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Shade Selection Of Composite In Esthetic Dentistry

A Project Submitted to
The College of Dentistry, University of Baghdad,
Department of Conservative Dentistry in Partial Fulfillment
for the Bachelor of Dental Surgery

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Certification of the Supervisor

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I certify that this project entitled "Esthetic concerns in shade selection of composite" was prepared by the fifth-year student **Momen Zain Al-Abideen Mostafa Sahib** under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name: **Assistant Prof. Dr. Ahmed Hamid Ali**

Dedication

.....

"I think art is the second most beautiful thing in the world. I think nature comes first."

- Stefani Germanotta

I have always believed that art, in whatever form, healed something of me. And to be honest, I cared about the artistic side of my field more than anything else about it. How to use the artistic element to make someone happy. So I decided to choose a concept that is related to something I care about, spiritually and habitually.

I want to thank myself, first, for all the effort I made throughout the previous years. For me being there for me, always. I want to appreciate the effects that everybody left on me, positively or negatively. I am here because of them. My family, my colleagues, and the artists that reshaped my life. It's all a mosaic piece that was made from the smallest details of everyone and everything.

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.....

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Table of Contents

Title No.	Subject	Page No.
	Dedication	II
	Acknowledgment	III
	Table of Contents	IV
	Table of Figures	V
	Introduction	1
	Aims of the study	3
	Chapter One: Review of Literature	4
1.1.	Light phenomena related to dentistry	4
1.2.	Artistic elements related to dentistry	5
1.2.1.	Color	6
1.2.1.1.	Hue	6
1.2.1.2.	Value	7
1.2.1.3.	Chroma	8
1.2.2.	Transparency and translucency	9
1.2.3.	Opalescence	9
1.2.4.	Fluorescence	9
1.3.	Color concepts related to dentistry	10
1.3.1.	Color of teeth	10
1.3.2.	Color of gingiva	12
1.3.3.	Color of skin	13
1.4.	Color matching and shade selection	13
1.4.1.	Tools of shade selection	14
1.4.1.1.	VITA classical shade guide	15
1.4.1.2.	VITA System 3D-Master shade guide	16
1.4.1.3.	Other shade selection devices	17
1.4.1.4.	Drawbacks and limitations of shade guides	20
1.4.2.	Guidelines for shade selection	20
1.4.2.1.	Guidelines related to position and posture	20
1.4.2.2.	Guidelines related to light	21
1.4.2.3.	Guidelines related to the environment	22
1.4.2.4.	Guidelines related to the condition of the teeth	22
1.5.	Clinical application of shade selection; procedures and methods	23
1.6.	Problems in shade selection	28
1.6.1.	Problems related to shade guides	28

1.6.2.	Problems related to the dentist	29
	Chapter two: Conclusions	30
	References	31

Table of Figures

Figure Title	Page No.
Figure 1: Optical phenomena related to the teeth	5
Figure 2: Hues of teeth in VITA classical shade guide	7
Figure 3: Value changes with age	8
Figure 4: Munsell's scale of hues, values, and chromas in color space.	8
Figure 5: Changes in value (lightness), chroma and hue between different teeth	10
Figure 6: Different colors of teeth surfaces in anterior and posterior teeth	12
Figure 7: Different colors of the gingiva	13
Figure 8: Clark's Tooth Color Indicator, the oldest shade guide designed by E.B. Clark in 1931	14
Figure 9: VITA classical shade guide tab	15
Figure 10: Types of VITA System 3D-Master shade guide	17
Figure 11: Dental colorimeter	18
Figure 12: Dental spectrophotometer	18
Figure 13: SpectroShade device	19
Figure 14: Digital cameras; a. Shade scan b. Shade rite dental vision system	19
Figure 15: The ideal position to hold the shade sample	21
Figure 16: Effect of changing light sources on teeth appearance, ranging from cooler to warmer tones	22
Figure 17: Correct order of composite resin layers, from darker to lighter shades	26
Figure 18: Different layering techniques to get a final shade that resembles a natural tooth	27
Figure 19: Differences between different brands of the same shade of composite (A3)	28

Introduction

With the new advances in all dentistry fields, there is an increasing tendency towards both; receiving and performing, an enhancement of appearance, with reasonable strength and proper longevity. That's observed in the shift that occurred gradually from metallic restorations to the new tooth-colored restorations. All together with the advocate application of the term "restoration" with all its mechanical and adhesive concepts instead of the term "filling" which has esthetic and physical concepts only.

The term "**esthetic**" is derived from an ancient Greek origin '**αισθητικός**' (*aisthētikós*) which means perceptive, sensitive, pertaining to sensory perception. (**Harper, 2000**).

According to **Mosby's Dental Dictionary (2018)**, esthetic dentistry is defined as “the skills and techniques used to improve the art and symmetry of the teeth and face to enhance the appearance as well as the function of the teeth, oral cavity, and face.” This definition deals with appearance as a focal point of esthetic dentistry. Dental esthetics (also spelled aesthetics in a British accent) connects with the principal aspect of appearance and physical attractiveness. Accordingly, esthetic dentistry provides benefits that extend far beyond total dental health toward total well-being throughout life. This means that the general focus of dentistry is therefore minimized to personal advantage.

Beauty is not absolute, but extremely subjective. therefore there is no standardized definition of it. Each of us has a general sense of beauty. Our own individual expression, interpretation, and experiences make something unique when someone else will not. Beauty is influenced by culture and self-image. What one culture perceives as disfigured may be

acceptable to another. Many factors and dimensions determine a person's appearance, among which physical attractiveness phenomenon. The physical attractiveness phenomenon is a bias based on physical attractiveness.

As discomfoting or superficial as it may be for people to acknowledge, the reality lives. Individuals with an appearance of higher physical attractiveness do experience more benefits throughout life that their counterparts of lower physical attractiveness do not; regardless of age, gender, race, ethnicity, socioeconomic level, geographical location, and so on. So, logically esthetic dentistry is a cornerstone of the physical attractiveness phenomenon, and vice versa. Therefore, esthetic dentistry possesses considerable capability and responsibility to provide the benefits and detriments that individuals experience throughout their lives.

