Smile Analysis
Diagnosis and Treatment Planning

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KEYWORDS

• Diastemas • Maxillary • Orthodontics • Smile • Smile Design
• Interdisciplinary Treatment Planning • Lip • Gingiva • Smile Arc • Facial flow
• Airway • Global Diagnosis • FGTP • Digital Smile Design

INTRODUCTION

The Power of a Smile

"Even the simulation of an emotion tends to arouse it in our minds."[1] Charles Darwin was the first to explain the hidden power of a smile. In his Facial-Feedback hypothesis, he suggests that a smile has a systematically positive effect on the mind and body. A widely cited 30-year longitudinal study on the analysis of smile expression in women's college pictures revealed that women displaying positive emotions in pictures had favorable outcomes in their marriages and well-being and had more favorable personalities.[2] Another study found that people with new smiles altered by cosmetic dentistry were regarded as more attractive, intelligent, interesting, and wealthier.[3] The power of the smile is clearly exponential, and we are the architects of the new smile.

What Is Smile Design?

Smile design is defined as the process of creating an esthetic smile based on scientific and artistic guidelines established through studies, perception, and cultural and racial standards that have been recognized over time.[4] Smile design is a dynamic field with evolving trends that take into consideration: facial esthetics, lip dynamics, pink and white esthetics, and personality. Traditional smile design focused on the orodental complex. Modern smile designers must have a global understanding of the entire patient to design the perfect smile. Subjectivity is fundamental when it comes to smile design. Purely scientific smiles are generic, symmetric, and seem fake. Copying and pasting the same smile using the same tooth library and gingival esthetics for each patient results in an unesthetic result. No 2 smiles are identical, and each smile must take on an identity of its own based on the guidelines outlined later. In the era of social media, it is popular for dentists to showcase artificial smiles. What sets a beautiful smile apart is the integration of organic guidelines to achieve "perfect" results. In essence, embracing nature and its imperfections is the next level of smile design (**Fig. 1**).

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Fig. 1. Natural and artificial smiles created by restorative dentistry. Natural smiles (*A*). Natural smile (*B*). Artificial smiles (*C*). Artificial smile (*D*).

Global Components of the Smile

In this section, the authors discuss the fundamentals of smile analysis and the parameters to design the most esthetic smile. The term *Ideal smile* has been used in the literature; however, as discussed one can argue that no smile is ideal and that "Beauty is in the eye of the beholder."[4] As such no smile design is successful without the comprehensive involvement of the patient. Therefore, the first step in smile design is *patient communication*. In the era of digital dentistry, several applications and software exist that can facilitate discussions with patients and understanding of expectations and possibilities.

Three smile types have been shown in the literature: commissure smile (Mona Lisa smile), social smile (cuspid smile), and spontaneous smile (complex smile)[5] (**Fig. 2**). *Smile design should be performed on the patient's spontaneous smile, as it depicts true emotions*. The social smile is usually used to disguise negative aspects of their

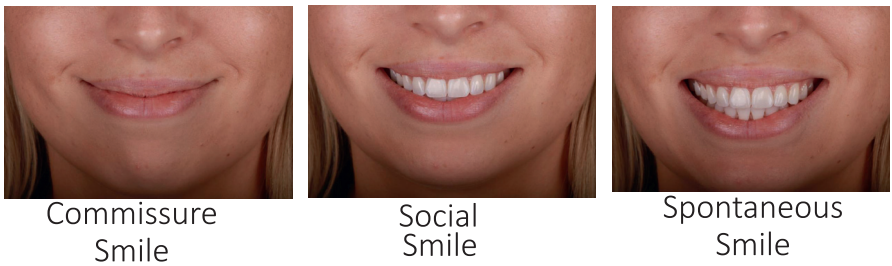

Fig. 2. Different types of smile: commissure smile, social smile, and spontaneous smile.

smile and should not be used. It is challenging to get a patient in a dental chair to reproduce a spontaneous smile. Therefore, the recommendation is to film the patient in a nontreatment room with a relaxed ambiance. Several frames are cropped from the video to provide dynamic data of the patient's smile.[6] Failure to recognize the spontaneous smile can lead to incorrect diagnosis and catastrophic failure.

The four building blocks of the modern esthetic smile

1. Facial esthetics: in this section, the authors discuss determinants of facial esthetics (**Fig. 3**). All measurements are made in repose and natural head position. Repose is defined as a rest position with the teeth and lips slightly apart.[7] Natural head position is defined as a reproducible position of the head in an upright posture with the eyes focused on a point at eye level.[8]
   a. Facial view
      i. *Facial proportions:* the rule of thirds divides the face into 3 sections (**Fig. 4**). The heights and ratio of the middle to lower third in repose play a significant role in smile esthetics and diagnosis. The ideal ratio of the middle:lower third is 1:1. A longer lower third is diagnosed as vertical maxillary excess (VME) and can result in a gummy smile.[7] A shorter lower third may indicate a reduced occlusal vertical dimension (OVD).
      ii. *Reference lines:* the 3 reference lines used in modern smile design in a frontal view are the *interpupillary line (IPL), the commissural line (CL), and the facial flow* (**Fig. 5**).[9] The IPL is defined as a straight line that passes through the pupils and is used to determine the transverse position of the maxillary occlusal plane. The CL is determined by a straight line drawn between the right and left lip commissure.[9] Parallelism between the IPL and CL results in facial harmony. A recent report analyzed top celebrity smiles and found that the most esthetic smiles were when the IPL, CL, and occlusal plane were all parallel.[10] In situations where there is a lack of parallelism between the IPL and CL, laypeople preferred the occlusal plane to be parallel with the CL.[11] The facial midline is a straight line drawn through the glabella, the tip of the nose, philtrum, and the tip of the chin.[9] More recently, emphasis has been given to the

Building blocks of modern smile design

Face	Lips
• Facial proportions • Reference lines • Shape of face	• Shape and volume • Length • Mobility
Gingiva	**Teeth**
• Design • Exposure in smile • Papilla height	• Incisal edge position • Smile arc • Dimensions • Symmetry • Anterosuperior proportions • Diastemas • Buccal corridor • Midline • Color • Anatomy

Fig. 3. Building blocks of modern smile design.

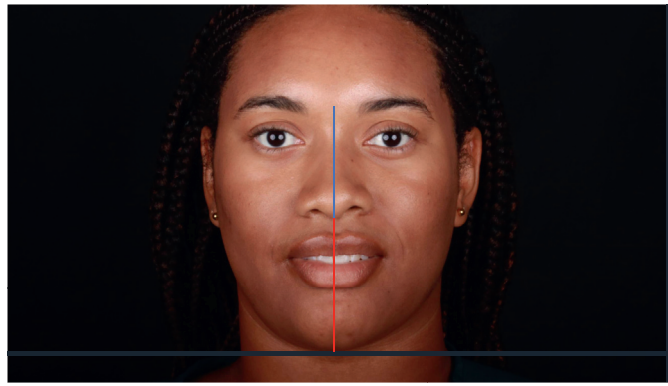

Fig. 4. Facial proportions: middle to lower third ideally is 1:1. A longer lower third is diagnosed as VME (patient consent). This patient's middle third measures at 64 mm and lower third is 74 mm.

facial flow concept that states that due to the natural asymmetry of the human face, it is impossible to define a straight line as the midline. Rather, a curved line connecting facial landmarks is more acceptable.[12] The relationship of the dental midline with the facial flow is discussed later in this article.

b. Profile view
   i. Reference lines (**Fig. 6**)
      1. *The Frankfort horizontal*, which is defined as a straight line from the highest point on the margin of the auditory meatus to the lowest point of the orbit, should be parallel to the horizon when the patient is in NHP.[13]
      2. *Camper's plane or Ala-Tragus line*, which is a line running from the inferior border of the ala to the superior border of the tragus of the ear, determines the maxillary occlusal plane.[13,14] Different systems have shown reliability in reproducing the maxillary occlusal plane, such as the Kois Dento-Facial Analyzer, virtual face-bows, and the Behrend system that relies on the use of photographs to determine tooth position and is the prototype of Digital Smile Design (DSD).[15]

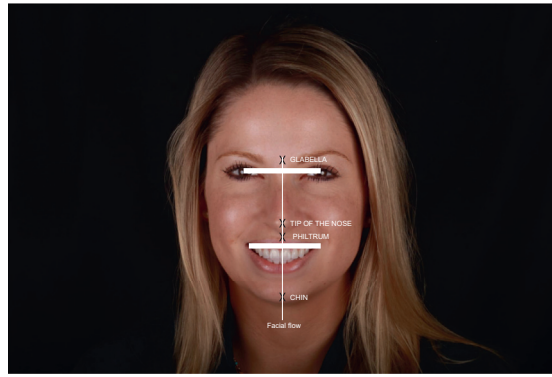

Fig. 5. Facial reference lines: the interpupillary line, the commissural line, and the facial flow line as shown in the figure.

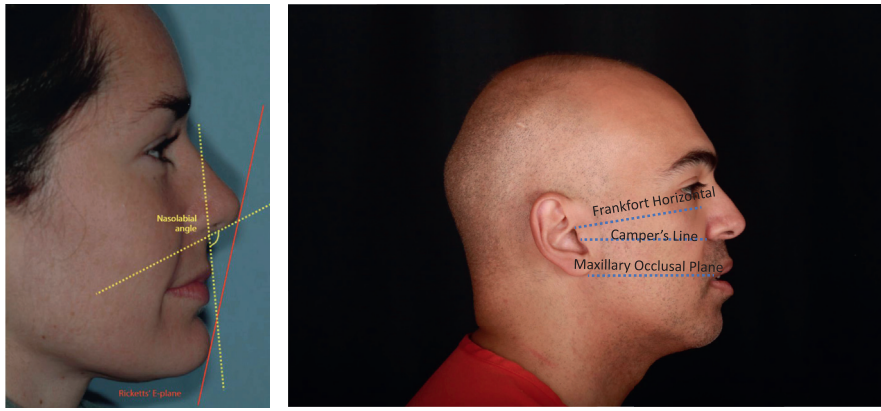

Fig. 6. Profile reference lines. The Frankfort horizontal, Camper line, nasiolabial angle, and E-Line are all important in smile design. (*From* Levine JB, Finkel S. Smile Design Integrating Esthetics and Function. Vol Volume Two. (Levine JB, ed.). ELSEVIER; 2016.)

