PATIENTS' ACCEPTANCE OF SHADE SELECTED IN THE FABRICATION OF PFM CROWNS: SPECTROPHOTOMETRIC METHOD COMPARED WITH THE VISUAL METHOD.

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ABSTRACT

BACKGROUND: Aesthetic factors are increasingly important in the fabrication of dental prostheses. Ultimately, dental restoration must accurately reproduce the tooth shade that matches the neighboring teeth to satisfy the patient's aesthetic demand.
Objective: To compare the effectiveness of conventional visual and digital spectrophotometric methods of shade selection for porcelain-fused-to-metal crown restoration with respect to patients' acceptability of the outcome product.

MATERIALS AND METHODS: Twenty-six teeth were included in the study. Three calibrated examiners performed the visual shade selection, while the primary investigator performed the spectrophotometric shade selection. The shade of the fabricated PFM crowns for each method was subjectively rated by the patient and objectively rated by measuring the CIEL*a*b* colour difference. Data were analysed using IBM SPSS version 23 ($p < 0.05$).

RESULTS: There was a poor agreement with the shades selected using conventional and spectrophotometric methods. Inter-examiner and intra-device reliability for both methods were 0.11 and 0.39, respectively. The shades of PFM crowns from the spectrophotometric method were more acceptable to participants than the visual method. (p value=0.002).

CONCLUSION: The patient's acceptance of the shade of the porcelain-fused-to-metal crown was higher in the spectrophotometric shade selection method. The difference in the total colour of the PFM crown from the conventional visual and spectrophotometric method was not statistically significant

KEYWORDS: Tooth shade, Shade selection, Conventional, Visual, Spectrophotometer, PFM crowns.

INTRODUCTION:

The quality of an object or substance with respect to the light it reflected or transmitted is referred to as colour[1]. the visual perception of light defines the appearance of our surroundings, whether beautiful or otherwise, so without light, colour does not exist [2]. Colour is most of the time determined visually by measurement of hue, chroma, and value, which is the luminous reflectance of the light reflected [3]. Hue or tint is measured by the wavelength of the light, which depends on spectral reflectance; it is the first attribute by which colour is identified and distinguished. The basic hue of a tooth is determined by the dentine colour underlying the enamel. Hence, dentine imparts the entire colour, while enamel conducts the light through its rods. Value is described by the amount of light reflected by an object, while chroma is the intensity of colour; it is the purity or saturation of the colour of dentine, which increases as the object gets darker. However, chroma is affected by the value and the thickness of the enamel[4,5].

Measuring colour is a complex and tricky phenomenon as it cannot be directly measured by any instrument in the actual sense of it. Tooth colour is much more complex because a natural tooth does not present a perfectly smooth surface unless it has worn out from prolonged usage, and this can affect brightness, colour intensity, lustre etc [5,6]. Matching of tooth shade is essentially a subjective sensation which can only be described in idealized and standardized terms using numbers that correlate with what is perceived [7,8]. In determining the colour of an object or substance, three entities are important to be considered. These are the light source (illuminant) that illuminates the object, the spectral reflectance of the object and the perceptible nature of the human eyes (detector), which visualizes the object. Consequently, variations in any of these three characteristics will have an effect on the visual perception of the colour [9].

It has been pointed out that patients' expectations are often frustrated at the point of prosthesis delivery, resulting from either real factors such as technique error or the anticipation of a better outcome [10]. Therefore, precise colour communication is paramount to developing aesthetic harmony and overall restorative success[11]. The first step to achieving a good clinical outcome in cosmetic dentistry is identifying the tooth colour we need to imitate correctly, and then, to convey this information appropriately to the dental laboratory for the shade that best matches[12]. There are various methods of achieving the above. The first approach is to directly match the tooth colour with the aid of the human eye using a shade guide. The other is the instrumental method through a device by placing technology in the observer role while eliminating the effect of negative visual illusion to deliver exact and reproducible information. Despite all these recent advances, the main method of tooth shade selection remains the conventional visual method. The conventional method of shade selection seems quick and cost-effective. However, it is difficult, if not impossible obtaining the objective information required [13].

