Growth of The Soft Tissues

Postnatal Growth
Postnatal growth is defined as the first 20 years of growth after birth. Kroghman, 1972.

The study of growth in growing children is for two reasons:
- For health and nutrition assessment of children living in a nation.
- For comparison of a growing child with a large sample of other children in the same population.

Division of the Body into Hard and Soft Tissues is Arbitrary

<table>
<thead>
<tr>
<th>Hard Tissues</th>
<th>Soft Tissues</th>
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<tr>
<td>- Bone and bones</td>
<td>- Muscles</td>
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<td>- Teeth</td>
<td>- Nerves</td>
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<td>- Cartilage</td>
<td>- Fat</td>
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<td>- growth plates</td>
<td>- Connective tissue</td>
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<tr>
<td>- articular cartilages</td>
<td>- tendons, ligaments, fascia,</td>
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<td>- synovial fluid</td>
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<td>- cartilages of nose, ears,</td>
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<td>- respiratory tract</td>
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<td>- Viscera</td>
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<td>- Gland</td>
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Why Make Such a Division?
- When animals die the soft tissues quickly disappear, but hard tissues usually persist.
- Hard tissues are often the only material available for paleontologists and anthropologists to study.
- Thus, there is a qualitative difference between the hard and soft tissues; they look, feel, and behave differently.

But, most importantly, because the hard tissues lend support and shape to the soft tissues, conventional wisdom views the overall size and shape of an animal with a rigid bony skeleton to be dependent on those hard tissues. But, it is also possible that the size and shape of the skeleton is affected by the soft tissues.
Descriptions of Human Size and Shape

- Laypeople describe each other as:
  - fat vs. thin
  - short vs. tall
  - attractive vs. unpleasing
- Scientific classifications include:
  - Body types, or Somatotyping
  - Anthropologic Head shape
  - Anthropologic Face shape

Shape of the Head (Cranium)

- Physical anthropologists assess head shape with the cranial index, which is expressed as the ratio of cranial width to cranial length.
- Two extremes are possible:
  - brachycephalic
  - dolicocephalic

Dolicocephalic Head Shape

The cranial index is 74.9 or less, thus the head is relatively long and narrow.

Brachycephalic head shape

The cranial index is 80 or more, thus the head is relatively short and wide.

Shape of the Face

- Physical anthropologists describe faces as either euryprosopic (short and wide) or leptoprosopeic (tall and narrow).
- Orthodontists have mostly ignored these terms, and instead refer to faces as “brachyfacial” or “doliofacial” when describing short and wide, or tall and narrow faces, respectively.

Reasons for Describing Head and Face Shape

- The growth direction of the face and jaws is different in each type of head and/or face.
- “Brachy” faces tend to grow horizontally.
- “Dolico” faces tend to grow vertically.
- Knowing the general pattern of the face jaws, and the expected direction of facial growth can be helpful in orthodontic diagnosis and treatment planning.
Some Common Measurements of Hard Tissues

- Body height (essentially, the length of the axial skeleton plus the head and lower limb)
- Craniofacial dimensions (length and proportions of the head, face, and jaws)
- Tooth size (usually mesiodistal width, useful in assessing dental crowding)

Some Common Measurements of Soft Tissues

- Facial profile (can be quantified with cephalometrics)
  - convex, straight, concave
  - retrognathic, orthognathic, prognathic

What is the Problem with Soft Tissues?

- Unlike the hard tissues, soft tissues are elusive because they are often elastic, extensible, or distortable
- They can increase or decrease in absolute size much more readily than the hard tissues, and in this can happen in a short period of time.

The Problem with Soft Tissues

Thus, in many instances, quantitative measurements of soft tissues are either unavailable or unreliable

Nevertheless, soft tissue growth is of interest.

Specific Measurements of Hard and Soft Tissue Growth

- Longitudinal measurement of growth in height
  - distance curve
  - velocity curve
  - growth spurt
- Longitudinal measurement of growth in weight

Why Measure Height and Weight?