3. *Nasolabial angle:* this is an angle created at the subnasale by the intersection of a tangent to the base of the nose with a tangent to the outer edge of the upper lip.[9] In individuals with normal profile the angle is between 90° and 95° in men and 95° to 115° in women. Smaller angles indicate a prominent maxilla and excessive lip support. Less dominant restorations are recommended in these situations.[9]
4. *Ricketts E-plane:* a line drawn from the tip of the nose to the chin. In most races, the upper lip is about 2 to 4 mm posterior to the line, whereas the lower lip is 0 to 2 mm posterior in a normal profile. In a concave profile (angle class III malocclusion), the lower lip is in front of the line. The maxillary centrals can be made more dominant to get closer to the E-line. Conversely, in a convex patient (angle class II malocclusion), the lower lip is more than 2 mm behind the line and the maxillary centrals should be less dominant.[7,16]

c. *Facial shapes:* "The law of harmony" suggested a correlation between facial shape and contours of upper permanent incisors. The facial shapes described are oval, triangle, and square.[17] More recently, a correlation between facial shape, personality, and tooth shapes has been proposed in what is called Visual Identity of a Smile (VIS).[18]

2. Lip esthetics
   a. *Lip shape and volume:* lips are classified as thin, medium, or thick. Voluminous lips are seen as more attractive in women with the lower lip closer to the E-line (**Fig. 7**).[19] Slightly protruding inverted upper lips have been shown to convey youth and attractiveness.[20] In men less prominent lips are a sign of masculinity and social dominance.[21] With voluminous lips being the current standard of beauty, care should be taken when retroclining maxillary incisors to avoid negative impacts on lip volume.[20]
   b. *Lip length* (**Fig. 8**): the upper lip is measured from the base of the nose to the inferior border of the upper lip. A normal upper lip measures 20 mm to 22.0 mm in women and 22 mm to 24 mm in men.[22] A long upper lip decreases incisal display, resulting in a less esthetic smile. Lip lifting is a technique that can be used to unveil maxillary incisors.[20] Conversely, a short upper lip results in

Fig. 7. Different types of lips: thin, medium, and thick.

excessive incisal display and a possible gummy smile and can be treated by Botox.[7]

c. *Lip mobility* **Fig. 9**: upper lip mobility is defined as the amount of lip movement in a full smile; this can be measured by subtracting incisal exposure at rest from dentogingival exposure during a spontaneous smile or by subtracting lip length in a spontaneous smile from lip length in repose.[22] Normal lip mobility is 6 to 8 mm.[7] A hypermobile lip can be treated using Botox.

d. *Lower lip*: the role of the lower lip in smile esthetics has not been analyzed as comprehensively even though the lower lip creates the smile frame. The current standard of beauty is a voluminous lower lip. Furthermore, the maxillary incisal edge should touch the lower lip in a social smile; however, a 0.5 mm gap was still considered esthetic.[23] The smile index is defined as the intercommisural width divided by the interlabial gap during a smile (**Fig. 10**).[24] Generally, an esthetic smile index is greater than 5.0 and less than 7.5.[25] A spontaneous smile with interocclusal space will generally have a greater smile index than a posed smile. A smile index greater than 7.5 indicates the aging of a smile due to the

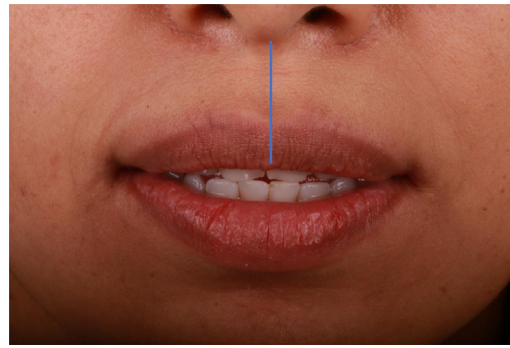

Fig. 8. A. Lip length. Measured from the base of the nose to the inferior border of the upper lip.

Fig. 9. Lip mobility. Length of blue line to red line = 9 mm. Hypermobile. Lip resulting in excessive gingival display.

greater width and the smaller interlabial gap. If the upper lip and maxillary occlusal planes are in the ideal position, the reduced interlabial gap is due to the higher position of the lower lip position, which could be due to the reduced OVD.

3. *Gingival esthetics*: gingival architecture is fundamental to smile design. Color, stippling, and biotype are essential components of pink esthetics.
   a. *Gingival design:* as discussed by Fradeani, the gingival margin should maintain parallelism with the occlusal plane and horizontal references such as the IPL and CL (**Fig. 11**).[9] Furthermore, the gingival margin should maintain the proper curvature to match incisal edges and the smile arc. Soft tissue grafting and crown lengthening are periodontal procedures used to achieve harmonious gingival margins. The classic gingival design is where the canines and central incisor gingival margin falls on the same line with the laterals slightly coronal (1–2 mm).[5] Variations exist such as the modified gingival designed where the centrals and laterals are on the same line. The classic literature has focused on the anterior 6; however, with the focus on wider smiles, the posterior teeth gingival margins should be taken into consideration. Crawford and colleagues[26] suggested the esthetic zone for posterior teeth, which is defined as a tangent from the canine margin to the lower border of the upper lip superior to the first molar. An acceptable range for the premolars is 2 mm apical to the line and 1 mm for molars. Further studies are needed to evaluate posterior teeth

Fig. 10. Smile index = intercommisural width/interlabial gap. The esthetic range is 5 to 7.5. A greater smile index could be related to a smaller interlabial gap due to a collapsed OVD.

Fig. 11. Ideal gingival design. (1) Canine sand centrals on a straight line; (2) laterals slightly incisal to the line. Gingival margin follows smile arc. (*From* Levine JB, Finkel S. Smile Design Integrating Esthetics and Function. Vol Volume Two. (Levine JB, ed.). ELSEVIER; 2016.)

esthetics as the demand for wider smiles increases. The gingival zenith is defined as the most apical point of the gingival margin. Traditionally, the zenith is located slightly distal to the midline of the centrals and in the center for laterals and canines.[27]

b. *Gingival exposure:* Robbins and colleagues[7] suggested that gingival display more than 2 mm in a high smile is regarded as excessive. In the spontaneous smile, Machado and colleagues[5] suggested that 3 mm is the threshold for a gummy smile. Therefore we suggest that gingival exposure of more than 2 to 3 mm is regarded as excessive (**Fig. 12**). Treatment of a gummy smile depends on the *Global Diagnosis system* discussed later in this article.

c. *Papillary height:* Hochman and colleagues[28] reported that the length of the papilla was 40% the length of the tooth from the zenith to the incisal edge. Furthermore, they reported that 87% of patients with low smiles displayed papilla. Therefore, when designing smiles of patients with low smiles, it is crucial to maintain the papillary display.[28] Long contacts with no papilla are regarded as unesthetic and should be avoided. Tooth and restoration shapes play an important role in papilla height. Triangular and oval-shaped restorations have shorter contacts and longer papilla. If the height from the base of the contact to the crest of the bone is more than 5 mm then a longer contact or more square restoration is necessary to avoid the formation of a black triangle.[29]

4. *Dental esthetics:* in this section, the authors discuss different specifics of white esthetics that need to be taken into consideration during smile design.

a. *Incisal edge position:* this is the most important factor in determining tooth position in smile design. Maxillary central incisal edge is determined in repose and full smile. In repose, if lip length is normal, the incisal edge display is 3 to 4 mm in

Fig. 12. Excessive gingival display in full smile.

women and 1 to 2 mm in men (**Fig. 13**).[30] More incisal display indicates a more youthful and attractive smile. In full smile, Gaikwad and colleagues reported that the best esthetic result is when the maxillary centrals contacted the lower lip even though 0.5 mm distance between the incisal edge and the lower lip was still considered esthetic.[23,31] Moreover, Pound reported that in an E-Smile (spontaneous) the maxillary centrals should occupy between 50% and 80% of the interlabial distance.[32] The F sounds are also used to determine the incisal edge position. During gentle pronunciation of the F sounds, the incisal edge should touch the wet/dry border of the lower lip.[16]

b. *Smile Arc:* smile arc refers to the position of the maxillary incisors in a vertical position. Profitt and colleagues[33] reported that the smile arc is the most important factor of the smile. Smile arc is classified into 3 categories: convex/positive, straight/plane, or inverted/reverse (**Fig. 14**). The positive smile is the most esthetic and is defined as when the maxillary incisal edges cradle the lower lip. Al Johany and colleagues[34] found that positive smiles were seen in 78% of celebrity smiles. In a positive smile, the incisal edge of the maxillary central is more incisal than the canines. Furthermore, there is a 0.5 to 1 mm step between the incisal edge of the maxillary centrals and the laterals in men and 1.0 to 1.5 mm step in women.[5] This ensures the dominance of the maxillary centrals. To create a less dominant smile, the clinician can decrease the maxillary-lateral incisal edge step and position the maxillary central incisal edge at the same level as the canine edge.

c. *Maxillary central dimensions and symmetry:* once the vertical position of the maxillary centrals is established, the length and the width need to be determined. The range for width:height ratio of the maxillary centrals is 75% to 85%.[35] Slender teeth are more common in women, whereas male teeth are closer to 85%. Any ratio greater than 85% is regarded as unesthetic. The esthetic guide for hard tissue developed by Chu and colleagues[36] uses mathematical formulas to calculate the width and height of maxillary and mandibular anteriors as well as intratooth relationships. If the width of the central is X, the lateral is X-2, whereas the canine is X-1. The height can then be calculated by dividing by 0.78 (dentist preferred W/H ratio) (**Fig. 15**). Based on this formula: the width of the mandibular central = X-3 and the average dimensions of the centrals are 8.5 mm wide and 11 mm long. Gender and face size play a major role in teeth dimensions.[36] Natural smiles have a degree of asymmetry;

Fig. 13. Incisal edge position in repose. 3 to 4 mm in women and 1 to 2 mm in men.

however, symmetry was found to be most crucial for the maxillary central incisors. Asymmetry was less noticeable further from the midline.[37]

d. *Proportions between anterosuperior teeth:* the intertooth relationship between the maxillary anteriors has been studied extensively through the years. Levin proposed the golden ratio in 1978, which suggested that in the facial view the width of the laterals is 62% the width of the centrals and that the width of the canines is 62% the width of the laterals.[38] The golden proportion was found to not exist in nature and was regarded as unesthetic in several studies due to the narrowing of the smile.[39] With the emphasis on wider smiles in modern smile design, other proportions are regarded as more esthetic. The recurring esthetic dental (RED) proportion has been proposed by Ward and colleagues[40] as a model for modern smile design. RED proportion ranges from 62% to 80% and differs based on the desired length of teeth and height and gender of the patient. For shorter teeth, the 80% RED proportion was found to be the most esthetic, whereas for longer teeth the 62% RED (Golden) was ideal (**Fig. 16**).
e. *Presence of diastemas:* in general, all anterior diastemas should be closed unless requested by the patient. An untreated maxillary median diastema (MMD) of more than 0.5 mm was regarded as less esthetic[41] Moreover, MMD of more than 4 mm is recommended to be restored by an interdisciplinary approach of orthodontics and restorations.[41] In these cases the use of restorative alone results in abnormal tooth shape that does not follow the W/H ratio of 78%. Recently, Bioclear has been marketed as a solution for diastema closures. It is the authors' opinion that Bioclear results in W/H ratio greater than 78%, which produces an unesthetic smile with square teeth, long contacts, and papillary height less than 40%.
f. *Buccal corridors:* this is defined as the dark space between the buccal of the maxillary teeth and the labial commissure during smiling. Buccal corridors can be classified as narrow, intermediate, or wide.[5] The effect of the buccal corridor on smile esthetics has been controversial, with some studies reporting that laypeople did not notice a difference, whereas other studies reported that

Fig. 14. Positive, straight, and negative smiles.

an intermediate buccal corridor is more esthetic.[42] Furthermore, a recent study analyzing celebrity smiles found that only 22% of celebrity smiles had a wider corridor.[43] A wide buccal corridor can be treated by camouflaging the space with restorative dentistry; however, a wider corridor usually indicates a narrow arch. With the current emphasis on airway in treatment planning, the ideal

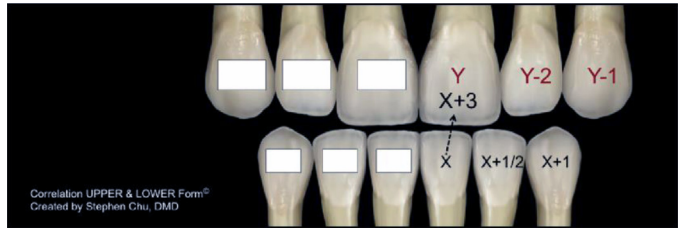

Fig. 15. Intratooth dimensions as proposed by Chu. (*From* German DS, Chu SJ, Furlong ML, Patel A. Simplifying optimal tooth-size calculations and communications between practitioners. Am J Orthod Dentofac. 2016;150(6):1051-1055. https://doi.org/10.1016/j.ajodo.2016.04.031.)