Studies[14,15] have shown that visual shade matching is subjective, making outcomes vary among and within individual observers. This subjectivity is probably due to many factors that influence the matching of tooth colour. The colour scales available in the dental market have shown some limitations due to the non-standardization among the manufacturers. Also, the background colour may influence the perception of the colour of a given object. This can be demonstrated when the teeth from the colour scale are analysed by changing the background colour or viewed against the dark background of the oral cavity or the patient's skin tone. More so, the translucency of enamel and the polychromatic nature of dentine

together produce a complex depth of shade that is not easy to characterize [16]. Consequently, the distribution of shade guides on the Commission Internationale de l'Eclairage (CIELAB) colour space is not uniform; hence, the entire range of natural tooth shades is not covered [17]. Fatigue, personality, gender, and colour defects are other physiological factors affecting visual tooth matching [3].

A number of colour measuring instruments such as Colorimeters, Spectrophotometer, and Digital cameras have recently been developed to overcome the shortcomings of the traditional shade matching methods[13,18]. Spectrophotometer is a sophisticated device with many configurations. It evaluates the colour characteristic of the tooth by measuring the light intensity as a function of the colour. It measures the reflectance for each light wavelength and allows the value to be calculated [19]. Spectrophotometer can be used to measure the colour of the natural tooth in reference to a known colour, and it can also be used based on the setting of other shade matching systems such as VITA shade guide and 3D master shade guide. The data generated is transmitted to software that displays the different shades on a digitised screen. These devices are believed to be more accurate in quantifying the natural tooth shade and aid in communication between the laboratory and the clinic[13]. However, there are controversies regarding the effectiveness and reliability of these devices. Some studies[9,20] have reported no significant difference in shade selection between these devices and the visual method. Other studies[7,15,21] indicated that these newer methods could only serve as adjunct to visual methods, especially in difficult situations where colour measurements are uncertain when using conventional means, or could serve as a useful educational tool for the colour management in dental schools.

Correct shade selection for porcelain-fused-to-metal crowns, especially in the anterior aesthetic region, has been a challenge in dental clinics over the years due to the subjectivity of the visual methods used [14,15,18]. Also, some teeth may have a complex colour for which it may be difficult to pick a particular shade with an unaided eye. Many finished porcelain-fused-to-metal crown works have met with patients' dissatisfaction or frank rejection due to poor colour match, and in some occasions, might even require a re-fabrication of the crown. Furthermore, most of the studies that compared the conventional visual and instrumental shade selections were in Caucasians[9,14,18,22,23], and certain of these studies were in vitro studies[9,18], which did not represent the exact condition of shade selection in the mouth.

Therefore, this study focused on assessing and comparing the effectiveness of the conventional visual and the digital spectrophotometric methods of shade selection during the fabrication of porcelain-fused-to-metal crowns from the patient's perspective. The hypothesis for the study states that there is a statistically significant difference in the aesthetic outcome (colour match) and patient acceptability in the porcelain-fused-to-metal crown fabricated using the digital spectrophotometric method of tooth shade selection compared to the conventional visual method.

METHODOLOGY:

The cross-sectional comparative clinical study was conducted at the Conservative Dentistry outpatient clinic of the Dental Centre, University College Hospital, Ibadan. Consecutive patients who presented to the clinic to fabricate porcelain fused to metal crowns during the study period were included. Exclusion criteria were patients with discoloured adjacent teeth, tooth bleaching, orthodontic appliances, unrealistic aesthetic expectations, molar teeth, patients requiring all-metal crowns, and colour-blind patients. The minimum sample size calculated using the formula $N= 2 (Z\alpha + Z\beta)^2 S^2/(\mu 1-\mu 2)2$ was 23. Attrition was determined to be 3, making the total sample size 26 teeth with reference to Moodley et al.[7] Ethical approval was obtained from the University of Ibadan/University College Hospital (UI/UCH) Ethics Review Committee with the number UI/EC/17/0507 before the commencement of the study. Each participant signed a written informed consent following a detailed explanation of the procedure and the purpose of the study.

