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Mapping the Adolescent Smile: A Systematic Review of Esthetic Determinants in Ephebodontics

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Abstract

Background: Esthetic dentistry has become increasingly important in children and adolescents, as dentofacial appearance influences self-perception, social interaction, self-esteem, and oral health-related quality of life. Ephebodontics focuses on the dental needs of adolescents, in whom facial growth, changing dentition, soft-tissue dynamics, and individual esthetic perceptions must be considered during treatment planning. Esthetic smile design therefore requires an integrated understanding of tooth color, morphology, proportion, gingival architecture, lip-tooth relationships, and facial harmony.

Material and Methods: A narrative review of the available literature was undertaken to comprehensively evaluate esthetic considerations relevant to ephebodontics. The dissertation reviewed the principles of shade selection and shade matching, including visual and instrumental techniques, optical properties of teeth, smile anatomy, components of a balanced smile, determinants and influencing factors of smile esthetics, and contemporary approaches to smile evaluation and design. Static photographic assessment, dynamic digital videography, biometric measurements, and emerging digital smile-design technologies were also reviewed.

Results: The review demonstrated that adolescent smile esthetics is a multidimensional concept involving facial, dentolabial, dental, and gingival components**.** Accurate shade selection depends on hue, value, chroma, translucency, opalescence, fluorescence, surface texture, lighting conditions, and observer-related factors. Smile evaluation is enhanced by standardized extraoral and intraoral photographs, dynamic assessment, and direct biometric measurements. Important smile parameters include smile arc, tooth proportions, gingival display, gingival contour, dental midline, buccal corridors, tooth display, and lip-tooth relationships. Digital smile-design systems provide additional opportunities for visualization

and treatment planning; however, individual facial characteristics and multidisciplinary clinical assessment remain essential.

Conclusion: Esthetic smile designing in ephebodontics should be considered a patient-specific, dynamic, and multidisciplinary process rather than the application of a single ideal esthetic standard. Comprehensive evaluation of facial proportions, lips, teeth, gingiva, color, smile dynamics, and the developmental status of the adolescent is essential for predictable and harmonious outcomes. Contemporary digital technologies can facilitate diagnosis, communication, and treatment planning, but should complement rather than replace clinical judgment and individualized esthetic assessment.

Keywords: Ephebodontics, Adolescent Dentistry, Dental Esthetics, Smile Design, Smile Analysis, Shade Selection, Digital Smile Design, Smile Esthetics.

Introduction

A simple smile can bring out all the positive emotions in you. The mouth is the center of communication in the face; the smile plays an important role in facial expression and appearance. This has been demonstrated in studies with photographs, where higher intellectual and social abilities were attributed to individuals with esthetic smiles. They were also judged to be more attractive than the same individuals on photographs with modified lower-level esthetic smiles.[1]

Dentistry with its several specialties has focused on both function and esthetics. Recently, both dentists and patients have emphasized on esthetic dentistry because the society gives a high value to a person's appearance. Because of this obvious change in perception, the dental practice has completely changed from just restoring carious teeth to treating healthy teeth and creating an esthetic smile. [2]

Therefore, esthetics should be defined as the patient's perception of "visually pleasing or satisfying" and the clinician's experience in assessment of acceptable anatomic architecture coupled with proper function of the masticatory system (Brisman, 1980). A beautiful and attractive smile is among the important targets of dental treatment and is provided with an ideal smile line. Smile is affected by certain factors in addition to ideal smile line, such as buccal corridors, gingival display, arch width, tooth shapes, asymmetries, and age (Frush & Fisher, 1958 and Tuzgiray & Kaya, 2013).[2]

Esthetic dentistry is focusing to modify the teeth with pleasing proportions and their well arrangement in harmony with the surrounding soft tissues. A smile analysis, thus determines the proper esthetic appearance of the smile in relation to the facial symmetry, lip line and phonetics. Smile design is thus, the application of smile analysis to bring one's true potential into reality (Malarvizhi *et al*, 2017).[2]

➢ **What is an ideal Smile?**

- Esthetic dentistry aims at two significant targets including well arrangement of teeth and beautiful smile.
- A beautiful and attractive smile is provided with an ideal smile line. The latter is the relation between the curvature of the incisal edge of the maxillary anterior teeth and that of the upper edge of the lower lip which should be parallel to each other (Frush and Fisher, 1958).
- This paralisem is known as the prerequisite for a ''consonant'' smile. However, if the maxillary incisors' incisal edge curvature is flatter than the lower lip's upper edge curvature during smiling, this smile is called ''non consonant.''
- Another prerequisite for a consonant smile is that maxillary incisors should be entirely visible during

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smiling (Wong *et al*., 2005). Maulik and Nanda, (2007) from the dynamic records, concluded that the smile line did not get flatter as it was expected, it got even more parallel to the lower lip curvature in orthodontically treated young adults.

In an ideal smile, besides this parallel alignment, minimum buccal corridors and gingival display should be provided, first molar teeth should not be visible, and the width between the upper canines should be equal to the nose width (Hulsey, 1970 and Murakami *et al*., 2008).[2]

Dental esthetics (also spelled aesthetics) connects with the principal aspect of appearance—physical attractiveness. Each of us has a general sense of beauty. Our own individual expression, interpretation, and experiences make it unique. In addition, we are also influenced by culture and self-image. What one culture perceives as disfigured may be beautiful to another. [3]

Indeed, esthetic dentistry naturally plays a critical role in a person's appearance, particularly in the link between dental esthetics and physical attractiveness. Therefore, it is reasonable to recognize esthetic dentistry as one dimension of physical attractiveness phenomenon. It is also reasonable to view the reality caused by, or at the least correlated with, physical attractiveness phenomenon to be significantly interrelated. In other words, esthetic dentistry possesses considerable capability, opportunity, and responsibility concerning the benefits and detriments that individuals experience throughout their lives.[3]

Dental aesthetics is an essential chapter among children and adolescents with influences on self-perception, social integration, and self-esteem, sense of coherence, and treatment outcome expectations. Thus, by the age of eight years, children start to self-perceive the appearance of their teeth and begin to worry about the surrounding persons' opinions regarding their teeth and dentofacial aspects, which ultimately affects their self-esteem.[4]

The awareness of these personal aesthetic characteristics is based on two essential factors: perception and self-perception. Perception is defined as the capacity to use the senses for seeing, hearing, or becoming conscious of something or the way something is being viewed, comprehended, or interpreted. Self-perception is a person's view of their self or any mental or physical attributes that constitute the self. Such a view may involve genuine self-knowledge or varying degrees of distortion and subjectivity. [4]

History

Cosmetic dental treatment dates back more than four millennia. Throughout history, civilizations recognized that their accomplishments in the field of restorative and cosmetic dentistry were a measure of their level of competence in science, art, commerce, and trade. There are repeated references in history to the value of replacing missing teeth. In the ***El Gigel*** cemetery located in the vicinity of the great Egyptian pyramids, two molars encircled with gold wire were found. Gold was also used to splint anterior teeth and may be thought of as a luxurious way of saving teeth.

