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# Craniofacial morphology of skeletal Class III Malocclusion in two different age groups

[1] Angie S. Abu Taleb, [2] Amr H. Labib, [3] Mona S. Fayed
[1] *(Assistant Lecturer at the Department of Orthodontics and Dentofacial Orthopeadics, Faculty of Oral and Dental Medicine / Ahram Canadian University)*
[2] *(Professor at the Department of Orthodontics and Dentofacial Orthopeadics, Faculty of Oral and Dental Medicine / Cairo University)*
[3] *(Assistant Professor at the Department of Orthodontics and Dentofacial Orthopeadics, Faculty of Oral and Dental Medicine / Cairo University)*

***Abstract:*** *The purpose of this study was to investigate the different components of skeletal class III, and its relative growth transformation in the three dimensions of space. The sample of skeletal Class III included 79 individuals; 41 in mixed dentition stage, and 38 in permanent dentition stage. The control group included 83 individuals; 40 in mixed dentition stage, and 43 in permanent dentition stage. Lateral and postero-anterior films were taken for each individual, and then digitally analyzed, and planned measurements were performed. Among skeletal Class III types, combined maxillary retrusion and mandibular protrusion showed the highest percentage of incidence, and normal vertical growth pattern showed the highest incidence. Mandibular rotation didn't increase with age in skeletal Class III individuals. Transverse dimensions of the mandible of skeletal Class III individuals had no correlation with the antero-posterior discrepancy. Treatment of skeletal Class III cases is recommended in the early mixed dentition stage with big emphasis on the antero-posterior dimension.*
***Keywords:*** *Cephalometric, Craniofacial, Growth, Skeletal Class III.*

## I. Introduction

It is hard not to recognize a skeletal class III, especially the one with a prognathic mandible, so as a skeletal problem it represents a great challenge because it compromises esthetics, function and temporomandibular joint as well. Many investigators identified the components, etiology, and progression of this problem in order to facilitate its treatment at any stage of human growth and development. Different data outcomes were revealed, and as a conclusion, skeletal class III was found to worsen with age, negatively affecting the craniofacial morphology, function, and esthetics. Thus, the investigation of the different components of skeletal Class III, and its relative age transformation in the three dimensions of space would help orthodontists to make a proper treatment timing decision, thus eventually upgrading their treatment outcome.

Pertaining to Skeletal Class III components Ellis & McNamara (1), Chang et al (2) and Battagel (3) concluded that there was dental compensation to the underlying jaw discrepancy manifested by lower incisors' retroclination and upper incisors' proclination, while **Staudt and Kiliaridis (4)** in a study of random population of white young men, concluded that dental compensation was found with proclined maxillary incisors in only 42.1% of the cases and retroclined mandibular incisors in only 26.3% of the cases. Baccetti et al (5) and Alexander et al (6) stated that Skeletal Class III condition worsens with age, in fact Kuc-Michalska and Baccetti (7) found out that the mean duration of pubertal growth spurt in Class I subjects lasted 11 months while in Class III it lasted 16 months. Baccetti et al (5) evaluated 22 white Class III subjects at two different time points, showed that maxillomandibular relationship worsens over time. However, there were no untreated controls, so they could not conclude growth deficiencies or excesses of the craniofacial components. Alexander et al (6) described the longitudinal growth between 4 and 20 years of age of 103 Class III whites, also showed definite worsening of anteroposterior skeletal relationships, but they were also unable to characterize the differences, again as a result of the lack of controls.

From the above mentioned data, it is evident that skeletal Class III malocclusion is still an issue of controversy due to its multifactorial nature, and difference in manifestations among different age groups, only scarce information is available concerning the progress of this type of skeletal discrepancy in the three dimensions of space.

Aim of the study is to measure craniofacial morphology of skeletal Class III malocclusion in mixed and permanent dentition groups.

## II. Material and Methods

### *2.1. Subjects*

- The sample for this study was chosen from the Out-patient Clinic of the Department of Orthodontics, Faculty of Oral and Dental Medicine, Cairo University.
- Sample inclusion criteria based on clinical examination were: 1- Concave or straight profiles.

