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Footprints to Achieve Digital Smile Design and Esthetic: Narrative Review

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Abstract:

The Digital Smile Design (DSD) is a multi-use conceptual tool that will strengthen diagnostic vision, improve communication, and enhance predictability throughout the treatment. It allows for a thorough analysis of the patient's facial and dental characteristics, as well as any potential issues that may be identified during clinical examination, photography, digital impression, or diagnostic cast evaluation procedures. Drawing the reference lines and shapes over the extraoral-intraoral digital photographs in a predetermined sequence can widen the diagnostic visualization. The DSD helps the restorative dental team evaluate a given case's risk factors and limitations, including any disharmonies, asymmetries, and violations of esthetic principles.

Key words: Digital, smile design, esthetic.

Introduction

Esthetic dentistry is a delicate combination of scientific principles and artistic abilities. Mathematical parameters used by the dentist and laboratory technician combine to produce an attractive esthetic appearance. The disharmony between the soft and hard tissues can cause embarrassment during smiling and restlessness in others (Matheus et al., 2020). An attractive, confident smile is the desire for all. However, before starting the treatment, the patient must be able to visualize the treatment outcome. Digital smile designing (DSD) is a conceptual tool that facilitates esthetic planning and improves communications between the clinician and patient regarding the predictability of the treatment. DSD is a digital mode that helps the clinician to create and project the newly designed smile by attaining a simulation and pre-visualization of the final result of the proposed treatment (Jafri et al., 2020).

For digital planning, it is essential to consider the fundamental aspects of the treatment plan in order to achieve the expected outcomes and minimize possible failure (Matheus et al., 2020). The dentist must also consider the subjective concerns of the character and the individual patient's lifestyle when designing a natural smile. Esthetic judgement is not an entirely objective criterion; the creativity of the procedure makes each case unique, and the dentist's job pleasingly varied and rewarding.

The DSD protocol needs communication between the interdisciplinary dental team, including the

dental technician. Team members can identify and highlight soft or hard tissue morphology discrepancies and discuss the best solutions using the amplified images. Every team member can add information directly on the slides in writing or using voice-over, thus simplifying the process even more. All team members can access this information whenever necessary to review or add elements during the diagnostic and treatment phases (Coachman and Calamita, 2012).

The DSD protocol offers advantages in the following areas:

• Esthetic diagnosis

• Communication

• Feedback

• Patient management

• Education

No two humans are alike in appearance and character; therefore, each restoration should be designed according to a particular individual's needs and characteristics, especially in the anterior teeth.

To achieve the best esthetic results in dentistry, we should use "frames," "from the inside out": the line angles and axial inclinations that frame a single tooth, the gingival edge that frames the teeth, the lips that frame the teeth and gingiva, and, finally, the face that frames all these components and acts as the master or the original frame in which all the components interact in a natural or optimally restored dentition to present pleasing and esthetic smile (Gürel, 2003).

DSD is a multi-use tool that can support the diagnostic vision with the patient from pre-established facial photographs and digital drownings. Any discrepancies not observed during clinical diagnosis can be diagnosed in the DSD app, with the possibility of changing their corrections. However, to achieve the best outcome, using DSD requires dentist training and skill to ensure its effective use.

Evolution and history of the Digital Smile Design:-

Digital smile designing has progressively evolved from 2D to 3D, which has advanced from physical analogue to digital designing. According to Christian Coachman in 2017 who has proposed the evolution of the digital smile design in generations as- :

•**1st Generation**: - The analogue was drawings over the patient's photos with a pen to visualize the treatment prognosis. However, there was no correlation to the analogue/study model.

•**2nd Generation**: - Digital 2D drawings and visual connection to the Analogue model. Specific software like PowerPoint permitted digital drawing. Although the second-generation drawing was 2D and was not specific to dentistry work, it resulted in more accurate and less time-consuming than the first generation. The drawing could be visually connected to the study model; however, the physical connection was still lacking in this.

•**3rd Generation**: - Digital Two Dimension drawings and analogue connected to the study model. The third generation was the beginning of the digital-analogue connection in which the first software drawing was introduced to digital dentistry, which linked the 2D digital smile design to 3D wax-up. Furthermore, the facial integration into the smile design was introduced at this stage. However, the connection to the 3D digital world was missing.