- To assess whether an individual child is developing normally--this is of particular interest to pediatric endocrinologists who must treat disorders of growth.
- The jaws and face grow more or less in concert with the rest of the body--growth of the face and jaws is of particular interest in patients with malocclusion and/or syndromes with craniofacial manifestations.
What Else Do Measurements of Height and Weight Tell Us?
- They can indicate how far along an individual has progressed toward maturity.
  - The pubertal or adolescent growth spurt marks the beginning of the end of somatic growth, including craniofacial growth.
  - In females, the onset of menstruation, termed menarche, usually occurs near the end of the growth spurt.

Growth of Skeletal Muscle
- Skeletal muscle can grow in length, and in girth, or diameter.
- Growth in girth can be easily modified by usage, which can dramatically affect muscle mass.

Growth in Length of Skeletal Muscle
In a growing individual, as the distance between the bony attachments of skeletal muscle increases, the length of the muscle must also increase. This can be measured.

Muscle Growth
- Muscles grow in length by the addition of sarcomeres in series.
- This is necessary because sarcomeres do not function properly if they are either too long or too short.

Modification of Muscle Growth
- As muscles grow in length, they do so by adding new sarcomeres in series.
- But, the number of sarcomeres added depends upon the functional conditions.

The Chicken and the Egg Problem
- Bite force measurements show that individuals with divergent skeletal patterns have weaker muscles than those with a “low angle” pattern.
- But, even though the idea that functional muscle activity can influence the size and shape of bones is very attractive, there is no clear evidence to support this.
The Growing Face at 8 Months, 6, 8, and 20 Years of Age

Why Attempt to Measure Soft Tissues?
- The facial appearance we all present to the world is soft tissue which covers the underlying bones and teeth.
- Soft tissues may play an important role in determining the size and shape of the dental arches.
- Soft tissues may play an important role in craniofacial growth.

Soft Tissue Effect on Facial Appearance

Facial Appearance
- Lips
  - size
  - length
  - thickness
  - position
  - strain

Facial Appearance

Facial Appearance
- Nose
  - size
  - shape
  - profile effect
Facial Appearance

- Nose
  - size
  - shape
  - profile effect

Facial Appearance

- Chin
  - retracted
  - protruded
  - contribution to profile (mentonis strain)

Facial Appearance

Faces look different before puberty than afterward, this boy is shown at ages 12-15%. His face reflects both bone growth and changes in the amount and distribution of the facial soft tissues.

Soft Tissue Effect on Dental Arch Form

- Equilibrium theory
  - tongue
  - lips and cheeks
- Habits
  - thumb, finger sucking
- Injuries
  - paralysis, scarring

Soft Tissue Effect on Craniofacial Growth

- Theories of craniofacial growth
  - Classical Theory—bone growth is primary, soft tissues adjust to the growth of the bones
  - Functional Matrix Hypothesis—soft tissues functional demands are primary, bones grow in response to functional demands

Classical Theory

- Size and shape of craniofacial skeleton is genetically determined.
- Bones will grow to genetic potential unless disease, nutritional deficiency, or other environmental factors intervene.
- Soft tissue growth also has a genetic component but must adjust to skeletal growth.
Functional Matrix Hypothesis

- Functional demands which originate in, or are expressed by the various soft tissues are the primary cause of craniofacial growth.
- Skeletal units (bones) grow secondarily in response to these functional demands.
- Genes are important only to set the whole process in motion.

Which Theory of Craniofacial Growth is Correct?

- Classical theory probably puts too little emphasis on soft tissues and environmental factors.
- Functional Matrix Hypothesis has not been verified by experiment.

Soft Tissue Growth

1. Prenatal growth
   - I. Nasal growth
   - II. Lip growth
2. Postnatal growth
   - I. Nasal growth
   - II. Lip growth
   - Lip length
   - Lip thickness
   - III. Chin growth

The most important goals of orthodontic treatment are harmonious facial esthetics, optimal functional occlusion and stability.