Also there is the popular thought that esthetic dentistry is only about vainglory provided exclusively to rich and famous people, which lacks accuracy. Yes, function matters, is essential and is a must, but combining function with good form that improves appearances matters even more.

Comprehensively, dental esthetics exert a key role in a person's self-image, confidence and overall. **(Ronald *et al.*, 2018)**

Before diving deep into the esthetic concerns of our topic, one must understand the luminous and chromatic basics that have relations to esthetics in general, and dentistry in particular.

Aim of the study

1. To have a background in color concepts and their clinical relation to esthetic dentistry.
2. To learn about the various types of shade selection tools.
3. To know the guidelines and techniques of shade selection.
4. To understand the reasons behind the inaccuracy in shade matching and attempt to minimize them.

Chapter One

Review of literature

1.1. Light phenomena related to dentistry

A tooth, as a colored entity, does not only absorb and reflect light, but also refracts, diffracts, transmits, scatters, and creates unique light optically. Some of the optical phenomena that relate to light include

- **Direct transmission:** When light passes freely and finds no obstacle.
- **Diffuse transmission:** When light takes many directions after hitting the object.
- **Selective transmission:** When only certain wavelengths can pass.
- **Reflection:** When light is rejected.
- **Refraction:** When light travels at a different direction and speed when incorporated into another vehicle.
- **Diffraction:** When light stops traveling in straight lines and creates self-interference with the beams that have followed this path.

(Jordi and Anna, 2012)

As a general rule, while assessing the shade of the restoration, we have to check it under four types of lights, namely are:

- Average natural light 5000 K
- Dim natural light 3000 K
- Average artificial light 5000 K
- Dim artificial light 3000 K

This is done to ensure that the shade matches the natural color of the tooth under all or almost all circumstances, as they may match at some lightings and not at others. **(Bernard *et al.*, 1999)**

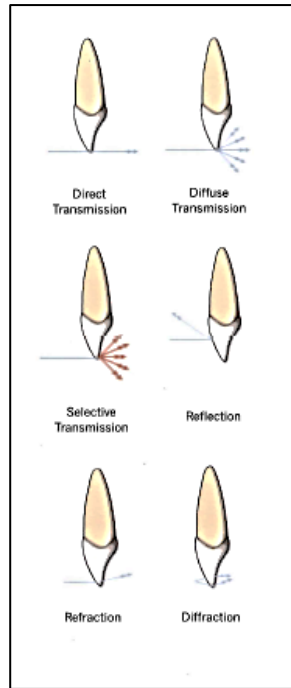


Figure 1: Optical phenomena related to the teeth

1.2. Artistic elements related to dentistry

Despite the result, a dentist should consider certain basic artistic elements to ensure an optimal esthetic result. In conservative esthetic dentistry, these elements include the following:

- Shape or form
- Symmetry and proportionality
- Position and alignment
- Surface texture
- Color
- Transparency and translucency
- Opalescence

Some or all of these elements affect every conservative esthetic dental procedure, but the ones that relate to shade selection are mostly the last three ones. **(Harald *et al.*, 2011)**

1.2.1. Color

Color can be defined in three distinct ways:

- From the physical standpoint, color is defined by three parameters: intensity of energy emitted, wavelength and spectral composition. This aspect involves radiant energy only.
- From the psychophysical standpoint, color is defined by three parameters: luminance, dominant wavelength and colorimetric value. This aspect involves light energy caught by the eye only.
- From the psychosensory standpoint, color is defined by three parameters: hue, chroma, and value. This aspect relates to the way that the brain interprets color, and therefore is the concept that interests us for shade selection in esthetic dentistry. (**Bernard *et al.*, 1999**)

In dental esthetics, the harmony we look for is obtained from the esthetic triad: shape, texture, and color. Color, in return, has three bases; hue, chroma, and value. Other essential aspects that are not always considered, include translucency and opalescence. (**Jordi and Anna, 2012**)

1.2.1.1. Hue

Hue is defined as the particular variety of color, shade or tint. Munsell stated about a hue that *"It is that quality by which we distinguish one color family from another, as red from yellow, green from blue, or purple"*. Hues are divided into 10 quadrants, yellow, yellow-red, red, red-purple, purple, purple-blue, blue, blue-green, green, and green-yellow. And each gradation is subdivided, e.g. red can be written 1R-10R. Hue always corresponds to the wavelength of the object. It should be remembered that the hue must always be selected under the appropriate

light (5000 K). (Sikri, 2010). VITA classical shade guide comprises four hues:

- A. reddish-yellow-brown
- B. yellow-orange
- C. greenish-gray
- D. pinkish-gray

The majority of natural teeth fall into the range of yellow and yellow-red. (Jordi and Anna, 2012)

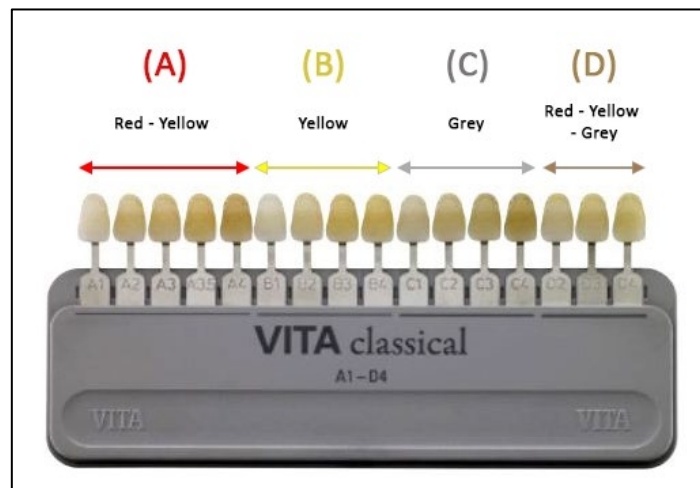


Figure 2: Hues of teeth in VITA classical shade guide

1.2.1.2. Value

Value is defined as the relative darkness or lightness of a color or the brightness of an object. Munsell stated that value “*It is that quality by which we distinguish a light color from a dark color*”. According to the axis of Munsell's color system, the value ranges from 0 to 10 with 0 representing black at the bottom and 10 representing full white present at the top. Natural teeth range in value from 4-8. The common unaesthetic nature of metallic restorations is caused by very high values (too bright)

which can easily be detected by an observer. Value is inversely related to age. (Boksman, 2007)