Data collection

Data collection forms, which contained sections A-E, were designed; section A was the socio-demographic data of the participant; section B was relevant medical/dental history and clinical examination of the oral cavity; section C contained the natural tooth shade selection, which was obtained on the day the shade was taken. Section D contained the objective colour rating of the fabricated porcelain-fused-to-metal crown using the CIELAB L*a*b* colour of the finished crown and the CIELAB L*a*b* colour of the adjacent tooth. Section E was on the patient's subjective rating of the crown shade, recorded on the day they came for trial fitting and final crown cementation.

Two methods of tooth shade selection were used for each patient: the conventional visual method and the spectrophotometric method. Scaling and polishing were done a week before the shade selection to remove any extrinsic stain, and the patient brushed for one minute just before the shade selection to remove any accumulated plaque.

Visual shade selection procedure

The visual shade selection was done for each patient using the VITA classical shade guide (VITA Zahnfabrik H. Rauter GmbH & Co.KG D-79713 Bad Sackingen, Germany) by three examiners who were calibrated before the shade matching procedure. Examiners were also tested for colour vision defect using online Ishihara's colour chart. Two cases were used to pre-test and calibrate the examiners to ensure they followed the same standard protocol.

Shade was matched under a daylight colour-corrected light device (Corrected dental light, Bremadent Premier (Bristol) LTD, Walthanshn, London E177PJ) with correlated color temperature 5500k to mimic natural daylight. Each examiner selected shade along with the patient. The patient's clothes were covered with a grey bib; coloured eyeglasses were removed, as well as coloured makeup (such as lipstick) in female patients. The examiner positioned themselves at about 28 to 33cm from the patient while taking the shade. The comparison of tooth colour with shade tabs was not viewed for more than 7 seconds each time in order to avoid fatigue, The shade of the middle third of the tooth was taken with the teeth well hydrated using a jet of clean water. The shade guide was moistened with water to mimic the tooth constantly bathed with saliva in the mouth and was thoroughly disinfected with methylated spirit after each shade selection exercise in every patient. Shade guide tab labels were covered and assigned three-digit ID numbers (code), with the code clearly written on it. The order in which the target shade tabs were arranged was randomized for each shade-matching session. The examiners recorded the code for whatever shade they selected to blind the examiners and prevent them from guessing the shade based on the pre-knowledge of the shade commonly selected for a particular tooth. Shade

guide teeth were placed close to the tooth to be matched, above or below it (not by the side to avoid binocular effect).

Spectrophotometric shade selection procedure

The primary investigator used the Spectrophotometric shade selection method using VITA Easyshade advance V digital dental spectrophotometer (Vasa Denticity Private Limited. Ghitorni, Delhi, India.). The investigator trained in the use of the device by going through its protocol manual and video prior to the commencement of the shade selection procedure. The VITA Easyshade device was calibrated according to the manufacturer's specifications and set at VITA classical shade guide mode. Shade was taken with the probe of the device covered with the disposable infection control shield for each participant to prevent cross-infection. The device probe was positioned firmly on the middle third of the tooth perpendicular to its surface. The activation button on the instrument handle was pressed until a beeping sound was heard to confirm that the measurement was completed.