Assyrio –Babylonian cuneiform tablets dating from the dawn of recorded history advise the following: "if a man‟s teeth become yellow … thou shalt bray together "salt of akkad", ammi, lolium, pine- turpentine with these, with thy fingers shalt bur his teeth".[3]

Other historical evidence that ancient cultures were concerned with cosmetic alteration of the teeth includes reference to the Japanese custom of decorative tooth-staining called *ohaguro* in 4000-year-old documents. Described as a purely cosmetic treatment, the procedure had its own set of implements, kept as a cosmetic kit. The chief result of the process was a dark brown or black stain on the teeth. Studies suggest that it might also have had a caries-preventive effect.[3]

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Smiles are evidenced as early as 3000 BCE.1 A smile on the face of a statue of an early king of Abab is noted in the art of Sumer. Aboucaya noted in his thesis that the smile was absent or not very marked in early works of art and, when present, was almost always labial.

The dentolabial smile, where the teeth are seen behind the lips, starts to emerge in the first decades of the 20th century. This is attributed to an increased emphasis of awareness of the body and art of cosmetics due to the evolution of social life and the change in habits and manners. Teeth began to play an increasingly important role as more attention was paid to the face, which exhibited more open and unrestricted expressions. The resulting emphasis on dental treatment and care also created an interest in the improvement of the esthetics of the smile.[4]

Greene Vardiman Black, better known as G.V. Black – the father of dentistry as practised in the 20th century – was responsible for 'bringing dentistry into the modern world' and 'putting it on a solid scientific foundation'.While best known for his cavity classification and work on dental amalgam, he made frequent references to esthetic considerations in his numerous publications and was working on the unsightly effects of fluorosis, including enamel mottling, at the time of his death in 1915. [4]

Criteria of Shade Selection in Ephebodontics

Successful esthetic restorations require an understanding of light, color perception, and the optical properties of restorative materials. Effective shade matching combines artistic and scientific principles and requires clear dentist–technician communication to reproduce the natural appearance of teeth. While restorative dentistry traditionally focused on restoring function and replacing missing teeth, increasing esthetic expectations have emphasized harmonious integration of restorations with the patient's facial structures and remaining dentition.[5]

Significance of Shade Selection in Dentistry

- In the last few years, the conception of beauty and esthetic restoration sensibility of teeth has increased and been extensively improved among both dental practitioners and patients.
- It is necessary for dentists to provide an esthetic restoration of a tooth that perfectly matches with the natural teeth of a patient.
- However, due to the availability of a wide range of natural tooth shades, it has now become a challenging task for dental practitioners to provide an accurate counterpart to adjacent teeth shade between natural teeth and prosthesis.
- It has also been observed that various prostheses have been unsuccessful in providing a perfect tooth match due to inappropriate shade choice; therefore, it is imperative for dental practitioners to be well aware and conscious at the time of selection of shade in order to get the best results.

- Researchers have viewed that almost one million color shades can be distinguished by the human brain, whereas around 10 million different shades can be sensed through the latest designed electronic devices.
- As opposed to the human eye, which can only distinguish 1% of these dental hues, electronic instruments can classify about 100,000 dental shades.[6]

Different Methods of Shade Matching

- **Visual Method**

1. Visual shade selection uses dental shade guides to check the shade of the teeth or restoration. The shade tabs are placed near to the tooth in the same plane.

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2. Then, for fabrication of a restoration, the shade that is most similar to the shade of the tooth and shade of the surrounding teeth and restorations is chosen.
3. Shade guides should have specific characteristics like proper distribution in color space, rational arrangement, acceptable precision and accuracy.[7]

- **Dental shade guides**

➢ Dental shade guides can be categorized according to their concept (theoretical, empirical, evidence-based), fabrication type (custom or stock), material (ceramic, composite resin, or acrylic resin), and shape (strip,disk, or tooth shaped).

➢ There are no changes in shade matching precision between tabs and disks.

➢ These are made of different materials like composite resin, ceramics, denture teeth.

➢ Manufacturers have created their own shade guides for the products due to variations in colors and optical properties among different materials and brands.

➢ To ensure a better match between the shade guide and the restorative material, it has been suggested to fabricate shade guides using the actual restorative material.

➢ This is because using non homogeneous shade guides may result in differences in shade and optical properties.

➢ Specifically, when it comes to ceramic restorations, using actual ceramic shade guides has been found to produce more acceptable color matching .[7]

- **Various conditions and factors related to visual method**

➢ The light source, the object, and the observer are the three variables that influence how an observer interprets an object's color.

➢ The electromagnetic radiation emitted by a light source can be identified by its color temperature.

➢ The temperature of an ideal black-body radiator that emits light with a color close to the light source's is known as the color temperature of the light source.

➢ The features of the object influence the shadow taking outcomes. When evaluating shade and translucency, teeth should be moist to prevent any influence on value, hue, and chroma, among other color qualities.

➢ Wetting teeth and shade tabs with a medium viscosity clear glazing liquid is advised since dehydrated teeth have more lightness, less chroma, and less translucency.

➢ This can also counteract the impacts of tooth morphology and surface roughness on the choice of shade.

➢ Therefore, choosing a shade should be done as soon as possible during the visit, preferably within the first minute, and before isolation or restoration procedures cause teeth to become dehydrated.

➢ Matching shades by the observer determines how effective shade selection is.

➢ Age, gender, experience, kind of shade guide, training, potentials for color perception, and illnesses can all have an impact on this capacity.

➢ Despite the fact that gender has been acknowledged as a significant factor—that is, the fact that women perceive color better than men.

➢ The accuracy and precision of the observer might be positively impacted by professional experience. For shade discrimination, precision's between and among observers are essential.

