

A review on smile arc - An orthodontist's perspective

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ABSTRACT

Smile is one of the most important features of face contributes to the facial esthetics and also plays a significant role in personality development and social interaction. There are eight major components of a smile - lip line, smile arc, upper lip curvature, smile symmetry, lateral negative space, frontal occlusal plane, dental components, and gingival components. These components determine an attractive smile. A smile analysis can be conducted for better understanding of smile in the following sequence: General facial analysis, dentofacial analysis, dentolabial analysis, the dentogingival analysis, and finally the esthetic (dental) analysis. To achieve a balanced composition among the elements of the smile, it is important to consider the eight major components in the analysis while planning the orthodontic treatment. The aim of this review article was to explore the smile arc in smile analysis and the important aspects that have to be considered during smile designing. **Clinical significance:** While the patients visit an orthodontist to correct their unsatisfactory smile, the orthodontists tend to have their mind set on dental correction. Hence, it is mandatory that dental occlusion is made to synchronize with the overall orofacial esthetics as a part of smile designing.

KEY WORDS: Components of smile, Dental esthetics, Orthodontist, Smile, Smile analysis, Smile arc, Smile line

INTRODUCTION

Beauty, one of the biggest religions of the human brain, has been defined differently in various cultures since the standard of beauty appeared to differ in different cultures and with the progression of time. However, one thing which did remain acceptable to all was the proportions and symmetry of the face as major contributors of esthetics such as the width of the eye, chin, the width of lips, and the midline relationship of teeth to the face.^[1]

During social interactions, the mouth is one of the most attention-seeking features of the face emphasizing the significance in the smile as a facial feature. Thus, the esthetic enhancement has become the growing reason for dental visits as it has a major role in social interactions. For an orthodontist to provide the satisfactory smile corrections, knowledge of esthetics of human face is necessary to enable orthodontic corrections to enhance the attractiveness of a smile. The present review upraises the eight essential

components of smile, namely lip line, smile arc, upper lip curvature, smile symmetry, lateral negative space, frontal occlusal plane, dental components, and gingival components from an orthodontists perspective.

THE ANATOMY OF SMILE

The display framework of the smile is the upper and lower lip within which the other important component of the smile, namely gingival scaffold and teeth, can be noticed. Affecting the frameworks are other significant soft tissue constituents such as the prominence of the chin, recession or prominence of the nose and its degree, and nasolabial angle.^[2] According to Ackerman, the anatomy of the smile is the normal curvature of lips, the proper exposure of the red zone of lips, undisturbed nasolabial grooves, and an undistorted philtrum.^[3]

CLASSIFICATION OF SMILE

The smile was classified by a few pronounced members; Edward Philips, Ackerman and Ackerman, Rubin L R, Anthony H.L. Tjan, Gary D. Miller, and Josephine G.P.^[4]

Rubin classified it as neuromuscular smile patterns: Cuspid smile, complex smile, and Mona Lisa smile.

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The cupid smile can be differentiated by the diamond-like lip formation. There will be a dominance of levator labii superioris which results in the exposure of the cupid teeth. The complex smile can also be known as a full-denture smile. This type of smile is expressed by the combined action of the elevators muscles of the upper lip and depressors muscles of the lower lip. The Mona Lisa smile can be described with actions of the zygomaticus major muscles resulting in the superficial and vertical movement of the outer commissures.^[4]

Ackerman and Ackerman classified smile as social and enjoyment smile. Social smile is the type of smile which is intentional and unstrained monotone expression. This type of smile can be seen during greetings. Enjoyment smile is the type of smile seen when one is honestly delighted such as when one is laughing. This type of smile is a spontaneous type of smile. This can be described with features such as the contraction of the elevator and depressor muscles of the upper and lower lip, and extreme exposure of anterior tooth and gingiva.^[2]

Philips classified smile into styles, stages, and types. Smile styles can be classified as the commissure smile, the cupid smile, and the complex smile. While, stages of smiles can be classified as Stage 1, Stage 2, Stage 3, and Stage 4; Stage 1 is where the lips are closed, Stage 2 is where the lips are in resting phase, Stage 3 is when there is natural smile including a three-quarter expansion, and Stage 4 is the stage where there is a fully expanded type of smile. Finally, there are five types of smile which are classified based on the exposure extent of the teeth. The first type is where there is only maxillary tooth exposure. The second type includes the exposure of maxillary teeth and more than 3 mm of gingival exposure. The third type of smile includes the exposure of mandibular teeth alone. Whereas, the fourth type is when both maxillary and mandibular teeth are exposed. The fifth type is when neither the maxillary nor mandibular teeth are visible.^[5]