Assessment of the shade of the fabricated PFM crown

The tooth was prepared to receive the extra-coronal restoration according to Shillingburg's principles of tooth preparation. Using the Putty-wash impression technique, upper and lower arch impressions were made with rubber-based impression material (Silibest silicone, ISO4823, BMS Dental, Capannoli, Pisa, Italy). A temporary crown was fabricated with cold cure acrylic (MR. Dent, Meadway cold cure Dentine KIT, 4 Manor way, Surrey GU22 9JX England) chairside and cemented with zinc phosphate cement (Zinc F+, Prevest Den Pro). The two shades selected for each test tooth using the conventional visual and spectrophotometric methods were recorded on the job card and sent to the Dental laboratory alongside the impression. Two porcelain-fused-to-metal crowns from the two shades selected were fabricated for individual test teeth in each participant. All the crowns were fabricated in the same dental laboratory and by the same dental laboratory technologist, with the involvement of the primary investigator to monitor the process. On the second visit to deliver the definitive crown, the colour of the two finished fabricated crowns for the two methods was matched with the adjacent tooth of normal colour intra-orally during the trial fitting of the restorations. Using the five-point modified Likert scale, the patient rated the colour match of the two crowns, with Grade 1 as poor, Grade 2 as fair, Grade 3 as good, and Grade 4 and 5 as very good and excellent, respectively. The digital spectrophotometer was then set at L*a*b* colour system (total colour) mode to objectively measure the actual colour of the two porcelain-fused-to-metal crowns and that of the reference adjacent tooth and recorded. The CIELab colour coordinate difference (ΔE) was calculated to quantitatively record the colour difference between the fabricated restorations from the two methods.

Data collected was analysed using the IBM Statistical Package for Social Science (SPSS) software version 23. The normalcy of the data assessed with the Kolmogorov-Smirnov test was normally distributed. Descriptive statistics, including frequency, means, and standard deviation, were used to report parameters for each method of shade selection analysed in the study. Means for quantitative variables in the groups were compared using the Student t-test. The chi-square test was used to compare and investigate association between categorical variables.

RESULTS

Twenty-six teeth were treated in 24 participants, which were made up of 9 (37.5%) males and 15 (62.5%) females. Most participants (45.8%) belonged to the 20-39 age group while 25.0 % were 40-59 years old. The mean age of the participants was 39.9 ± 18.47 years, and the majority (75.0%) of the participants had tertiary education. (Table 1)

Table 1: Socio demographic characteristics of participants

Socio-demographic characteristics	Frequency	Percentage
Gender	N= 24	(%)
Male	9	37.5
Female	15	62.5
Age group (years)		
20-39 years	11	45.8
40-59 years	6	25.0
≥ 60 years	7	29.2
Marital status		
Single	10	41.7
Married	11	45.8
Divorced	3	12.5
Educational level		
Primary	1	4.2
Secondary	5	20.8
Tertiary	18	75
Occupation		
Group 1	8	33.3
Group 2	4	16.7
Group 3	2	8.3
Group 4	10	41.7
Tribe		
Yoruba	19	79.2
Others (Igbo, Urhobo, Tiv, Afemai)	5	20.8

Occupational group:

Group 1- Chief executives, managers, professionals, and high-profile businessmen

Group 2- Technicians (pharmacy, engineering, and medical) Information Communication Technologists, clerks, secretaries and skilled agricultural workers

Group 3- Cooks, waiters, all artisans, casual workers and traders

Group 4- Unemployed graduates, Dependents and housewives

Out of the 26 teeth that received porcelain-fused-to-metal crowns, upper right central incisor , upper left central incisor and upper right first premolars were the most prevalent, constituting 15.4% each (n-4) of the total. This was followed by upper right lateral incisors, upper right second premolars and upper left first premolars having 3

(11.5%) each. The least prevalent were the lower left lateral incisor, lower right first and second premolars, upper left second premolar and upper left canine.