•**4th Generation**: - The Digital 2D drawings now are digitally connected to the 3D model. During this era, it was time when digital dentistry progressed from 2D to 3D analysis. The 3D wax-up could be done with the involvement of facial integration and predetermination of dental aesthetic parameters.

•**5th Generation**: - Complete 3D workflow.

•**6th Generation**: - The 4D concept in which the addition of a motion to the smile design process took place. (Jafri et al., 2020)

Requirements for DSD: -

- Computer with one of DSD software.
- A digital SLR camera or smart phone.
- A digital intraoral Scanner for digital impression.
- 3D printer and CAD/CAM

Photography protocol for DSD

It is crucial to follow a photography protocol to achieve a correct digital planning.

1- Frontal views – three photos

- Full face with a wide smile and the teeth apart.
- Full face at rest.

- Retracted view of the full mandibular and maxillary arch with teeth apart.

2- Profile views – two photos :-

- Side profile at rest.
- Side profile with a full smile.

3- A 12 o'clock view with a wide smile; the incisal edge of maxillary teeth visible and resting on the lower lip.

4- An intra occlusal view of maxillary arch from second premolar to second premolar

Types of smile:

According to Rubin, there are three smile levels or patterns (Figure 1):

1. The commissure smile, also known as the Mona Lisa smile (67 %), is commonly found when people greet each other in social contexts or at unusual locations such as the elevator in this smile, the commissures are pulled upward and outward. Then the Levators of the upper lips will contract to show the maxillary teeth. In this type of smile, the action of the zygomaticus major muscle is dominant.
2. Cuspid or social smile (31 %). It has been globally used in self-portraits divulged on social networks. The Levator labii superioris contract first (dominant action) to expose the canines, then followed by contraction of the corners of the mouth to pull the lips upward and outward. This smile Shows anterosuperior teeth spontaneously or not.
3. Complex smile (Full denture smile), characterized by the lower lip movement and wide movement of the upper lip. It is also known as a spontaneous smile (usually involuntary) which realistically depicts patients' smile design (Rubin et al., 1974).

A (commissure smile) **B (social smile)** **C (spontaneous smile)**

Figure 1: Different types of smiles according to (Rubin et al., 1974).

Components of an Esthetic Smile

Perfect integration of facial and dental composition is one of the requirements for harmonizing an esthetic smile. A smile design should include the analysis and evaluation of both the facial and dental composition; the facial composition which consists of the hard and soft tissues of the face, while the dental composition relates specifically to teeth and their relationship to gingival tissues.

1. <u>Facial composition</u>

Analyzing, evaluating, and treatment planning for facial esthetics often involve a multidisciplinary approach, including orthodontics, orthognathic surgery, cosmetic dentistry, periodontal therapy, and plastic surgery. Thus, an esthetic approach to patient care produces the best facial and dental beauty. However, if there is an obvious discrepancy in the face, the smile makeover will be restricted to the dental composition only.

Facial beauty is based on standard esthetics principles involving proper alignments, symmetry, and face proportion. There are two facial features which do play a significant role in the smile design:

- the interpapillary line
- Lips.

Regarding the interpapillary line should be perpendicular to the midline of the face and parallel to the occlusal plane. On the other hand, lips are important since lips create the boundaries of smile design.

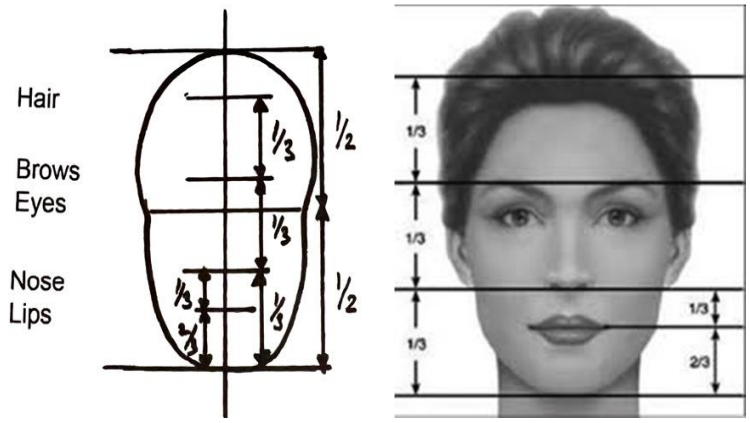
In case the dentist encounters major discrepancies between the lips and the interpapillary line, then he or she must seriously consider the correction of the facial composition before considering the correction of the dental composition.