Anthony H.L. Tjan, Gary D. Miller, and Josephine G.P. are known for having classified open smile. They classified open smile into three types; high smile, average smile, and low smile. The high smile is the type of smile with characteristic features exposing the complete cervicoincisal length of the anterior teeth of the maxilla along with a contiguous band of gingiva. The average smile exposes 75–100% of the maxillary anterior teeth along with the interproximal gingiva. The low smile shows <75% of the anterior teeth.^[6]

Smile Analysis

Mc Laren introduced a specific analysis for evaluating the smile design. The sequences begin with general facial analysis, dentofacial analysis, examination of dentolabial analysis, the dentogingival analysis, and then last the esthetic (dental) analysis.^[7] This systemic

evaluation goes in order from what we see, in general, to the detailed evaluation. Furthermore, it is important to know that a deviation in any one of these elements can cause a total change in smile.

The general facial analysis is the stage where basically the general facial balance is assessed. The analysis aids in evaluation of the face with lips at rest, in full smile, and the profile of the individual. The full smile has two main factors; the parallel relationship between the interpupillary line and occlusal plane of teeth, and the lip symmetry.

The dentofacial analysis is where the maxillomandibular relationship to the face is evaluated with the dental midline relationship. The dental midline relationship to the face is judged by the midline relation of central incisors to philtrum, left or right midline skewing, and the bilateral negative space.

The dentolabial analysis will involve evaluation of the relationship of teeth to the lips. It is inclusive of factors such as the upper lip positioning, alignment of upper incisal edge to lower lip, the tooth to lower lip positioning, and the number of teeth exposed during a full smile.

The dentogingival analysis is the assessment of relation of teeth to the gingiva. Ideally, the gingival line should be parallel to the horizon of the central and lateral incisors, and equally symmetrical from the midline.^[8] The gingival scallop should be in a radiating arch similar to the incisal line and it should be of 4–5 mm.

Finally, the esthetic (dental) analysis describes intertooth and intraarch relationships, with an emphasis on proportions of central incisor, and the proportion of central incisor to lateral incisor to canine width. It includes both the analysis of shape and size.^[9]

THE GOALS OF SMILE DESIGNING

Peter Dawson established the goal of smile designing as an esthetic modification of the orofacial components, to create a stable masticatory system where the hard and soft tissue components of the smile, functions in harmony.

THE COMPONENTS OF SMILE

The major components of a smile include lip line, smile arc, upper lip curvature, smile symmetry, lateral negative space, frontal occlusal plane, dental components, and gingival components.

Lip Line

The lip line is the amount of vertical exposure in a smile, which is the height of the upper lip in relation to

the maxillary central incisors. Lip line is optimal when the upper lip reaches the cervical margin of anteriors, exposing the incisocervical length of maxillary central incisors along with the interproximal gingiva. Lip line at rest is the starting point of the smile with an average display of maxillary incisors; 1.91 mm in men and 3.40 mm in women.^[10] In women, it is nearly twice the amount as in men. With aging, the exposure of maxillary incisors gradually decreases at rest. This steady decrease of the maxillary tooth exposure is accompanied by an increase in mandibular incisor display.^[11]

Upper Lip Curvature

The central position to the corner of the mouth in a smile determines the upper lip curvature. When the corner of the mouth is higher than the central position, then it is considered upward. When the corner of the mouth and the central position are at the same level, then it is considered straight. When the corner of the mouth is lower than the central position, then it is considered as a downward smile.^[12]

Lateral Negative Space

Lateral negative space is also known as transverse dental projection. The buccal corridor between the corner of the mouth and posterior teeth while smiling is the lateral negative space. Orthodontists prefer to eliminate these negative spaces by transverse maxillary expansion. The transverse dimension of the smile is also affected by the arch form. Broad arch will fill the buccal corridor when compared to a narrow and constricted arch.^[13]

Smile Symmetry

In the vertical plane, the relative positioning of the corners of the mouth is known as smile symmetry. It can be assessed by the parallelism of commissural and pupillary lines. An asymmetrical smile occurs when the upper lip has a large differential elevation which may be due to deficiency of muscular tonus on one side of the face. To overcome this deficiency and restore smile symmetry, myofunctional exercises have been recommended.^[14]