➢ Experienced general practitioners have a lower intra-observer precision of the visual approach than prosthodontists. There have been reports of inter

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observer precision ranging from 22.5% to 55% for observers without color vision deficiencies, with intra-observer precision estimating from 11% to 64%. If VITA 3D-Master is used instead of VITA classical, the inter-observer color matching could be lessened.[7]

- **Different Tools of Shade Selection**

➢ An important aim of color science in dentistry is to replicate oral structures using dental biomaterials, enabling an objective method to measure and evaluate these structures and dental materials in clinical settings.

➢ The predominant method used in clinics to assess tooth color involves visually matching shades against shade guides.

➢ Due to the possibility of observer and experimental conditions influencing visual shade selection, this method is arbitrary and incomplete. In dental research, there is a growing trend toward the use of color measurement systems and equipment.

➢ Nowadays, Spectrophotometer, Colorimeter, and Spectroradiometers are the most widely used instruments in dentistry for accurately assessing color.[5]

Visual method

1. **The Vita Classical Shade Guide:**

➢ The color space is divided into four groups: A, B, C and D; these comprise the leading HUE (name of color).

➢ These are A group has red and brown, red and B has yellow in group, gray in group C, and D has red and gray in group.

➢ Every letter group has sub-divisions indexed with arabic numbers, ranging from 1 to 4, which makes the overall number of 16 tabs.

As the number increases, the value decreases, whereas the chroma increases simultaneously.[6]



Figure 1: Vita Classical Shade Guide

Limitations of vita classical shade guide:

It is not positioned uniformally throughout tooth color space, no standard incremental difference between adjacent shades and in between shades are not accurate. These limitations led to the introduction of more shade guides.[6]

2. **Vita Toothguide 3D-Master:**

➢ Vita 3D-Master. There are three types of Vita 3D-Master shade guides: Toothguide, Linearguide, and Bleachedguide.

➢ This shade guide entails 26 tabs that are organized into five groups with respect to their value.

➢ The shade tabs are further arranged along with two axes inside the groups, i.e., vertical in relation to chroma and horizontal axes according to hue.

➢ The first group consists of two tabs, the second, third and fourth comprise seven each, whereas the fifth one has three tabs. [6]

➢ Moreover, every shade tab has three markers ranging from 1 to 5, presenting the group and the level of value that decreases as the number increases.[6]

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Figure 2: Vita 3D Master Shade Guide

VITA 3D-master -instructions for use:

STEP 1- Determining the lightness level (value):

When selecting the shade for a patient's teeth, it's important to hold the shade guide at an arm distance to their mouth. You can choose from groups 0, 1, 2, 3, 4 or 5. It's best to start with the darkest group first to get an accurate representation of the shade.

STEP -2 Selecting the chroma:

Selecting the middle hue group (M) will allow you to select the chroma once you've determined the brightness level. Choose one of the three shade samples that have been spread out like a fan.

STEP-3 Determining the hue:

Verify whether the natural tooth's color is more yellowish or reddish in relation to the chosen shade sample.[6]

- **Vita Bleachguide 3D Master:**

During teeth-whitening procedures, these color standards are used for shade matching or evaluation. There are 15 tabs in the guide, which match the 29 authorized shades by ADA. The use of a customized shade guide facilitates communication between the patient and the dentist and helps to provide a more realistic assessment of the teeth-whitening procedure.

It has been observed that a number of improvements have been developed for the Vita.[6]

1. **3D Master shade guide, as compared to Vita Classical:**

There is an extensive range of value. The red spectra are wide-ranging. The shade tabs are more correspondingly divided into the color space. The development in distribution of groups has improved and become more concise.[6]

2. **Chromascop Shade Guide:**

To identify hues, the Chromascop numbering system is employed. Depending on the color, it is divided into categories (100 = white, 200 = yellow, 300 = orange, 400 = gray, 500 = brown) and within the groups, as chroma increases from 10 to 40.[5]

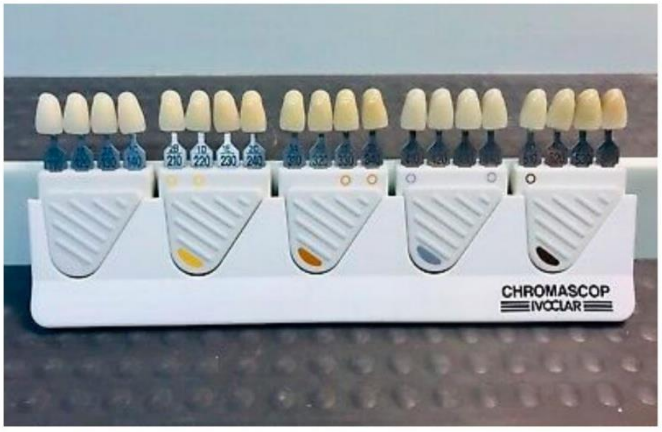


Figure 3: Chromascop Shade Guide

3. **Custom shade guides:**

The entire range of hues and chroma values found in the human dentition cannot be represented by the standard shade guide. It is helpful for 85% of the color selection; the remaining 15% require its modification or the creation of custom shade tabs.

Custom shade guides are made from ceramic, acrylic, or composite resin materials. Surface colorants or aluminum oxide surface abrasion can be used to modify the shade guide.

Fine line markers and colored pencils are employed to replicate subtle shade differences, mimic analogous translucency, and distinguish between various hues.[5]

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4. Dentin and extended shade guides:

Veneers and translucent all-ceramic crowns can be made with the dentin system. This shade guide facilitates the dental laboratory's understanding of a particular shade.

Specially colored die elements that correspond to the dentin shade are used, allowing the technician to assess the restoration's esthetics.

