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Research Article

Smile analysis

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Introduction

We are part of the “how we look” world, and our well-being is not simply defined by our intellectual integrity or spiritual substance, but by a marriage of image and substance. Fashion, television and advertising have played a dynamic role in the promotion of the image, the face.

The new emphasis on physical appearance is leading not only to a demand for dentofacial orthopedics but also to an increased demand for orthognathic surgery. According to **Wylie** – “the goal of orthodontic treatment should be the attainment of the best possible esthetic result, dentally and facially”.

It is important for orthodontists to make every effort to develop a harmonious balance that will produce the most attractive smile possible for each person being treated.

Smile analysis and smile designs have become key elements of orthodontic diagnosis and treatment planning over the last decade.

Definitions

Smile - according to Webster

“A change of facial expression involving a brightening of the eyes, an upward curving of the corners of the mouth with no sound and less muscular distortion of the features than in a laugh that may express amusement, pleasure, tender affection, approval, restrained mirth, irony derision or any of the various other emotions.”

Esthetics

“Concerned with beauty or appreciation of beauty.” 2 dimensions involved in description of esthetics are:

- 1) Objective beauty (admirable) - based on consideration of object itself, implying that the object possesses properties that make it unmistakably praiseworthy.
- 2) Subjective beauty (enjoyable) – is the quality that is value laden relative to the tastes of the person contemplating it.

In the dentogenic concept, the placement of the central incisor controls the midline, the lip support, the labioversion of the teeth, and the composition of the “smiling line”. The lateral incisor is the personality tooth, and is subordinated to the central incisor. Sex emphasis comes from its rotation and the shape of its incisal edge.

Canine position is very important to the concept of “smiling line”. This tooth supports the anterior arch at its widest part and also controls the size of the buccal corridor, the space between the buccal surfaces of the teeth and the comers of the lips when the patient smiles. The canine should be carefully positioned to dominate the lateral incisor and to complete the desired upward curvature of the “smiling line”.

Why soft tissue analysis

- Interaction of soft tissue to hard tissue is the key to appropriate and contemporary treatment planning and this interaction should ultimately lead us to our final treatment decisions.

- Hard tissue analysis plays a major role in treatment planning in orthodontics. This has been mainly through the various analyses done on lateral cephalograms. However, there are certain disadvantages of lateral cephalogram –
 1. Reflects a snap shot of growing entity
 2. Does not reflect soft tissue dynamics – especially smile
 3. Comparison of patient's numbers to favourable cephalometric analysis, directing that patient's treatment towards the analysis.
- There has been a paradigm shift in orthodontic diagnosis and treatment planning with significant emphasis on the face and profile. If the face is now a major determinant of treatment choice, assessment of hard tissue relations alone is entirely inadequate for successful diagnosis and treatment. Though knowledge of the changes the soft tissue of the face undergoes throughout life is essential to good treatment in both the growing patient and the adult.

Basic requirements for assessing Dentofacial esthetics

1. A dynamic and static 3-dimensional evaluation of the face derived primarily from the clinical examination of the patient.
2. A determination of lip – tooth relationships and anterior tooth display at rest and during facial animation.
3. An analysis of the dental and skeletal volume of the face as it affects the soft tissue facial mask. When possible this should be an interactive process with the patient and is best facilitated through the use of graphic images via computer simulation.

Diagnostic records

Examination of patient

- Detailed esthetic judgements can only be made by viewing patients from the front, in conversation, facial expressions and smiling.
- Following esthetics factors can be analysed by sitting or standing in front of patient.
 - Crown lengths or maxillary and mandibular incisor.
 - Incisal edge contours
 - Axial inclinations of all maxillary and mandibular incisors
 - Midlines (upper, lower labial and facial)
 - Crown torque (canines, premolars and molars on both sides)
 - Smile line (rest portion and full smile)
 - Right – left symmetry of crown shapes and sizes and gingival margin levels.

Facial photographs

- 1) Frontal –
 - a. Frontal at rest
 - b. Teeth in maxillary intercuspation, with lips closed.
- 2) Frontal dynamic (smile) – Reveals
 - Amount of incisor show on smile
 - Amount of gingival display
- 3) Close – up image of posed smile.
 - For analysis of smile relationship.
- 4) Three-quarter view (45-degree)
 - Important for examination of midface.
- 5) Profile
- 6) Optional submental view
 - Mandibular asymmetries.

