Growth changes in the soft tissue profile of Yemenis females: A cross-sectional study

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Abstract

Aim: To investigate the changes in soft tissue parameters of three age groups of untreated Yemeni females.

Materials and Methods: The sample comprised 300 Yemeni females which were randomly selected and divided according to age into three equal groups (Group I: 7.34 ± 0.65 years [prepubertal], Group II: 11.11 ± 1.07 years [pubertal], and Group III: 22.17 ± 3.04 years [postpubertal]). Lateral cephalometric radiographs were taken for each subject, and soft tissue measurements were performed. Comparison between the three groups was done. One cephalogram representing the mean of its group was selected from the three groups; the selected three cephalograms (one from each group) were superimposed for growth changes evaluation.

Results: Linear, as well as angular soft tissue measurements were significant for all measurements between the different age groups except Ls-Sn Pog', Li-Sn Pog', GSn Pog' and nasolabial angle, respectively. Conclusion: The identified changes with growth in Yemeni females having Class I skeletal and dental relationship should be considered during planning for orthodontic and/or orthognathic treatments.

Keywords: Female, growth, lateral cephalometry, profile changes, Yemeni

Introduction

Cephalometric norms are an important aid in orthodontic diagnosis as has been extensively studied in literature since the early work of Broadbent.[1] The strict value of norms and standards on the clinical analysis of individuals has been questioned, but the utilization of ethnic norms is widely accepted. The main factors in the selection of appropriate norms are age, sex, and ethnic groups.

Orthodontists are interested in understanding how the face changes from its embryonic form through childhood, adolescence, and adulthood. It is an accepted fact that the growth of the various parts of the head does not proceed at the same rate Björk.[3] There is also a consensus that, within the dentofacial complex, the changes in the various parts of the face do not follow a constant pattern with time.

The purpose of this study was to examine the changes in some soft tissue parameters of untreated three Yemeni female age groups. Grouping was based on a pubertal growth spurt as described by Björk and Helm,[3] and Marshall and Tanner[4] as: Prepubertal (preadolescent), pubertal (adolescent), and postpubertal (adulthood).

Materials and Methods

The study method was approved by the Faculty of Dentistry Ethical Committee. The patients and parents were informed about the nature of the study and informed consent forms were signed. A sample of 300 Yemeni females was collected randomly from school children, university students, and government employees. The selected sample fulfilled the following inclusion criteria:

- Yemeni in origin (as verified from the third grandparents)
- Free from any congenital abnormalities
- Angle Class I molar relationship
- Normal overjet and overbite

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The sample was divided according to age into three equal groups: Group I: 7.34 ± 0.65 years, Group II: 11.11 ± 1.07 years, and Group III: 22.17 ± 3.04 years). Lateral cephalogram for each subject in each group was taken (as a part of their pretreatment records) while the subject was in the natural head position. A forehead support was used to stabilize the head. Subjects were guided to close in centric occlusion and look into their eyes in an opposing mirror.

Cephalometric radiographs were digitally traced using Viewbox® cephalometric analysis software program. Nine linear and seven angular soft tissue measurements were used as shown in Figure 1a and b.

A lateral cephalogram representing the mean of its group was selected as follows: Each cephalogram in the range of 0.8 from the mean of each measurement was given a score for each one. Then, the range was decreased to 0.4 from the mean of each measurement. By decreasing the range to 0.2 from the mean of each measurement, the selected cephalograms were chosen as the template representing Group I, Group II, and Group III. Each cephalogram acted as a template representing its own group. The selected cephalograms (one from each group) were superimposed according to the following superimposition system for growth change evaluation:

- For assessment of facial profile growth changes, the cephalograms were registered at sella and superimposed along sella-nasion (SN) as described by Steiner,[8] Björk,[9] and Pancherz[7]
- For assessment of maxillary and mandibular growth changes, the cephalograms were registered at nasion and superimposed along SN as noted by Broadbent.[10]

Statistical analysis
Numerical data were presented as means and standard error values. One-way analysis of variance (ANOVA) was used to compare means among different groups. Tukey’s test for pairwise comparisons was used to determine significant differences between means when ANOVA test is significant.

Intra- and inter-observer reliability was measured using Cronbach’s alpha reliability coefficient. Cronbach’s alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach’s alpha coefficient is to 1.0, the higher the reliability. An alpha of 0.8 is probably a reasonable goal.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with statistical package for scientific studies 16.0® for Windows (IBM SPSS Statistics).