The tabs for every material used to create the extended shade guide are included in the reconstruction. It can also be used to increase the range of shade options.[5]

➢ **Advantages of shade guides:**

- It is affordable and long-lasting, meaning that it does not need to be replaced as often
- It offers a useful comparison to the color of teeth in their natural state
- The most popular technique used by dentists, dental assisting professionals, and dental laboratory employees to represent teeth's proper translucency, brightness, and color
- Easily acquired. [6]

➢ **Disadvantages of guides for shade:**

- Each company may have different colors in their shade guides
- The production of porcelain restoration cannot be managed by guides
- The shades of a tooth in a shade guide do not fill the color space that is normally empty in natural teeth, nor do they are organized rationally
- Synthetic resin with a density higher than that of a crown is used to create a standard shade tab
- A shade guide tab gives the appearance of vitality by reflecting and changing light-forming translucency.[6]

➢ **Merits of Shade Guides**

- The most common method of shade selection is using a visual shade guide.
- It is economical and durable, i.e., does not require frequent replacement of the shade guide.
- It provides an efficient comparison with natural tooth color.
- Most frequently used by dentists, dental assistants and dental laboratory technicians to communicate the proper tooth color, brightness and translucency.
- Easily available. [6]

➢ **Demerits of Shade Guides**

- In shade guides, the colors may differ for each company.
- Porcelain that is used for restoration of teeth may be different with a shade guide.
- Guides are not able to direct the manufacturing of porcelain restoration.
- The shades of a tooth in a shade guide are not rationally arranged and do not cover the capacity of color space that is normally unoccupied in natural teeth.
- A normal shade tab is prepared from synthetic resin having greater density than a crown.
- A shade guide tab reflects and transforms light-forming translucency and provides a look of vitality.[6]

Instrumental Technique In Shade Selection

There are four basic types of devices used for shade selection:

1. Digital camera and RGB devices, for example, shade scan
2. Colorimeter, for example, shade vision
3. Spectrophotometer, for example, Vita easy shade
4. Spectroradiometer [5]

- **Digital Camera & Imaging System:**

➢ Consumer video or digital still cameras, commonly referred to as RGB devices, acquire red, green, and blue image information that is utilized to create a color image.

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- Digital cameras are not color-measuring instruments, and they primarily enhance communication between the dentist and the laboratory technician.[8]
- The way the camera perceives color will change depending on factors such as lighting and angle.
- According to Kumar *et al.*, when commercial SLR cameras are combined with appropriate calibration techniques, they can be useful in the color replication process.
- In addition to using professional-grade color-corrected film (such as Kodak EPN-100, E100-S, or EPP) and a high-quality photo lab to develop them, Spear suggested that taking vector shots at 65°–70° while looking down and keeping an incisal edge away from chroma and hue can help increase the amount of reflection.[5]
- Digital cameras show the most basic method for electronic shade measurement, still demanding a certain degree of independent shade selection with the human eye.
- Digital imaging systems are becoming progressively more widespread in measuring the shade of teeth.
- The quality of the camera and image-processing method affects its precision and accuracy. A number of researchers found that digital cameras may be dependable instruments for determining the color of teeth and gingiva when applied in combination with the proper standardization procedures.[6]

- **Calorimeter:**

- Color (hue, chroma, and value), as seen by the human eye, is measured by a colorimeter. Its ability to measure color is restricted to stimulus values under fixed illumination and observer conditions.
- The two main optical components are the integrating sphere and the detector (three or four filters).
- The purpose of a colorimeter is to quantify color – hue, chroma, and value – as seen by the human eye. The ability to distinguish between different tooth shapes and colors, as well as the superior intraoral and macroscopic views provided by the SOPRO 717 intraoral camera.
- When compared to traditional visual methods, the Sopro 717 intraoral camera's Sopro shade concept provides dependable support for visual color assessment. Compared to spectrophotometers and digital cameras, colorimeters are substantially less reliable.
- Colorimeter are not capable of recording spectral reflectance and their accuracy can be diminished because of over usage of the filters as compared to spectrophotometers.
- A colorimeter presents a complete measurement of light absorbed; however, a spectrophotometer quantifies the light absorbed at differing wavelengths Shade Vision (X-Rite, Grandville, MI, USA) is an imaging colorimeter.
- Comprehensive tooth appearance is provided by the use of three distinct records, particularly for gingival, middle and incisal third.[6]
- Originally, the response of the human visual system was simulated using three glass filters (red, green, and blue), whose transmittance spectra mimicked the CIE color matching functions.
- A filter bank was then used to improve the accuracy of the gadget. To determine an object's color, the colorimeter's sensors may calculate the total of the various wavelength spectra that the object reflects.
- Thanks to advancements in sensor technology, colorimeters can now measure opaque objects with accuracy.[7]

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- **Spectrophotometer & Spectroradiometer:**

- Surface color analysis is a common application for spectrophotometers. They gauge how much of the body's spectral reflection there is.
- It is a photometer that uses wavelength, or more precisely color, to determine intensity. The monochromator, detector, and light source make up the optical elements.
- The test sample that needs to be examined and the entrance slit allow the transmission of various wavelengths.
- Different light wavelengths are selectively absorbed by the sample. The light then passes through the exit slit and hits the detector.
- The detector converts light intensity at a particular wavelength into an electrical signal. After that, the signal is strengthened and displayed on a screen or plotted on a chart.[5]
- In dentistry, spectrophotometers are amongst the most precise, expedient and flexible instrumental method used for general color matching.
- They quantify the extent of reflected light energy from an object at 1–25 nm intervals alongside the observable spectrum.
- A spectrophotometer comprises an optical radiation source, a means of scattering light, an optical system for determining, an indicator and a means of transforming light to a signal that can be evaluated.
- The data acquired from spectrophotometers must be employed and explained in a form valuable for dental experts.
- The dimensions gained by the instruments are commonly entered to dental shade guides and changed to shade tab correspondent. [6]
- A spectrophotometer varies from spectroradiometer as it mostly comprises a stable light source. These gadgets have been made using two different straightforward designs.
- The standard scanning apparatus has a single photo diode sensor that counts the amount of light at all wavelengths.
- The latest designed devices employ a diode arrangement with a specified element for every wavelength. This design supports the synchronized incorporation of all wavelengths simultaneously.
- Both types are crucial for research into the development of more precise color-measuring equipment, even though they operate much more slowly than filter colorimeters.
- Vita Easy Shade® V is an illustration of a spectrophotometer.



Figure 4: Vita Easyshade® V, Bad Sackigen, Germany

- In comparison with interpretations by the human eye, or conventional techniques, it was observed that spectrophotometers presented a 33% accuracy increase and 93.3% of cases offered a more objective match.
- A number of researchers recommend that visual color-matching methods along with the instrumental technique are more valuable when used in combination, as they complement each other .[6]

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- Spectrophotometers can measure an object's color by analyzing its transmittance curve or spectral reflectance. They provide light output in the 400–700 nm wavelength range using a white light source, which can be an LED lamp or a tungsten filament bulb.
- After that, the light is focused via a prism to produce a spectrum of wavelength bands, usually ranging from 10 to 20 nm. After then, the light is focused on the object, where it may scatter, pass through, or reflect.
- The quantity of light that the object emits or transmits through it for each visible spectrum wavelength band is then measured by the spectrophotometer.
- It's critical that handheld spectrophotometers have properties including high accuracy and precision, high shock resistance, simple control, quick measurement, respectable working life, suitable light source, and affordable price.
- Certain dental spectrophotometers have the ability to use a mouthpiece to separate the oral cavity from outside light, removing the influence of ambient light on color readings.
- The tooth shade is calculated using VITA 3D-Master and VITA classical, and the CIE L ab/CIEL Ch values are measured with the VITA Easyshade spectrophotometer.