Concerning the participants' rating of shades of PFM crowns selected with both methods of shade selection, participants compared the shades of the finished PFM crowns to the referenced natural tooth. While the shades of PFM crowns selected with conventional visual method were rated excellent for 2 (7.7%) crowns, 9 (34.6%) rated fair, 4 (15.4%) crowns were rated excellent in the Spectrophotometric group, and only 1(3.8%) in the group rated fair. (Figure1)

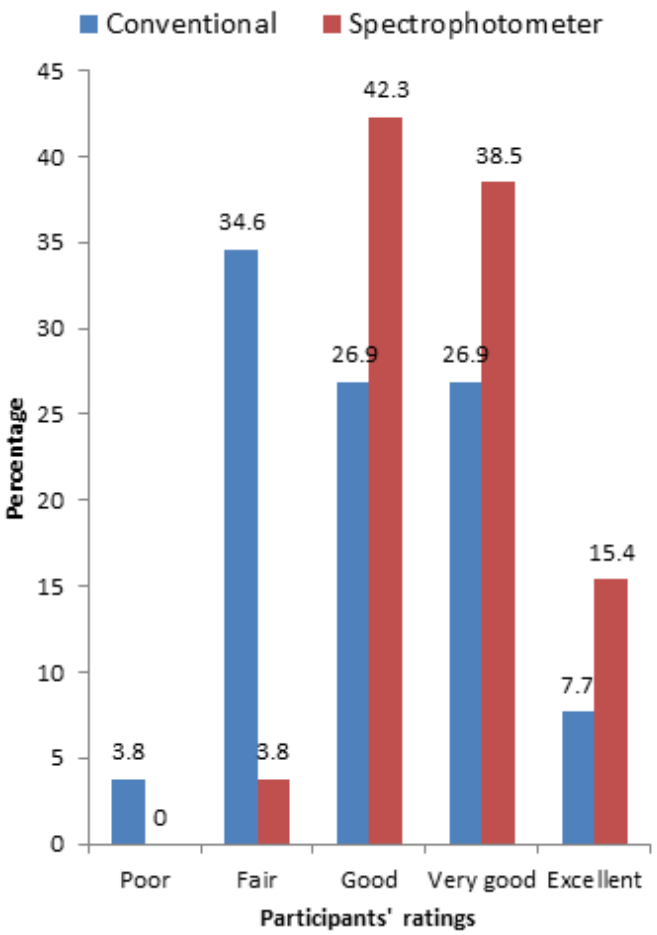

Figure 1: Participants' rating of tooth shades of PFM crowns fabricated using conventional visual and spectrophotometric shade selection methods. Fisher's exact test= 13.09; p-value= 0.44

Furthermore, considering only the final shade of the restoration, 10 (38.5%) crowns fabricated using the shade selected by the conventional visual method were accepted by participants. On the other hand, 21 (80.8%) of the crowns fabricated using shades selected by spectrophotometer were accepted by participants. The difference in the participant's acceptance of the crown fabricated using the shade selected by the two methods was statistically significant (p value= 0.002). (Table 2)

Table 2: Participants' acceptance of crowns fabricated using the conventional visual and spectrophotometric shade selection methods.

Acceptance	Visual shade selection N (%)	Spectrophotometric shade selection N (%)	X^2	p-value
Yes	10 (38.5)	21 (80.8)		
No	16 (61.5)	5 (19.2)	*9.90	*0.002
Total	26 (100)	26 (100)		

Chi-square test value

The majority of the male participants, 7 (77.7%), accepted the shade of crown fabricated using the conventional visual method, while only a few 3 (20%) of the female participants did so. Also, 7 (77.7%) of the male participants accepted shades of crowns fabricated using the spectrophotometric shade selection method, whereas all the female participants (100%) accepted the shade of crowns from the spectrophotometric shade selection method. This gender difference in participants' acceptance was statistically significant (p-value = 0.024 and 0.01 for conventional and spectrophotometric, respectively). (Table 3)

Table 3:Gender comparison of participants' acceptance of the shade of crowns fabricated using the conventional visual and spectrophotometric shade selection methods.