Figure 3: Value changes with age

1.2.1.3. Chroma

According to Munsell, chroma was defined as “it is that quality by which we distinguish a strong color from a weak one; the departure of a color sensation from that of white or gray; the intensity of a distinctive hue; color intensity”. It is simply seen as the strength of a given hue or the concentration of pigment. According to Munsell's color system, the radii of the different discs represent chroma, starting from a ‘pure’ color at the outer edge and becoming progressively less saturated towards the central axis. Natural teeth range in chroma from 0 to 7. (Terry *et al.*, 2002)

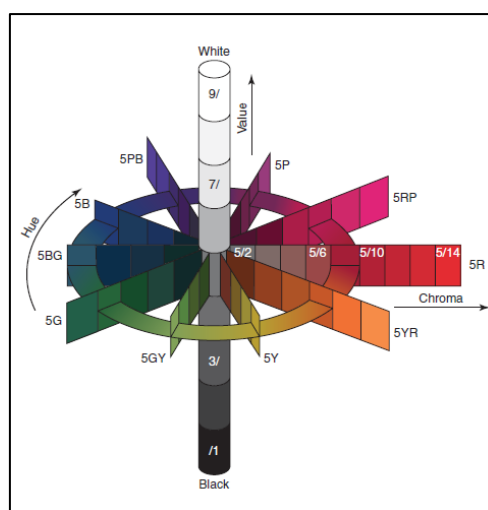


Figure 4: Munsell's scale of hues, values, and chromas in color space.

1.2.2. Transparency and translucency

Transparency is the physical property of allowing light to pass through the material without an appreciable scattering of light "There is a uniform index of refraction". On the other hand, translucency is the physical property of allowing light to pass through, but scattered at either of the two interfaces "there is a change in the index of refraction". **(Thomas, 1999)**

1.2.3. Opalescence

Opalescence is the phenomenon in which a material appears to be of one color when light is reflected from it and of another color when light is transmitted through it. The hydroxyapatite crystals of enamel act as prisms. When illuminated, opals and enamel will transilluminate the reds and scatter the blues within their body. For that reason, enamel appears bluish even though it is colorless. The opalescent effect of enamel brightens the tooth and gives it optical depth and vitality. **(Fondriest, 2003)**

1.2.4. Fluorescence

Fluorescence is the absorption of light by a material and the spontaneous emission of it in a longer wavelength. In a natural tooth, it primarily occurs in the dentin because of the higher amount of organic material. **(Terry et al., 2002)**. **Jordi and Anna (2012)** stated that those concepts can be related to the following tissues/areas:

1. Hue, chroma and value: the first two ones are related to the dentin that is superimposed by enamel, the latter is strictly related to enamel
2. Opalescence: it is confined to the incisal third
3. Translucency: it is confined to the enamel
4. Fluorescence: It is confined to dentin

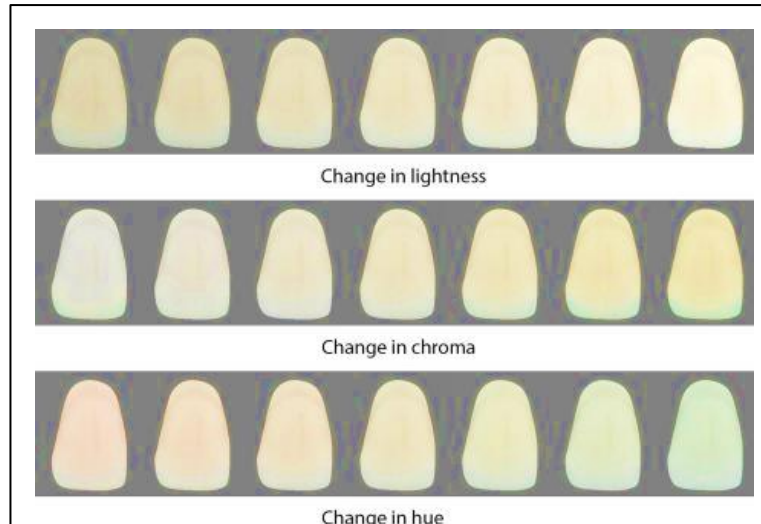


Figure 5: Changes in value (lightness), chroma and hue between different teeth

1.3. Color concepts related to dentistry

1.3.1. Color of teeth

The color of human teeth differs by dentition. Permanent teeth tend to be darker and more chromatic than primary teeth. It also differs by individual and by tooth type for the same person. Incisors are the lightest teeth in general while the canines are the darkest and most chromatic. It also differs for the same tooth by the tooth area, moving from gingival to incisal, mesial to distal and buccal to lingual, and throughout the lifetime. A gradation of color usually occurs while moving from the gingival region to the incisal region, with the gingival region being darker because of thinner enamel. Thus indicating the choice of a darker shade of composite in that area if restored. (Paravina *et al.*, 2007)

When colors of permanent teeth were compared by gender: female teeth were lighter and less chromatic. The same was found for comparisons between bleached and non-bleached teeth, and teeth of smokers and

nonsmokers. In general, lighter teeth are less chromatic and less red, regardless of all other variables mentioned above. **(Paravina *et al.*, 2015)**

