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"The Spectral Showdown"- Comparative Evaluation Of Different Tooth Shade Systems In Aesthetic Dentistry

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Abstract

Introduction:-

With the development of newer digital methods of shade selection along with the existing traditional shade guides, the process of shade selection for natural looking restorations is a constantly evolving process. This clinical study aims to compare visual shade selection under both natural and ambient lighting conditions to digital shade selection using an intraoral scanner

Materials and methodology:-

A total of 15 patients were taken with clinically normal maxillary incisors and good oral hygiene. The incisors were cleaned and then inspected under white light (Group 1) and ambient light(Group 2) using VITA classical shade guide (A1-D4). This was followed by shade matching using digital methods involving use of intraoral scanner(Group 3) for the same set of teeth. Each approach was focused on the middle third of the tooth for shade selection. The data from all the groups was recorded and sent for statistical analysis with T-test

Result:-

The intergroup analysis showed statistically significant difference between ΔE scores of both visual and digital group, with visual shade selection showing acceptable difference from control.

Conclusion:-

In a comparison of these techniques, the visual shade selection method showed more consistent colour matching results compared to digital shade matching.

Keywords: Colour difference; Intraoral scanner; Shade matching; Tooth colour; Visual shade selection

Introduction

In aesthetic dentistry, the accurate selection of tooth shade is a critical factor in achieving natural-looking restorations. The success of restorative treatments relies on how well ./the chosen shade blends with the patient's natural dentition. Accurate shade selection has become essential in meeting patients' aesthetic expectations. (1)

Conventionally, visual shade selection with shade guides such as the Vita Classical or Vita 3D Master has been the commonly used method. However, this method has many drawbacks , it's non uniformity, incapability to include complete range of natural tooth shade, variation due to surface texture influenced by variables such as lighting conditions, clinician experience, and the inherent variability in human

colour perception.[2] In recent years, digital shade selection systems have emerged as a promising alternative. Digital tools such as spectrophotometers, colorimeters, digital cameras, and some Intraoral scanners are considered more objective.[3]

The accuracy of artificial tooth shade matching is influenced by factors such as the light source, the object being viewed, and the observer [4]. During shade matching of artificial teeth in prosthetics, the evaluation should be carried out under a single light source, since the combination of multiple light sources can lead to metamerism [5]. A change in the light source or the light reflected from an object can alter the perceived color. The ideal conditions for tooth shade matching are achieved with a light source having a color temperature between 5,500 K and 6,500 K [6]. Light sources with higher Kelvin temperatures typically emit a cooler, bluish hue resembling daylight, whereas those with lower Kelvin values produce a warmer, reddish tone. Northern natural lighting, daylight, is considered the most desirable match because it produces a broad spectrum of colour[7][8].

IntraOral scanners (IOSs) are used to take impressions during digital workflows[3]. The market for intraoral scanners (IOSs) is growing, with numerous manufacturers offering different models equipped with advanced features such as tooth shade assessment, caries detection, and smile design tools. There is an increasing trend toward built-in tooth shade determination, typically using a light-emitting diode (LED) as the light source.[9]

Many prior studies have compared visual shade selection techniques and the devices used to perform shade selection; however, there is no consensus regarding the ideal shade selection technique[10,11,12].

The purpose of this study is to compare the consistency of visual shade selection with digital shade-matching devices in restorations. This comparison aims to determine which method provides more reliable results for aesthetic outcomes

This clinical study aims to compare visual shade selection under both natural and ambient lighting conditions to digital shade selection using an intraoral scanner. The null hypothesis suggested that there is no significant difference in shade selected by visual or digital shade selection method in all lighting conditions

Materials And Methods:-

The study received approval from the institute's Ethics Committee. The participants were recruited from a pool of patients referred to Department of conservative dentistry and Endodontics. A total of 15 patients were taken for the study with clinically normal maxillary incisors and good oral hygiene. Informed consent was taken from all participants.

Case selection for the study was done according to the following criteria:-

Inclusion criteria :-

Patients with clinically normal maxillary incisors and good oral hygiene and no missing anterior teeth between the age of 20 to 40 years were selected.

Exclusion Criteria:-

1. Extensively carious anterior teeth
2. Periodontally damaged maxillary incisors
3. Restored maxillary incisors
4. Teeth with developmental disorders
5. Malaligned or rotated teeth
6. Recently bleached teeth

Shade Selection

Localised oral prophylaxis was performed. For shade selection, the teeth were divided into three parts namely cervical, middle and incisal third and the shade is determined from the middle third of the teeth. Each approach was focused on the middle third of the tooth for shade selection since the shades of the other two regions can be influenced by the gingiva in the cervical region and by the increasing transparency in the incisal tooth area. All the sets of data were recorded by separate people to avoid influencing the results from either method.

Group 1:- Visual Shade selection under white light

The incisors were dried using cotton and shade was selected by using VITA classical shade guide **(**A1-D4). It includes 16 tooth shades, categorized into four groups based on shade (A, B, C, and D), with each group further divided by intensity and saturation levels (1, 2, 3, and 4).

The shade was selected firstly under white light, with chairside light switched off so that natural daylight

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was available. The shade selection was done for 2-5 seconds.

Group 2:- Visual shade selection under ambient light

This was followed by shade selection under ambient light using the chairside light, which was done within 2-5 seconds by a different operator.