SOFT TISSUE GROWTH

The importance of the oral musculature in orthodontic practice is that it influences significantly the form of the dental arches since the teeth lie in a position of equilibrium between the lingual and bucco-labial musculature. Therefore they are important factors in the aetiology of malocclusion, and greatly affect the stability of the result after orthodontic treatment.

Soft Tissue and Cephalometric

The soft tissue analysis is basically a graphic record of a visual observation made in the clinical examination of the patient.
The facial musculature is well developed at birth, considerably in advance of the limbs, because of the need for the baby to suckle and maintain the airway. Other functions soon develop: mastication as teeth erupt, facial expressions, a mature swallowing pattern (as opposed to suckling) and speech.

The lips, tongue, and necks guide the erupting teeth towards each other to achieve a functional occlusion. This serves as a compensatory mechanism for a discrepancy in the skeletal pattern; for example, in a Class III subject the lower incisors may become retroclined and the upper incisors proclined to obtain incisor contact. Sometimes this compensatory mechanism fails, either because the skeletal problem is too severe or the soft tissue behavior is abnormal.

An example of this is where lower lip function worsens a Class II division I malocclusion by acting behind the upper incisors rather than anteriorly to them.

The lips lengthen as they mature in late stage of growth, tending to become more competent.

Muscles growth must be coordinated with the growth of the associated bones, with the muscles lengthening as their bone attachments separate.

Neuro-muscular activity regulate the position of the jaws, and it has been suggested that the whole process of facial skeletal growth is determined by the soft tissues which surround the bones.

Summary Slide

• SOFT TISSUE GROWTH
Growth in all living things implies that “changes” occurs as a function of “time”. The term “growth changes” refers to any modification in the physical size, shape, or position of a structure.

The term “development” will be reserved to describe an increase in the complexity of a function. Facial development is a continuous process spanning the pre and post natal periods.

**SOFT TISSUE GROWTH**

**B1: Nasal growth**

The face at the fifth week is about 1½ mm wide. At this time, the oral pit is bounded above by the frontal area and below by the mandibular arch, which appears shovel shaped.

**Nasal growth**

At the sixth week, two small, oval, raised areas appear just above the lateral aspects of the future mouth. In the next 48 hours, the centers of these raised areas become depressions as the tissues around them continue to grow anteriorly. The depressions deepen into pits that will become the future nostrils and the masses surrounding them will become the bridge and the sides of the external nose.

**Nasal growth**

The tissue between the nasal pits is termed the medial nasal process and those lateral to the pits are called the lateral nasal processes.

**Nasal growth**

The distance between these two nasal pits does not increase during this important period of development, although the pits themselves increase in both height and length. The two epithelial-covered processes together form alamina termed as the (nasal fin).
Lip growth

At 6½ weeks, the facial proportions appear to have changed greatly, due to an increase in dimension laterally to the pits. There has been in this short span of time an expansion of anterior region of the brain causing the lateral maxillary regions to move the front of the face. Thus, the eyes adjacent cheek tissues are rotated 90 degrees from the sides to the front of the face because of this differential growth.

Nasal growth

As soon as contact and adhesion of two epithelial sheet occurs, they become fused into a single sheet and then degeneration of this sheet occurs, resulting in connective tissue penetration through sheet.

Nasal growth

This area of penetration expands rapidly and the nasal fin is eliminated except at its anterior and posterior limits. At the posterior limits of the epithelial fin, the same two epithelial sheets split apart, reducing and opening between the nasal pits and the roof of the oral cavity.

Lip growth

This posterior opening of the nasal pit is termed the internal nares and is the posterior limit of the primary palate. Later, the nasal cavities enlarge posteriorly to form a space overlying the entire oral cavity. The oral and nasal cavities are then separated by the secondary palatal shelves which close the anterior nasal opening, causing the resulting nasal cavity.