The 1st data on color ranges in human teeth were measured by Dr. E. B. Clark, a dentist, in 1931 using the Munsell coloring system. Clark suggested that hue ranged from 6 YR (yellow and red) to 9.3 Y (yellow), value ranged from 4 to 8, and chroma ranged from 0 to 7. The studies suggest that teeth are in the yellow–red to a yellow range of the spectrum that is comparatively high in value and low in chroma. The amount, location and quality of translucency vary with the individual and with age. **(Evans and Douglas, 2009)**

The color of teeth varies with the translucency, thickness, and distribution of enamel and dentin and the age of the patient. Other factors such as fluorosis, tetracycline staining, and endodontic treatment also affect tooth color. Because of those many variables, it is necessary to match the individual surface of the tooth to be restored. **(Sturdevant, 1968)**

According to tooth tissues, five color shades form a natural extensive chromatic range:

- **Yellow/Orange:** Dentin
- **White:** Enamel and internal enamel characteristics
- **Blue:** Free enamel opalescence
- **Amber:** Opalescence, counter-opalescence, and various enamel and dentin characteristics

According to the location, four colors offer features and optical properties common to most teeth:

- **Yellow/Orange:** Cervical and middle thirds
- **White:** Mammelons, incisal halo, occlusal and facial surfaces
- **Blue:** incisal edge and proximal surfaces

Amber: incisal halo, incisal edge, and facial surfaces (characteristics)
(Jordi and Anna, 2012)

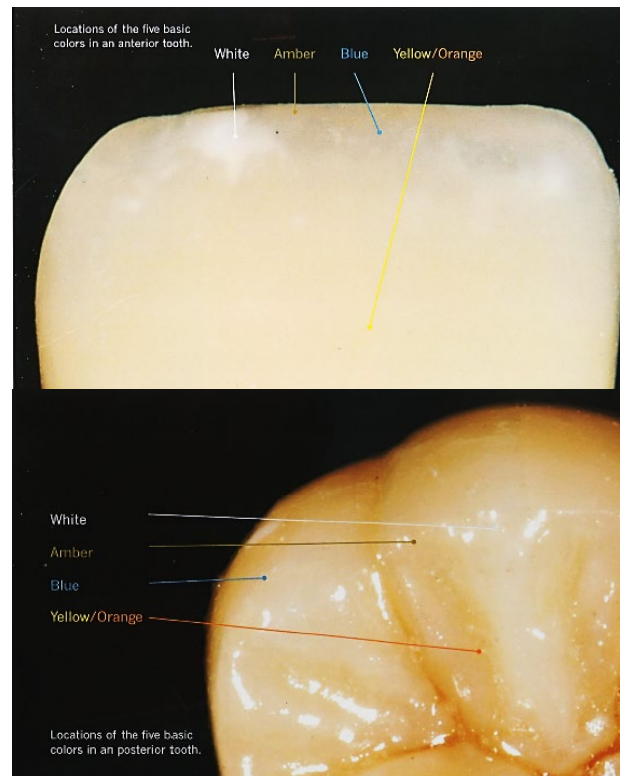


Figure 6: Different colors of teeth surfaces in anterior and posterior teeth

1.3.2. Color of gingiva

The color of the surrounding environment influences what is seen in the patient's mouth. Inflammation and tooth whitening can also cause reversible color changes in gingival tissue. In this case, shade selection should not be affected by the current state of the gingiva. **(Harald *et al.*, 2011)**

The color range of healthy human gingiva is far beyond the “ideal” light pink. Wide ranges of color coordinates make restoring the color of the gingiva more challenging whether dental materials (ceramics, acrylic, or composite resins) or human tissues are used. Ideally, the darker color of

the gingiva the more contrast it will be if a lighter shade is selected, thus, the esthetic balance should be maintained. (Bayindir *et al.*, 2009)



Figure 7: Different colors of the gingiva

1.3.3. Color of skin

Studies found a significant inverse association between the color of skin and tooth shade, mainly value. People who had darker skin had lighter teeth than those who had lighter skin. Thus, the esthetic balance should be taken for granted. (Rajtilak *et al.*, 2012)

1.4. Color matching and shade selection

The color matching term has broad aspects in life. Yet shade selection is the most derived term of it relating to dentistry. It is significant for every dentist in every dental branch. It is used in operative dentistry, prosthodontics and dental implantology. So every dentist must be aware of the artistic quality of the shade selection procedure. It is beneficial to test the color vision for all dental students and professionals using both conventional (non-dental) and customized (dental) tests. Testing color discrimination competency (CDC) in dentistry has been described in the technical report by the International Organization for Standardization (ISO TR 28642). The dental test includes matching pairs of tabs from two shade guides under controlled conditions and methods. Shade selection remains a "trial and error" method, in which the professional places shade

guides close to the area of interest to establish the best match. (ISO, 2016)

1.4.1. Tools of shade selection

Historically, early shade guides were derived from tooth colors that were considered pleasing rather than from the distribution of shades found in the general population. E.B. Clark introduced a custom shade guide in 1931 based on the visual assessment of human teeth, recorded in Munsell Hue, Value and Chroma, acknowledging the deficiencies of the available guides. It was called "Clark's tooth color indicator" with 60 shades. (Yuan *et al.*, 2007)

Meanwhile, the Hayashi shade guide consisted of combinations of five lightness, five chroma, and five hue levels, for a total of 125 printed chips. (Paravina and Powers, 2004)

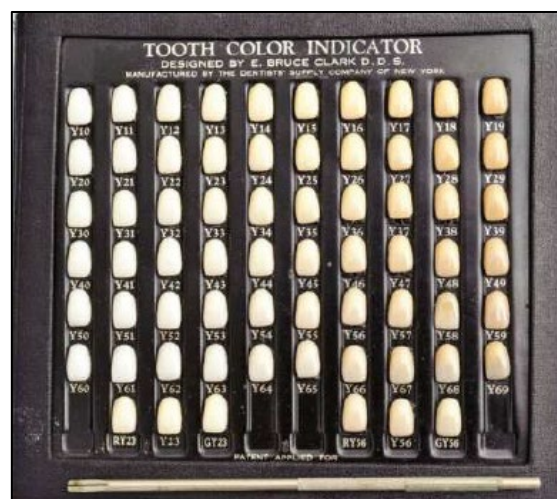


Figure 8: Clark's Tooth Color Indicator, the oldest shade guide designed by E.B. Clark in 1931

