The test plates contain a hidden number visible only to the operator with colour confusion from red-green colour blindness. Most often Ishihara plates are used to perceive acquired defects in colour vision even though they are only proposed as a screening test for congenital colour blindness. Frequently the acquired defects in colour vision arise as a consequence of disease of the macula or the optic nerve or from bilateral strokes involving the ventral portion of the occipital lobe [19].

Colour blindness is a rare condition. Only 2% of the operators were found to be colour blind [Table/Fig-1]. Colour blindness is a hereditary condition occurring only in males [8]. Both the operators in the study having colour blindness were males [Table/Fig-1]. Amongst the 19 operators who had colour vision deficiency, there were two females but their condition can be attributed to systemic causes (steroids, visual acuity 6/18). The difference in accuracy of shade matching was evaluated. It was found that the difference in shade matching accuracy between the normal vision individuals and those with colour vision deficiency was statistically not significant. The same was true for the difference between normal vision operators and the colour blind [Table/Fig-2]. Defects in colour vision did not seem to have significant effects on the accuracy of shade matching.

Jaju RA et al., emphasized the importance of education and knowledge of color science in shade matching of teeth and observed that the shade matching progressively improved from 1st year to 4th year [21]. Bamise CT et al., also emphasized proper mode of selection of tooth shade to be incorporated in the dental curriculum and continuing dental education program [22].

The present study established that not all of the operators could identify the shades accurately irrespective of the vision. But because colour blindness is a rare condition the number of subjects who have this defect are very less which made it difficult to establish a difference with the normal vision operators as being statistically significant. Further studies are required on a larger population to reach a definitive conclusion. The common procedure of matching the shades of teeth is mostly the perception of the dentist leading to inaccuracies thereby affecting the final outcome of the treatment. The selection of shades should be done by the dentist and an assistant rather than by the dentist alone for more accurate results. The use of colorimeter and spectrophotometer should be encouraged in the sphere of shade matching of teeth to eliminate possible errors along with emphasis on education and training in colour science and shade matching of teeth.

LIMITATION

There are some limitations of the present study including the small sample size which was selected using purposive sampling. Moreover, the level of experience of the included study subjects was not standardized which could have resulted in biased results. Hence the results of the present study should be interpreted with caution and further studies on a larger sample with similar expertise level should be undertaken.

CONCLUSION

Colour blindness is a rare condition. It is sex-linked and is found to exist only in males. It is uncommon for dental professionals to undergo the test for colour vision. Defects in colour vision do not have a significant effect on the accuracy of shade matching of teeth. Further research needs to be done on a larger population to come to a definite conclusion. The use of colourimeter and spectrophotometer should be encouraged to determine the shades of teeth and dentists should undergo further training in colour science to improve their colour matching skills. The shades of teeth should be matched not solely by the dentist but in conjunction with an assistant for more accuracy.

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