In classical terms, the horizontal and vertical dimensions of an ideal face are as follows:

1. Horizontal:

• The width of the face should be the **width of five "eyes".**

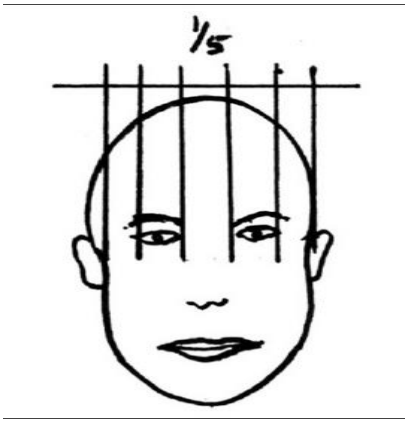
• The distance between the eyebrow and chin should be equal to the width of the face (**Figure 2-A) (Bhuvaneswaran, 2010), (Bukhary *et al.*, 2007).**



(Figure 2) Horizontal dimensions of face

2. Vertical:

- The facial height is divided into three equal Parts from the forehead to the eyebrow line, from the eyebrow line to the base of the nose and from the base of the nose to the base of the chin.
- The full face is divided into two parts, eyes being the midline.
- The lower part of the face from the base of the nose to the chin is divided into two parts, the upper lip forms one third of it and the lower lip and the chin two-thirds of it (**Figure 2-B) (Bhuvaneswaran, 2010).**



(Figure 2-B) Vertical dimension of face

The basic shape of the face when viewed from the frontal aspect can be:

1- Square
2- Tapering
3- Square tapering
4- Ovoid

The lateral profile of an individual can be:

1- Straight
2- Convex
3- Concave

The basic shape of the face and lateral profile play a role in determining the tooth size, shape and the lateral profile. In brief, Tooth morphology is dependent on the facial morphology **(Figure 3)**.

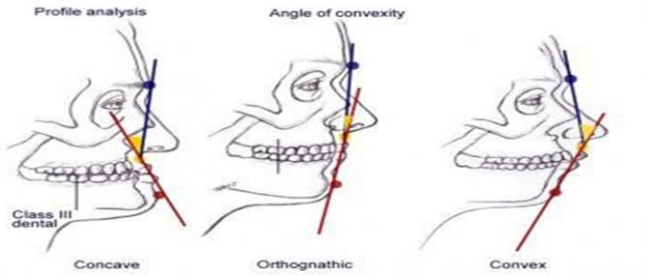


Figure3: lateral profile of an individual

2- Dental components includes:-

1. **Tooth components**

A. Dental midline
B. Incisal lengths
C. Tooth dimensions
D. Zenith points

2.Soft tissue components

A. Gingival health
B. Gingival level and harmony
C. Interdental embrasure
D. Smile line

1. Tooth components:-

1.1 Dental Midline: -

The midline can be referred to as the vertical contact interface between two maxillary central. The midline should be perpendicular to the incisal plane and parallel to the midline of the face. Any minor discrepancies between facial and dental midlines are acceptable and, in many instances, not noticeable **(Fradiani 2006, Bhuvaneswaran 2010)**. However, a canted midline would be more pronounced, and therefore, less acceptable. The maximum allowed discrepancy in midline can be 2 mm and sometimes greater than 2 mm discrepancy is esthetically acceptable as long as the dental midline is perpendicular to the interpupillary line. Various anatomical landmarks such as the midline of the nose, forehead, chin, Philtrum, interpupillary plane can be used as guides to assess the midline **(Kokich et al., 2001**).

However, the Philtrum of the lip is considered one of the most accurate of these anatomical guides to determine the midline because it is always in the center of the face except in surgical, accident or cleft lips cases. The center of the Philtrum is the center of the cupids bow, and it should match the papilla between the centrals. If these two structures match and the midline is incorrect, then the problem is usually incisal inclination. If the papilla and Philtrum do not check, then the problem is an actual midline deviation. A midline that does not bisect the papilla is more noticeable than the one that does not bisect the Philtrum **(Paul, 2001).**

Midline should be:

A. **Parallel to the long axis of the face:** the line angle that forms the contact between the centrals should be parallel to the long axis of the face.
B. **Perpendicular to the incisal plane**: the line angle that forms the contact between the centrals should be perpendicular to the incisal plane.
C. **Midline should be perpendicular to the dental papilla**: the midline should drop straight down from the dental papilla. A face bow transfer or even a reference stick aligned parallel to the interpupillary plane provides valuable information in laboratory communication regarding midline inclination and the possible presence of a canted incisal plane.