Group 3:- Digital Shade selection

Intraoral scanner (Medit) was used for the same set of teeth for the digital method. The maxillary arch of each patient was scanned using the intraoral scanner device by a third operator, which was calibrated according to manufacturer's instruction, which was followed by the use of shade tool in the software for determining the shade of each tooth.

Figure 1 shows the entire process of shade selection. The group for shade selection using white light was used as control group and compared with the other two groups. The data from all the groups was recorded in a tabular form and ΔE scores were calculated between the groups using CIELAB values for each shade. The data was sent for statistical analysis with T-test.

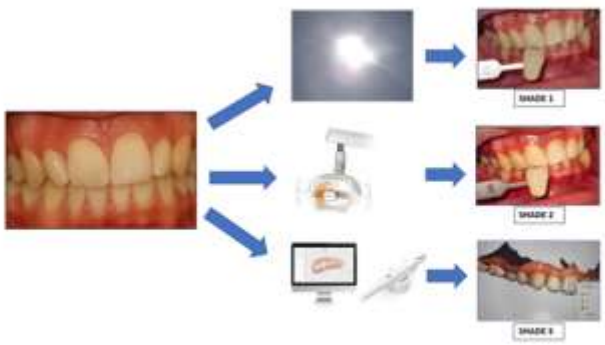

Fig 1. Process of shade selection

Results:-

Analysis was done for all 15 patients using the resulting shade of each individual group. The CIELAB scores were obtained using the shade of each group and ΔE scores were calculated for the groups as shown in Table 1 using the formula

$$\Delta E^* = \sqrt{((\Delta L *)^2) + (\Delta a *)^2 + (\Delta b *)^2}$$

ΔL*, Δa*, and Δb* are the differences in lightness–darkness, green–red coordinate and blue–yellow coordinate, respectively.

The mean difference of shade between Group 1 and 2 (0.9 ± 2.00) was less than Group 1 and 3(4.2 ±3.5) as shown in Table 2, which showed that shade matching under ambient operatory light showed a closer shade match to the shade in natural daylight as compared to intraoral scanners. Also, the mean difference was below the score of 3.7, considered within acceptable range of colour difference. The use of t-test also showed significant difference between the two comparison groups (p=0.001), suggesting strong difference amongst the groups.

Discussion:-

The visual method of artificial tooth shade matching using a standard shade guide is the most commonly used method in dentistry [13]. The human eye can successfully distinguish even slight differences in colour. However, the visual assessment of tooth colour is considered imperfect, as variations can exist because of change in observers and lighting conditions[14]. Hence, digital intraoral scanners are playing an increasingly important role in colour determination in dentistry.

In the present study, the intergroup test analysis showed a significant difference between the two groups, which may be attributed to the intraoral scanner using artificial white light during the scan procedure, as opposed to the ambient operatory light.

The null hypothesis of the study was hence rejected as difference was seen between the groups. Natural daylight was used as a control in this study as it is considered as gold standard in colour matching providing a full spectrum, balanced light source.

According to Johnstone et al in, the average color difference between compared teeth rated as a match in the oral environment was 3.7[16]. Scores greater than this value can be perceived by the human eye as a different shade. Hence, the shade difference less than 3.7 was considered acceptable.

Visual shade matching outperformed digital intraoral scanner shade selection in this study, as evidenced by lower ΔE scores**.** This is likely due to the human eye's superior ability to detect subtle color variation and the contextual awareness provided by visual assessment, which collectively result in more accurate and harmonious shade matching.

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TABLE 1:- Colour difference between the groups using CIELAB scores

Sr. No.	`1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
ΔE1	0	0	0	0	0	0	0	0	0	6.21	4.97	0	1.66	0	0
ΔE2	4.84	7.32	4.84	4.84	4.33	0	13.45	5.74	1.62	4.84	0	4.97	4.84	0	1.68

ΔE1:- Colour difference between shade selection under white light and ambient light
ΔE2:- Colour difference between shade selection under white light and intraoral scanner

TABLE 2:- Mean value of scores in each group calculated using t-test

White light vs Ambient light	White light vs Intraoral scanner	P
0.9 ± 2.00	4.2 ±3.5	**0.001***

P < 0.5= Statistically significant

An in vivo study by Abu Hossin et.al. compared visual shade selection to digital shade selection concluded that visual shade assessment by a skilled practitioner remains highly valuable and complements the use of digital intraoral scanners and that it remains of great importance to improve the technology of intraoral scanners and to increase the repeatability, with regard to color determination.[15]

One limitation of this study is the use of the VITA Classical A1-D4 shade guide, which offers only 16 tabs, rather than the VITA Tooth guide 3D Master, which provides 28 tabs and allows for a more comprehensive and nuanced evaluation of the tooth shade. Another limitation is the absence of a standardized scanning protocol for shade matching using a digital scanner, with factors like scan angle and distance, lighting conditions, and operator experience potentially affecting the outcome and can be hard to control.

Conclusion:-

In a comparison of these techniques, there is an appreciable difference in shade selection under different light sources and similarly considerable difference in visual and digital methods. Visual method is fond to be showing lesser difference is shade compared to its digital counterpart. Both the methods of shade selection have its own merits and demerits. Hence , shrewd clinical judgement is necessary alongside the technique used for the best results.

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