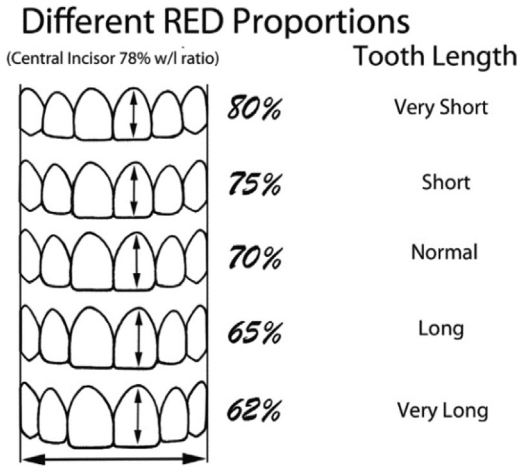

Fig. 16. Different RED proportions for anterior teeth ratios. (*From* Ward DH. Proportional Smile Design. Dent Clin N Am. 2015;59(3):623-638. https://doi.org/10.1016/j.cden.2015.03.006.)

treatment modality should be maxillary expansion to position the teeth in the correct transverse position.[7]

g. *Midline position and angulation:* the position of the *maxillary midline* plays a controversial role in smile esthetics. Classic literature indicates that a midline shift of 3 to 4 mm was not recognized by laypeople.[44] In these studies, however, the face was not included, which undermines the importance of the face in smile design. More contemporary literature reports that a midline deviation of greater than 2 mm was regarded as unesthetic.[45] In addition, 48.8% of celebrity smiles had a midline deviation, which underscores that minimal deviation is not noticeable and should not alter the treatment plan to unnecessarily correct the maxillary midline.[43] Although the midline changes are not as noticeable, classic literature suggested that *angulation of the midline* had a more pronounced effect on smile esthetics. A cant of 2.0 mm in the midline was readily noticed by laypeople and resulted in an unesthetic smile.[44] More recently, the concept of *facial flow* has suggested that canting or shifting of the midline is acceptable if it follows the facial flow (**Fig. 17**). The direction that the facial flow points toward is called the green side. Angulation of the midline or shifting toward the green side is less noticeable, resulting in a blended-in effect. If the midline is shifted or canted toward the opposite direction (red side), greater visual tension occurs, resulting in an unesthetic smile.[12]

h. Tooth color and anatomy
   i. *Color:* studies have shown that brighter tooth shade significantly increased the attractiveness of a smile. Moreover, it was reported that women preferred lighter shades than men. Therefore, the current recommendation is to whiten teeth to a lighter shade before cosmetic procedures.[46] Furthermore, biomimetic dentistry advocates the use of minimally invasive restorations such as contact lens veneers with greater translucency, thus the stump shade would have greater effects on the final shade of the smile.
   ii. *Anatomy:* several anatomic components affect the shape of the smile (**Fig. 18**):[16]

Fig. 17. Facial flow: the green side is the side that the dental midline can "flow" toward. A midline shift toward the red side is more noticeable.

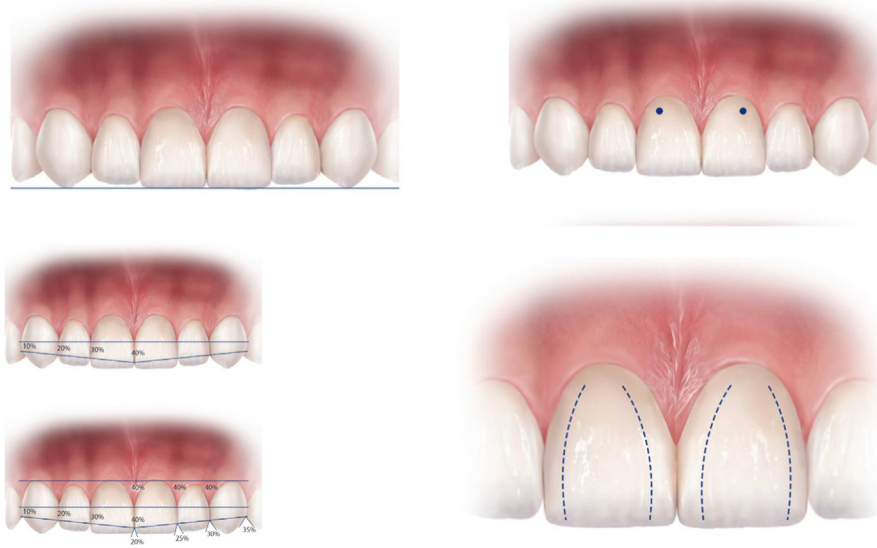

Fig. 18. Teeth anatomy fundamentals in modern smile design. (*From* Levine JB, Finkel S. Smile Design Integrating Esthetics and Function. Vol Volume Two. (Levine JB, ed.). ELSEVIER; 2016.)

1. Line angles: these give the general outline of the teeth and control the width. Altering the line angles can make a tooth look wider or narrower.
2. Height of contour: located distal to the midline in the gingival third. Anterior maxillary teeth have 3 planes.
3. Contacts: contact areas start at 40% at the midline and decrease distally. Contact points move more apically as in a distal direction.
4. Incisal embrasures: incisal embrasures increase gradually as we move distally starting at 20% of the tooth height at the midline to 35% at the distal of the canines.
5. Incisal edge: incisal edge anatomy and translucency are essential in creating a more natural smile. Younger patients have more defined incisal edges with mamelons. The opalescence that is seen at the incisal edge must be created in restorations to avoid the artificial look.
6. Texture: microtexture: these are developmental grooves that are found in younger teeth and usually run horizontally. Macrotexture refers to lobes that divide the facial surface of teeth into distinct concavities and convexities.[9]
7. Tooth shape: different concepts have been proposed to aid in the selection of tooth shapes and forms. Leon Williams proposed that the shape of the maxillary anteriors should match the face form. The 3 proposed shapes were square, triangular, and ovoid.[47] Contemporary teeth selection has focused on incorporating a patient's personal identity and facial features to create a more personalized smile.[18] Gurel and colleagues created the VIS, which developed an association between esthetics, function, artistic visual language, facial recognition, and personality typology to develop 4 smile design types outlined as follows:
   a. Strong: composed of mainly rectangular shapes, strong dominance
   b. Dynamic: triangular shapes, standard dominance
   c. Delicate: oval shapes, medium dominance.
   d. Calm or stable: smoothly rounded square with weak dominance
8. Teeth library: historically, the anatomy of restorations depended on the laboratory technician fabricating the case and their comfort level. Digital dentistry has opened the possibility for infinite libraries, shapes, and molds of teeth. In addition, patients can select and visualize a tooth library before fabrication; this is one of the main principles of DSD. In addition, digital dentistry allows us to "copy" natural libraries from one patient and "paste" them into another. This copy-paste concept was developed by Dr Christian Coahcman and emphasizes the use of natural teeth library to create a natural-looking smile, rather than using artificial libraries.

Clinical tip: all the following lead to aging of the smile and should be avoided during smile design[18]:

- Flattened incisal edges
- Smaller incisal embrasures
- Smoother facial texture
- Prominent mandibular display
- Increase chroma
- Anterior splaying

Contemporary Treatment Planning and Smile Design

So far, we have focused on the fundamentals of smile design. As suggested in the previous section, smile design is interdisciplinary. A practitioner who just focuses on

esthetics without an understanding of airway, function, structure, and biology will always fail in treating most smile design cases. Patients who report for smile makeovers usually have complicated cause that has resulted in the unesthetic outcome presented. Therefore, the modern smile design team should consist of general practitioners and specialists with interdisciplinary knowledge.

Several interdisciplinary treatment planning concepts have been developed over the years. Dr Roblee proposed the *interdisciplinary dentofacial therapy (IDT) model*.[48] Dr Roblee defines *IDT* as a synergist relationship "between" specialties rather than each specialty acting independently (multidisciplinary). The IDT model has evolved to the more contemporary model called mature IDT. Mature IDT focuses on an evidence-based approach with common goals and cloud-based communication. Communication had been the biggest challenge when dealing with these cases. The development of DSD and asynchronous communication by Dr Christian Coachman has revolutionized the treatment of these interdisciplinary cases.[49]

Another interdisciplinary treatment planning concept is the *facially generated treatment planning (FGTP)* approach proposed by Dr Frank Spear and Dr John Kois.[50] Traditional treatment planning focused on collecting data and findings through a comprehensive diagnostic approach with casts, radiographs, and a clinical examination to develop a treatment plan; this is an "inside-out" approach, starting with the biology, structure, function, and then esthetics of the teeth. As a result, the esthetic result was frequently compromised, as the end result could not be visualized ahead of time. Think about trying to put pieces of a puzzle together without knowing what the outcome should look like. Furthermore, the esthetic result relied primarily on the orodental complex without much attention to the face.

FACIALLY GENERATED TREATMENT PLANNING

The Great Pyramids of Giza are some of the wonders of the world that took 30 years each to build. Imagine the ancient Egyptians inspecting the structure of each block and stacking them one by one without having an end goal. Thirty years later they decide they did not like the final result. That is how inside-out treatment planning works (**Fig. 19**). The ancient Egyptians used an "outside-in" approach, where they visualized an end result, then reverse-engineer the construction. Frank Spear and John Kois were the first to adopt this "outside-in" approach to treatment planning.[50] The logic stemmed from the popular saying by Dr Peter Dawson: "If you know where are and know where you want to go, getting there is easy."[16] In essence, you need to know what the puzzle looks like before putting the pieces together. FGTP starts with the end in mind with emphasis on facial and dental *E*sthetics followed by *F*unction, *S*tructure, and *B*iology (EFSB system).[51] More recently, *A*irway has been added to the equation, where airway has become the first step in FGTP (AEFSB system) (**Fig. 20**). Instead of expanding the smile with veneers and camouflaging a constricted maxilla, expanding the airway with orthodontics would result in ideal esthetics while addressing airway issues resulting in a healthier outcome.[52] Linking esthetics to health emphasizes the newly discovered importance of ideal smile design in achieving overall health.

- *Airway phase:* this starts with the examination of the airway before deciding on the position of the teeth. The first step is a sleep questionnaire such as the Epworth Sleeping Scale (ESS), Berlin, or the Wisconsin sleep questionnaire.[53] A proper examination is needed that includes body mass index, craniofacial morphology, tongue, and pharyngeal size, palatine tonsils, and teeth wear patterns. Once airway involvement is suspected, several screening tools are

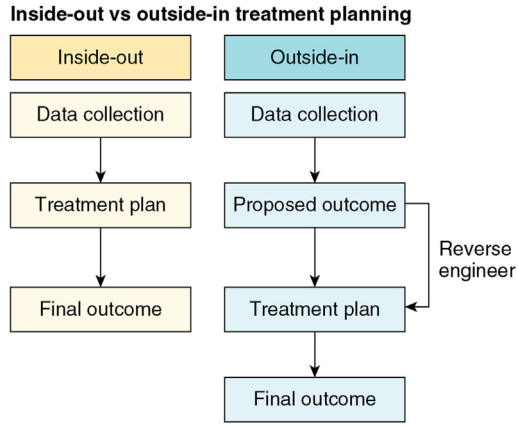

Fig. 19. Inside-out treatment planning versus outside in treatment planning.

recommended by Dr Jeff Rouse, such as high-resolution pulse oximetry (HRPO) for 2 to 3 days, which measures oxygen desaturation and pulse rate changes. If apnea is suspected, the patient is referred to a physician to diagnose sleep apnea. Several treatment interventions are available to expand the airway as part of interdisciplinary treatment, such as surgically facilitated orthodontic therapy, miniscrew-assisted palatal expansion, or orthognathic surgery. These interventions lead to changes in teeth position and affect the smile frame. As a result, this model suggests that it is important to rule out airway issues before smile design.