Acceptance	Conventional visual Acceptance		Spectrophotometric Acceptance		Both visual & Spectrophotometric	
	Male N (%)	Female N (%)	Male N (%)	Female N (%)	Male N (%)	Female N (%)
Yes	7 (77.7)	3 (20.0)	7 (77.7)	15 (100)	5 (55.6)	3 (20)
No	2(22.3)	12 (80.0)	2 (22.3)	0 (0.0)	4 (44.4)	12 (80)
Total	9 (100)	15 (100)	9 (100)	5 (100)	9 (100)	15 (100)
p-value	0.024		0.01			

Considering the acceptance of shade by age, the PFM crowns fabricated from the shade selected with conventional visual method were accepted by 46% of the participants below age 40. Contrarily, a greater proportion of the participants in all the age groups accepted the crowns fabricated from the shade selected with spectrophotometer. This observation was however, not statistically significant. (p-value=0.193 (conventional) and 0.185 (spectrophotometric). (Table 4)

Table 4: Age group and participants' acceptance of the shade of crowns fabricated using the conventional visual and spectrophotometric shade selection methods.

Age group of participants in years	Conventional visual Acceptance		Spectrophotometric Acceptance	
	Yes N (%)	No N (%)	Yes N (%)	No N (%)
20-39	6 (46.0)	7(54.0)	10 (77.0)	3 (23.0)
40-59	2 (33.0)	4 (67.0)	5 (83.0)	1 (17.0)
≥60	1 (20.0)	4 (80.0)	5 (100)	0 (0.0)
Total	9 (37.0)	15 (63.0)	20 (83.0)	4 (17.0)
p-value	0.193		0.185	

Fisher's exact test = 0.193 and 0.185 for conventional and spectrophotometric methods, respectively

Furthermore, a comparison of the mean value of lightness (CIEL) of the shades selected with the conventional visual method (51.4±9.2) with the CIEL of the reference teeth (54.4±8.1) showed no statistically significant difference (p-value = 0.23). However, the mean CIEL of shades selected with the spectrophotometric (48.6±8.4) and that of the reference teeth (54.4±8.1) showed a statistically significant difference (p-value = 0.02). Also, the difference in the mean values for CIEa (Chroma along the red-green axis) of conventional (6.8±8) and CIEa of reference teeth (9.2±2.9) and that of spectrophotometric selection (7.5±1.8) with reference teeth (9.2±2.9) was statistically significant (p-value = 0.004 and 0.01 respectively). However, the difference in the mean CIEb (Chroma along the yellow-blue axis) for the spectrophotometric method and the reference teeth was not statistically significant (p-value = 0.08); that of the conventional method with reference teeth was. (p-value = 0.001). (Table 5)

Table 5:Comparison of the CIEL*a*b* for shade selected using conventional visual and spectrophotometric methods

	Mean ± SD	t-value	95% Confidence Interval	p-value
CIE-L Conventional	51.4 ± 9.2	-1.2	-7.8 – 1.9	0.23
CIE-L Reference tooth	54.4 ± 8.1			
CIE-a Conventional	6.8 ± .8			
CIE-a Reference tooth	9.2 ± 2.9	-3.03	-3.9 – 0.9	0.004*
CIE-b Conventional	11.3 ± 2.4			
CIE-b Reference tooth	13.8 ± 2.6	-3.69	-3.9 – 1.2	0.001*
CIE-L Spectrophotometer	48.6 ± 8.4			
CIE-L Reference tooth	54.4 ± 8.1	-2.5	-10.4– 1.2	0.02*
CIE-a Spectrophotometer	7.5 ± 1.8			
CIE-a Reference tooth	9.2 ± 2.9	-2.6	-3.1– 0.4	0.01*
CIE-b Spectrophotometer	12.6 ± 2.4			
CIE-b Reference tooth	13.9 ± 2.6	-1.8	-2.7– 0.1	0.08

**Statistically significant*

The mean difference in the CIELab total colour difference (ΔE) of the fabricated crown and the reference adjacent tooth for the conventional visual shade selection (9.6±4.8) was lower than that of the spectrophotometric shade selection method (9.9±5.9). However, the difference was not statistically significant (p-value = 0.886). (Table 6)

Table 6: Comparison of CIELab total colour difference for crown fabricated using the shade selected by conventional visual and Spectrophotometric methods.