2-Normal (1-3mm) or negative (> 0mm) overjet.
3- Canine Class I and III.

- Patients with medical problems, syndromes, facial malformations, and dental anomalies were excluded.
- 178 patients were clinically examined, 16 patients showed pseudo class III upon functional examination, so they were excluded. The remaining 162 patients were referred for lateral and postero-anterior cephalometric radiographs, and after analysis of the lateral cephalograms, individuals with true skeletal Class III were assigned to the Class III sample, meanwhile those with skeletal Class I were assigned to the control group. Patients were all treated afterwards according to their chief complaints, and elaborated treatment plans.
- All the patients who participated in this study signed a consent of agreement.
- The classification of the sample into skeletal Class I and Class III was based upon these two measurements: **A'-D' (Beatty) (8), and A-B difference (McNamara) (9)**.

- Accordingly, skeletal Class III subjects (as assessed by clinical examination and confirmed by lateral cephalometric analysis) were divided into two groups:

a) Mixed dentition group **(6-13 years),** there number was **41** subjects.

b) Permanent dentition group **(16-20 years),** there number was **38** subjects.

Also, the Control group (skeletal class I) was divided into two subgroups as well:

a) Mixed dentition group **(6-12 years),** there number was **40** subjects.
b) Permanent dentition group **(16-20 years),** there number was **43** subjects.

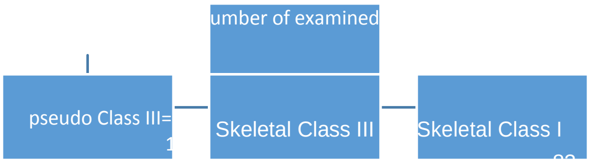


**Fig (1): A chart demonstrating the final classification of the examined patients**

### *2.2. Methods*

*2.2.1. Cephalometric radiographs*

Lateral and postero-anterior cephalometric films were taken for each subject with teeth in centric occlusion. The basic equipment required for both lateral cephalometric and postero-anterior views consisted of an x-ray source, an adjustable cephalostat and digital intensifying sensors*.

Digitized films were obtained and digital landmarks identification was chosen over manual tracing to be performed for its higher degree of accuracy, and time saving. Dental Tracer © software**, *Fig. (2)*, was chosen to trace the films.

*OC100 Instrumentarium Imaging Finland ** Software NileDelta

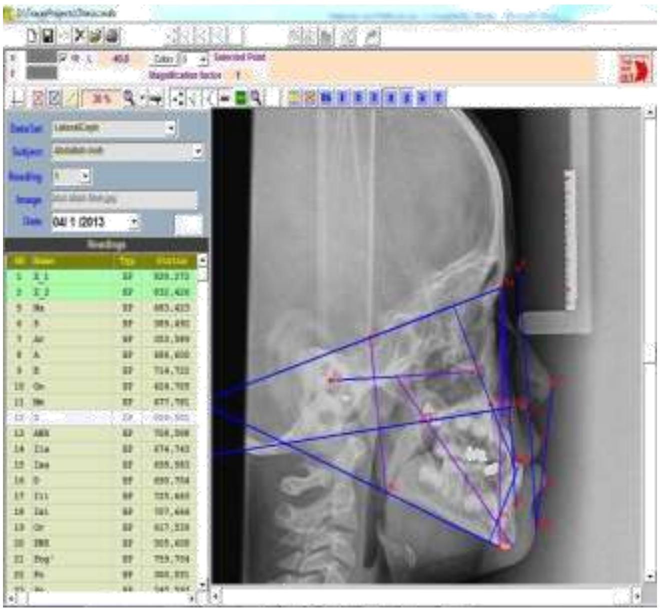

**Fig (2): Tracer Software used for landmarks' identification, and obtaining linear and angular measurements**

Each landmark on each film was identified twice by the same investigator within two weeks interval, and by another investigator once, one of the investigators is involved in the study, and the other was verifying the accuracy of anatomic structures and landmark placement.

Norms of the proposed measurements specific for the Egyptian population were obtained from Soliman (10).