- *Esthetic phase:* this phase consists of 8 steps based on the guidelines discussed earlier in this article:
  - *Central incisal edge position:* determine the position of the incisal edge in full smile and repose in a vertical position.
  - *Maxillary incisor inclination:* determine the labial inclination of the maxillary incisors.
  - *Maxillary occlusal plane:* determine the position of the rest of the maxillary teeth relative to esthetics.
  - *Gingival levels*: determine ideal gingival levels using the width and length proportions of each tooth and gingival displays as a guide.
  - *Mandibular incisor edge position*: determine the position of the mandibular incisor edge relative to the maxillary arch.
  - *Mandibular incisor occlusal relationship*: set the mandibular incisal edge against the lingual of the maxillary incisors; this determines the OVD.
  - *Mandibular occlusal plane:* the remaining mandibular teeth are set at the established OVD in the intercuspal position.
  - *Mandibular Gingival Levels:* Determine the position of the mandibular gingiva relative to appropriate tooth dimensions.
- *Functional phase:* the goal of this phase is to integrate the esthetic analysis with a functional occlusion. This phase consists of 3 steps:
  - *Joint signs and symptoms:* evaluation of the temporomandibular joint (TMJ) function and movement.
  - *Muscle pain and tenderness:* evaluation of muscles for signs of tenderness and pain.

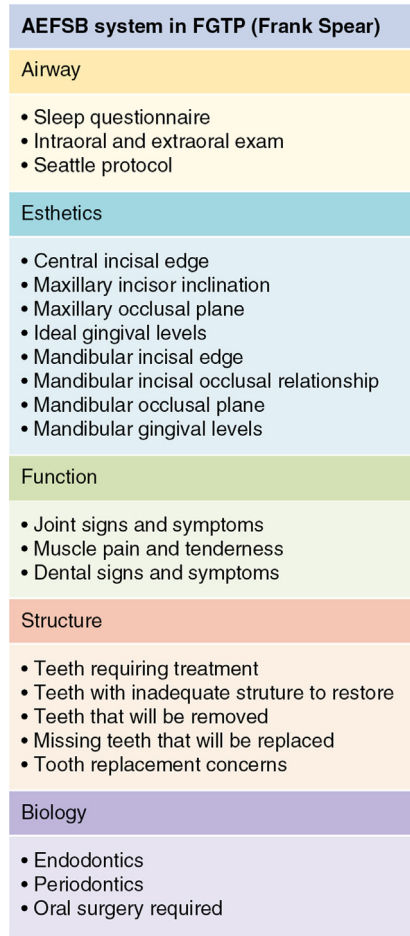

Fig. 20. AEFSB system in facially generated treatment planning.

- *Dental signs and symptoms:* evaluation of signs of wear, fractures, sensitivity, and cracks.

- *Structural phase:* during this phase, the clinician determines the following:
  - Teeth that require treatment
  - Teeth with inadequate structure to restore
  - Teeth that will be removed
  - Missing teeth that will be replaced
  - Tooth replacement concerns
- *Biological phase*: At the biological phase, the clinician takes into consideration endodontic therapy and periodontal care and oral surgery. The 3 steps for this phase are as follows:
  - Endodontics
  - Periodontics
  - Oral surgery.

GLOBAL DIAGNOSIS

In 2016 Robbins and Rouse established a model to address gingival display[7]. They concluded that even though the incisal edge position generated by FGTP was ideal, the final result may be unsatisfactory in some cases due to excessive gingival display. They developed the *Global Diagnosis* approach that focuses on the "gummy smile."[7] The 4, 5, 6 concept states that there are *(4) global diagnoses* for interdisciplinary treatment planning, *(5) core questions* to determine the diagnosis, and *(6) treatment options* (**Fig. 21**).

- The 4 global diagnoses:
  1. *Upper lip*: short/long or hypermobile/hypomobile
  2. *Clinical crowns:*
     - Short: microdontia, incisal wear or altered passive eruption
     - Long: recession
  3. Dentoalveolar extrusion (DAE)
  4. Skeletal discrepancy: vertical maxillary excess, vertical maxillary deficiency, angle class II or class III malocclusion
- *The 5 core questions*:[7]
  1. "What are the facial proportions?"
     - Normal middle:lower face is 1:1
  2. "What are the length and mobility of the upper lip?"
     - Normal lip length: 20 to 22 mm in women and 22 to 24 mm in men.
     - Normal lip mobility during smile: 6 to 8 mm in full smile.
  3. "What is the relationship between gingiva levels and the horizon?"
     - Straight line from canine to canine with centrals on the line and laterals 1 to 2 mm below the line
  4. "What is the length of maxillary central incisors?"
     - 10 to 11 mm
  5. "Is the cementoenamel junction (CEJ) palpable in the sulcus?"
     - CEJ should be detected in the sulcus

Once the dentist answers the 5 core questions, a Global Diagnosis can be made. In this section*, all 5 cores questions are assumed normal except for the one discussed.* It is possible that several variables can be affected in which case several Global Diagnoses would be considered.

1. *Vertical maxillary excess:* the patient has a longer lower face compared with the middle third. If the patient has a shorter lower face compared with the middle third, the diagnosis is *vertical maxillary deficiency.*
2. *Short upper lip*: the patient's lip is shorter in length than the standards discussed earlier*. Long upper lip*: the patient's lip is longer than the standards shown earlier (**Fig. 22**).
3. *Hypermobile upper lip:* the patient's lip moves more than 6 to 8 mm in full smile. If the patient's lip does not move 6 to 8 mm in full animation then the diagnosis is *hypomobile upper lip*
4. *Dentoalveolar extrusion:* in this case, the patient's gingiva is concave when drawing a line from canine to canine. The maxillary central incisors do not fall on the straight line. All other variables are normal, including palpation of the CEJ (**Fig. 23**).
5. *Microdontia:* the patient has smaller teeth than the norms discussed earlier. The CEJ is palpable, and there is no wear.
6. *Incisal attrition:* the patient has short teeth, CEJ is palpable, and there is incisal edge wear.

Global diagnosis (Robbins and Rouse)

4 Global diagnoses	5 Core questions
• Upper lip ° Short/long ° Hypermobile/hypomobile • Clinical crowns ° Short microdontla, Incisal wear, APE ° Long • Dentoalveolar extrusion • Skeletal discrepancy: VME, VMD, class II, class III malocclusion	1. Facial proportions? 2. Length and mobility of upper lip? 3. Gingival level VS horizon? 4. Length of maxillary centrals? 5. CEJ location?

6 Treatment Options	
• Orthognathic surgery ° Diagnosis VME. VMD. class II or III malocclusion • Plastic surgery: ° Diagnosis short/long upper lip, hypermobile/hypomobile upper lip • Orthodontics: ° Diagnosis: dentoalveolar extrusion ° Class II or III malocclusion	• Restorations: ° Diagnosis: microdontia, incisal attrition • Crown lengthening ° Diagnosis: altered passive eruption, dentoalveolar extrusion • Connective tissue grafting: ° Diagnosis: long clinical crown

Fig. 21. Global diagnosis concept.[4–6]

7. *Altered passive eruption:* the patient has short teeth, CEJ cannot be detected in the sulcus, and usually there is no wear on the incisal edge (Fig. 24).
8. *Recession:* the patient's teeth are long, and the CEJ is visible
   - The 6 treatment options:
     1. Orthognathic surgery:
        - Global Diagnosis: VME
          - Primary treatment: maxillary Le Fort I impaction
          - Alternative treatment: Botox
          - Alternative treatment: crown lengthening and restorative dentistry.
        - Global Diagnosis: VMD: maxillary downfracture, bilateral sagittal split osteotomy (BSSO)
        - Global Diagnosis: angle class II or class III malocclusion
          - Primary Treatment: orthognathic and orthodontics.
     2. Plastic surgery:
        - Global Diagnosis: short upper lip
          - Primary treatment: Botox and lip fillers
          - Secondary treatment: behavior modification.
        - Global Diagnosis: long upper lip
          - Primary treatment: lip lift
        - Global Diagnosis: hypermobile upper lip
          - Primary treatment: Botox

Fig. 22. Long upper lip resulting in no incisal edge display.

- Secondary treatment: plastic surgery, behavior modification
- Global Diagnosis: hypomobile upper lip:
  - Primary treatment: Botox of depressor muscles

3. Orthodontics:
   - Global Diagnosis: dentoalveolar extrusion
     - Primary treatment: orthodontic intrusion, restorative dentistry
   - Global Diagnosis angle class I or class II malocclusion.
     - Primary treatment: orthodontics, orthognathic if needed.
4. Restorations
   - Global Diagnosis: microdontia.
     - Primary treatment: restorative such as veneers, crowns, or composites
   - Global Diagnosis: incisal attrition.
     - Primary treatment: restorative such as veneers, crowns, or composites
5. Crown lengthening:
   - Global Diagnosis: altered passive eruption
     - Primary treatment: esthetic crown lengthening is completed from facial line angle to line angle 3 mm apical to the CEJ.
   - Global Diagnosis: dentoalveolar extrusion
     - Primary treatment: functional crown lengthening is performed to correct the concave gingiva followed by restorative dentistry.
6. Connective tissue grafting:
   - Global Diagnosis: long clinical crown
     - Primary treatment: soft tissue grafting to correct the recession
     - Secondary treatment: restorative dentistry with pink porcelain if needed

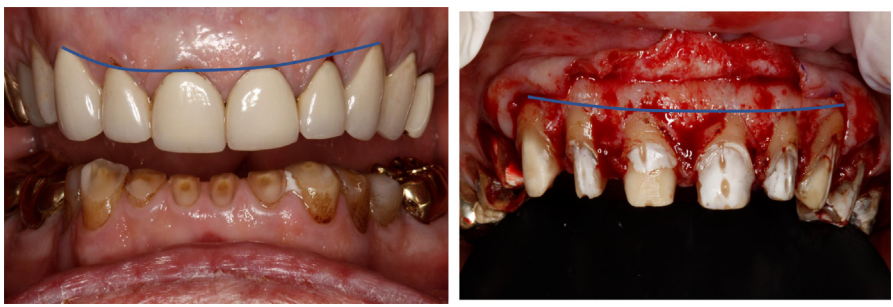

Fig. 23. U-shaped gingiva and bone in dentoalveolar extrusion of maxillary anterior teeth. Treatment is functional crown lengthening.

Fig. 24. Altered passive eruption treated with esthetic crown lengthening.

It is important to note that alternative treatment plans can be proposed if the patient does not want to proceed with the "ideal" plan, especially in the case of orthognathic surgery. Even though a La-Forte 1 might be indicated, an alternative plan such as crown lengthening, Botox, and restorative might be enough to address the patient's esthetic concern; this is the power of digital planning, where the patient can visualize the end result of several plans and mock-ups and go with an informed decision. As with all treatment plans, the pros and cons need to be discussed with the patient. Care should be taken not to compromise the final result when selecting an alternative plan.