Spectroshade:

1. One of the most representative dental spectrophotometers is SpectroShade, which is also quick, accurate, and simple to use.
2. Digital color imaging and spectrophotometry based on LED (light emitting diode) technology are combined in SpectroShade Micro.
3. The linear polarized filter on this instrument helps to eliminate gloss reflections. The device memory stores a variety of shade guide data, allowing for the comparison of obtained images with various shades.
4. Its program can perform coarse and fine color mapping, email data to labs, and offer virtual examination by superimposing the restoration image over the dental image.
5. With the ability to compare two color measurements, SpectroShade Micro may be used to map dental surface inhomogeneities, assess teeth both before and after treatment, and ensure that the restoration is an accurate replica of the original tooth.
6. The spectrophotometric results are influenced by the tooth's position. Tooth surface (mesial or distal portions) and tooth type (posterior teeth, lower incisors) have an impact on SpectroShade's repeatability and reproducibility.
7. The labial surface of the lower incisors and the convex surfaces of the posterior teeth must therefore be measured carefully.[7]
8. The type of processing—freehand or standardized—certainly influences the outcome.
9. To prevent the effect of probing angulation and also similar areas of the teeth, the use of specially designed acrylic jigs is advised in this regard.
10. Exceptional precision is what dental spectrophotometers provide, not great accuracy. Nevertheless, taking into account their precision (87.4% to 99.0%) and accuracy (66.8% to 92.6%).[7]

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Figure 5: Spectro Shade Micro Spectrophotometer

Intraoral scanners:

- Even though intraoral scanners were first used to take digital impressions, some of them came with a dental shade guide tool.
- The device makes use of a portable digital scanner with a high-definition camera inside. Following an LED light scan of the teeth, software analyzes the tooth's color and displays it using VITA shades ratherthan color characteristics.
- The restoration is fabricated using the chosen shade and digital imprint.[7]



Figure 6: TRIOS intraoral scanner

Conditions and effective parameters pertaining to intraoral scanners

1. Intraoral scanners need to meet two important criteria in order to be taken seriously as a feasible method of shade selection: color imaging and data processing.
2. While intraoral scanners are capable of measuring tooth color and gathering three-dimensional data from the tooth surface, there are several circumstances that could compromise their capacity to match colors.
3. Dental shade guides are used by intraoral scanners to display color results. having the use of VITA shade guides as references, an LED light, a high resolution camera, and color analysis software.
4. More recent scanners, such TRIOS demonstrate both superiority over the eye approach and findings that are comparable to those of a spectrophotometer .
5. In contrast to spectrophotometers, lighting conditions can have an impact on intraoral scanners operating in VITA Classical or 3DMaster mode. As a result, it is advised to estimate the shade using a second instrument.
6. When the shade is recorded as VITA 3D Master shades (53.3% accuracy, 90.3% accuracy) rather than VITA Classic shades (27.5% accuracy, 87.2% accuracy), TRIOS 3 has higher accuracy/precision.
7. Furthermore, there is a discrepancy between the shade results obtained from the spectrophotometer and the intraoral scanner.
8. Generally speaking, factors including ambient light, image capture, color analysis software, and the tone control mode being utilized affect the choice of shade while using scanners.[7]

- **Accuracy and precision of intraoral scanners :**

1. SpectroShade Micro, SpectroShade, VITA Easyshade, and VITA Easyshade Advance 4.0 all have better shade matching accuracy than Trios

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2. Though TRIOS 3's precision is respectable (>85%), it is not as accurate as a spectrophotometer that has undergone validation.
3. Intraoral scanners and Spectrophotometers are more accurate than visual techniques that rely on a skilled clinician's shade guidance, whether or not a light correction device is used.
4. While some \researchers suggest using an intraoral scanner instead of a spectrophotometer for shade selection, others come to the conclusion that a scanner like the CEREC.
5. Omnicam cannot match shades accurately enough. TRIOS has a maximum color measurement precision of 86.66%, whilst TRIOS 3 has a maximum precision rating of 87.17% to 90.33%.
6. While accuracy ranged from 44.3% (Easyshade V) to 51.9% (Omnicam), it was 78% for Easyshade V, 66% for TRIOS, 57% for Omnicam, and 63% for Prime scan.
7. Because scanners use a non-polarized light source, they are able to report lighter hues than spectrophotometer and visual approaches. [7]

- **Advantages of instrumental technique**

1. Removal of subjectivity from the color measurement process
2. The removal of the environmental factor from color measurement because constant light sources are used and calibrated regularly.[5]
3. It gets rid of subjectivity while performing shade selection.
4. The results are reproducible reliable, and precise as compared to traditional visual systems.
5. If the dental practitioner and the laboratory are using the same software then it is possible to replicate the desired shade completely.
6. It gets rid of the environmental influencing factors because it uses light corrected sources.
7. Involves less chair-side time.
8. The quality control aspect is a real advantage.

- **Disadvantages of the instrumental technique**

1. A power outage can have an impact on the accuracy of color measurement
2. Transparent recording is insufficient for all systems
3. It seems that the mouthpiece or probe's settling is essential for the measurement to reappear
4. No digital shade guide can operate in a formulation mode in a way that is satisfactorily progressive.
5. The color measurement accuracy is affected by the type of lighting used, the condition of teeth being measured (such as presence of stains/ restorations), and the operator's experience and techniques
6. It is important to take these factors into account and use appropriate techniques and instruments to ensure accurate color matching and restoration.
7. To ensure the efficacy of this procedure, the research laboratory must be furnished with the latest and most sophisticated systems.

- **Restrictions of Digital Shade Guide**

a. The color measurement accurateness is affected due to the loss of power supply.

b. For all systems, translucent recording is insufficient.

c. Settlement of the probe or mouthpiece appears to be vital for the reappearance of the measurement.

d. No digital shade guide is satisfactorily progressive to function in a mode of formulation.[5]

Factors Influencing Smile Esthetics

- **Principle in Smile Design Theory**

➢ **Malarvizhi *et al.*, (2017)** identified four important principles in designing a smile, including, facial esthetics, gingival esthetics, micro esthetics and macro esthetics.