Method of shade selection	CIEL Mean ± SD	Mean difference	t-value	p-value	95% CI
CIELab total colour difference for conventional visual	9.6 ± 4.8	-0.22	-0.15	0.886	-3.2 – 2.8
CIELab total colour difference for conventional visual	9.9 ± 5.9				

DISCUSSION

Findings from this study showed poor agreement between the conventional and the spectrophotometric methods of shade selection, with higher inter-examiner and intra-device reliability in the spectrophotometric method of tooth shade matching. The patient's acceptance of the shade match of the porcelain-fused-to-metal crowns was greater in the spectrophotometric method than the visual shade selection method, implying that spectrophotometric tooth shade selection is more effective.

Before the advent of shade-matching devices such as colorimeter and spectrophotometer, tooth shade selection had been conventionally carried out for various procedures in restorative dentistry using commercial shade guides. These devices were introduced to clinical practice to overcome the shortcomings and subjectivity associated with the conventional method[22]. The effectiveness of conventional visual shade matching has been challenged by the deficiency in human visual perception[23]. The shade selection instruments tend to stand in the place of the human eye, thereby reducing the human error associated with shade matching. As good as the discovery of the new devices may be, there have been controversies about their clinical use.

This study found that the upper central incisors and the upper left premolars were the most prevalent teeth that received extra coronal restorations among the teeth in the aesthetic zone. For the upper central incisors, this may be attributed to the fact that this tooth type is more prone to trauma, necessitating them to be indicated for PFM crown, especially if it sustained an uncomplicated crown fracture[24]. In this study, VITA Easyshade advance V was set on VITA classical shade guide mode to select a shade for the Porcelain-fused-to-metal crown and compared it with that selected using conventional visual method with VITA classical shade guide, being the commonest in our environment. In this study, the patients' rating of the shade of porcelain-fused-to-metal crowns fabricated was compared between the two methods of shade selection. It was found that crowns fabricated with shade selected by spectrophotometer received a higher rating of excellent 15.4%, 80.8% very good and good compared to conventional visuals, which had 7.7% excellent and 53.8% very good and good. It was also found that most (80.5%) of the crowns fabricated using shade selected by spectrophotometer were accepted by the participants, while less than half (38.5%) of those made utilizing conventional visual method were accepted. The

difference in acceptance between the two methods of shade selection was statistically significant (p value=0.002). The negative effect of some human factors such as fatigue and subjectivity of perception that are absent in the spectrophotometer might have accounted for this difference. This finding was similar to the results of separate studies by Kalantari et al.[8] and Da silva et al.[25], who reported that the acceptance/rejection ratio of the crowns fabricated by spectrophotometric colour-match method was significantly higher than that of conventional method. Da silva et al.[25], further stressed the fact that crowns fabricated using the conventional method were 12.5 times more likely to be rejected than those made using spectrophotometric systems. Kalantari et al.[8], found that the crowns made using a spectrophotometric shade matching were preferred in 90% of cases to the crowns made by visual. On the contrary, Li and Wang[26] in their study, when comparing visual colour matching using vintage hallo shade guide and instrument (colorimeter) reported that none of the methods showed excellent colour matching and that there was no significant difference between them.

The observation of gender influence on the acceptance of the shade of PFM crown in this study showed all the female participants (100%) accepted the shade of crowns from the spectrophotometric group. In contrast, most males accepted crowns shade from the conventional group. This may be attributed to gender influence on shade matching, as females can discriminate between shades over males due to their better colour perception[3]. In addition, women are probably more conscious of their aesthetics, so they are not easily satisfied with the difference in the shade of prosthesis and their natural teeth.

The study showed no age influence on the acceptance of shade. However, a greater proportion of the participants, regardless of age, accepted the shade of crowns fabricated with the shade selected by the spectrophotometer, unlike in the conventional group. This was an incidental finding with no statistical significance. The finding can be attributed to the fact that the majority (70.6%) of the participants were in the young and middle age group, which means that they are still active and more likely to be aesthetically conscious. Hence, they accepted the PFM crowns fabricated using the shade selected by spectrophotometer more than that of conventional.