Certain variables were selected from the most common analyses that represent the following measurements:

***2.2.1.1. Lateral cephalometric Measurements:***

1-Cranial base measurements **(Bjork) (11).**

2-Maxillary base measurements **(McNamara, Riedel) (9, 12)**

3-Mandibular base measurements **(McNamara, Riedel) (9, 12)**
4-Facial skeleton (profile) measurements **(Beatty, Down, Jaraback, McNamara, Riedel, Steiner) (8, 13, 14, 9, 12, 15)**
5-Dental measurements **(Riedel) (12)**

6-Soft tissue measurements **(Holdaway, Ricketts) (16, 17)**

*2.2.1.2. Postero-anterior cephalometric measurements: (Ricketts) (17)*

1-Bizygomatic width (Z-Z) (mm)

2-Bimaxillary width (J-J) (mm)

3-Bigonial width (Go-Go) (mm)

## III. Statistical Analyses

Data were presented as mean, standars deviation (SD) and standard error (SE) values. All data showed normal parametric distribution except for A-D (mm), AB-diff Nv (mm), ANB (°), A-Nv (mm), PP/SN (°), B-Nv (mm), U1-Na (mm), L1-NB (mm), Ls-E line (mm), and Li-E line which showed non parametric distribution. Inter- and intra-observer reliability was measured using Cronpach's alpha reliability coefficient. For parametric data, Student's unpaired t-test was used to compare between subjects with mixed and permanent dentition as well as to compare between subjects with with skeletal Class III and Class I. For non-parametric data, Mann-Whitney U test was used to compare between subjects with mixed and permanent dentition as well as to compare between subjects with skeletal Class III and Class
I. The significant level was set at P≤ 0.0. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

## IV. Results

***4.1. Lateral cephalometric measurements:***

*4.1.1. Cranial base measurements:*

Subjects with Class I showed statistically significantly higher mean saddle angle measurement than subjects with Class III in permanent dentition.

*4.1.2. Maxillary base measurements:*

Class III subjects with permanent dentition showed statistically significantly higher mean PNS-Ap Max (mm), A-Nv (mm), ANS-Na (mm) and SNA (°) measurements than subjects with mixed dentition of the same group.

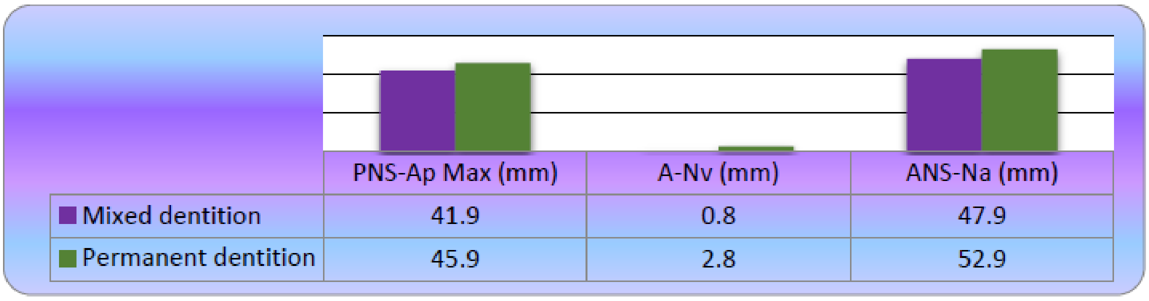


**Fig. (3): Mean linear maxillary base measurements in Class III subjects in the mixed and permanent dentition**

***4.1.3. Mandibular base measurements:***

Class III subjects showed statistically significantly higher mean mandibular base measurements than subjects with Class I except for MP (°).

Subjects with skeletal Class III permanent dentition group showed statistically significantly higher mean Ar-Go (mm), Cd-Gn (mm), Corpus length (mm), B-Nv (mm) and SNB (°) measurements than subjects with mixed dentition.