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- Facial esthetics involves the facial and muscular considerations which is determined through photographs taken before and after treatment. [9]
- Gingival esthetics means the gingival health and appearance. Microesthetics involves the specific anatomy of each tooth with consideration to the specific incisal translucency, characterization, lobe development and incisal haloing. Macroesthetics is the relationship of the teeth to the surrounding soft tissue and patient's facial characteristics.
- Also, the authors suggested various proportions which aids in smile analysis before establishing the treatment plan. [9]

- **Divine Proportion**

- Pythagoras in 530 BC proposed the golden number, represented by the Greek symbol Δ
- The reciprocal of Δ is 0.618 and is termed as the Golden or Divine proportion (Gillen *et al*., 1994).
- It was believed that the objects whose features conform to this ratio were perceived to have innate beauty.
- If all the objects conform to this ratio, we would be surrounded by clones. Hence, repeated or recurring ratios are more significant than a specific ratio.[9]

- **Dental Proportions**

- It has been reported that the height of the central incisor should be 1/16 the height of the face from ideal hairline to the chin and its width should be 1/16 the interzygomatic width (Oschsenbein and Ross,1999).

- **Golden Proportion**

- The golden proportion has been used to relate the successive widths of the anterior teeth as seen from the front.
- The width of the central incisor should be multiplied by the value defined as the golden proportion, which is 0.618, or approximately 62%.
- The resultant width of the lateral incisor should be multiplied by 62% to give the width of the canine [9]

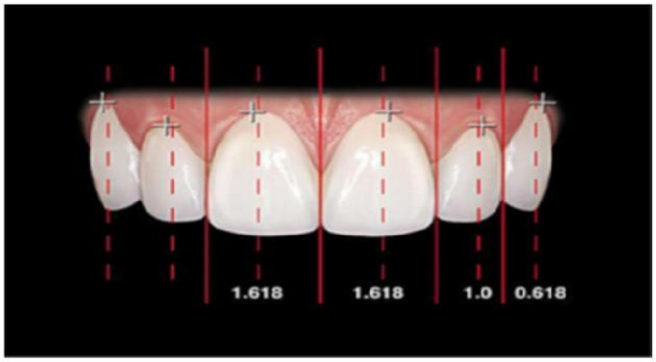


Figure 7: Golden Proportion.

- **Repeated Ratio**

- The use of a "continuous proportion or repeated ratio has been suggested and established between the width of central and lateral incisor and continued in the ratio of the placement of the remaining teeth and spaces."
- The proportion of the width of the central incisor and the lateral incisor should be consistent between the width of the lateral incisor and the canine and from the canine to the first premolar moving distally.
- The ratio between the width of the central incisor and the lateral incisor should be applied consistently to define the desired ratio between the lateral incisor and the canine (Lombardi, 1973). [9]

- **Recurring Esthetic Dental (RED) Proportion**

- The RED proportion states that the proportion of the successive widths of the teeth as seen from the frontal view should remain constant as one move distally.
- Instead of accepting the proportion already defined by the widths of the central and lateral incisors, the dentist can define his or her desired RED proportion

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which gives greater flexibility (Lombardi, 1973; Wagner *et al*., 1996).[9]

- **Width –to –Height Ratio**

➢ An important proportion that has to be evaluated is the width-to-height ratio of the central incisor which has been preferred to be in the range of 66% - 80% (Mathews, 1997).

- **Facial Image View Evaluation (FIVE)**

➢ The use of a photograph to evaluate and measure the relative teeth dimensions and proportions in a smile is called Facial Image View Evaluation (FIVE).

➢ An image taken parallel to the facial plane and at least 8 inches away from the teeth should be used to minimize distortion.

➢ A common dimension of a central incisor is measured first on the photograph and then on the cast (Silnes, 1980).

➢ The cast dimension is divided by the image dimension to compute a conversion factor, which correlates the size of the image to the actual size of the teeth. The height of the central incisor is preferred, but the width can be used if the gingival margin is not totally visible.

➢ The photographic image widths and heights of the anterior 6 teeth are measured and recorded. The photographic measurements are multiplied by the conversion factor to give the FIVE dimensions.

➢ It was found that the further distal the dentist moves, the greater is the discrepancy between the FIVE and the cast dimensions. [9]

- **Red Smile Design**

➢ The ideal width and height of a central incisor can be determined using the equation {(FIVE width of the anterior 6 teeth) / 2(1+ RED + RED2)} = width of central incisor (The RED should be expressed as a decimal <1) (Width of central incisor / Width-to-height ratio) = height of central incisor.

➢ (The width-to-height ratio should be expressed as a decimal <1) (Levin) [9]

Principles of Smile Designing

➢ Designing a perfect smile using the software requires a thorough knowledge about the muscles and dimensions of the display zone along with their esthetic proportions

➢ Since not all individuals are alike, each person should evaluate and study with accurate detail in order to come up with their perfect smile.

➢ All these elements are connected with each other. Any change will definitely affect the other element.

➢ Although a software algorithm is used in predicting a perfect smile, clinical smile designing requires a multidisciplinary intervention that includes branches of dentistry such as orthodontics, orthognathic surgery, periodontal therapy, and plastic surgery.

➢ Facial features that are key in planning for esthetic smile redesign include facial symmetry, facial profile, and proportion of the facial structures.

➢ According to literature, an ideal facial feature should have the distance between two superciliary arches equal to the total width of the face (from one zygomatic prominence to the other).

➢ The intercanthal line or the pupillary line should be perpendicular to the Frankfurt's horizontal occlusal plane.

➢ Considering the normal verticalis part of the face, three imaginary lines drawn should divide the face into three parts: the glabella to the superciliary arch, from the arch to the tip of the nose, and from the subnasale to the mention of the chin.

➢ An ideal smile should have the foundation of an ideal lip. When smiling, around 2 mm of the

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maxillary incisors along with the interdental papilla should be visible.

- Too much exposure reveals the gingiva, resulting in a gummy smile, while too little exposure flattens the philtrum of the upper lip and produces a frowned appearance.[10]

- **Evolution of smile design**

- Before the invention of photoshop and advanced photo tracers, perfect smile lines were drawn by hand and then printed over the photos of the patient and would often be discussed with patients for their input.
- This process has now been largely replaced by smile automation software, referred to as Digital Smile Design (DSD) software, all of which with the click of a button tells us the modifications needed to be executed in order to get a perfect smile.