Frontal Occlusal Plane

The line running from the tip of right canine to the tip of the left canine is considered as the frontal occlusal plane. This relationship of the smile to maxilla cannot be determined by intraoral images or study casts, and the photographs might be misleading. Thorough clinical examination and documentation of digital video are very important in making a differential diagnosis between facial asymmetry and smile asymmetry.^[15]

Dental Components

The quality and beauty of dental elements of smile are essential to make it appear pleasant. The

dental components can be classified into two types: Tooth components and soft tissue components. The tooth components include dental midline, incisal lengths, tooth dimensions, zenith points, axial inclinations, interdental contact area and interdental contact point, incisal embrasure, sex, personality, age, and last the symmetry and balance.^[16] It also includes color, size, and shape. For an esthetic smile, dental midline is very essential.

The dental midline is an imaginary vertical contact line between the maxillary central incisors. Optimally, the midline has to be perpendicular to incisal plane and parallel to the midline of the face. Minor discrepancy of 2 mm or slightly above is considered acceptable as long as the dental midlines are vertical. The anatomical guide landmarks for dental midline are midline of the nose, chin, forehead, interpupillary plane, and philtrum. The philtrum is considered as the ideal guide for the dental midline assessment. As long as the interproximal contact area between the upper central incisors is vertical, the mild midline discrepancy is acceptable.

The zenith point refers to an imaginary line which is positioned directly apex to the cervical margin where the gingiva is most scalloped.^[17] The zenith points are generally marked as the imaginary line slightly distal to the central line of an anterior tooth. The zenith point is responsible for a balanced establishment of mesial and distal dimensions. They are necessary evaluation process when closing diastemas, reducing exaggerated triangular forms, and tilting the tooth orientation. To achieve a balanced smile, arch symmetry is also very essential that is why missing or peg-shaped lateral incisors are challenging. The midline diastema and lack of interproximal contacts are the other factors which can disturb the continuity of dental compositions.^[18]

Gingival Components

The soft tissue components of smile include the gingival health, gingival levels and harmony, interdental embrasure, and last but not the least the smile line.^[19] The color, texture, contour, and height of gingiva are the factors expressing the gingiva. The esthetic quality of the smile will be reduced when there is inflammation, open gingival embrasures, blunted papilla, and uneven margins. Black triangle is the space formed by a missing papilla above the contact point of central incisors which may be caused due to triangular teeth, advanced periodontal diseases, and root divergence.^[5]

A healthy gingiva can be indicated as coral pink in color, stippled, knife edge margins, firm in consistency, and scalloped contours. A discoloration of the gingiva can be due to pigmentation, vascularity, and keratinization. A gingiva is considered healthy when it is located 3 mm above the alveolar crestal

bone and interdentially located at 5 mm above the intercrestal bone papilla.

The Smile Arc

It is in the dentolabial analysis stage where the evaluation of a component of the smile, the smile arc occurs. The smile arc is an attribute of smile which is seen in the extraoral feature. The smile arc can be defined as the relationship of the maxillary incisal curve to the mucosal contour of the lower lip with a smile.

The smile arc is also known as smile curve and it can be divided into three types: Parallel, straight, and reverse smile arc.^[20] Parallel smile arc is where the curvature of the maxillary incisal edges is parallel to the border of the lower lip in smiling. The parallel smile arc has been found to be the normal type of smile arc in untreated individuals, and considered optimal and esthetic.^[6] The same has been set as the objective in esthetic oral rehabilitation, including orthodontic and orthodontic-prosthetic treatment. A straight or reverse smile curve may contribute to a less facial appearance. The reverse curve is frequently associated with marked abrasive wear of the upper incisors.