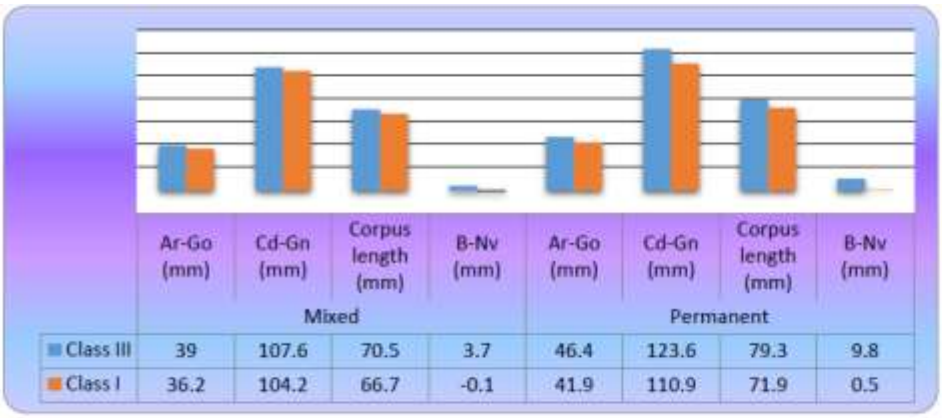


**Fig (4): Mean linear mandibular base measurements in subjects with Class III and Class I**

Class III

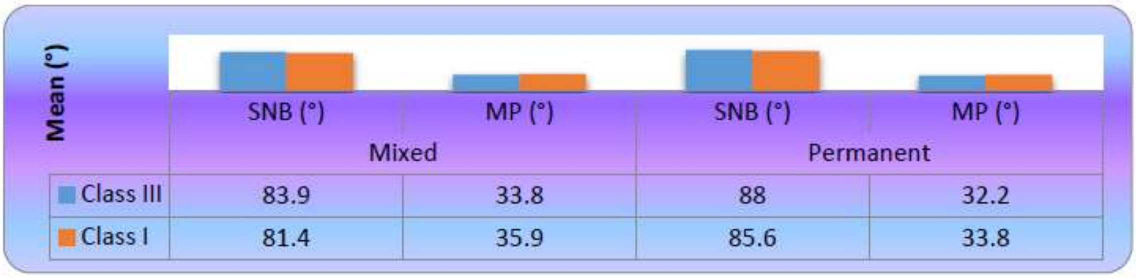


**Fig (5): Mean angular mandibular base measurements in subjects with Class III and Class I**

***4.1.4. Facial skeleton measurements:***

Subjects with Class III showed statistically significantly lower mean A-D (mm), AB diff-Nv (mm) and ANB (°) measurements than subjects with Class I in both mixed and permanent dentition groups.

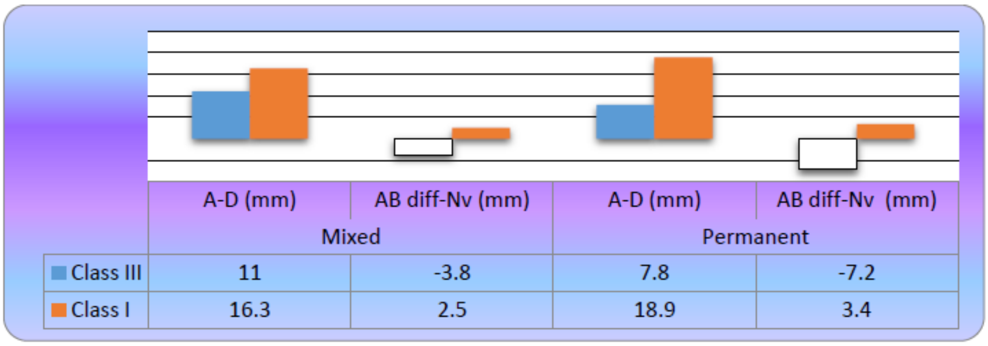


**Fig (6): Mean linear facial skeleton measurements in subjects with Class III and Class I**

***4.1.5. Dental measurements:***

Class III subjects showed statistically significantly lower mean L1-NB (mm) and Li inclination (°) measurements than subjects with Class I.

Class III subjects showed statistically significantly higher mean interincisal angle (°) measurements than subjects with Class I.

Subjects with Class III permanent dentition showed statistically significantly higher mean U1-NA (mm) and Ui inclination (°) measurements than subjects with mixed dentition.