Guidelines for extra oral photography

- 1) Study the patient from the front, and observe the anterior vertical tooth display during normal conversation.
- 2) Rest position photograph:
 - a. Instruct the patient to:
 - b. “Say ‘Mississippi’”
 - c. “Wet your lips and open your mouth slightly (about half an inch)” and/or
 - d. “Swallow and say ‘N’”
 - a. Check the patient's position twice to be sure the incisor display reflects the true rest position of the lips (with the posterior teeth slightly apart).
 - b. In rest position the teeth should be slightly apart, and the perioral soft tissue and mandibular posture must both be unstrained. At full smile the teeth should be lightly closed.
- 3) Full smile photograph
 - a. Instruct the patient to bite together lightly, smile, and say, “Cheese....”
 - b. Check that the smile is full and natural.

Digital videography

- Standardized digital videography allows the clinician to capture a patient's speech, oral and pharyngeal function, and smile at the same time.
- On first viewing of the Quick Time video clip, the clinician should assess tongue posture and lip function, particularly during speech. Immature oral and pharyngeal function with unfavorable tongue posture can easily be detected.

Terminologies used and classification of smile types

- High smile – reveals the total cervicoincisal length of maxillary anterior teeth and a contiguous band of gingiva.
- Average smile – reveals 75% to 100% of maxillary anterior teeth and interproximal gingiva only.
- Low smile – displays less than 75% of anterior teeth.

According to Tjan *et al.* (JPD 1984)

High smile - 11%, (predominantly female) Average smile - 75%

Low smile - 20% (predominantly male)

Smile types

- Peck and Peck – stage I and II
- Ackerman *et al.* posed (social) and unposed (spontaneous) (enjoyment)

Posed / social smile

- Voluntary, unstrained, static facial expression, and need not be elicited or accompanied by emotion.
- Typically used as a greeting,
- The lips part due to moderate muscular contraction of the lip elevator muscles, and the teeth and sometimes the gingival scaffold are displayed.
- The lip animation is fairly reproducible, similar to the smile that may be rehearsed for photographs or school pictures.

Unposed/enjoyment smile

- Involuntary, dynamic and natural, in that it expresses authentic human emotion.
- Elicited by laughter or great pleasure
- Results from maximal contraction of the upper and lower lip elevator and depressor muscles, respectively that

causes full expansion of the lips, with maximum anterior tooth display and gingival show.

- The differing visual presentations reflect inner emotions and are mechanically governed by all the facial muscles of expression and the differential nuances of recruitment and use of these muscle sets.

Smile style

Soft tissue determinant of the dynamic display zone, which depends on direction of elevation and depression of the lips and predominant muscles groups involved. The three types are –

1. The cupid smile – characterized by the action of all the elevators of the upper lip, raising it like a window shade to expose the teeth and gingival scaffold.
2. The complex or full denture smile – characterized by the action of elevators of the upper lip and depressors of the lower lip acting simultaneously, raising the upper lip like a window shade and lowering the lower lip like a window.
3. The Mona Lisa or commissure smile – characterized by the action of the zygomaticus major muscles, drawing the outer commissures outward and upward, followed by a gradual elevation of the upper lip.

Smile analysis

- In treating the smile, the social smile generally represents a repeatable smile.
- However, a social smile can mature and might not be consistent over time in some patients.
- Smile analysis is done in 4 dimensions: frontal, oblique, sagittal and time-specific.

Frontal dimension

- Smile index – describes the area framed by the vermilion borders of the lips during the social smile and is determined by dividing the inter-commissure width by the interlabial gap during smile.
- 2 major dimensions of the smile are visualized and quantify frontally-
 1. Vertical characteristics
 2. Transverse characteristics
- Vertical characteristics
 - Two main features 1) those pertaining to incisor display 2) those pertaining to gingival display
 - Relationships between the incisal edges of the maxillary incisors and the lower lip
 - Relationship between the gingival margins of the maxillary incisors and the upper lip.
- Transverse characteristics
 - Arch form
 - Buccal corridor
 - Transverse cant of the maxillary occlusal plane.

Oblique dimension

- Anteroposterior canting
- Consonant / nonconsonant smile arc.