SMILE DESIGN TREATMENT PLANNING

Rationale: the 2 treatment planning concepts outlined earlier provide the practitioner with very powerful tools to guide planning advanced interdisciplinary cases. It is the authors' opinion that these 2 concepts can be merged into a more inclusive comprehensive treatment plan philosophy focused on the concepts of *Digital Smile Design* with *Global Diagnosis* and *FGTP*. This proposed concept is termed *Smile Design Treatment Planning (SDTP)* and provides the practitioner with a treatment sequence when dealing with smile design cases. Once the ideal smile is designed, the clinician uses the decision trees discussed later to decide treatment options. Because of the novelty of this concept, changes will be made in the future to address emerging concepts.

Nine steps for SDTP:

1. Data acquisition phase
2. Airway analysis
3. Facial analysis
4. OVD and TMJ analysis
5. Lip analysis
6. Dental analysis
7. Gingival analysis
8. Mandibular arch and occlusal analysis
9. Virtual treatment analysis

- Step 1: data acquisition phase:
  - *Phase summary:* during this phase, the clinician collects diagnostic data for case analysis. These data are used to construct a virtual patient for digital treatment planning. An *SDTP* checklist is also used to provide clinical data (Fig. 25).
  - *Requirements:*

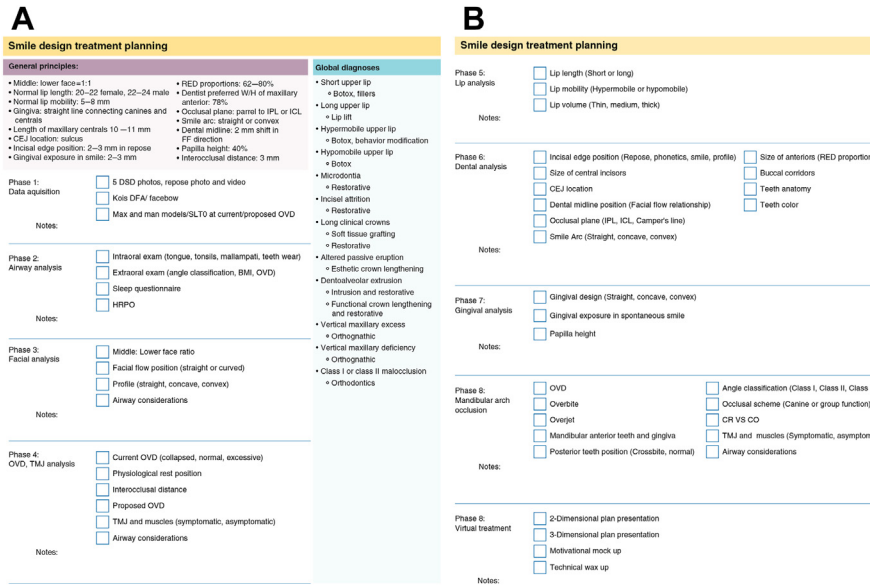

Fig. 25. SDTP checklist.

- 5 DSD photos: frontal smile with teeth apart, frontal retracted with teeth apart, profile at rest, profile at smile, and 12 o'clock smile view[54]
- Repose picture at physiologic rest position (PRP)
- Video of the patient in repose, full smile, spontaneous smile, phonetics
- Kois Dento-Facial Analyzer or digital facebow.
- STLs at current OVD and proposed OVD
- SDTP checklist.

Optional data: facial scan, cone beam computed tomography (for implant planning, guided crown lengthening), cephalometric (orthognathic, orthodontics, and airway analysis), Viewing/Design Software—DSD, Smilefy, Exocad, 3Shape Trios, BlueSky-Bio (Free), MeshMixer (Free)—or other applicable alternatives.

- Step 2: airway analysis
  - *Phase summary:* during this phase, the dentist screens the patient for possible airway involvement. This involves an extraoral and intraoral clinical examination, sleep questionnaire, and possible use of HRPO if airway issues are suspected (discussed earlier). OVD is also assessed at this phase and whether the airway would benefit from increasing the OVD. Airway analysis is also integrated into some of the following steps. Possible airway changes must be considered in each step of SDTP.
- Step 3: facial analysis (**Fig. 26**)
  - *Phase summary:* during this phase, the face is analyzed in repose at PRP in profile and frontal view. Global diagnosis rules are followed.
    - In the frontal view: if the middle:lower face is 1:1 then face proportions are normal. If the lower third is longer then the diagnosis is VME, and the primary treatment is La-Forte 1 impaction. If the middle face is longer then the diagnosis is VMD, and the primary treatment is maxillary downfracture, BSSO.[7]

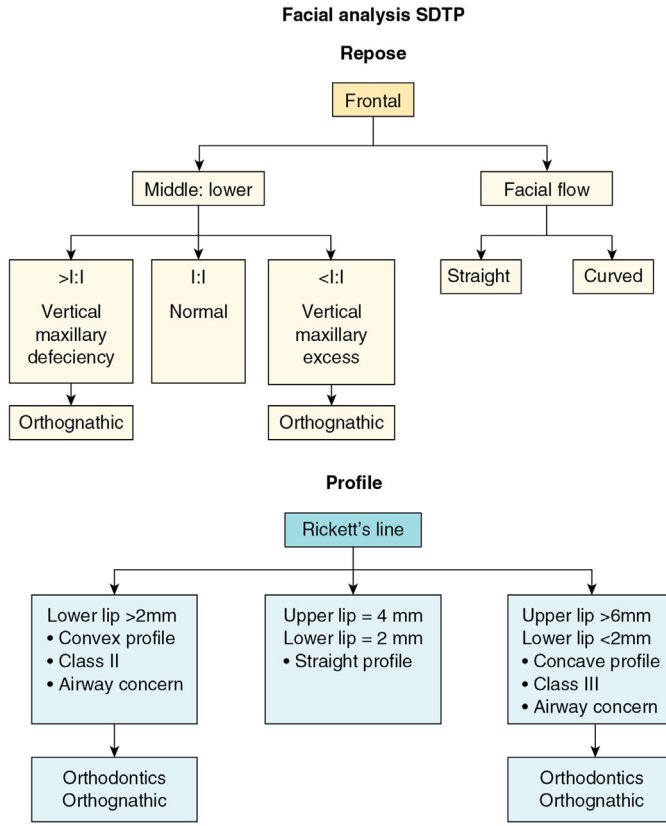

Fig. 26. Facial analysis in SDTP and treatment options.

- The facial flow is also analyzed in this view and decided whether it is perpendicular or curved.
- In profile, Rickett's line is used as a reference. If the lower lip is greater than 2 mm posterior, then the face is convex, and the patient is class II. The dentist should be aware of possible airway issues in class II patients due to decreased airway volume.[55] In addition, if the OVD is increased, care should be taken whether to restore the patient in centric relation (CR) or centric occlusion (CO). Restoring a class I or class II patient in CR could worsen airway issues by decreasing airway volume due to the posterior reposition of the mandible. An airway analysis should be conducted with provisional restorations or splint at an open OVD if CR will be used to examine airway volume.[56] If the lower lip is less than 2 mm posterior to the line, then the face is concave (class III), and orthodontics and orthognathic surgery should be considered. Opening the OVD could improve the overbite/overjet relationship for these patients. In some class III patients, the maxilla is deficient and airway volume is decreased.[57]

- *Step 4: OVD and TMJ analysis* (**Fig. 27**)
  - *Phase summary:* once facial and airway analysis is complete, the clinician can now assess the patient's OVD. There are several methods to determine the PRR and OVD.[58] Facial esthetics can be used as a guide to determine the

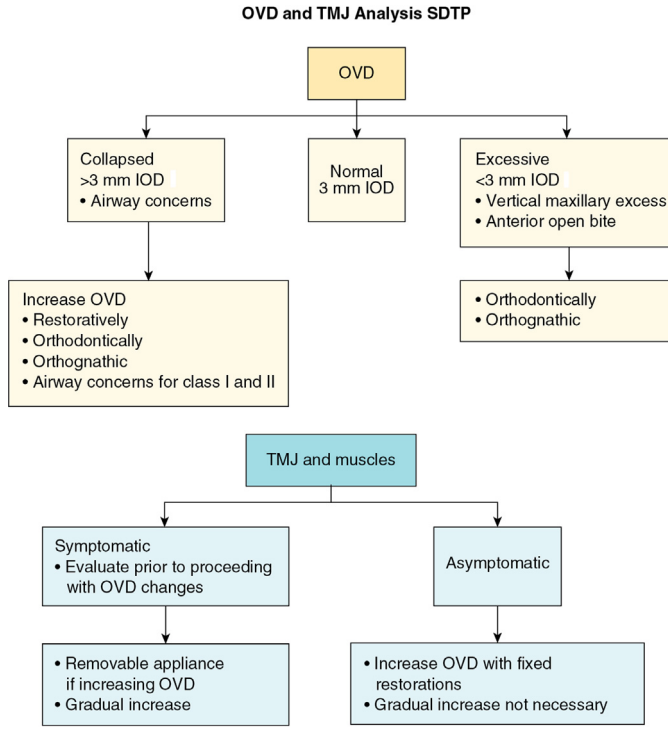

Fig. 27. OVD and TMJ analysis in SDTP and treatment options.

OVD. The accepted interocclusal distance (IOD) is 3 mm but can be a range as noted in a recent study.[59] If the patient has greater IOD, the clinician can use several methods to determine a new OVD such as splint or leaf gauge. The clinician also needs to take into consideration the airway and the patient's Angle classification as discussed earlier. If the OVD is excessive such as in cases of anterior open bite or VME, then orthognathic surgery and orthodontics are recommended to decrease OVD. TMJ and muscles also need to be assessed during this phase. There is strong clinical evidence that the stomatognathic system can adapt to changes in OVD.[59] However, care should be taken on patients with existing TMD when considering changing the OVD. TMD and muscle issues should be addressed prior. It is also recommended to use a removable appliance to increase the OVD gradually before considering irreversible procedures.[60]

- *Step 5: lip analysis* (**Fig. 28**)
  - *Phase summary:* during this phase, the length, volume, and mobility of the lip are analyzed.
    - Lip length: normal lip length is 20 to 22 for women and 22 to 24 for men. A short lip is to be treated with Botox, whereas a long lip can be treated with a lip lift procedure.
    - Lip mobility: normal mobility is 6 to 8 mm. A hypermobile lip is treated with Botox, whereas a hypomobile lip can be treated with Botox and smile exercises.
    - Lip volume: thin lips are treated with lip fillers.