When matching tooth shade visually with the use of shade guide, value (lightness) is usually considered first followed by the chroma, and then hue. This is often overlooked by operators. It was observed in this present study that there was no statistically significant difference in the lightness of fabricated crown and the natural reference teeth with the conventional visual method while there was statistically significant difference between the lightness of the crown fabricated with the spectrophotometric method and the reference teeth. This may imply that the human eyes can easily differentiate lightness of a tooth. However, there was fair agreement between the two methods in selecting lightness which was evidenced by the non-statistical significant difference of the mean CIEL for the two methods. A similar result was obtained by Alshiddi et al.,[27] who reported no significant difference in the overall value (lightness) between visual and spectrophotometric methods. Gomez polo et al.,[22] Khoo [9] and Fani et al.,[28]also found correlation between the visual method and instrumental methods with regards to value determination. However, Da Silva et al.,[25] found dissimilar results in their study as they reported that mean ΔE value (lightness) between the target teeth and crowns fabricated using the spectrophotometric method was significantly lower than values achieved by the conventional visual method. This result is at variance with the study of Ghada et al.,[29] who reported higher mean values (86.05) for instrumental than that of visual method. This difference may be due to the 3D master shade guide used in the study as against the VITA classical shade guide used in the present study.

Regarding chroma (a* and b*), this study found a significant difference in the mean chroma of the crowns fabricated using shade selected with the conventional visual and spectrophotometric shade-matching. A contrary finding was reported by Ghada et al.,[29] in which there was little or no difference in the mean chroma of shade selected by visual method (18.39) and instrumental (18.49). This variance may also be due to the fact that 3D master shade guide was used against the Vita classical shade guide that was used in the current study. It may, therefore, be pointed out from this present study that lightness is easier to determine by visual methods than chroma.

The total (actual) colour of crowns fabricated using the two methods of tooth shade matching was compared to the total colour of the adjacent natural reference teeth. This study found no difference in the mean total colour of the crown fabricated using the conventional visual and spectrophotometric methods. (p= 0.886) The extreme values obtained in some of the cases may account for this. However, this finding is in accordance with what was observed in a study by Li and Wang[26], where they also reported no significant differences between the instrumental (3.14+1.17) and the visual approach (3.58 +1.03) concerning total colour. Similar to this finding were the results of the study by Meireles et al.,[30] who recorded that the difference between the visual assessment and digital spectrophotometric analysis was not statistically significant (p=0.07). However, conflicting observation was reported by Paul et al.[31], in their study, where they documented the mean total colour difference of 3.15 ± 1.08 for the visual shade selection and the mean of 2.099 ± 0.94 for the spectrophotometric shade determination; hence their statistical analysis revealed a highly significant difference between the two groups. This was attributed to the mathematical background of the spectrophotometer used compared to the human eye.

Finally, the mean of the total colour difference between the two methods of tooth shade matching was compared, and it was found not to be statistically significant. Overall, the shade of porcelain-fused-to-metal crown fabricated using the shade selected by the spectrophotometer was more acceptable and preferred by the participants. Hence, the spectrophotometric method of shade selection is more reliable and effective than the conventional method, although the latter is cheaper. However, more research in this field with more participants may be necessary.

Limitations of the study

The metal substructure of the porcelain-fused-to-metal crowns may affect the patient's acceptability of the colour reproduction. Therefore, all ceramic restoration is recommended for future studies.

CONCLUSION

Within the limitation of this study, it can be concluded that the patients' acceptance of the shade of porcelain-fused-to-metal crown was higher in the spectrophotometric shade selection method when compared to the conventional visual. However, there was no statistically significant difference in the total colour of the porcelain-fused-to-metal crown fabricated with both shade selection methods.

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