Current shade selection tools are divided into three main groups as the

following:

- VITA classical shade guide
- VITA System 3D-Master shade guide
- Other shade selection devices

All of them can be used in any dental procedure that requires shade selection, such as composite restorations, crown and bridge, veneer, complete and removable dentures, and dental implants. (**Hassel *et al.*, 2005**)

1.4.1.1. VITA classical shade guide

The VITA classical (A1–D4) was a gold standard for shade selection in dentistry for decades and to a large extent it still is. The vast majority of resin composites, dental ceramics, and denture teeth are keyed to this shade guide. VITA classical shade guide contains 16 shade tabs. The original tab division is known as the “A to D” arrangement, with four groups created based on hue: A is reddish-brown (A1, A2, A3, A3.5, A4), B is reddish-yellow (B1, B2, B3, B4), C is gray (C1, C2, C3, C4), and D is reddish- gray (D2, D3, D4). The older preserved shade guide, the Vita Lumin Vacuum guide (Vident), has existed since 1956, it was made from porcelain which affected the visual properties of the shades, but recent versions are made up from composite to not compromise the validity of shade selection procedure. (**Paravina *et al.*, 2007**)



Figure 9: VITA classical shade guide

1.4.1.2. VITA System 3D-Master shade guide

It is another shade guide that was introduced in 1998. It is divided into numbers (1, 2, 3, 4, and 5) in front of the letters representing the group number and lightness level; a lower number indicates a higher lightness. the more chromatic tabs are indicated by larger numbers. The major difference between the Vita Classical and Vita 3D-Master shade guides is that the Vita Classical shade guide is built on the color hue and the Vita 3D-Master is built upon the color value. The Vita 3D-Master shade guide is considered superior to the Vita classical shade guide. (**Parameswaran et al., 2016**)

One of the other advantages of VITA 3D-Master is the repeatability of shade selection with the system. It was concluded that the use of this system compared with the classic guide improved intra-rater repeatability among dental practitioners. (**Hammad, 2003**)

There are three major types of this shade guide:

- A. **Tooth guide:** It has 11 sets of teeth, which consist of 26 samples ranging from lightest to darkest value, from lowest to the highest intensity and from yellow to red.
- B. **Linear guide:** It enables the quick determination of precise tooth shades using the same principles of the VITA 3D-Master guide, the only difference is that it is sleeker and in a linear design.
- C. **Bleached guide:** It is a modified design with the introduction of 6 groups in it. No. 0 for the shade matching of bleached teeth which has the (0M1, 0M2,0M3) shades, with more lightness, three levels of chroma and a middle hue. (**Baltzer and Kaufmann, 2005**)

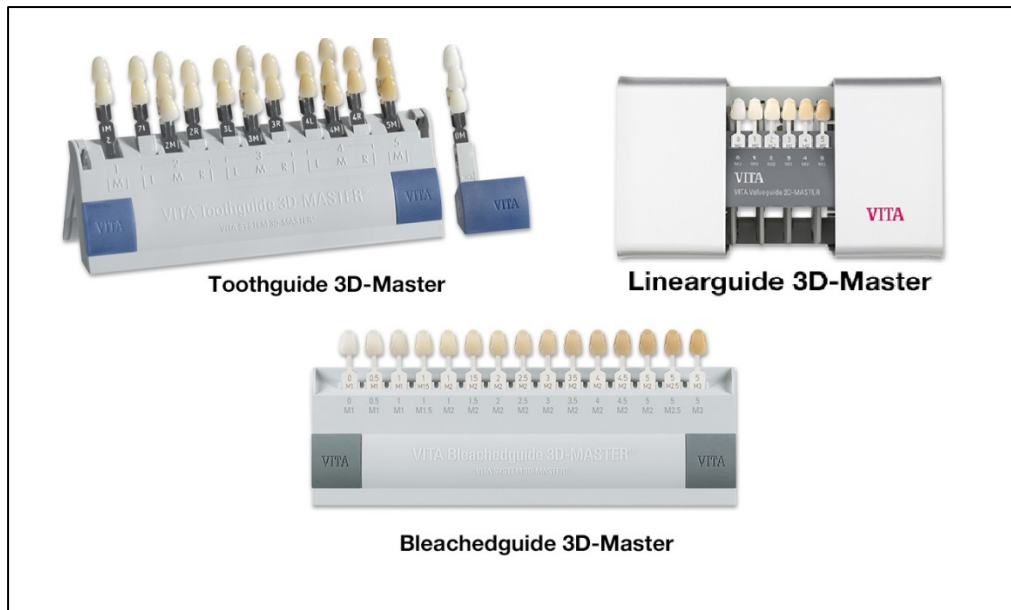


Figure 10: Types of VITA System 3D-Master shade guide

1.4.1.3. Other shade selection devices

These devices have been designed to aid clinicians and technicians in the specification and control of tooth color. They are mainly composed of a detector, signal conditioner and software that processes the signal in a manner that makes the data usable in the dental operatory or laboratory. Most of them are so costly and are not frequently used except in some advanced cases of extra esthetic needs. Some examples of those devices include:

- Dental colorimeter

This measures color (hue, chroma, and value) as perceived by the human eye. It can only measure color by measuring the stimulus values under fixed illumination and observer conditions. It is composed of a light source, an integrating sphere, and a detector. It has already become an old trend as it is replaced by dental spectrophotometers. (**Todorov *et al.*, 2020**)



Figure 11: Dental colorimeter

- Dental spectrophotometer

This analyzes surface colors by measuring the amount of spectral reflection from the body, its intensity based on color, or more specifically, wavelength. It is composed of a light source, monochromator, and detector. *Vita EasyShade* is an example of a dental spectrophotometer. (Ballard *et al.*, 2017)