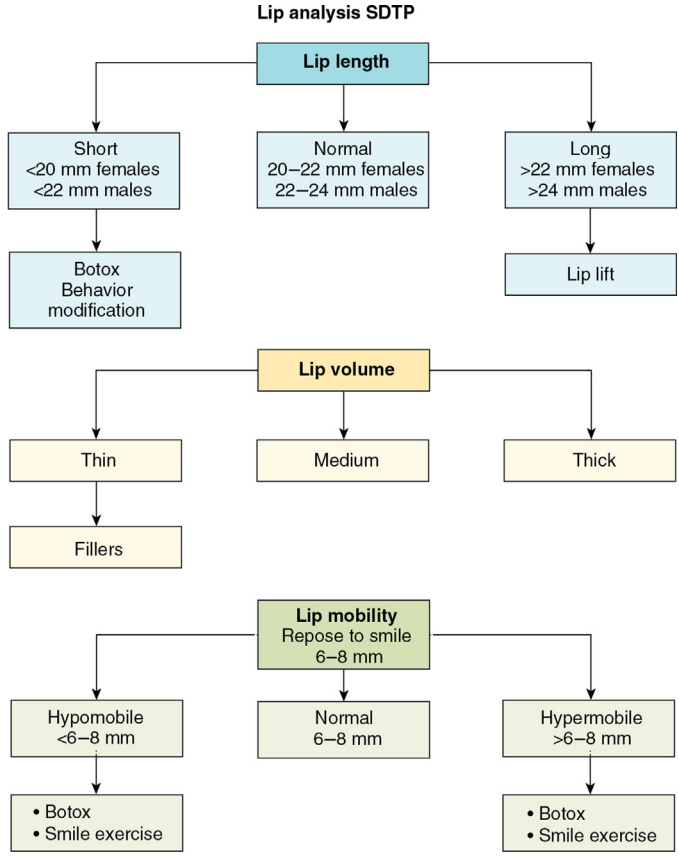

Fig. 28. Lip analysis in SDTP and treatment options.

- Step 6: dental analysis
  - *Phase summary:* during this phase, the position, size, midline, occlusal plane, smile arc, shape, and color are established.
    - Incisal edge position: In a patient with normal lip length and facial proportions the maxillary central incisal edge position is analyzed in repose. In the frontal position, there should be 2 to 3 mm of the incisal display. Phonetics is also used to analyze incisal edge position. The normal position is for the incisal edge to touch the wet-dry border during F sounds. If the incisal display is greater or less, then orthodontics or restorative are considered to correct the position. In the profile view: the nasolabial angle is assessed to evaluate the anterior-posterior position of the maxillary centrals. The normal angle is 90° to 95° in men and 95° to 115° in women. A wider angle or narrower angle can be corrected with orthodontics or restorative (**Fig. 29**).

The following are analyzed in full spontaneous smile with the following assumptions. Any variations need to be taken into consideration.

- Normal lip mobility
- Normal facial proportions
- CEJ is detected in the sulcus. If not, the Global Diagnosis is APE and gingival analysis should be completed first.

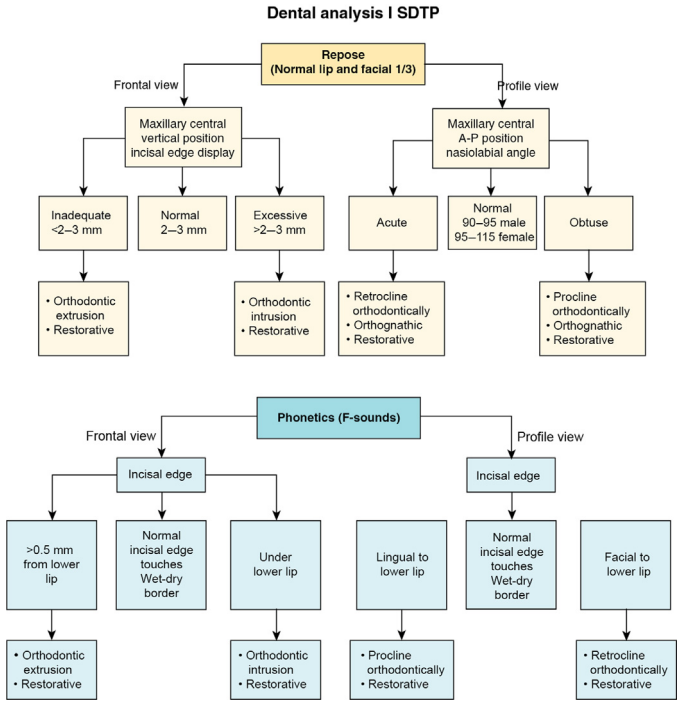

Fig. 29. Incisal edge position analysis, facial analysis phase of SDTP.

- Size of maxillary centrals: the average size is 10 to 11 mm. Short teeth indicate microdontia or incisal wear and are treated restoratively. Longer teeth with exposed CEJ are treated restoratively or with soft tissue grafting (**Fig. 30**).
- Dental midline position: once the centrals are set, the dental midline is analyzed in reference to the facial flow. Up to 2 mm deviation is considered esthetic. If the flow is straight, the midline should be parallel. In cases where the flow is curved, the midline angulation should flow in the same direction as the flow toward the green side. Deviations can be treated with orthodontics or restorative (see **Fig. 30**).
- Occlusal plane: the horizontal plane should be set parallel to the IPL. In cases where the IPL and ICL are not parallel, the ICL is recommended. The transverse plane is set parallel to Camper's line. Variations are treated with orthodontics, orthognathic, or restorative (see **Fig. 30**).
- Smile arc: straight or convex smile arcs are recommended. If a more dominant smile is desired, the incisal step between the laterals and the centrals is made to be steeper. The smile arc should follow the lower lip. In the case of a concave smile arc, the treatment options are extrusion of the incisors with orthodontics or restorative dentistry to make the teeth longer. The clinician must consider how this would affect OVD, overjet, overbite, incisal edge display in repose, and envelop of function as discussed later (see **Fig. 30**).
- Size of anterior teeth: once the size of the maxillary centrals is established, the RED proportions and Chu guidelines are used to decide on the size of the remaining anterior teeth. The RED proportions vary between 62% and 80% depending on the gender and size of the patient. If the teeth are wider than

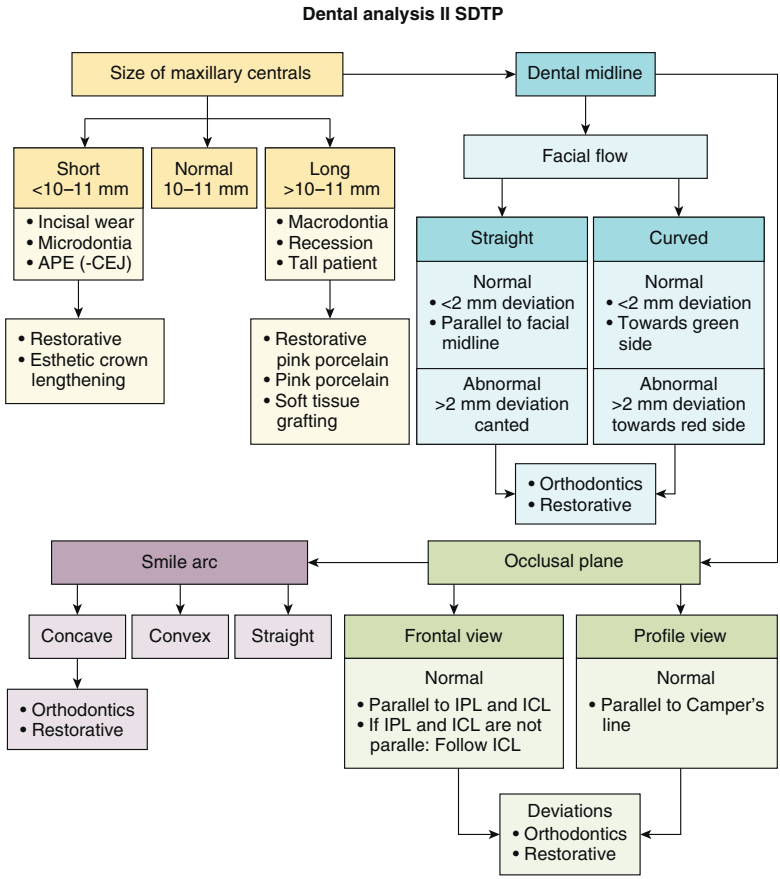

Fig. 30. Size of maxillary centrals, position of dental midline, occlusal plane orientation, smile arc position. Facial analysis phase of SDTP.

desired, orthodontics or restorative options are considered. If the teeth are narrower than desired and diastemas are present, restorative options can be used to close the contacts. If diastemas are absent, that means that the maxillary arch is narrow, and the buccal corridors are wide. Decrease in airway volume is a concern in these situations, and palatal expansion is recommended (**Fig. 31**).

- Tooth anatomy: the anatomy of teeth is then decided with variables such as line angles, contact length, height of contour, embrasures, texture, and shape. A natural or artificial library can be used (see **Fig. 31**).
- Tooth color: the color of the teeth is altered either by bleaching protocols or by restorative options. In cases of dark teeth that will be restored with translucent ceramics, the stump shade needs to be identified (see **Fig. 31**).

- *Step 7: gingival analysis* (**Fig. 32**)
  - *Phase summary:* once the teeth are set, the gingival architecture is analyzed. If the gingiva is convex when connecting the maxillary anteriors and the maxillary centrals are in the correct position, there is either recession of the maxillary incisors that needs to be treated with soft tissue grafting or APE that can be treated with esthetic crown lengthening. If the gingiva is concave, the

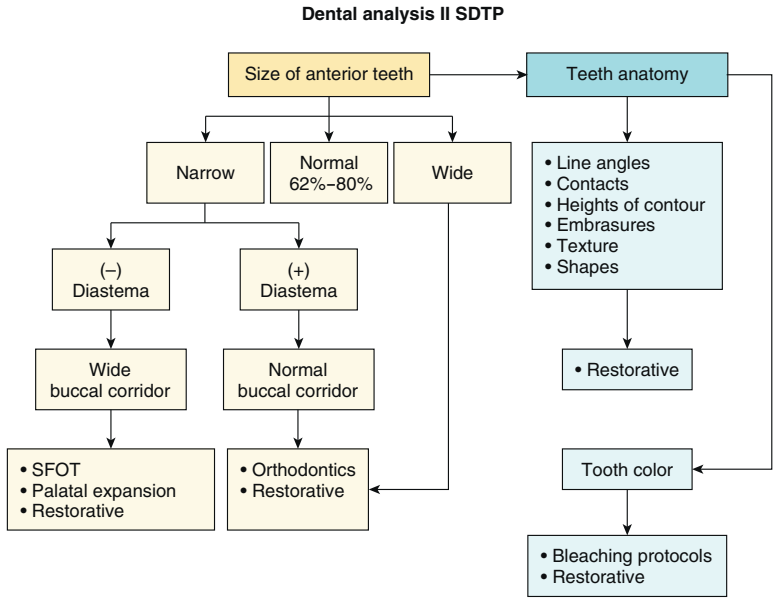

Fig. 31. Size of anterior teeth, tooth anatomy, tooth color, facial analysis phase of SDTP.

diagnosis is DAE, and the treatment options are orthodontic intrusion or functional crown lengthening and restorative. Gingival exposure in full smile should be *2 to 3 mm.* Excessive gingival exposure can be due to hypermobile lip, short lip, VME, or APE if CEJ is not detectable. If gingival exposure is deficient, reasons could be long lip, hypomobile lip, VMD, or recession. Treatment options for these have been described earlier. Papillary height ideally is 40%. If it is more than 40%, crown lengthening and changing the shape of the teeth can be done if desired. If papilla height is less than 40% and black triangles are present: longer contacts are recommended. If black triangles are absent, then changing the shape of the teeth and soft tissue grafting may lead to an increase in height of the papilla.

