Changes in Frontal Soft Tissue Dimensions of the Lower Face by Age and Gender

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Facial soft tissue dimensions greatly affect important esthetic variables for patients undergoing orthodontic treatment, including the amount of incisor and gingival display at rest and upon animation. This cross-sectional study of 1867 individuals who sought orthodontic treatment provides a database of esthetically related facial soft tissue dimensions in patients from 7 to > 40 years of age. The length of the philtrum of the upper lip is short initially and increases faster than commissure height at adolescence, resulting in maximum display of the maxillary incisors at 11 years of age in females and 12 years of age in males. Of the patients with > 2 mm gingival display at rest, one-third had a philtrum height of 17 mm or less, showing that excessive gingival display often has a soft tissue component and is not just an indication of vertical maxillary excess. There is a 0.9 correlation coefficient between the philtrum length-commissure height difference and lip separation at rest. Incisor display at rest and smile, gingival display on smile, and lip separation at rest all decreased after adolescence in both males and females, particularly beyond 20 years of age. Incisor display is a youthful trait, so both the short- and long-term effects of maxillary incisor intrusion require careful consideration in planning esthetic treatment. World J Orthod 2002;3:313-320.

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Editors note: See "Ask an Expert" by Emily U. Zacharias in this issue, pages 356-364.
into separate components, such as philtrum, commissure, and lip vermilion. In contemporary orthodontic clinical practice, greater emphasis on appearance and smile analysis has evolved as part of overall treatment goal-setting. Through direct clinical measurement, tooth relationships to soft tissue, both statically and during animation, can be recorded. This is the simplest form of a biometric tool to assess the dynamics of the anterior tooth display. Evaluation may also be performed with video recordings. It is important that orthodontic treatment be planned with aesthetic concepts and considerations in mind, well beyond the end of treatment. Since orthodontists are generally the first professionals to begin to assess and treat esthetic problems in growing children, it is important to have as clear a picture as possible as to the functional and aging characteristics of the soft tissues of the face and how orthodontic treatment may prolong a youthful appearance or unfortunately hasten the onset of the appearance of aging. Incisal-to-lip relationships are key components of an immediate esthetic outcome and, thus, patient satisfaction. But the incisor-to-lip relationship is dynamic and it has been well documented that this relationship changes with age. In plastic surgery literature, sagging of the soft tissues of the face and specific aging changes to the circumoral areas, such as changes in vermilion display and dropping of the commissures, are common topics."
In the dental literature, the maturation and aging process is described by a decrease in maxillary incisor display at rest, and an increase in mandibular incisor display. This has been discussed extensively in both current literature and lectures on esthetics. There has been discussion about why the amount of incisor display diminishes with age. Possible etiologies include: (1) inferior migration of the surrounding soft tissue, and (2) atrophy and wear of the anterior teeth resulting in shortening of the teeth. Therefore, tracking and quantifying the changes of these esthetic dimensions, with a recognition of age-related changes such as upper lip bagging, are indicated and useful in long-term orthodontic treatment planning. Many studies have tracked facial soft tissue changes into early adulthood. However, more data are needed into and past middle age since increasing numbers of adult patients are receiving orthodontic treatment and also for appropriate forecasting of where the adolescent patient should be finished for the best long-term benefit in terms of dentofacial appearance.

This article presents further quantification of selected dimensions from the frontal plane, from childhood into and past middle age. The goal is to allow practitioners to understand and predict changes in these esthetically important dimensions, and incorporate those predictions into the treatment plan for a more aesthetic outcome over a greater amount of time.

METHODS
A cross-sectional sample of 1367 patients, 691 females and 676 males, was obtained from a diagnostic database of initial records for private practice patients in Birmingham, AL, USA. Age and gender for the sample are shown in Table 1. Subjects were not categorized by race, but the great majority was white. One clinician (OMS) obtained all measurements on intact examination, using a millimeter ruler. These measurements were:

1. Philtrum height
2. Commissure height
3. Amount of maxillary incisor show at rest
4. Percentage of incisor display on smile
5. Amount of gingival display on smile
6. Incisor-crown height

Data were entered into Microsoft Excel for calculations of mean, standard deviations, and quartile analysis. Philtrum and commissure height dimensions were obtained, as shown in Fig. 1.

RESULTS
Means and standard deviations for each of the selected frontal dimensions are shown by age and gender in Table 3. The consistently greater dimensions of philtrum and commissure height in males than females can be seen to correspond with less display of maxillary incisors at rest and greater on smile. The amount of incisor displayed at rest, gingival display on smile, percent intercusp display on smile, and lip separation all decreased after adolescence in both males and females, particularly beyond 20 years of age, while crown height remained unchanged.

One interesting effect of aging is the tendency for philtrum height to increase at a faster rate than commissure height, starting in early adulthood (Fig 4). This finding explains the decrease in incisor and gingival display at rest and during animation with increasing age. It also explains why lip incompetence is more prevalent in young patients than older patients.

The youthful resting upper lip should have a soft "M" shape to the upper vermilion border, with a parallel shape to the lip eminences between the upper and lower lips. The height of the philtrum should be roughly equal to the height of the commissures. Aging lips are characterized by a flattening of the "M" shape of the upper vermilion border, a diminished turgor (firmness) of the lips, and drooping of the commissures, resulting in a reverse resting interlabial curvature. The growth, maturation, and aging of the perioral soft tissues have a profound effect on the appearance of both the resting and smiling presentations (Fig 5). These data demonstrate the lengthening of the philtrum and commissure, with the rate of philtrum lengthening greater than that of the commissures. This would explain the flattening of the "M" characteristics of the vermilion border of the upper lip in the older lip in comparison to the youthful lip. The lengthening of both the philtrum and commissure with age, as demonstrated in the curves, results in a corresponding reduction in tooth display at rest and reduction in gingival display on smile seen with maturation and aging.