Some of the key milestones in the evolution of smile design include:

- **Generation 1:** Manual hand drawings using pencil markers were made over the patient's full profile photographs. The drawback of this method was that if taken with a study model, the correlation between the patients full profile photo and study model was very poor.
- **Generation 2:** With the creation of Microsoft Office, drawings were often done digitally and then correlated with the model. This helped in tracing minor modifications that needed to be done. Diagrams were often 99% accurate.
- **Generation 3:** The next generation enabled the two-dimensional (2D) drawings to be linked with physical analog models which permitted a wax-up of the final smile.
- **Generation 4**: The 2D drawings were written up into an algorithm that was then processed digitally and this step enabled the technique of facial 3D analysis, also determining the facial components and aesthetic parameters.
- **Generation 5:** Innovation of intraoral camera which allowed us to scan and take digital impressions which were more accurate than impressions taken with any other conventional method.
- **Generation 6:** Introduction of 4D where digital sensors placed on the patient's jaw captures the smile motion and movement inside the 3D environment using the MODJAW software and designing the smile with CAD/CAM technology.
- This technology reduces the need for changes, including reduced tooth preparation and other issues by testing the design with the real movement of the jaw.[11]

Digital Smile Design

- Digitalization has now assumed an important aspect not only in engineering but also in the dental field.
- Digital Smile Design (DSD) is a modern versatile innovative dental treatment planning tool invented by the Brazilian dentist Christian Coachman in 2007 that permits the professional in digitally design the smile of the patient from a series of pre- and post-DSD photographs.
- DSD software also allows the clinician to educate the patients regarding the improvements that can be done and also helps in collecting the patient's own preferences and requirements, thereby making the patient feel like he is a part of the decision-making process rather than just being on the receiving end.
- DSD was described by its developers Christian Coachman and Marcelo Calamita as an innovative multipurpose analytical software that is capable of diagnosis, performing meticulous analysis of the patient's facial and dental traits that may have

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eluded conventional photography and the human eye.[10]

- **Requirements of digital smile design**

Some of the software that can be used for digital smile design include

1. Photoshop (Adobe)
2. Microsoft PowerPoint (Microsoft Office, Microsoft)
3. Smile Designer Pro (SDP) (Tasty Tech Ltd)
4. Aesthetic Digital Smile Design (ADSD - Dr. Valerio Bini)
5. DSD App by Coachman (DSDApp LLC), Keynote (iWork, Apple, Cupertino, California, USA)
6. NemoDSD (3D) and Exocad DentalCAD,
7. A digital SLR camera.

- A digital impression of both the jaws is taken with a digital intraoral scanner. The impressions are then uploaded to the CAD/CAM processing machine where they are 3D-printed.
- High-resolution full profile photographs representing the facial profile and frontal views of the patient are essential and videos that record the dynamic changes of the teeth, gingiva, lips, and facial muscles brought about by smiling and talking are essential as this documentation forms the blueprint on which smile design is executed.[10]

Three basic photographic views are fundamental in smile design, they include :

1. Full facial view with a natural smile.

2. Resting face.

3. A view representing the maxillary and mandibular arch not in occlusion.

- A magnification of a 1:1 view picture of the central incisor with a black background provides in-depth detail for the lab technician to work on.

The videographic demonstration containing documentation is imported into the slide presentation. The facial and dental components of the smile and their points previously discussed above influence the majority of smile design.

Commercially available DSD software include;

1. CEREC Smile Design (SIRONA)
2. Digital Smile System (DSS),
3. Smile Design Pro (TASTY TECH)
4. G Design (HACK DENTAL)
5. Romexis Smile Design (PLANMECA)
6. Smile Composer (3 SHAPE)

- These digital platforms integrate these photographic and videographic inputs to facilitate precise aesthetic planning.[10]

Digital Smile Designing Procedure

- The cosmetic aspects in different DSD software vary, but the method of constructing a smile stays the similar.
- All of the programme allow you to build your own smile by drawing reference lines and structures on intraoral and extraoral images.
- The front image of the face is created using reference lines of facial analysis.
- The horizontal guiding lines are intercommissural lines and interpupillary lines which offer a perfect balance on the horizontal parts of an aesthetically attractive face, while the vertical guiding lines are the glabella, nose, chin, dental midline and mandible.
- DSD allows a relative analysis of the teeth and face after determining horizontal and vertical proportion.
- Dentogingival analysis is performed after face analysis. The gingiva shown is determined by the measurement of height of the top lip at rest and during smiling. The smile curve is obtained by connecting the curvature of the incisal margins of the upper front teeth.

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- The proportions of the lower lip and the anterior posterior curve of the teeth establish the dental contour. This face image's intraoral view is then cropped.
- On the teeth, three reference lines are drawn: a horizontal straight line from tip of one canine to the tip of another canine, a vertical line crossing the midline (passing from the interdental papillae) and a horizontal line on the incisal margins of central incisors.
- This helps to reproduce the cross, i.e., the reference facial midline on the face and interpupillary line, onto the intraoral view.[11]
- A few other lines are drawn for a full dental study, such as the connecting lines of the gingival and incisal battlements and the gingival zenith.[11]

Workflow Of Digital Smile Designing

The following are the proportions used in smile designing;

- Golden proportion: The golden proportion was initially stated by Lombardi in dentistry and Levin subsequently developed it.
- When a line is divided into two sections in the golden proportion, the ratio of the small segment to the large segment is equal to the ratio of large section to overall line.
- The golden proportion or divine proportion, ratio of following terms is about 1:1.618
- Facial proportion: The rule of thirds separates the face vertically into about three equal portions in facial proportion. The lower 3rd of the face is then divided into three parts, with the incisal plane ideally situated at the intersection of the top and middle third.
- Dental proportion: The height of the ideal central incisor should be one-sixteenth of the height of the face from the ideal hairline to the chin and the width should be one sixteenth of the inter-zygomatic width.
- Golden percentage: Snow analysed the individual apparent tooth width as a proportion of the overall apparent width of the six anterior teeth bilaterally.
- In order to generate an aesthetically attractive grin, he established the golden percentage, which states that the proportionate width of individual tooth should be 25% central incisor, 15% lateral incisor and 10% canine of the overall width of the anterior section.
- The DSD workflow begins with digital scanning of the patient's dentition using an intraoral scanner, which is then imported to the respective DSD software.
- Using the various different shapes and forms available in the digital repository, we can overlap the teeth for a given esthetic procedure.[10]

The DSD workflow then proceeds as follows:

1. After uploading the facial photographs, two baselines are drawn on the center of the slide so that it forms a + sign, in a way that it appears to be placed between the upper and lower anterior with the teeth apart.