- *Step 8: mandibular arch and occlusion analysis*
  - *Phase summary:* once the maxillary arch is set, the mandibular arch and occlusion are established.
    - Mandibular incisal edge is decided at the proposed vertical from step 4. If the overbite is excessive, then the OVD needs to be increased or orthodontics or orthognathic surgery is considered. If the overbite is reduced, the clinician should consider reducing the proposed OVD if possible while considering the airway. If restorative space is needed, then orthodontics or orthognathic surgery should be considered. For class I and class II patients, increasing the OVD will increase the overjet, resulting in bulkier lingual restorations of the maxillary anteriors or longer restorations on the mandibular anteriors to obtain coupling.[58] Longer mandibular anterior crowns can affect the envelope of function, anterior guidance, and esthetics. Steeper interincisal angles should be avoided to prevent functional and structural damage.[58] *As a general rule, increasing the OVD by 1 mm in the posterior decreases the overbite by 2 mm, and the overjet increases by 1.3 mm*[58] (**Fig. 33**).

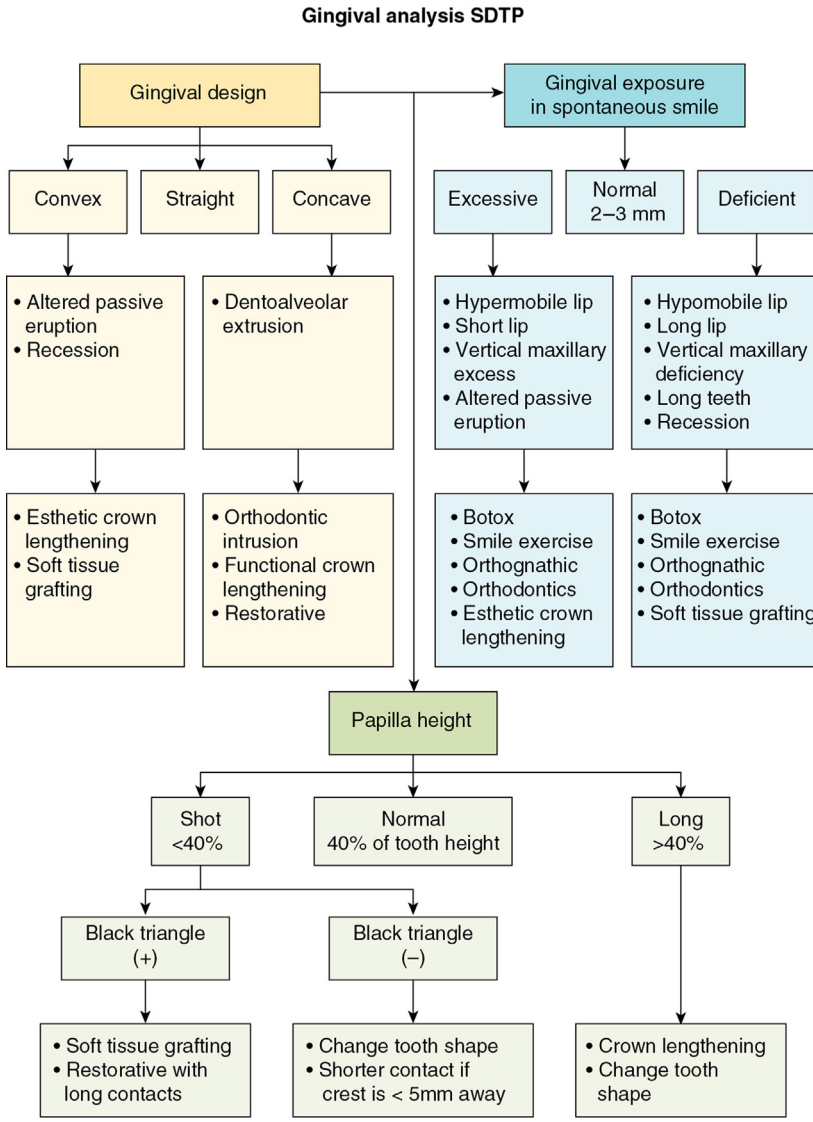

Fig. 32. Gingival analysis of SDTP.

- Guidance and occlusion: the guidance is then established to achieve anterior and canine guidance if possible. The mandibular posterior teeth are set in occlusion with the maxillary posterior at the correct OVD and Angle classification with mutually protected occlusion and no posterior interferences. In cases where canine guidance is not possible, group function can be considered to share the load.[61]
- Teeth shape and gingiva: the shape and size of the mandibular teeth are related to the maxillary teeth using Chu's guidelines. Moreover, the gingival architecture follows the same guidelines outlined earlier for the maxillary gingiva in terms of design. DAE is common in patients with sleep apnea or

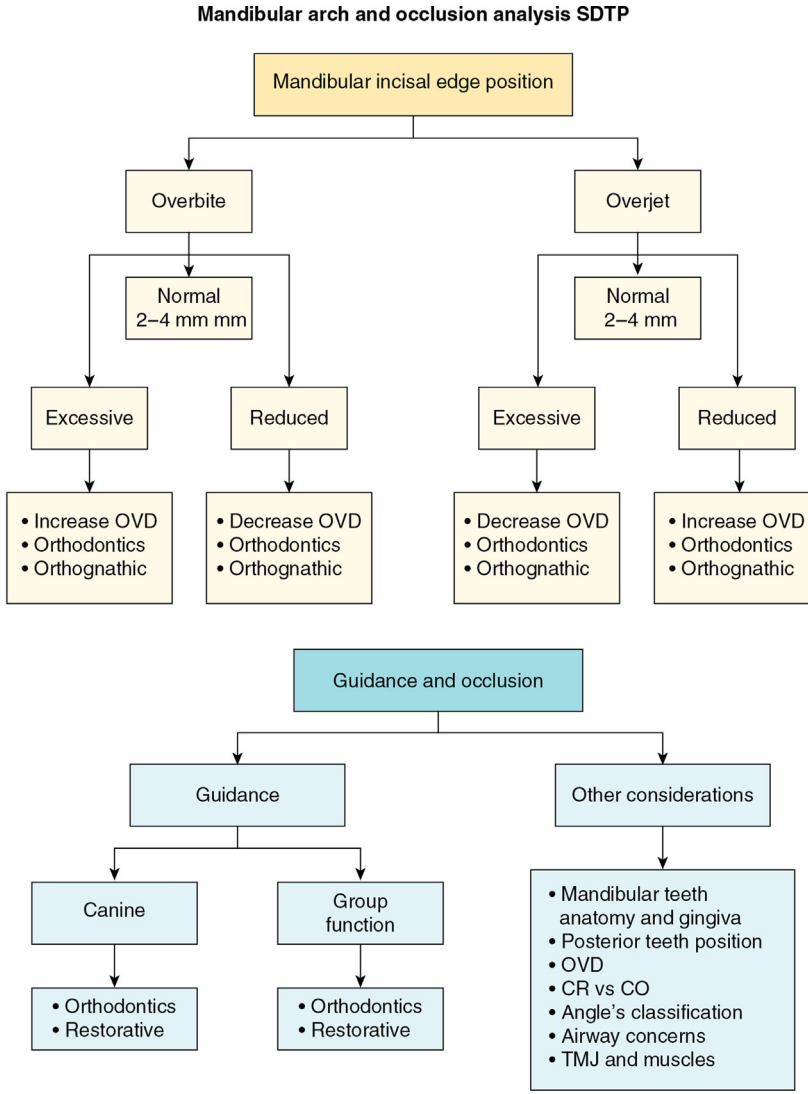

Fig. 33. Mandibular arch and occlusion analysis of SDTP.

patients with mandibular wear (Fig. 34). The treatment of choice is functional crown lengthening and restorative or orthodontic intrusion and restorative.

- *Step 9: virtual treatment phase* (Fig. 35)
  - *Phase summary:* once the virtual plan is established, the patient is presented with 2 plans. The 2-dimensional plan is based on a photographic mock-up using traditional applications such as PowerPoint or contemporary digital technology such as DSD, SmileFy, or Exocad. During this phase, the clinician involves the patient in step-by-step plan such as selection of teeth library, shape, sizes incisal edge display, gingival design, and other variables. The more powerful part of the virtual treatment is based on the 3-dimensional design with the

Fig. 34. Dentoalveolar extrusion of the mandibular anteriors. Patient treated with functional crown lengthening of lower anteriors and crowns.

diagnostic wax-up. Two types of wax-ups should be created: a motivational wax-up and a technical wax-up. The motivational wax-up is used to simulate the final result in the patient's mouth. This is an additive wax-up and can be used as a diagnostic tool by the dentist to evaluate occlusal plane, OVD, gingival display, and other variables. If the mock-up is subtractive, then a computer-simulated plan will have to be used instead. The technical wax-up is used

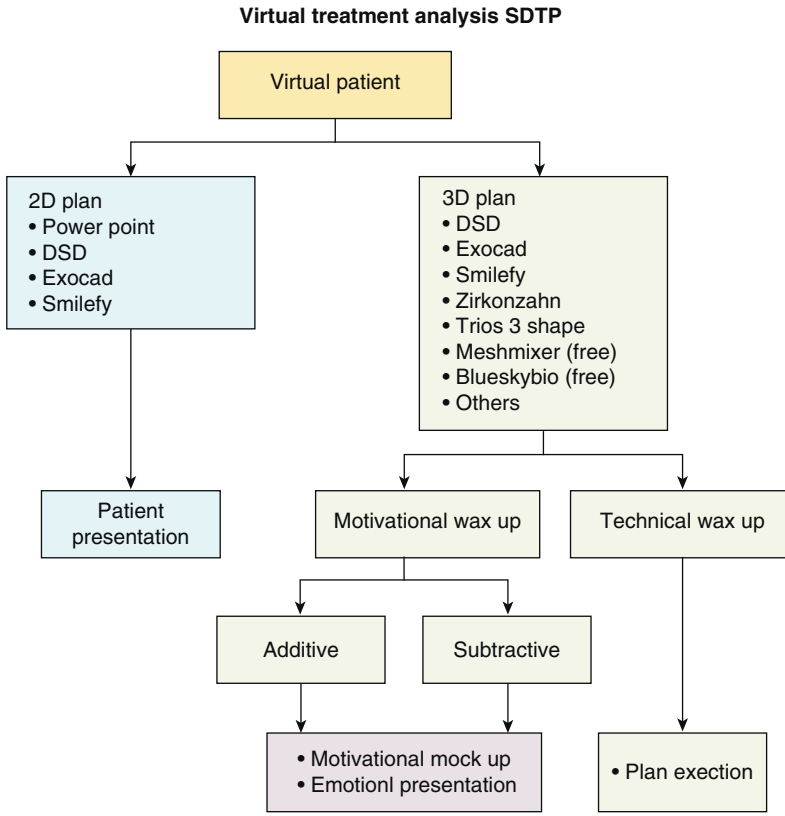

Fig. 35. Virtual treatment phase of SDTP.

when the actual treatment starts; this is not additive and is more anatomic. This step is explained in more detail when discussing DSD.[62]

SUMMARY

Smile design is an interdisciplinary process that requires a detailed understanding of the principles outlined earlier. A thorough understanding of treatment planning principles and options is essential when dealing with smile design cases. Digital technology has allowed us to improve our interdisciplinary capabilities and deliver a more predictable outcome with better quality control. In this book, each article discusses the specifics of different diagnoses and treatment options outlined in this article. The overall goal is to provide the smile designers with a comprehensive overview of treatment options when constructing a new smile.

CLINICS CARE POINTS

- Smile Design is multi-factorial and depends on a thorough understanding of all components of the smile: Face, gingiva, lips and teeth.
- Natural teeth libraries are more esthetic than artificial-looking libraries.
- Lip length and mobility affect incisal edge and gingival display.
- Facial midline can be curved or perpendicular. The midline should follow the facial flow.
- Incisal edge position is the most important factor in determining tooth position in smile design but is affected by lip dynamics.
- Different ratios can be used to determine the width of maxillary anteriors with the current trend focusing on a wider smile.
- Contemporary treatment planning starts with facial esthetics
- Airway analysis is a fundamental component of smile design.
- Global Diagnosis addresses different reasons for excessive gingival display and treatment options.
- Smile design treatment planning builds off of previous treatment planning models with emphasis on the use of digital dentistry to facilitate diagnosis and treatment planning.