Mandibular and maxillary midlines do not coincide in 75% of cases. Hence, it is not advisable the usage of the mandibular midline as a reference point for establishing the maxillary midline. Misalliance between the maxillary and mandibular midline does not affect esthetics because the mandibular teeth are not visible while smiling (Paul, 2001).

The midline between the facial midline and maxillary central incisors must coincide whenever possible. Suppose the dental and facial mid-lines do not coincide or are far apart. In that case, the dental midline should be kept perpendicular to the pupillary or horizontal lines to prevent the illusion of asymmetry due to an excessive right or left shift of the dental midline. Once it is straight, the composition will appear symmetrical or at least

pleasing. Even if the midline is placed in the precisely correct position, and if it is oblique in relation to the facial midline, it will disturb the symmetry.

In any restored dentition, slanting is a major, unacceptable flaw. Therefore, the mid-line, the center of attraction, should be as perpendicular as possible to avoid distortion (Morley and Eubank, 2001).

1.2. The Incisal Length

Maxillary incisal edge position is the most crucial determinant in smile creation because once set, it serves as a reference point to choose the proper tooth proportion and gingival levels. The parameters used to help establish the maxillary incisal edge position are:

1. The degree of tooth display.
2. The phonetics.
3. The patient input.

Degree of tooth display: When the mouth is relaxed and slightly open (3.5 mm), the incisal third of the maxillary central incisor should be visible in a young individual. Patients' age and tooth wear can affect the visibility of tooth structure at rest. As age increases, the decline in the muscle tonus results in more miniature tooth display (Figure4).

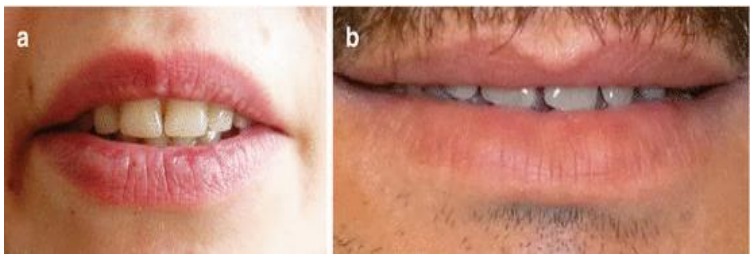


Figure 4: (a) Visibility of tooth structure at rest for a 20-year-old patient. (b) Visibility of tooth structures at rest for a 50-year-old patient (Themes, 2016).

Phonetics: Phonetics is a significant determinant of tooth length. To determine proper lip, tongue and incisal support and tooth position, it is necessary that the patient sits either in a postural head, upright position or stands during the phonetic exercises **(Bloom and Padayachy, 2006).** The various phonetics used are as follows:
E sound: Pronunciation of "E" by the patient shows the widest smile, which allows evaluation of the maxillary anterior and the incisal line. By having the patient say "E" without interruption, e.g., "eeeeee" or "cheeeese," the clinician can examine the incisal edge in this maximum extension position of the lips. The maxillary incisal edge position should be positioned halfway between the upper and lower lip during the E sound. Loss of muscle tonus caused by ageing and tooth wear can affect the visibility of the teeth during the pronunciation of the extended "E" sound and results in less or no incisal edge display**.**

Figure 5: Pronunciation "E" sound, such as saying "cheeeeeese," helps the clinician to evaluate the incisal edge position of the maxillary anterior and the incisal line (Themes ,2016).

M sound: After pronunciation the letter "M" and keeping the lips relaxed, the lips return to their regular rest position, allowing the clinician to determine the incisal edge position of the central maxillary teeth and evaluate the amount of the tooth displaying rest position **(Figure 6).**

Figure 6 : After repeatedly pronouncing the letter "M" and keeping the lips at rest, aid clinician to determine the incisal edge position of the maxillary central teeth (Themes, 2016)

S sound: During pronunciation, the mandibular central incisors are positioned 1 mm behind and 1 mm below the maxillary incisal edge **(Figure 7) (Bhuvaneswaran 2010, Themes, 2016).**

Figure7: Evaluation of the patient during pronunciation of the "S".