Clinically, when orthodontists see a grumpy smile, they tend to think of it as result of vertical maxillary excess. There are, however, many other possible etiologies of excessive display, such as upright maxillary incisor angulation, excessive smile animation, and short philtrum height. In this sample, individuals with a philtrum height of 17 mm or less had a 36% greater chance of more than 2 mm gingival display on smile than those with longer philltrums, so incisor display frequently is not just an indication of vertical maxillary excess but a result of resting soft tissue anatomy.
Table 1  Measurements of the study sample according to age and gender

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Mean age (years)
Fig 4  Dimensional means for female subjects by age. Note the decrease in the difference between commissure height and philtrum height with increasing age, the nearly constant crown height beyond early adolescence, and the decreasing lip separation at rest and display of maxillary incisors with age. Gingival display on smile remains constant.

Fig 5 (left) The characteristics of youthful lips include a distinctive “M” shape of the upper lip vermilion, and a parallel but softer “M” at the junction of the upper and lower lips. Both lips should exhibit fullness and turgor (tissue thickness). As the lips age, the “M” flattens, and the commissures descend inferiorly. The lips atrophy, resulting in wrinkling and loss of turgor.

Fig 6 (below) Commissure height–philtrum height difference (mm) vs. lip separation (mm) at rest for each patient. Regression analysis shows an excellent fit with a straight line, especially beyond a 10-mm difference, with a remarkably high correlation coefficient. There is a strong soft tissue component, therefore, to excessive lip display at rest. \[ y = 0.95 - 6x + 0.133x^2; R^2 = 0.9187 \]
Plotting the difference between philtrum and commissure height (Fig 6) shows a remarkably linear relationship with lip separation at rest—the correlation coefficient is 0.92 (see Fig 5). In 93% of our female sample, the degree of lip separation exactly equaled the difference between commissure height and philtrum height. This relationship was consistent throughout all age groups and could serve as a good predictor of lip incompetence.

**Fig 7** The use of computerized database programs enables the clinician to make numerous clinical measurements in little time and is a simple biometric tool by which soft tissue rest and smile dynamics can be seen.

**DISCUSSION**

Although direct measurements of facial soft tissue dimensions are not yet a routine part of orthodontic diagnostic evaluation, it is clear that data of this type can play an important role in planning appropriate treatment. It takes little time to enter soft tissue measurements when a computer databasing system is available to the clinician (Fig 7). These systems for orthodontic use are being developed now and should include a systematic approach to collection of these data.
Orthodontic patients can be categorized as preadolescent, adolescent, and adult. In the first category, the orthodontist must consider that the facial soft tissues are still in a growth phase. Treatment decisions pertaining to the relative facial divergence (posteriorly or anteriorly) 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." It is in the last category of adults where nuances in the aging of personal and facial soft tissues become increasingly important. We know from orthodontic cephalometric research that, on average, profiles flatten over time. Whether this is mostly related to pliosa of the soft tissues or resorptive fields in the hard tissues of the midface is still somewhat debated, but is nevertheless an unfavorable consequence of getting older. Assessment and quantification of the frontal dimensions of both the resting tissues and lips-tooth relationships on smile have not received the attention they demand because of a lack of physiologic measurements (such as cephalograms serve the profile) and biomechanical tools.

Facial soft tissue dimensions change over time, so that iminor and gingival display decrease, starting in early adult life. Note that the maximum display of incisors at rest and maximum lip incompetence occurs at 11 years of age in females and 12 years of age it males. Philtrum height increases during the adolescent growth spurt (note the difference in girls at 11 and 12 years of age) and both philtrum and commissure height increase in adults. Grow height remains constant, as does the amount of gingival display on smile, so the soft tissue changes at rest are the major contributor to decreased display of teeth with increasing age. Although the lips sag downward at rest, the ability to elevate the lip on smile is retained.

As would be expected, there are variations in dimensions and proportions within the age groups evaluated here. Sexual dimorphism, which has been noted previously, relates both to the different timing and extent of the adolescent growth spurt, which affects both the soft and hard tissues of the face, and to the somewhat different pattern of age changes in males and females. The general pattern of change, however, is a guideline for what should be expected.

The data from this study have several implications for orthodontic treatment planning:

1. Lip separation at rest and the amount of display of teeth and gingiva are strongly influenced by soft tissue dimensions, and are not just reflections of underlying skeletal proportions. It would be a mistake, therefore, to plan intrusion of maxillary incisors just on the basis of their display, without checking to see if lip dimensions are normal. The relationship between philtrum height and commissure height is more important than either of these dimensions alone.

2. Display of the maxillary incisors at rest and on smile is a youthful characteristic. In many cases, therefore, impulsion of maxillary incisors inevitably makes the patient look older. Too much display is unesthetic, but since it can be predicted that incisor display will decrease with age, leaving the incisors somewhat more prominent than the ideal for early adolescence can provide better esthetics later.

3. If lip dimensions and proportions are outside the normal range and contribute significantly to a dentofacial problem, orthodontists should consider referral for correction of the soft tissue problem. Acknowledging that the soft tissues are an important part of dentofacial characteristics is the first step toward a broader view of the goals of treatment and the means by which they can be achieved.

Further information as to the effects of orthodontic treatment, orthognathic surgery, and facial plastic surgery on soft tissue dimensions and proportions is needed to improve the predictability of treatment outcomes. It is important to gather data from clinical measurements, not just cephalometric data. In modern outcome studies. Better data of this type should be seen in the near future, its application to orthodontic diagnosis and treatment planning can improve the benefit of treatment for our patients.

ACKNOWLEDGMENT

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REFERENCES