Sagittal dimension

- Over jet
- Incisor angulation

Time specific changes

- Growth
- Maturation
- Aging

Incisor to lip relationship (Upper lip to incisor)

Philtrum height

- Measured in mm from subspinale to most inferior portion of upper lip on vermilion tip of the Cupid's bow.
- Absolute linear measurement is not particularly important.
- Relationship to the upper lip and commissures of the mouth is more significant.
- Philtrum height commonly shorter than commissure height in adolescents.
- Short philtrum in adults – results in unesthetic reverse – resting maxillary lip line that resembles a frown.
- Treatment solution for improvement of the short philtrum include
 - Esthetic lip surgery
 - V-Y cheiloplasty (in combination with LeFort I osteotomy or rhinoplasty).

Commissure height

- Measured from a line constructed from the alar bases through subspinale and then from commissures perpendicular to this line.
- Normally no more than 2-3mm greater than philtrum height in adults.
- Changes in commissure height not easily attainable.
- Most common problem dropping of commissures as a result of aging and facial jowling.
- Improvement attained through rhytidectomy (facelift).

Incisor display - excessive maxillary incisor show (gummy smile)

- The amount of maxillary incisor that shows at rest is a crucial esthetic parameter because one of the inevitable characteristics of aging is diminished upper incisor show.
- In adults, the amount of upper incisor display at rest decreases with age, whereas the amount of lower incisor display increases.
- Males show less upper incisor and more lower incisor at rest Females – more upper incisor and less lower incisor at rest. (2:1)
- Excessive incisor show result from a number of hard tissue and soft tissue factors.
 - Short upper lip philtrum height
 - VME
 - Excessive crown height
 - Detorqued maxillary incisors.

Significance

- The dental characteristics of aging is to show less upper incisor and More Lower incisor.
- Surgical or orthodontic overintrusion of maxilla / maxillary teeth may result in esthetically disastrous aging of the patients face.
- Upper incisor intrusion to correct deep bite – should be a carefully considered procedure.

Treatment in adolescents

- If incisor display is moderately excessive (4-5mm) – no treatment indicated
- If severely excessive incisor display (6-8mm) – intrusion of maxillary incisor with intraoral arches or extraoral intrusion forces provided typically by J-hook headgear.
- In severe cases (>8mm excess) – delaying treatment and considering surgical maxillary impaction is desirable.

Treatment in adults

- VME – maxillary impaction using LeFort I
- Short philtrum – V-Y cheiloplasty
- Excessive crown length – reduction within limits
- Detorqued maxillary incisor (Class II division 2) - orthodontic intervention.

Measuring the amount of gingival display on smile easily quantitates a “gummy smile”. However, the decision whether the amount of gingival display is an esthetic problem requiring treatment is a highly personal choice. Orthodontists and oral and maxillofacial surgeons tend to see the gummy smile as an unesthetic characteristic, whereas lay persons see only the more extreme cases as unesthetic.

Incisor display – inadequate incisor show

- Low smile lines – predominantly male characteristic (2.5:1)
- Reasons
 1. Excessive upper lip philtrum height
 - a. Rarely seen except in older adults.
 - b. Result of soft tissue aging and loss elasticity.
 2. VMD
 3. Inadequate crown height
 - a. Lack of tooth eruption
 - b. Gingival encroachment
 - c. Attrition
 4. Flared maxillary incisors
 5. Diminished vertical dentoalveolar development secondary to thumb sucking habit.

Treatment

1. VMD – maxillary downgrowth using LeFort I
2. Long philtrum – direct / indirect lip lift
3. Inadequate crown length – increase crown length through use of cosmetic dental procedures – crowns, veneers, bonding
4. Flared maxillary incisors – orthodontic torque, retraction or both.
5. Frenectomy – if hypomobile lips.
6. Habit control

Tooth exposure by gender – mean amount exposed at rest (mm) (Vig and Brundo 1978)

Gender	Maxillary central incisor	Mandibular central incisor
Male	1.91	1.23
Female	3.40	0.49

Tooth exposure by race – mean amount exposed at rest (mm) (Vig and Brundo 1978)

Race	Maxillary central incisor	Mandibular central incisor
White	2.43	0.98
Black	1.57	1.42
Asian	1.86	1.58

Arch form

- Plays a pivotal role in the transverse dimension of the smile.
- Recently, much attention has been focused on the use of broad, square arch forms in orthodontic treatment.
- When the arch form is narrow or collapsed, the smile may also appear narrow and therefore present inadequate transverse smile characteristics.