As a comparison, a colorimeter measures the overall amount of absorbed, while a spectrophotometer measures the specific amount of light absorbed at varying wavelengths. Spectrophotometers are more reliable and accurate over time but slower than colorimeters. (Cal *et al.*, 2006)



Figure 12: Dental spectrophotometer

- SpectroShade device

It is a hybrid device that provides a combination of digital imaging and spectrophotometric analyses. It provides a more advanced procedure of shade selection by comprising the images to thousands or millions of light-sensitive elements known as photosites, this enables more precise results. (Brewer *et al.*, 2004)



Figure 13: SpectroShade device

- Digital cameras

Digital camera technology is being used nowadays for shade selection. They depend on the idea of capturing images using charged coupled devices (CCDs), which contain millions of microscopically small light-sensitive elements, known as photosites, providing pixelated accuracy. The *ShadeRite Dental Vision System* and *ShadeScan* combine digital color analysis with colorimetric analysis. (Cal *et al.*, 2004)

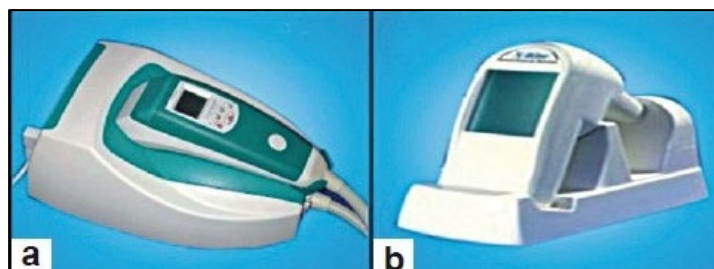


Figure 14: Digital cameras; a. Shade scan b. Shade rite dental vision system

1.4.1.4. Drawbacks and limitations of shade guides

1. Do not cover the complete color space of natural teeth color
2. Shades are not systematic in their color space
3. None of the commercially available shade guides are identical
4. Quality control issues regarding color mismatches of shade tab and composite batches from the same manufacturer
5. Limitations of the instrumental method
6. Translucency mapping is inadequate
7. Positioning of the probe or mouth piece seems to be critical to the repeatability of the measurement
8. Only a limited area is measured
9. Designed to measure flat surfaces (Effects of surface texture on light reflection)
10. Prone to edge loss effects
11. Fail to account for the variability found in natural teeth, e.g. fluorescence, opalescence, translucency, enamel thickness, and objectivity (Stephen *et al.*, 2023)

1.4.2. Guidelines for shade selection

Before any shade selection procedure, a few guidelines should be applied for better and more accurate results:

1.4.2.1. Guidelines related to position and posture

The operator, mostly a dentist, should stand directly in front of the patient. Angulations may cause shadowing that alters the shades. Also, the patient's teeth should be viewed at the operator's eye level so that the most color-sensitive part of the retina will be used. Shade selection should be made quickly on an upright or slightly reclined position, with

the color samples placed either above or below the tooth to be matched, never place the shade tab adjacent to the tooth to avoid the binocular effect. Shade guides should be placed parallel to the tooth. A distance of 61 cm (2 feet) to 183 cm (6 feet) distance from the accused tooth is considered ideal for shade matching. **(Basavanna *et al.*, 2013)**



Figure 15: The ideal position to hold the shade sample

1.4.2.2. Guidelines related to light

Sunlight in the middle of the day is considered optimal timing for shade selection, as this exposure contains an almost equal blend of all wavelengths of light. However, modern clinics might not depend upon natural lighting, also, pollution and another climate in this case artificial light should be used to simulate sunlight, although no artificial light lamp can perfectly duplicate sunlight. Shade selection should be made under different lighting conditions, ideally under a 5,500 K light source. According to the sequence of significance. Shade selection should be made initially at natural light and then reassured under incandescent and fluorescent lightening. The light source should be directly focused on the accused area. **(Christopher, 2007)**

Various light sources produce different perceptions of color, making two colored objects "for example; a tooth and composite restoration" look the same under one set of illuminants but different under another, this phenomenon is called "Metamerism". (Sproull, 1973)

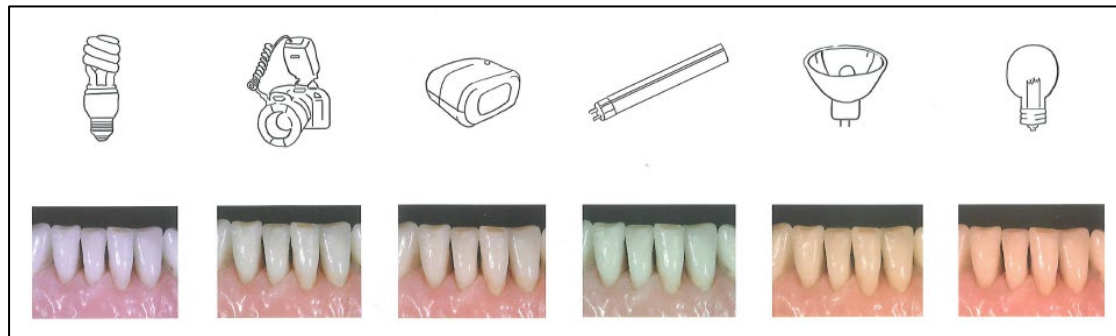


Figure 16: Effect of changing light sources on teeth appearance, ranging from cooler to warmer tones

1.4.2.3. Guidelines related to the environment

Bright-colored surroundings like wallpapers should be avoided as they interfere with proper color matching by influencing the colors in the reflected light. A drape can be used to mask undesirable colors in the patient's clothing and jewelry. Lipstick should be removed as it may cause a contrast that affects color perception. A very light gray color provides the ideal background for color matching, so after each color matching procedure or if moving from shade to shade, it is advisable to focus on a gray-blue surface immediately before a comparison since this balances all the color sensors of the retina and resensitizes the eye to the yellow color of the tooth. (Van der burgt *et al.*, 1985)