F and V sounds: When the patient correctly pronounces the "F" and "V" sounds, **(Figure 8)**the incisal edge of the anterior maxillary teeth should come in slight contact with the wet-dry line or vermilion border of the lower lip. Thus, fricative sounds help to determine the labiolingual position and length of the maxillary teeth. In another approach, correct labiolingual positioning of the anterior maxillary teeth by placing the incisal edges on the wet-dry border of the lower lip allows the patient to pronounce "F" and "V" correctly **(Themes, 2016).**

Figure 8: Phonetic evaluation during patient pronouncing the "F" sound to determine the incisal edge of the maxillary centrals. (a) Phonetic evaluation with the temporaries. (b) Phonetic evaluation without temporaries (Themes, 2016).

Patient input: Cosmetic preview of the intraoral and temporary restorations helps to decide the correct placement of the final incisal edge position. The patient's desires must be met as best as possible without interfering with the parameters previously discussed.

Correct incisal edge position is crucial because it is related to the pitch of the anterior teeth, labial contours, anterior guidance, lips support, lingual contours, and tooth display. The combination of proper lip support and the lingual labial position of the incisal edge determines the pitch of each anterior tooth. This location influences anterior guidance and the labial and lingual contours. In short, all these factors play a dominant role in both esthetics and function (**Bhuvaneswaran, 2010**).

1.3. Zenith Points

Zenith points are the most apical points of the clinical crowns; which are the height of contour. Their positions are dictated by the root form anatomy, cementoenamel junction (CEJ), and the

osseous crest, where the gingiva is scalloped the most. The zenith points are generally located just distal to a line drawn vertically through the middle of each anterior tooth. The lateral incisors are one exception to that rule,

as their zenith points are placed more centrally or on the mid-line of the tooth margin **(Stein 1977, Kay 1982).**

The positions of the zenith points gain importance in cases of changing the distal or mesial tilted position of the teeth or closing diastemas . In the case of diastema closure, if the zenith points are not moved mesially from their originally existing

positions, the finished porcelain laminate veneers may give the perception

of being mesially tilted. In addition, the extreme distal positions of the gingival zeniths will result in an exaggerated triangular form (Moskowitz and Nayyar, 1995). To prevent these occurrences and to create an illusion of bodily shifted central incisors towards the mid-line, the zenith points should also be moved mesially. These are examples of moving the zenith points horizontally. In the case where the tooth needs to be shown longer or more tapered at the gingival 1/3rd, the zenith points can be moved apically. Such an apical movement obtains a triangular Shape. An equilateral triangle will always appear longer in height than in width, proving that a tapered tooth design will make the tooth seem longer than it is. This procedure should therefore be used with shorter teeth, where elongation towards the apical direction is required.

Consequently, zenith points (Figure 9) can enhance the perception of the tooth axis as well as the length and the gingival shapes, which can be achieved by horizontal or vertical alterations (Gürel, 2003).

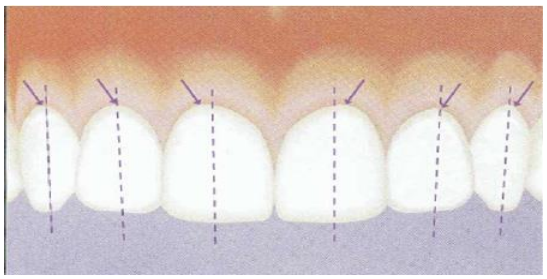


Figure (9) zenith point

When the zenith points of the maxillary incisors and the canines of a natural smile are followed, it is readily observed that they are not aligned on an imaginary straight line. Usually, the zenith points of the lateral incisors are 0.5 to 1 mm below those of the central incisors and canines, while the zenith points of the canines and central incisors remain on the same horizontally drawn imaginary line. This relationship of the zenith points actually forms a type of an imaginary triangle**.**

When the zenith points of the maxillary incisors and the canines of a natural smile are followed, it is readily observed that they are not aligned on an imaginary straight line. Usually, the zenith points of the lateral incisors are 0.5 to 1 mm below those of the central incisors and canines. In contrast, the zenith points of the canines and central incisors remain on the same horizontally drawn imaginary line. This relationship of the zenith points forms a type of an imaginary triangle **(Gürel, 2003).**

The angles or the depth of this triangle do not follow any rules. Any kind of the triangle in which the zenith of the lateral incisors stays below will usually reflect a pleasant relationship. If the teeth are aligned on a straight line, it is an indication of high lateral zenith point placement and in some cases, this display is a reversed or inverted triangle, where the gingival level of the lateral incisor is placed even more apically than the central incisor and the canines, creating an unaesthetic configuration. This will affect the gingival harmony, but also result in short lateral incisors, with relatively correct proportions.