Results
Analysis of experimental error
The results of intra- and inter-examiner reliability for measurement error showed very good intraobserver reliability ranged from 0.854 to 0.995. There was also very good interobserver reliability ranged from 0.872 to 0.996.

Linear soft tissue measurements
Table 1 and Figure 2 showed descriptive statistics and one-way ANOVA for linear soft tissue measurements among the three groups. (a) The length of the upper lip (Sn Sto) there were a significant increase from Group I through Group III ($P < 0.001$), also (b) the length of the lower lip (Sto Sm) showed a significant increase from Group I through Group III ($P < 0.001$). (c) Thickness of the upper lip (A-Sn) both Group II and Group III showed the same significant increase from Group I ($P < 0.001$) while (d) thickness of the lower lip (B-Sm) and (e) thickness of soft tissue chin (Pog-Pog’) showed significant increase from Group I through Group III ($P < 0.001$).

Table 1: Descriptive statistics and one-way ANOVA for linear soft tissue measurements among the three groups

| Age group | Measurement | 6-8 years | 10-13 years | 18-30 years | $P$  |
|-----------|-------------|-----------|-------------|-------------|-----|
|           | Mean | SE | Mean | SE | Mean | SE |       |     |
| Sn-Sto    | 18.5 | 0.2 | 19.6 | 0.3 | 20.8 | 2.3 | 0.001*** |   |
| Sto-Sm    | 16.2 | 0.2 | 17.6 | 1.6 | 19.4 | 0.2 | 0.001*** |   |
| A-Sn'     | 12.5 | 0.2 | 14.2 | 0.2 | 14.5 | 0.3 | 0.001*** |   |
| B-Sm      | 8.7  | 0.2 | 9.9  | 1.2 | 11.5 | 0.2 | 0.001*** |   |
| Pog-Pog'  | 8.5  | 0.2 | 9.7  | 0.2 | 11.6 | 0.4 | 0.001*** |   |
| Ls-Sn Pog' | 3.5  | 0.2 | 3.3  | 0.3 | 2.9  | 0.3 | NS   |   |
| Li-Sn Pog' | 2.9  | 0.2 | 3.5  | 0.2 | 3.2  | 0.4 | NS   |   |
| Ls-E line | −1.2 | 0.2 | −2.3 | 0.3 | −5.1 | 1.2 | 0.001*** |   |
| Li-E line | 0.03 | 0.2 | 0.2  | 0.2 | −1.5 | 0.4 | 0.001*** |   |

***Significant at $P \leq 0.001$, means with different letters are statistically significantly different according to Tukey’s test results. NS: Not significant; SE: Standard error; ANOVA: Analysis of variance

Figure 1: A tracing of lateral cephalometric radiographs showing (a) linear and (b) angular soft tissue measurements.
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Measurements evaluating the relative protrusion or retraction of the upper lip (Ls-Sn Pog’) and the lower lip (Li-Sn Pog’) showed the insignificant change between the three Groups (P > 0.005).

There was a significant increase from Group I through Group III (P < 0.001) for the relative protrusion of the upper lip to the esthetic line (Ls-E line), on the other hand there was significant increase for both Group I and Group II from Group III (P < 0.001) for the relative protrusion of the upper lip to the esthetic line (Li-E line).

Angular soft tissue measurements

Table 2 and Figure 3 showed descriptive statistics and one-way ANOVA for angular soft tissue measurements among the three age groups. Concerning the prominence of the upper lip in relation to the N’ Pog’ (H-angle) Group III showed a significant decrease from both Group I and Group II (P < 0.001) while Z-angle (expressing the amount of lip protrusion) and soft tissue convexity (N’ Sn Pog’) both Group I and Group II showed the same significant decrease from Group III (P < 0.001).

Regarding the soft tissue convexity including the nose (N’ Pn Pog’) Groups II and III showed the same significant decrease from Group I (P < 0.001), on the other hand the degree of nasal prominence (Pn N’ Sn°) both Groups II and III showed the same significant increase from Group I (P < 0.001).

There were insignificant change between the three groups (P > 0.005) for the convexity of soft tissue profile (G Sn Pog’) and nasolabial angle.

These findings are obvious in Figure 4 showing superimposition of the three cephalograms for the assessment of growth changes among three groups. Intra- and inter-observer reliability were measured using Cronbach’s alpha reliability coefficient. Cronbach’s alpha reliability coefficient normally ranges between 0 and 1. The closer the Cronbach’s alpha coefficient to 1.0, the higher will be the reliability. An alpha of 0.8 is probably a reasonable goal. The closer the value of the intraclass correlation coefficient to 1.0, the higher the agreement between the measures.