- Orthodontic expansion and widening of a collapsed arch form can dramatically improve the smile by decreasing the size of the buccal corridors and improving the transverse smile dimension.
- The transverse smile dimension (and the buccal corridor) is related to the lateral projection of the premolars and the molars into the buccal corridors. The wider the arch form in the premolar area, the greater the portion of the buccal corridor that is filled.
- Arch expansion might fill out the transverse dimension of the smile, but 2 undesirable side effects could result, and careful observation is needed to avoid these, if possible –
 - The buccal corridor can be obliterated, resulting in a denture like smile
 - When the anterior sweep of the maxillary arch is broadened, the smile arc may be flattened.

Buccal corridor

- Defined by Frush and Fisher as the space created between buccal surfaces of posterior teeth and commissures of the lips when the patient smile. The teeth should fill the comers of the smile.
- The buccal corridor is measured from the mesial line angle of the maxillary first premolars to the interior portion of the commissure of the lips.
- If is often represented by a ratio of the intercommissure width divided by the distance from first premolar to first premolar.

Cant of the maxillary occlusal plane

Transverse cant can be due to

1. Differential eruption and placement of the anterior teeth.
2. Skeletal asymmetry of the mandible resulting in a compensatory cant of the maxilla.
3. Soft tissue considerations, such as an asymmetric smile curtain.

Amount of maxillary projection

- Greatly influences smile characteristics in the frontal view
- When the maxilla is retrusive, the wider portion of the dental arch is positioned more posteriorly relative to the anterior oral commissure. This creates the illusion of greater buccal corridor in the frontal dimension.
- The advancement of the maxilla result in a wider portion of the maxilla being placed into the buccal corridor, reducing ‘negative space’.
- Transverse smile dimension, therefore, is a function of both arch width and anteroposterior position of the maxillary and mandibular arches.

Smile ARC

- Definition – The smile arc is defined as the relationship of the curvature of the incisal edges of the maxillary incisors, canines, premolars and molars to the curvature of the lower lip in the posed smile.
- Ideal smile arc – the maxillary incisal edge curvature parallel to the curvature of the lower lip upon smile: the term *consonant* is used to describe this parallel relationship. A *nonconsonant*, or flat, smile arc is characterized by the maxillary incisal curvature being flatter than the curvature of the lower lip on smile.
- Factors that contribute to the appearance of the smile arc are
 1. The sagittal cant of the maxillary occlusal plane
 2. The arch form

Reasons for smile arc flattening during orthodontic treatment

1. Normal orthodontic alignment of the maxillary and mandibular arches may result in loss of the curvature of the maxillary incisors relative to the lower lip curvature.
2. Maxillary intrusion arches or maxillary arch wires with accentuated curve used to reduce the gumminess of the smile.
3. Faulty 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 upon smile.
4. Habits may also be an etiologic factor. The reduction in anterior vertical dentoalveolar development secondary to thumb sucking is the most obvious example.

Smile designing

- It must be understood that there is no universal 'ideal' smile.
- Objective - The objective of creating a beautiful dental composition is to create harmony between the incisal edges of maxillary anterior teeth and superior curvature of lower lip.
- Smile design and mechanotherapy must be built around the esthetic plane of occlusion, which is often different from the natural plane of occlusion.
- Factors of importance –
 1. Individualized bracket positioning
 2. Changes in overall treatment mechanics. For example, in cases with high labial ectopic maxillary canines, leveling with a continuous arch wire will intrude the maxillary central and lateral incisors and thus flatten the smile arc. Segmented - arch technique using cantilever springs offer better control of leveling and of the esthetic plane of occlusion.
- Principles of cosmetic dentistry in orthodontics

The characteristics that constitute esthetic teeth and gingival relationships include

- 1) Tooth proportionality – height and width
 - Ideal maxillary central incisor should be approximately 80% width compared with height (66-80%).
 - The ranges of height and width are important to note, because the disproportionality of a tooth can then be evaluated with regard to what parameter is at fault and in need of improvement.
- 2) Contacts, connectors and embrasures
 - Contacts – exact place that the teeth touch. The contact points progress apically as teeth proceed from the midline to the posterior.
 - Connector (interdental contact area) – connector height is greatest between central incisors and diminishes from central to the posterior teeth.
 - Embrasures – triangular space incisal to the contact. Embrasures become larger as teeth progress posteriorly.
- 3) Gingival esthetics
 - Includes gingival shape and gingival contour
 - Gingival shape refers to curvature of gingival margin of the tooth, determined by cemento-enamel junction and the osseous crest.