1.4.2.4. Guidelines related to the condition of the teeth

The tooth of interest and its adjacent teeth should be free of plaque and other deposits and surface stains so it is advisable to provide teeth

cleaning before shade selection. It is debated whether the tooth should be dried or not before shade selection. However many researchers advised that the tooth should be moist with saliva as dehydration results in a whiter appearance, and a reduction of enamel translucency by 82%, therefore, it is also advised to select the proper shades before teeth preparation since after preparation, the shade appears lighter due to dehydration. The tooth becomes dryer after application of the rubber dam, therefore, shade selection should be performed before applying it. If the patient had a tooth whitening procedure, shade must be taken 2 weeks after their last whitening treatment. **(Borse and Chaware, 2020)**

1.5. Clinical application of shade selection; methods and procedure

There are several techniques for shade selection. Some might use arbitrary methods but the most common method is the "Three-Step shade matching" technique. The order of shade selection procedure in this technique is first selecting the value, then chroma, and lastly hue. Color matching should be done in a systematic way that ensures accuracy, uniformity, and predictable results which are important in esthetic dentistry.

We depend on the adjacent teeth mostly, then on opposing teeth, and then further teeth from the area. The tab which is closest or an appropriate combination is chosen. If there is no perfect match, a lighter shade is selected, to which extrinsic correction is done. **(Behle, 2001)**

After applying all the guidelines; the shade selection procedure is done as follows:

1. Hold the shade sample end to end to the patient tooth first, then hold it parallel and as close as possible to the incisal edge "if anterior" or the bulk of the tooth "if posterior".
2. Choose value first, then chroma, then hue.
3. To be certain of the proper shade, a small amount of the selected shade of the composite can be placed directly on the tooth without bonding, close to the area to be restored, and cured. This is called "the button technique". If the shade is correct, an explorer is used to remove the cured material from the tooth surface.
4. Make the selection quick yet precise. Overgazing might cause eye tiredness after 5-7 seconds and therefore mistakes can happen.
5. In case of doubt, trust the initial decision, inspect a gray/blue object and then reevaluate the shades.
6. Review the shade selected with magnification.
7. Reconfirm the decision with a dental assistant for checking, and if agreed, record the shade into the patient's chart, or case sheet, or just resume using the definitive shade.
8. Disinfect and/or sterilize the shade guide after each use as per manufactures guidelines. **(Paravina, 2009)**

Clinically, in class I and II "restorations of posterior teeth in general", the shade selection is less critical, as the area is less visible. Also, difficulty in access and visualization may alter the procedure anyways . In class V, it should be remembered that the tooth is darker and more opaque in the cervical third. **(Harald et al., 2011)**

However, the shade selection is more crucial in class III, IV, and compound filling with composite. The layering of various shades or opacities also may be required to achieve the desired result. While layering esthetic materials, we recognize three main layers:

- **IN:** The inner layer is formed of dentin, and imparts chromaticity, opacity, light scattering fluorescence, and the yellowish tooth appearance.
- **OUT:** The outer layer is formed by the enamel, which is responsible for regulating the tooth's value and transparency. This layer modifies the final color of the tooth.
- **MID:** The intermediate layer is used to reproduce special features that occur spontaneously in natural enamel and are located in the middle of the stratification; it provides opalescences, intensive effects, and characterization (**Jordi and Anna, 2012**)

The layering of composite material can be simple, involving one or two shades. The purpose of composite layering is to establish the dentin layer and the visual effects of a tooth and create the wonderful nuances of enamel and enamel effects that transform into incisal translucency. The dentin shade is best obtained from the gingival third of the tooth where the enamel is the thinnest or from the canines where the chroma is the greatest. The enamel shade is best obtained from the middle third of the tooth, where the enamel is the thickest. The translucent zone is not limited to the incisal edge/third but fades into the transitional line angle zones. (**Brian, 2007**)

The average hue enamel of incisors and canines is 580 nm (red-orange), which corresponds to the shades A2, A3, and A3.5 in the VITA shade guide. For dentin selection, it is best to choose the color A range and

ignore the rest of the hues. It has been clinically proven that other colors are very rarely needed. For example, in an A2 tooth, the dentin near the pulp would likely be shade A3.

For older patients where attrition and abrasion occur, or when discoloration is observed, we might put in mind the use of other categories of shades including B, C and D.

The larger the cavity preparation, the more shades should be included in the restoration. In a very small cavity preparation, the use of one dentin shade should work optimally. Depending on the composite system, arbitrary use of shades can ruin the outcome. In those cases, it is better to work with only one shade even in large cavities. (**Angelo Putignano. Layers**)

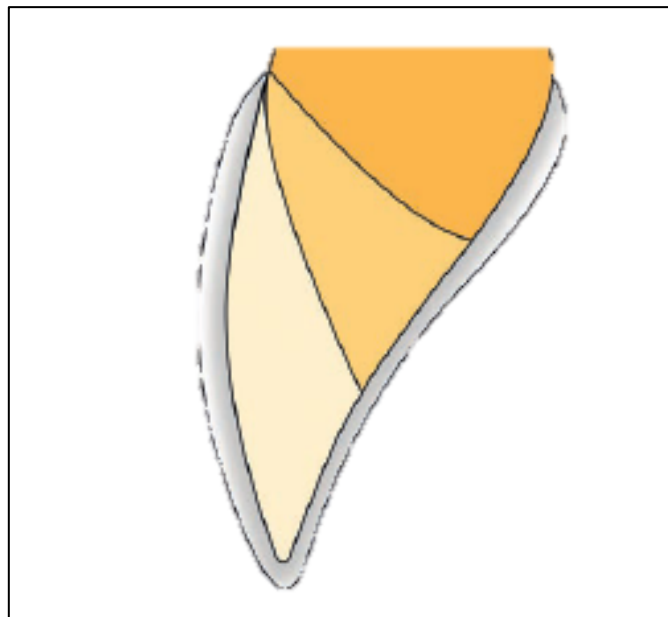


Figure 17: Correct order of composite resin layers, from darker to lighter shades

The following figure shows how can we get the final total shade by layering other shades.