The curvature of the lower lip is usually more pronounced in younger ages, and more pronounced for women than in men. The curvature tends to flatten with age. The smile arc can get flattened unintentionally during orthodontic treatment because of several factors. These factors include the inappropriate bracket positioning, steep upper canine tips, inappropriate canine bracket positioning in relation to the incisors, preexisting or iatrogenic incisor proclination, steepness or flatness of the occlusal plane, and broad anterior arch forms.^[20]

ORTHODONTIC PERSPECTIVE IN SMILE DESIGNING

Over Intrusion of Maxillary Incisors

The maxillary central incisors are always in the center of attraction when it comes to the esthetic planning. Ideal vertical positioning for the maxillary incisors is of superior importance in attaining good esthetics. Over extrusion of maxillary incisors may be seen when there is severe overbite or gummy smile. Moreover, to correct this unesthetic and unhealthy factor maxillary incisors are overintruded. However, if this is done without the consideration or monitoring of the incisor-lip position at rest, the smile arc may become flattened. Excessively proclined incisors will be associated with an everted lower lip, whereas uprighted or retroclined incisors will be partially covered by the lower lip.^[21]

Hence, orthodontic management should involve a thorough diagnosis to avoid indiscriminate use

of orthodontic biomechanics to prevent excessive intrusion or even extrusion. The utility arches or archwires with accentuated curves may end up flattening the smile arc. Furthermore, it may also lead to a decreased lip line at rest and in smiling, resulting in the patient looking aged. While the chief complaint of gummy smile and overbite might be treated by intrusion of the maxillary incisor, an unnoticed smile arc relationship might lead to the unwanted flattening of the smile arc. Females tend to have significantly more exposure of the maxillary anterior than the mandibular tooth, and this comparison is constant with age. It is of utmost importance to ensure that the practitioners record the incisor display at both rest position and posed smile before and after orthodontic treatment to avoid unwanted maxillary incisor exposure.

The maxillary archwire plane is to be kept parallel to the upper lip. That is to say that the incisal edges of the upper anterior teeth will follow the lower lip. The divergence of the wire from the occlusal cusp tips or incisal edges increases from posterior to anterior. The wire plane can increase the maxillary occlusal plane cant in relation to true Frankfort horizontal by having a greater differential from the buccal segments to the anterior segment. Furthermore, excessively broad arch forms in the anterior region will result in the flattening of the smile arc due to the extended intercanine span.^[21]

Bracket Positioning

Bracket positioning is very critical to orthodontic finishing and detailing. Precision in bracket positioning is needed to cater to the various types of smile arcs; parallel, flat, and reverse smile arc. For every different type of smile arc, respective type of bracket with varying height should be used. In the orthodontic treatment, bracket positioning in the modulation of smile arc is a three-dimensional control of tooth positioning which allows these significant esthetic features to be possible and predictable.^[22]

To achieve an optimal smile arc, the bracket positions must be customized to every individual patient's characteristic relationship of the incisal edge to the lower lip curvature. Hence, a standardized formula of bracket placement cannot be applied to all patients as acceptable esthetic criteria. For an esthetic smile arc, the maxillary anterior brackets are positioned more gingivally. In a reverse smile arc, for example, the brackets should be positioned higher than usual on the maxillary central incisors, and progressively lower on the lateral incisors and canines. In cases where an additional retroclination of the incisors is to be corrected, the upper anterior brackets are inverted at 180°.^[22] This helps by producing active lingual crown torque in the slot with larger dimensional archwires.

The Occlusal Plane

The occlusal plane can be affected by various factors such as the extraoral forces, intermaxillary elastics, orthognathic surgery, and subject's inherent growth pattern. More vertical growth in the posterior maxilla than in the anterior maxilla could result in a changed relationship between the occlusal plane and the curvature of the lower lip on smile. In this type of patient, high-pull headgear keeps the maxillary posterior teeth superior to the incisors and is, therefore, an aid in maintaining or improving the smile arc.^[23] If the maxillary occlusal plane is canted upward with anteriors in infraocclusion, the incisal edges are in reverse curve of Spee resulting in a non-consonant smile arc, making the smile arc less attractive.

Natural head position (NHP) is the most underrated physiological and anatomical orientation which helps in understanding the orientation of face, jaws, and teeth. While we may be doing sufficient dentofacial analysis, without proper analysis of the craniofacial complex, the teeth and jaws may not be harmonious. Thus, the NHP should be evaluated with cephalogram and later the teeth and jaws should be analyzed and corrected.^[23] The teeth and skeletal base are aligned based on the line of occlusion. The line of occlusion can be denoted by the teeth positioning and its reference to dental arch, arch form, symmetry of the arch, and the curve of Spee.