The gingival shape of mandibular incisor and maxillary laterals should exhibit a symmetrical half oral or half circular shape.

The maxillary centrals and canines should exhibit a gingival shape that is more elliptical. Thus, the gingival zenith (the most apical patient of gingival tissue) is located distal to the longitudinal axis of maxillary centrals and canines. The gingival zenith of maxillary laterals or mandibular incisors should coincide with their longitudinal axis.

Age related changes

- The growth, maturation and aging of the perioral soft tissues have a profound effect on the appearance of both the resting and smiling presentations.
- Orthodontics patients can be categorized as preadolescent, adolescent, and adult.
- In preadolescent patients, the facial soft tissues are still in a growth phase, and treatment decisions pertaining to the relative facial divergence at profile and frontal facial soft tissue topography must take this into account.
- Adolescent patients, or those at the point of pubertal onset, have experienced the maximum velocity in the growth of the skeletal subunits and have roughly achieved their facial soft tissue "look".
- In adults, nuances in the aging of perioral and facial soft tissues become increasingly important.

The effects of maturation and aging on the soft tissues can be summarized as

1. Lengthening of the resting philtrum and commissure heights,
2. Decrease in turgor,
3. Decrease in incisor display at rest
4. Decrease in incisor display during smile, and
5. Decrease in gingival display during smile.

Soft tissue changes between ages 18 and 42 (Formby *et al.* AJODO 1994) Males

1. Profile straightened and lips became more retrusive
2. Nose increased in size in all dimensions
3. Increased soft tissue thickness at pogonion
4. Decreased upper lip thickness with slightly increased lower lip thickness.

Females

1. Profile did not straighten and lips did not become retrusive.
2. Nose increased in size in all dimension.
3. Decreased soft tissue thickness at Pogonion.
4. Decreased upper lip thickness with slightly increased lower lip thickness.

Characteristics of average or typical smile

1. Overall Cervico incisal length of maxillary anterior teeth are displayed.
2. Gingiva does not show (except interproximal gingiva)
3. Incisal curvature of maxillary anterior teeth parallels the inner curvature of lower lip.
4. Incisal curvature may be either totally touching or slightly touching the lower lip.
5. Six maxillary anterior teeth and first or second premolars are displayed.
6. Midline coincides with a harmonious balance of smile.

Clinical guidelines to be followed during diagnosis and treatment planning

- Study the patient from the front to make a reliable esthetic evaluation.
- Routinely take extraoral photographs that record the pre and post treatment tooth display with the lips at rest.
- Be careful not to overintrude the maxillary incisors in a patient with average or low smile type.
- Establish an age – appropriate vertical anterior tooth display in rest position and normal conversation.
- Provide a curve of the maxillary incisors that is parallel to the inner contour of the lower lip in smiling.
- Reduce excessive gingival exposure in a long faced patient by active maxillary incisor intrusion coupled, if necessary, with labial gingivectomies.

Conclusion

- In order that patients may be served properly, the smile must be understood, recorded and analyzed so that desirable aspects may be preserved and graceless components returned to attractiveness.
- The ‘art of the smile’ lies in the clinician’s ability to recognize the positive elements of beauty in each patient and then create a strategy to enhance the attributes that fall outside the parameters of the prevailing esthetic concept.
- 2 things that must be acknowledged –
 - Esthetic considerations are paramount in planning appropriate orthodontic and orthognathic treatment.
 - Rigid rules cannot be applied to this process.
- Just as patients get individualized treatment plans, they also should have individualized designs for appliance placement.
- The difference between contemporary orthodontic practice and that of our predecessors is that we now can dynamically visualize and quantify our patient’s smiles.
- The focus on the lineaments of the smile is not a step back in time; rather, it represents a reemphasis of the importance of physical diagnosis and the appreciation of the soft tissues that both drive our treatment planning and limit the treatment response.
- New technology simply enhances our ability to see our patients more dynamically and facilitates the quantification and communication of newer concepts of function and appearance.

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