There are principles used as a guide in creating harmony and balance for individual tooth dimensions. These guides are as follow:

Maxillary central incisor: The central incisors are considered the focal point of an esthetic smile. The approximate length of the central incisors should be 10-11 mm, and the width is calculated so that the ratio falls between 75 and 80%.

Maxillary Lateral incisors: They are considered as the active part of the creation of a smile. Maxillary lateral incisors provide individuality, are never symmetrical, and influence gender characterization.

Maxillary Canines: They play a critical point in creating a pleasing smile because:-

1. Located at the junction between the anterior and posterior dental segments; Hence, only the mesial half of the canine is visible from the frontal view when the patient smiles.
2. Support the frontal muscles - The size and characteristics of the buccal corridor are determined by the canine's shape, position, and size.
3. Canine depicts the personality characterization (Feminine- soft and delicate while for the masculine - vigorous and aggressive)

Maxillary bicuspids: - Premolars play an essential role in arch design. They should fill the buccal corridor.

The presence or absence of the buccal corridor is considered a vital smile aspect. **Frush and Fisher** defined the buccal corridor as the presence of spaces between the facial surfaces of the posterior teeth and the corners of the lips when the patient is smiling **(Ioi 2009).** Another way to define the buccal corridor is to refer to the negative space (dark space) visible during smile formation between the corners of the mouth and the buccal surfaces of maxillary teeth. Many factors influence the appearance of the buccal corridor **(Bhuvaneswaran 2010)**:

1. The positioning of the labial surface of the upper premolar
2. Width of the smile and the maxillary arch.
3. The tone of the facial muscles
4. The prominence of the canine, particularly at the distal facial line angle
5. The existence of any discrepancy between the buccal of the premolars and the six anterior teeth.

Gummy Smile

The excessive gingival display while smiling, also known as a " gummy smile, " has mainly been viewed as unaesthetic, leading many patients to seek treatment to overcome this issue. The gummy smile is a non-pathological condition that is causing an esthetic disharmony where more than 3 to 4 mm of gingival tissue is exposed during smiling **(Dym, 2019).** Potential causes of excessive gingival display or gummy smile which lead to a gummy smile, including delayed tooth eruption or excessive tooth coverage with gingival tissue, inadequate upper lip movement hypermobile / hyperactive lip activity ,upper lip length (short lip length), and skeletal issues e.g. Dentoalveolar extrusion that can contribute to this condition. In general, the underlying etiology of a gummy smile dictates the primary treatment approach. Such techniques include crown lengthening procedures, orthodontic levelling of the gingival margins, maxillary tooth intrusion, lip repositioning, orthognathic surgery, and nonsurgical procedures such as administering botulinum toxin A **(Dym 2019, Ardakani 2021).**

Intercommissure Line

The position and amount of the maxillary anterior teeth play a role in the perception of age. Intercommissure line can be defined as parameter which uses the amount of tooth reveal below the intercommissure line. Youthful smiles generally reveal (75-100%) of the maxillary teeth below the intercommissure line. As the percentage of the amount of reveal tooth structure dips below (40 – 0 %), the face becomes markedly aged **(Figures 10&11) (MORLEY, 1999)**

Figure 10. The intercommissure line is used as a guideline to determine proper esthetics for a youthful smile (MORLEY, 1999).

Figure 11: Thirty-year-old patient reveling more than 80% of maxillary teeth under intercommissure line (MORLEY, 1999).

Figure 12: maxillary anterior teeth repositioned apically, showing how reduction in tooth reveal and inadequate amount of maxillary teeth below the intercommissure line appear to age the patient (MORLEY, 1999).

Conclusion:

The DSD can be used as a marketing tool to motivate the patient, an educational tool to help explain issues related to treatment, and an evaluative tool by comparing before and after photographs. Further, the library of slides from past treatments can be used to demonstrate treatment possibilities during patient consultation. The treatment planning presentation will be much more effective because the DSD allows patients to visualize the multiple factors responsible for their orofacial issues. In addition, DSD aids in patient acceptance by helping them visualize and understand both past and future treatments.

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