Nasal growth

Nasal growth

Lip growth

Lip development is a three-stage process, the first being contact of the two epithelial sheets covering the adjacent processes, the second, fusion of the epithelium into a single sheet and, finally, a penetration of this sheet by connective tissue of the lip growing through it.

Nasal growth

21 Lip growth

The medial nasal area now makes up only the relatively small medial nasal tissue interposes between the maxillary wedges at this stage and will become the site of the future philtrum of the upper lip.

Early in the seventh week, the face appears recognizably human as a result of the frontal location of the eyes, differentiation of the nose and enlargement of the mandible. At the seventh week, the furrows separating the mandibular, maxillary and nasal areas are less marked.
SOFT TISSUE GROWTH

B) Post natal growth

The human face has already achieved about 75% of its adult size by the age of two years, approximately 85% by the age of 970. The different components of the soft tissue profile have differing rates and timing of growth.12,106.

1) Nasal growth

Studies suggested that nasal growth proceeds at a relatively constant into adulthood and that the nose increases in relative prominence as maturity approaches25,28,77,86.

The overall contours of the nose, and in particular, the naso-labial angle, are not likely to change by more than 3 to 4 degrees as a child matures (Sorrell and Franks).

Lip growth

The rapid growth of the jaws and development of the teeth seldom give rise to a situation where the available tissue is adequate to provide good lip seal. This problem usually arises only after maxillary permanent incisors have been in the mouth some time and the development of the lip is relatively behind that of the dentition.40.

2) Lip growth

Postnatally, a baby’s mouth at rest is closed. The jaws are relatively little developed, the alveolar processes are not yet built up, the tongue lies partly between the arches of the jaws, and there is ample lip tissue to maintain mouth closure. In the period from birth to the first transitional period, normal mouth closure is maintained.

Lip length

The rapid growth of the jaws and development of the teeth seldom give rise to a situation where the available tissue is adequate to provide good lip seal. This problem usually arises only after maxillary permanent incisors have been in the mouth some time and the development of the lip is relatively behind that of the dentition.40.

a) Lip length

Lip position is affected by the placement and inclination of the maxillary and mandibular incisors and hence is responsive to orthodontic treatment.

The average increase in upper and lower lip length in males is more than two times that of females.

In age from 7 to 18 years, the total increase in upper and lower lip length in the males is 6.9 mm, in the female, it is only 2.65 mm.

Those with a short upper lip at 7 years will continue to have a short upper lip even at age 18 years. Nanda, et al.1998.
**Lip length**

The relative growth increment in upper and lower lip length is greater in the long face than it is in the short face subjects at age 7 years. (Nanda and Ghosh)

The longer upper and lower lips in the long-face groups could have been compensatory mechanism for the individuals to obtain a lip seal.

**Lip length**

Because shorter facial patterns have a decreased vertical dimension, the length of the upper and lower lips would not have to be as long for a seal to be produced.

Smaller lip length in short face subjects could be due to lip closure, however, it should lead to a greater gathering of lip tissue and an enhanced thickness.

**Lip thickness**

b) Lip thickness.

The tendency for females to have smaller soft tissue dimensions than males was clearly demonstrated in the relative thickness of the soft tissue of the lip and chin. Females demonstrated thinner lips at age 7 and grow similar amount to males up to age 12.

**Lip thickness**

The final lip thickness in females were often less by 2 mm or more at age 17 due to almost no increase occurring in females from age 12 to 17 years. Thus, a clinician retracting upper incisors in a 12 year old female might expect little compensatory lip growth, while in male as less detrimental facial effect might be expected if the normal two mm increase in upper lip thickness occurred from 12 to age 17 years.

**Lip thickness** at point A and B increased more than at the vermilion borders. The increase in lower lip thickness at vermilion border was very small for the females. These changes lead to thicker, longer lips for the males.