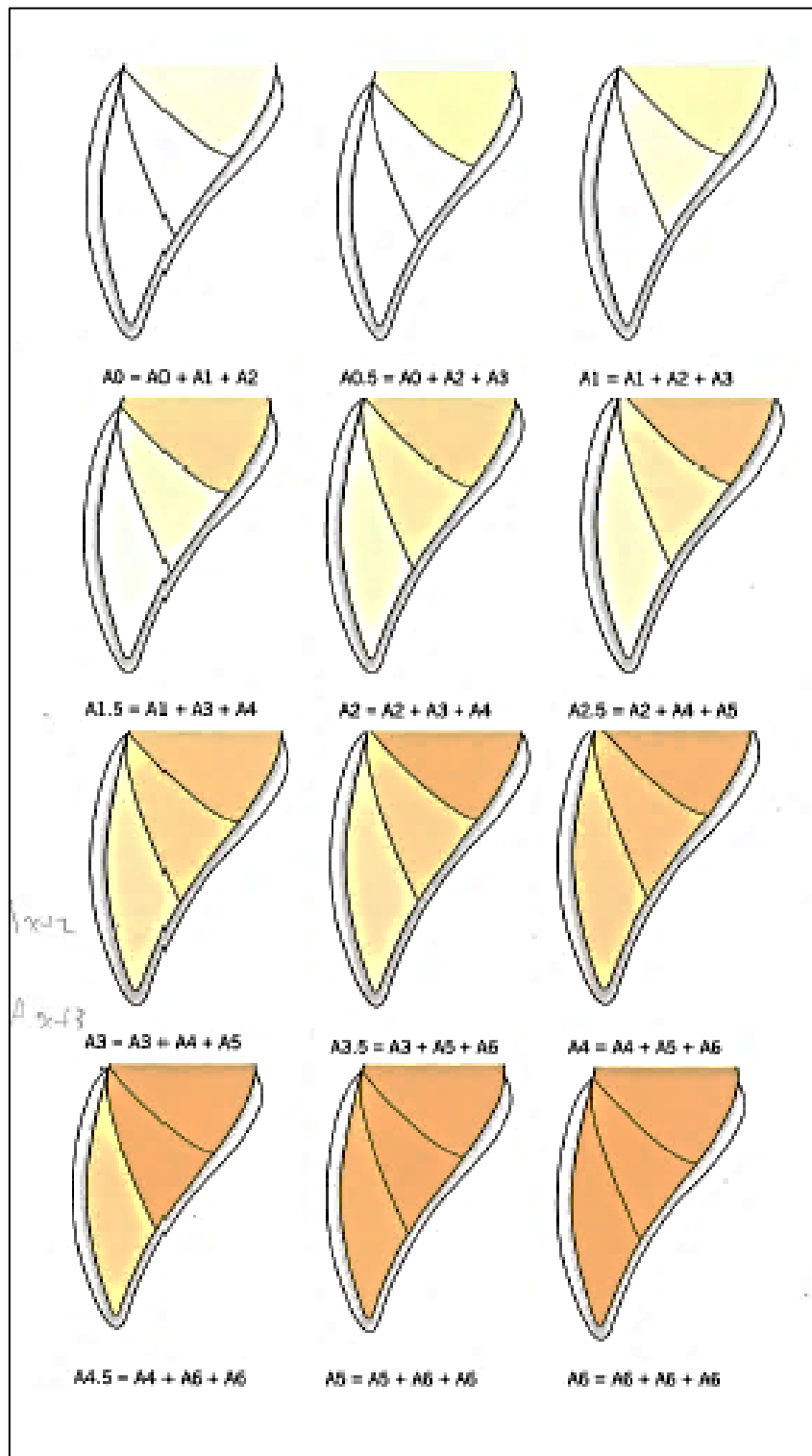


Figure 18: Different layering techniques to get a final shade that resembles a natural tooth

For A0-A4, we can use those equations to estimate the proper final shade:

$$A_X = A_X + A_{X+1} + A_{X+2}$$

$$A_{X.5} = A_X + A_{X+2} + A_{X+3}$$

1.6. Problems in shade selection

The inaccurate shade selection is caused by not following the guidelines; for example, when selecting shade after the tooth is dried or after isolation etc. The solution is by eliminating those causes. However, other problems can be related to either shade guides, or the dentist himself. **(Charbeneau, 1975)**

1.6.1. Problems related to shade guides

“No shade guide is the same as the other.”. This phrase has been controversial. It is known that the classic manufacturing of shade guides always resulted in a certain lack of color consistency between them. Differences between same-brand shade guides are easily found, especially when measured with precision. To overcome this procedure, we can make a personalized shade guide by making tooth shells with different shades of the used brand of composite in the clinic. **(Jordi and Anna, 2012)**



Different brand composite syringes. They are all intending to be A3 dentin, and despite this they appear completely different. Which one is the real A3? Every company uses its own color grading and compensating methods. That is the reason to use the same restoring material as trustworthy shade guide, no matter which material we choose.

Figure 19: Differences between different brands of the same shade of composite (A3)

1.6.2. Problems related to the dentist

Most of these problems are either due to the lack of skills in shade selection, or vision problems. Color vision problems/color blindness, metamerism, aging and fatigue lead to compromised visual accuracy, thus causing inappropriate shade selection. **(Denissen and Dozic, 2010)**

Chapter Two

Conclusions

Selection of the correct shade is the foundation for superior dental esthetics. Determining and closely reproducing the appearance and form of teeth is a challenging procedure. To provide an esthetic restoration to the patient, the dentist must have a full understanding of the science of color and color perception. Matching the correct shade satisfies both the dentist and the patient and gives a pleasing appearance to the patient. To achieve good esthetics, it is better to use more than one method as shade selection is a "trial and error" method. It is subjective procedure affected by the skills and dexterity of the dentist and his/her sense and awareness of art.

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