Discussion

The knowledge of how, when, and where facial growth occurs is of particular interest to both orthodontists and orthognathic surgeons. Moreover, prediction of facial esthetics can only be achieved if the amount and direction of growth can be correctly estimated.[8] Changes in the nose, chin, and lips affect facial profile, and these may be the key factors related to the prediction of stability after orthodontic treatment.[9]

Since the introduction of lateral cephalometric radiography by Broadbent and Hofrath in 1931,[1,10] several attempts have been made to study both soft and hard tissues of the dentofacial complex either to come up with cephalometric norms or to monitor the growth changes in different populations. For that reason, study designs ranged between...
cross-sectional, longitudinal, or mixed longitudinal. Despite
the superiority of longitudinal over the cross-sectional
studies in obtaining smoother data and detecting individual
pattern differences, yet, collecting data from a longitudinal
study could take years with possible sample attrition. On
the contrary, cross-sectional studies allowed for quicker
and easier data gathering together with the lower cost
involved. The majority of the previous studies adopted the
longitudinal study design[8,11‑24]  while few of them were mixed
longitudinal [4‑9](combining the advantages of both types of
study designs). Similar to our study, Ferrario and Sforza [24]
conducted a cross‑sectional study to develop a method for the
quantitative and qualitative analysis of the facial soft‑tissue
profile, and they applied it to analyze the pretreatment
lateral head films.

In previous studies, variations in the age ranges of the studied
samples were reported with a minimum of 4 years[17]  and a
maximum of 57 years.[18]  The age range in the current study
was between 7.34 and 22.17, and that was close to what
was reported in other studies.[8,12,13,22]  It was reported by
several studies[8,9,12‑14,19‑22,24]  that males and females present
significant differences in some aspects of the dentofacial
development. These differences sometimes become quite
evident and clinically significant in adulthood. Accordingly, in
this study, only female profile changes were appraised. This
was in accordance with Marshall and Tanner,[4]  whereas Foley
and Duncan[15]  included males only in their study sample.

Many reports in the field of dentistry and growth fail
to evaluate the relationship of race and gender to the
development of different populations, and some studies
might erroneously use the norms of one population for
another during diagnosis or treatment planning. It is well
documented that races differ markedly in such things
as facial features, physical growth, and maturation rate.
Unfortunately, most of the studies reporting changes in the
soft tissue profile were established from data for white
Caucasian populations.[18,8,19,20,22,24]  The paucity of data for
other races encourages further research.

Concerning lip length both upper lip length (Sn – Sto) and
lower lip length (Sto – Sm), showed a significant increase from
Group I through Group III. This increase was in agreement with
Hamamci et al.[20]  and Bergman et al.[22]  The later specified that
in females, the average length at age 6 was 18 mm, and at

| Table 3: Results of Cronbach’s alpha and ICC for intraobserver reliability |
|---------------------------------|------------|------------|
| Measurement                      | Cronbach’s alpha | ICC        |
| --------------------------------|---------------|------------|
| Cranial base measurements        |               |            |
| S - N                           | 0.755         | 0.607      |
| S - Ar                          | 1.000         | 0.999      |
| N - S - Ar                      | 0.999         | 0.997      |
| SN - F.H.                       | 0.997         | 0.994      |
| Maxillary base measurements      |               |            |
| A - NPg                         | 0.763         | 0.617      |
| ANS - PNS                       | 0.974         | 0.950      |
| N - A                           | 0.998         | 0.996      |
| SNA                             | 0.994         | 0.989      |
| SN - PP                         | 0.997         | 0.993      |
| Mandibular base measurements    |               |            |
| N - B                           | 0.997         | 0.993      |
| Ar - Go                         | 0.999         | 0.997      |
| Go - Pg                         | 0.767         | 0.732      |
| Cd - Gn                         | 0.999         | 0.996      |
| SNB                             | 0.965         | 0.956      |
| SN - MP                         | 0.978         | 0.974      |
| F.H. - MP                       | 0.959         | 0.954      |
| N - S - Gn                      | 0.994         | 0.992      |
| Skeletal profile measurements   |               |            |
| A-B difference A                | 1.000         | 1.000      |
| A-B difference B                | 1.000         | 1.000      |
| Ao-Bo (F.H.)                    | 0.998         | 0.997      |
| Ao-Bo (maxillary)               | 0.878         | 0.875      |
| Ao-Bo (occlusion)               | 0.996         | 0.993      |
| ANB                             | 0.990         | 0.987      |
| S - Gn                          | 0.999         | 0.997      |
| Dental measurements             |               |            |
| i - NA                          | 0.982         | 0.980      |
| i-NB                            | 0.983         | 0.980      |
| i/SN                            | 0.998         | 0.993      |
| i/PP                            | 1.000         | 1.000      |
| i/F.H.                          | 0.999         | 0.997      |
| i/MP                            | 0.994         | 0.993      |
| ICC: Intraclass correlation coefficient |