It is important that we know that the occlusal plane is different from the functional line of occlusion. In other words, we can consider occlusal plane as a two-dimensional evaluation while the line of occlusion can be validated as a three-dimensional evaluation due to the absence of bilateral vertical symmetry and curve of Spee in evaluation of occlusal plane. The three-dimensional evaluation is made easier with distinctive pitch, yaw, and roll illustrations. While the pitch denotes the extreme upward or downward rotation of the esthetic line of dentition, the roll refers to the transverse cant of occlusal plane and the yaw refers to the rotation of the line of occlusion and esthetic line around a vertical axis. Extreme yaw can be seen in cases where there is asymmetrical cross bite. However, yaw has been avoided as it is one of the most difficult factors in the analysis as there are no noticeable evaluations. However, with the advanced 3D-based records, these too are becoming possible. Although the pitch, yaw, and roll analysis might seem difficult, it can still be conducted with the aid of a fox plane.^[24]

Other factors that can also affect the smile arc are reduced clinical crown height due to attrition, oral habits, excessive posterior vertical growth, and lower lip musculature. Oral habits such as thumb sucking induce the reduction in anterior vertical height. The

excessive vertical growth can be seen in brachyfacial patterns.

SMILE ANALYSIS

Smile analysis can also be done based on the four dimensions: Frontal, oblique, sagittal, and time-specific dimension.^[25]

The Frontal Dimension

It was Ackerman and Ackerman who helped in better visualization and quantification of a frontal smile. They developed a ratio called the smile index which can be calculated by dividing the intercommisure width by the interlabial gap during the smile. In other words, the smile index is the illustrated area which is framed by the vermilion borders of the lips when producing a social smile. The smile index ratio makes smile comparisons among different patients or an individual's comparison in smile changes over time.

The two main characteristics of frontal smile are vertical and transverse characteristics.^[25] The vertical characteristics can be further subdivided into two main features: Those concerned with incisor display and those concerned with a gingival display. Other examples of vertical smile characteristics are the relationship between incisal edges of maxillary incisors and the lower lip; between the gingival margins of the maxillary incisors and upper lip.

The transverse characteristics of the smile are arch form, buccal corridor, and transverse cant of the maxillary occlusal plane. Arch form is an essential characteristic in the transverse dimension and has proven its significance by the frequent use of broad and square arch forms in orthodontic treatment. There is more capacity for transverse expansion in patients with upright premolars and molars. A narrow arch form will result in an excessive buccal corridor, thus decreasing the size of the buccal corridor necessary for orthodontic expansion and widening. While arch expansion may be efficient in enriching a transverse dimension of the smile, certain drawbacks can occur. The buccal corridor may become obliterated resulting in a denture like smile or the broadening of the anterior sweep of maxillary arch may result in a flattened smile arc.

The buccal corridor refers to the point from mesial line angle of the maxillary first premolars to the lip's interior portion of the commissure. The buccal corridor ratio is calculated as the intercommisure width divided by the distance from the first premolar to the first premolar. Furthermore, the dimension of the buccal corridor is closely associated to arch form and sagittal position of the maxilla. Finally, the transverse cant of occlusal plane denotes the differential eruption between anterior or posterior teeth or skeletal

asymmetry in vertical dimension, contributing to a non-consonant smile arc.^[25]

The Sagittal Dimension

When it comes to sagittal dimension, there are two concerned smile characteristics: Overjet and incisor angulation. Maxillary incisors proclination will eventually alter the incisor display at rest and on smile. While flared maxillary incisors will lead to reduction in incisors display, an upright maxillary incisor will lead to increase in incisor display. Even in frontal view, a greater anterior maxillary projection influences the smile characteristic by creating an illusion of greater buccal corridor.^[26]

Time-Specific Dimension

Time-specific dimension characterizes that the orthodontic prognosis will vary with age. Thus, the orthodontic patients are characterized as preadolescent, adolescent, and adult. The aging effects of the soft tissue are smile gets narrower vertically and wider transversely. The lengthening of the resting philtrum and commissure heights, decrease in turgor, decrease in incisor display at rest, decrease in incisor display during smile, and decrease in gingival display during smile are attributed to altered muscle tonicity with age.^[27]

CONCLUSION

An organized and systematic approach is required to evaluate, diagnose, and resolve esthetic complications efficiently. Although esthetics might be of the major concern to the patient, it is our responsibility that the final result of the orthodontic treatment is not based on the looks alone. Thus, every dental surgeon aiming at esthetics as the goal should strive to achieve a balanced composition in the various esthetic elements of the smile. The pitch, yaw, and roll should be included in the modern clinical analysis, preferably with modern three-dimensional records and systems.

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