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REFERENCES

1. Darwin C. In: Murray J, Street A, editors. The expression of the emotions in man and animals. 1872. Available at: https://pure.mpg.de/rest/items/item_2309885/component/file_2309884/content. Accessed February 8, 2022.
2. Harker L, Keltner D. Expressions of positive emotion in women's college yearbook pictures and their relationship to personality and life outcomes across adulthood. J Pers Soc Psychol 2001;80(1):112–24.

3. Beall AE. Can a new smile make you look more intelligent and successful? Dent Clin North Am 2007;51(2):289–97.
4. Davis NC. Smile Design. Dent Clin N Am 2007;51(2):299–318.
5. Machado AW. 10 commandments of smile esthetics. Dent Press J Orthod 2014; 19(4):136–57.
6. Mahn E, Sampaio CS, Silva BP da, et al. Comparing the use of static versus dynamic images to evaluate a smile. J Prosthet Dent 2020;123(5):739–46.
7. Robbins JW, Rouse JS. Global diagnosis A new vision of dental diagnosis and treatment planning, 4. Quintessence; 2016. https://doi.org/10.25241/stomaeduj.2017.4(3).bookreview.2.
8. Meiyappan N, Tamizharasi S, Senthilkumar KP, et al. Natural head position: An overview. J Pharm Bioallied Sci 2015;7(Suppl 2):S424–7.
9. Fradeani M. Esthetic rehabilitation in fixed prosthodontics, 1. Quintessence Publishing Co Inc; 2004. Available at: http://www.quintpub.com/display_detail.php3?psku=BI004#. Accessed February 13, 2022.
10. Arroyo-Cruz G, Orozco-Varo A, Vilches-Ahumada M, et al. Comparative analysis of smile aesthetics between top celebrity smile and a Southern European population. J Prosthet Dent 2021. https://doi.org/10.1016/j.prosdent.2021.03.019.
11. Silva BP, Jiménez-Castellanos E, Finkel S, et al. Layperson's preference regarding orientation of the transverse occlusal plane and commissure line from the frontal perspective. J Prosthet Dent 2017;117(4):513–6.
12. Silva BP, Mahn E, Stanley K, et al. The facial flow concept: an organic orofacial analysis—the vertical component. J Prosthet Dent 2018;121(2):189–94.
13. The glossary of prosthodontic terms ninth edition. J Prosthet Dent 2017;117(5): e1–105.
14. Priest G, Wilson MG. An evaluation of benchmarks for esthetic orientation of the occlusal plane. J Prosthodont 2017;26(3):216–23.
15. Mazurkiewicz P, Oblizajek M, Rzeszowska J, et al. Determining the occlusal plane: a literature review. Cranio 2019;1–7. https://doi.org/10.1080/08869634.2019.1703093.
16. Levine JB, Finkel S. Smile design integrating esthetics and function. vol. 2. Levine JB, editor. ELSEVIER; 2016;1:1–42.
17. Farias F de O, Ennes JP, Zorzatto JR. Aesthetic value of the relationship between the shapes of the face and permanent upper central incisor. Int J Dent 2010; 2010:561957.
18. Gurel G, Paolucci B, Lliev G, et al. The art and creation of a personalized smile: visual identity of the smile. Quintessence: VIS; 2019.
19. Sforza C, Laino A, D'Alessio R, et al. Soft-tissue facial characteristics of attractive italian women as compared to normal women. Angle Orthod 2009;79(1):17–23.
20. Stanley K, Caligiuri M, Schlichting LH, et al. Lip lifting: unveiling dental beauty. Int J Esthetic Dent 2017;12(1):108–14.
21. Fink B, Neave N, Seydel H. Male facial appearance signals physical strength to women. Am J Hum Biol 2007;19(1):82–7.
22. Roe P, Rungcharassaeng K, Kan JYK, et al. The influence of upper lip length and lip mobility on maxillary incisal exposure. Am J Esthetic Dentistry 2012.
23. Tosun H, Kaya B. Effect of maxillary incisors, lower lip, and gingival display relationship on smile attractiveness. Am J Orthod Dentofac 2020;157(3):340–7.
24. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 2. smile analysis and treatment strategies. Am J Orthod Dentofac 2003;124(2): 116–27.

25. Wang C, Hu W, Liang L, et al. Esthetics and smile-related characteristics assessed by laypersons. J Esthet Restor Dent 2018;30(2):136–45.
26. Crawford RWI, Tredwin C, Moles D, et al. Smile esthetics: the influence of posterior maxillary gingival margin position. J Prosthodont 2012;21(4):270–8.
27. Chu SJ, Tan JH, Stappert CFJ, et al. Gingival zenith positions and levels of the maxillary anterior dentition. J Esthet Restor Dent 2009;21(2):113–20.
28. Hochman MN, Chu SJ, Tarnow DP. Maxillary anterior papilla display during smiling: a clinical study of the interdental smile line. Int J Periodontics Restorative Dent 2012;32(4):375–83.
29. Salama H, Salama MA, Garber D, et al. The interproximal height of bone: a guidepost to predictable aesthetic strategies and soft tissue contours in anterior tooth replacement. Pract Periodontics Aesthet Dent 1998;. https://pubmed.ncbi.nlm.nih.gov/10093558/.
30. Al-Habahbeh R, Al-Shammout R, Al-Jabrah O, et al. The effect of gender on tooth and gingival display in the anterior region at rest and during smiling. Eur J Esthetic Dent 2009;4(4):382–95.
31. Gaikwad S. Influence of smile arc and buccal corridors on facial attractiveness: a cross-sectional study. J Clin Diagn Res 2016. https://doi.org/10.7860/jcdr/2016/19013.8436.
32. Pound E. Utilizing speech to simplify a personalized denture service. J Prosthet Dent 1970;24(6):586–600.
33. Proffit WR. Fields H.W.Sarver D.M.Contemporary orthodontics. 6th ed. Philadelphia, PA: Elsevier; 2018. p. 156–75.
34. Al-Johany SS, Alqahtani AS, Alqahtani FY, et al. Evaluation of different esthetic smile criteria - PubMed. Int J Prosthodont 2011;. https://pubmed.ncbi.nlm.nih.gov/21210007/.
35. Wolfart S, Thormann H, Freitag S, et al. Assessment of dental appearance following changes in incisor proportions. Eur J Oral Sci 2005;113(2):159–65.
36. German DS, Chu SJ, Furlong ML, et al. Simplifying optimal tooth-size calculations and communications between practitioners. Am J Orthod Dentofac 2016;150(6):1051–5.
37. Correa BD, Bittencourt MAV, Machado AW. Influence of maxillary canine gingival margin asymmetries on the perception of smile esthetics among orthodontists and laypersons. Am J Orthod Dentofac 2014;145(1):55–63.
38. Levin EI. Dental esthetics and the golden proportion. J Prosthet Dent 1978;40(3):244–52.
39. Mahshid M, Khoshvaghti A, Varshosaz M, et al. Evaluation of "Golden Proportion" in individuals with an esthetic smile. J Esthet Restor Dent 2004;16(3):185–92.
40. Ward DH. Proportional smile design. Dent Clin N Am 2015;59(3):623–38.
41. Reis PMP, Lima P, Garcia FCP, et al. Effect of maxillary median diastema on the esthetics of a smile. Am J Orthod Dentofac 2020;158(4):e37–42.
42. Prasad KN, Sabrish S, Mathew S, et al. Comparison of the influence of dental and facial aesthetics in determining overall attractiveness. Int Orthod 2018;16(4):684–97.
43. Cruz GA, Varo AO, Luna FM, et al. Esthetic assessment of celebrity smiles. J Prosthet Dent 2021;125(1):146–50.
44. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofac 2006;130(2):141–51.
45. Ferreira JB, Silva LE da, Caetano MT de O, et al. Perception of midline deviations in smile esthetics by laypersons. Dent Press J Orthod 2016;21(06):51–7.

46. Murro BD, Gallusi G, Nardi R, et al. The relationship of tooth shade and skin tone and its influence on the smile attractiveness. J Esthet Restor Dent 2020;32(1):57–63.
47. Kumar MV, Ahila SC, Devi SS. The science of anterior teeth selection for a completely edentulous patient: a literature review. J Indian Prosthodont Soc 2011;11(1):7–13.
48. Roblee RD. Interdisciplinary dentofacial therapy (IDT): a comprehensive approach to optimal patient care. Quintessence: Quintessence Publishing Co Inc; 1994.
49. Blatz MB, Chiche G, Bahat O, et al. Evolution of aesthetic dentistry. J Dent Res 2019;98(12):1294–304.
50. Spear Kokich FM, Mathews VG. Interdisciplinary management of anterior dental estheticsSpear. JADA 2006.
51. Sabbah A. An introduction to contemporary treatment planning.pdf. Metlife, ed. 2021. Available at: https://metdental.ecepartners.com/coursereview.aspx?url=1902%2FHTML%2FAn_Introduction_to_Contemporary_Treatment_Planning%2Findex.html&scid=15011. Accessed February 20, 2022.
52. Rouse J. Airway and 3D treatment planning - spear education. 2019. https://www.speareducation.com/spear-review/2019/11/airway-and-3d-treatment-planning. Accessed February 10, 2022.
53. Masoud AI, Jackson GW, Carley DW. Sleep and airway assessment: a review for dentists. Cranio 2016;35(4):206–22.
54. Yoshinga C. Yoshinga. DSD photo and video protocol. Available at: https://www.dsdplanningcenter.com/pdf/dsd-video-photo-protocol.pdf. Accessed February 20, 2022.
55. Kirjavainen M, Kirjavainen T. Upper airway dimensions in class II malocclusion. Angle Orthod 2007;77(6):1046–53.
56. Harrell WE, Tatum T, Koslin M. Is centric relation always the position of choice for TMDs? case report of how TMD and airway dimension may be associated. Compendium 2017. Available at: https://www.aegisdentalnetwork.com/cced/2017/04/is-centric-relation-always-the-position-of-choice-for-tmds-case-report-of-how-tmd-and-airway-dimension-may-be-associated. Accessed February 20, 2022.
57. Chen X, Liu D, Liu J, et al. Three-dimensional evaluation of the upper airway morphological changes in growing patients with skeletal class III malocclusion treated by protraction headgear and rapid palatal expansion: a comparative research. PLoS One 2015;10(8):e0135273.
58. Calamita M, Coachman C, Sesma N, et al. Occlusal vertical dimension: treatment planning decisions and management considerations. Int J Esthetic Dent 2019;14(2):166–81.
59. Goldstein G, Goodacre C, MacGregor K. Occlusal vertical dimension: best evidence consensus statement. J Prosthodont 2021;30(S1):12–9.
60. Abduo J, Lyons K. Clinical considerations for increasing occlusal vertical dimension: a review. Aust Dent J 2012;57(1):2–10.
61. Miralles R. Canine-guide occlusion and group function occlusion are equally acceptable when restoring the dentition. J Évid Based Dent Pract 2016;16(1):41–3.
62. Coachman C, Georg R, Bohner L, et al. Chairside 3D digital design and trial restoration workflow. J Prosthet Dent 2020;124(5):514–20.