Figure 4: A tracing showing assessment of facial profile
growth changes (a) the cephalograms were registered at S
and superimposed along sella-nasion (b)
Table 4: Results of Cronbach’s alpha and ICC for interobserver reliability

| Measurement                  | Cronbach’s alpha | ICC  |
|------------------------------|------------------|------|
| Cranial base measurements    |                  |      |
| S - N                        | 0.864            | 0.832|
| S - Ar                       | 0.857            | 0.798|
| N - S - Ar                   | 0.966            | 0.917|
| SN - F.H.                    | 0.710            | 0.656|
| Maxillary base measurements  |                  |      |
| A - NPg                      | 0.787            | 0.704|
| ANS - PNS                    | 0.905            | 0.973|
| N - A                        | 0.990            | 0.943|
| SNA                          | 0.791            | 0.773|
| SN - PP                      | 0.953            | 0.923|
| Mandibular base measurements |                  |      |
| N - B                        | 0.900            | 0.858|
| Ar - Go                      | 0.874            | 0.817|
| Go - Pg                      | 0.941            | 0.899|
| Cd - Gn                      | 0.990            | 0.912|
| SNB                          | 0.944            | 0.928|
| SN - MP                      | 0.981            | 0.901|
| F.H. MP                      | 0.961            | 0.910|
| N - S - Gn                   | 0.889            | 0.837|
| Skeletal profile measurements|                  |      |
| A-B difference A             | 0.977            | 0.933|
| A-B difference B             | 0.978            | 0.918|
| Ao-Bo (F.H.)                 | 0.967            | 0.932|
| Ao-Bo (maxillary)            | 0.904            | 0.878|
| Ao-Bo (occlusion)            | 0.902            | 0.884|
| ANB                          | 0.944            | 0.921|
| S - Gn                       | 0.975            | 0.941|
| Dental measurements          |                  |      |
| t - NA                       | 0.955            | 0.900|
|  t - NB                      | 0.963            | 0.896|
| t/SN                         | 0.844            | 0.803|
| t/PP                         | 0.967            | 0.943|
| t/F.H.                       | 0.789            | 0.715|
| t/MP                         | 0.970            | 0.934|
| t/t                          | 0.714            | 0.688|
| Soft tissue measurements     |                  |      |
| Sn-Sto                       | 0.755            | 0.807|
| Sto-Sm                       | 1.000            | 0.999|
| A-Sn’                        | 0.999            | 0.997|
| B-Sm                         | 0.997            | 0.994|
| Pog-Pog’                     | 0.963            | 0.917|
| Ls-Sn Pog’                  | 0.974            | 0.950|
| Li-Sn Pog’                  | 0.998            | 0.996|
| Ls-E line                    | 0.994            | 0.989|

Table 4: Contd...

| Measurement                  | Cronbach’s alpha | ICC  |
|------------------------------|------------------|------|
| LI-E line                    | 0.997            | 0.993|
| H-angle                      | 1.000            | 1.000|
| Z-angle                      | 0.998            | 0.997|
| N’ Sn Pog’                   | 0.878            | 0.875|
| N’ Pn Pog’                   | 0.996            | 0.993|
| Pn N’ Sn’                    | 0.990            | 0.987|

ICC: Intraclass correlation coefficient

Contd...

age 18 it was 21 mm. Moreover, Nanda et al.\textsuperscript{[8]} noted that the average increase in the upper and lower lip length in males was more than 2 times that of females. This was not in agreement with Vahdettin and Altug\textsuperscript{[21]} and Prahl-Andersen et al.\textsuperscript{[9]} Who reported an early decrease in the growth velocity of the upper lip in girls, at the age of 9 years and that there was hardly any increase showed in the upper lip length in the age span studied. On the other hand, Pecora et al.\textsuperscript{[18]} reported an increase in the upper lip length by 3.2 and 1.4 mm from 17 to 47 years and 47 to 57 years, respectively.