Horizontal reference lines are achieved through the interpupillary line creating a digital facebow.

2. Soft tissue features (gingiva, lips, facial lines) and their association with other components are evaluated by grouping and transferring them to the facial photograph.

- A template tooth that is set to be standard and exact in dimensions is placed over the original photograph so that axial inclinations, proportion in relation to adjacent teeth, and soft tissue silhouette are established.[10]

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The retracted view is engaged in order to evaluate whether the intraoral photograph is concurrent with facial baseline data, where three lines are drawn:

Line 1: Inter canine width measured from the tip.

Line 2: The middle third of the central incisor to the occlusal edge of the adjacent central incisor.

Line 3: From the philtrum of the upper lip to the interdental papilla and the incisal embrasure.

3. Rectangular crop mode is then chosen and placed over the region of both central incisors to measure the width/length proportion of the central incisors.
4. Using editing tools, the template tooth can be placed over the photographed tooth, and pasted and morphed according to the best esthetic outcome. The patient's preferences and inputs can also be gathered and included during this step
5. A digital ruler available in the software can be used to calibrate the real-time dimensions of the tooth by recording the measurement on the 3D model and then incorporating it into the software. Gingival contour and the proportion to attached gingiva width and incisal edges can also be calibrated.
6. Transferring the + sign to the cast: The measurement of baseline point till the free gingival margin is recorded and then transferred to the 3D cast with the aid of a caliper. [10]
7. Horizontal lines above the teeth which predict the gingival margin are marked on the cast using a pencil mark. The vertical lines are then marked using the interval between the incisal embrasures along with the facial component, which is then marked in the 3D model.
8. Wax up of the procedure to be performed for establishing a smile and then carried out on the cast and evaluated using DSD, after which it is tried on the patient.
8. Once the approval of the wax-up has been sought, minor corrections, if deemed necessary, are performed. [23]
9. Minimal intervention should be prioritized such as minimal reduction of tooth surfaces, and giving proper clearance for crowns, if required.
10. Attention to detail in each step in DSD usually results in an outcome that goes beyond the patient's expectations.[10]

Advantages of DSD

- DSD enables the patient to actively participate in their treatment plan, resulting in much higher compliance and better motivation, as the results are evident from the 3D pre visualization and simulation.
- The changes can be customized according to their desires.
- Digital scanning allows the clinician to detect any insidious disease due to the relatively high shades of gray (256 pixels) compared to 2a conventional radiograph (16–25 pixels).
- DSD shields the patient from any unnecessary radiation exposure due to the digital PSP sensors compared to the solid-state sensors.
- Digital imaging also saves on essential sources. A study conducted by Cervino G *et al.* in his review stated that DSD gives valuable feedback which can be discussed and improved upon.
- It drastically improves the communicative link between the patient, the clinician, and the technician in treatment planning to improve the smile line and facial features when smiling.
- This also gives the clinicians the comfort of avoiding any medico-legal issues as the approval of the patient pertaining to post visualization photographs is obtained before the treatment is implemented.

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- DSD assists patients in visualising the predicted outcomes prior to beginning treatment. This enhances the treatment's predictability.
- Operator can motivate and educate the patient by showing the final outcome digitally before doing any irreversible procedure this can also serve in crucial medico legal purposes.[10]
- Clinicians and patients can both digitally visualise and analyse gingival, dental and facial characteristics that will decide the final smile and facial aesthetics.
- DSD contributes to the personalisation of smile design by exceeding patient's involvement in their own smile designing, results in a more cosmetically motivated, emotive and confident smile.
- Before the treatment begins, comparison between before and after treatment images using a digital scale, horizontal and vertical reference lines can be done .
- DSD not only helps in better communication between patients and clinician but also helps in better communication between other team members, lab technician.[10]

Disadvantages of DSD

- Although DSD presents with an attractive treatment planning tool for the patients, it has certain limitations.
- It poses as an expensive set-up as the costs for purchase and repair are considerably high. It cannot be operated by any person; rigorous training is required to learn the tool.
- Sometimes, the patient disagrees with the pertaining outcome of the treatment even though the software had predicted a better outcome. In such cases, the software blame might seem illogical.
- This scenario has already been advertised by the manufacturers which often state "the enhanced image does not always match the original image"
- It is important to watermark the clinician's respective work so as to eliminate unauthorized reproduction of the images.
- It is recommended that copies of the original images be stored on the computer or network server.[23]
- The evaluation and further planning depend only on photos and videos, any variation in documentation may result in distortion of reference image and results in improper diagnosis and treatment planning.
- The treatment with DSD is economically expensive as for complete 3D digital work updated 3D software, CAD/CAM software, intraoral scanner and 3D printer are necessary.
- Some software requires specific training to operate software which makes it more costly and time consuming. [10]

Although, the complete procedure is time consuming, the results of the software are very good. As the technology is developing the limitations of the system can be overcome.[10]

Conclusion

Esthetic management is an integral component of contemporary ephebodontic care, particularly during the dynamic phase of adolescent growth and development.

Successful smile design requires consideration of facial, dentolabial, dental, and gingival components as an integrated unit.

Individual variations in facial growth, tooth morphology, color, soft-tissue relationships, and smile dynamics should guide esthetic assessment.

Accurate shade selection requires an understanding of color science, light interaction, tooth optical properties, and surrounding structures.

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Standardized photography and dynamic videography provide valuable information for comprehensive smile evaluation.

Digital smile design can enhance visualization, treatment planning, and communication between clinicians, patients, and laboratory professionals.

Nevertheless, digital technologies should complement rather than replace clinical examination and professional judgment.

Esthetic parameters should be considered individualized guidelines rather than rigid standards, particularly in growing adolescents.

Conservative, age-appropriate, and multidisciplinary approaches are essential to preserve biological health, function, and future treatment options.

Ultimately, esthetic care in ephebodontics should aim for a natural, harmonious, functional, and individualized smile that respects the adolescent's growth, expectations, and overall facial characteristics.

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