While the changes in the thickness of upper lip at liberal superius did not show any distinct pattern between the long face and short face subjects, the relative growth in the lower lip thickness at liberal inferius was greater in the short face subjects.
Lip thickness

After adulthood is reached, changes continue in the morphology of the craniofacial skeleton, position of the teeth, and soft tissues. The profile becomes straighter, the upper lip becomes longer and thinner, and the prominence of the lower lips decreases with age; is smiling and speaking the maxillary incisors show less, the mandibular incisors show more.

Lip thickness

because a lip growth only begins to catch up with vertical growth of the lower part of the face after completion of transition, it is the permanent incisors that dominate the face before and during adolescence. Only in following years dose the dentition retreat in to the face, due on the one hand to the continued forward growth of the jaws and the associated uprighting of the incisors, and on the other hand, the relatively greater increse in a lip length.40 Frans and v. lindin 1990.

Chin growth

Genecov and his co-worker reported in their study that the soft tissue chin thickness in females at 7 to 9 years was greater than in males (being 11.7 and 10.8 mm respectively) but only demonstrated a 1.6 mm increase up to age 17, while the males demonstrated 2.4 mm of increase any tissue thickness over this period.

Chin growth (cont.)

In women, the reduction in thickness at the soft tissue chin may have been caused by the increase in the anterior face height and small increase the mandibular plane angle causing slight stretching of the soft tissue over the chin (summary of profile changes in adult life follows).

SOFT TISSUE AND HARD TISSUE

The early studies suggested that there was a general consious of the pattern of skeletal growth assuming that the development of the soft tissue profile was coincident with the underlying hard tissues Brodie1953 Fishman1969 Reidel1957.
However a considerable body of evidence now exists which suggested that different components of the soft tissue profile have differing rates and timing of growth and that all parts of the soft tissue profile do not grow in direct proportion to their skeletal bases. Bishara et al. 1984, Subtelny 1959, Burstone 1984.

However, Burstone suggested that a close relationship of the soft tissue profile to the underlying skeletal pattern might not exist because of the variation in the thickness of the soft tissue covering the skeletal face.

Bowker and Meredith 1959, in their longitudinal study, showed changes in soft tissue profile between 5 and 14 years with growth; but did not relate this to the underlying skeletal pattern. Subtelny 1959, in a longitudinal study of soft tissue profile, measured vertical and horizontal relationship and found that not all parts of the soft tissue profile directly follow the underlying skeletal structures. For example, the soft tissue over bony A tended to increase in thickness with age.

Tulley and Campbell 1970, do not feel that Soft Tissue A and B points accurately reflect the position of skeletal points A and B; they recommend palpation of these areas. Wisth 1972, also observed that changes in soft tissue profile followed changes in skeletal profile but noticed variations over points A and B.

Mauchamp and Sassouni 1973, studied the effect of aging on the skeletal and soft tissue profiles. They found the soft tissue changes to be similar to the underlying skeletal changes. Another study done by Barnett, which supported the findings of Reidel, Subtenly, and Mauchamp and Sassouni that the soft tissue profile gives a good indication of underlying skeletal discrepancies. Indeed, their statistical tests indicate that the difference in maxillary and mandibular prognathism could be estimated as reliably from the soft tissue profile as from angle ANB.

They also found that the position of the bony B points is very accurately reflected by the overlying soft tissue contour while the bony A point seems to be more variable. This may be because it is a difficult landmark to locate on lateral skull radiographs. Nevertheless, its position is reliably reflected in the soft tissue profile and there is apparently no necessity to palpate the maxilla in this region.

It was interesting that the upper lip over A point is thicker than the lower lip over B point and the relationship remains unchanged with growth. Another interesting result showed that lower lip thickness was significantly corrected with chin thickness for the both group (ten years group and over 16 years group). But the correlation coefficient for the over 16 years old group was found to be less due to continued growth of the bony chin with age.
Soft tissue and cephalometric tracings.
Contribution to esthetic