As for the thickness of the upper and lower lip, the upper lip thickness for (A-Sn’) both Group II and Group III showed the same significant increase from Group I. This finding was in agreement with Wisth.\textsuperscript{[17]} who observed a thickening of the soft tissue overlying point A from 4 to 10 years old and was quite in agreement with Nanda et al.\textsuperscript{[8]} Who reported an increase of lip thickness at point A from 7 to 18 years. Similarly, thickness of the lower lip (B-Sm) showed a significant increase from Group I through Group III. This increase was in agreement with Nanda et al.\textsuperscript{[9]} and Wisth\textsuperscript{[17]} who reported a reduction of the depth of the mentalist sulcus due to this finding. Similarly, Bergman et al.\textsuperscript{[22]} Reported that in females, the average thickness of the upper lip at the age of 6 was 11 mm and increased to 12 mm at 18 years of age with a mean increase of 1 mm where the average thickness of the lower lip was 10 mm at the age of 6 and had increased to 12 mm at age 18 with an increase of 2 mm.

There was a significant increase from Group I through Group III for soft tissue chin thickness (Pog-Pog’), this finding was in accordance with that of Nanda et al.\textsuperscript{[8]} Pecora et al.\textsuperscript{[18]} Tibana et al.\textsuperscript{[19]} and Hamamci et al.\textsuperscript{[20]} On the contrary disagreement was reported with Wisth.\textsuperscript{[17]} He observed a relatively constant thickness of the soft tissue on the chin.

Concerning the position of the lips to the esthetic line, the upper lip (Ls-E line) showed a significant increase from Group I through Group III in the negative direction which was in agreement with previous studies\textsuperscript{[8,12,18]} indicating a gradual retrusion of the lip to this plane due to the increase in the nasal depth and height accompanied by anterior growth displacement of the chin as stated by Nanda et al.\textsuperscript{[8]} Similarly, there was a significant increase for Group I and Group II
from Group III for the lower lip (Li-E line), denoting a more recursive lip for Group III from both Group I and Group II. This finding was quite in agreement with Nanda et al.,[8] Bishara et al.,[16] and Pecora et al.,[18] who found a progressive retrusion of the lower lip during growth. On the other hand, Vahdettin and Altug[21] reported that the upper and lower lips and the chin moved significantly more forward and downward during growth. They added that the males’ upper and lower lips and chin moved significantly farther forward than those of the females in all growth phases during their study.

As regards the prominence of the upper lip in relation to the N’ Pog’ (H-angle) Group III showed less prominence compared to both Group I and Group II. This may be due to the constant thickness of the soft tissue overlying the Nasion as reported by Wisth[17] while soft tissue chin thickness increased with aging as noted by Nanda et al.,[8] Pecora et al.,[18] Hamamci et al.,[20] and Vahdettin and Altug.[21]

Regarding the Z-angle (expressing the amount of lip protrusion) and soft tissue convexity (N’ Sn Pog’), both Group I and Group II showed significantly smaller angle compared to Group III. Similar finding was found by Bishara et al.[12] whose average values for Z-angle ranged from 66.5° to 73.7°. These findings may be due to the constant thickness of the soft tissue overlying the Nasion as reported by Wisth[17] while soft tissue chin thickness increase with aging as noted by Nanda et al.,[8] Pecora et al.,[18] and Hamamci et al.[20]

Concerning soft tissue convexity including the nose (N’ Pn Pog’), Group II and Group III showed the same significant increase from Group I, which is due to the increase in nasal prominence relative to the rest of the soft tissue profile with growth as reported by similar investigations.[11,12,16,17,20] Most studies that evaluated facial profile found an increase in the nose, revealing an anterior protrusion of the midface with a consequent reduction of facial convexity angle when the nose was excluded, and an increase in facial convexity angle when excluding the nose. In this study, the degree of nasal prominence (Pn’ Sn’ ) for both Groups II and III showed the same significant increase from Group I. Prominence of the nose was reported with previous studies,[11,12,16,17,20] leading to increase in total facial convexity. Similar results were reported by Tibana et al.[19] who stated that the most significant variation in facial profile of the individuals in their sample was in nose depth with a mean increase of 1.07 mm (standard deviation 1.36 mm) in the studied period.

**Conclusions**

The identified changes with growth in Yemeni females having Class I skeletal and dental relationship should be considered during planning for orthodontic and/or orthognathic treatments.

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**Conflicts of interest**

There are no conflicts of interest.

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