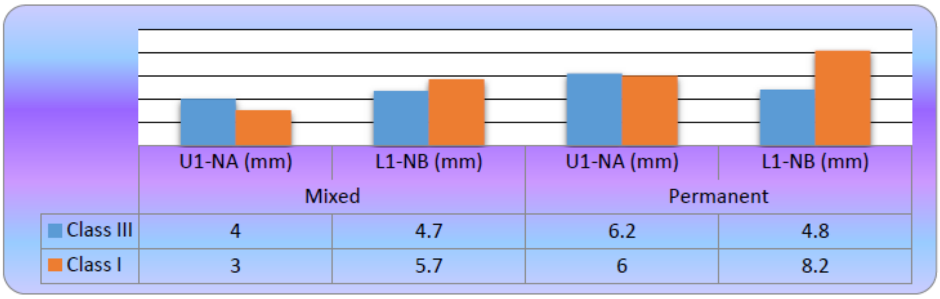


**Fig (7): Mean linear dental measurements in subjects with Class III and Class I**

***4.1.6. Soft tissue measurements:***

Class III subjects showed statistically significantly higher mean convexity (°) and facial angle (°) measurements than subjects with Class I.

Class III subjects showed statistically significantly higher mean Ls-E line (mm), upper lip thickness, convexity, and facial angle (°) measurements than subjects with Class I.

Subjects with permanent dentition showed statistically significantly higher mean Ls-E line (mm), upper lip thickness (mm), facial angle (°) measurements and convexity (°) than subjects with mixed dentition.

Subjects with permanent dentition showed statistically significantly lower mean Li-E line (mm) measurements than subjects with mixed dentition.

### *4.2. Postero-anterior measurements:*

There was no statistically significant difference between mean postero-anterior measurements in subjects with Class III and Class I.

There was no statistically significant difference between mean postero-anterior measurements in subjects with Class III and Class I.

Subjects with permanent dentition showed statistically significantly higher mean Bi-gonial width (mm) measurements than subjects with mixed dentition.

There was no statistically significant difference between mean Bi-zygomatic width and maxillary width (mm) measurements in subjects with mixed and permanent dentition.

Subjects with permanent dentition showed statistically significantly higher mean Bi-zygomatic width and Bi-gonial width (mm) measurements than subjects with mixed dentition.

There was no statistically significant difference between mean maxillary width (mm) measurements in subjects with mixed and permanent dentition.


| | Mixed | | | Permanent | | |
|---|---|---|---|---|---|---|
| | Bi-zygomatic width (mm) | Maxillary width (mm) | Bi-gonial width (mm) | Bi-zygomatic width (mm) | Maxillary width (mm) | Bi-gonial width (mm) |
| Class III | 132 | 70.8 | 94.9 | 136 | 67.2 | 101.2 |
| Class I | 132.2 | 70.9 | 92.8 | 137.4 | 71.2 | 98.6 |

**Fig. (8): Mean postero-anterior measurements in subjects with Class III and Class I**

## V. Discussion

In this study, the aim was to evaluate the craniofacial morphology of skeletal Class III in mixed (6-13 years) and permanent dentition groups (16-20 years), using different measurements on the lateral cephalometric view (cranial base, facial skeleton, maxillary base, mandibular base, dental and soft tissue), and on postero-anterior cephalograms (transverse widths of the face, maxillary base, and mandibular base), to describe the degree of abnormality upon comparison with the corresponding maturation levels of skeletal Class I normal growers, and to identify the skeletal variability among skeletal Class III subjects at different ages which would help clinicians deciding the proper treatment timing for these cases.

On comparing the permanent group of skeletal Class III with that of skeletal Class I there was only a statistically significant difference in the saddle angle, which was lower in Class III group. Hopkin et al (18) using point Articulare to represent the posterior limit of the cranial base, found out that the saddle angle systematically reduced from Class II, via Class I to Class III cases. These findings agree with those of the current study, but they didn’t explain why they were exclusive to the permanent dentition group.

Bhatia and Leighton (19) in an extensive longitudinal study, reported stability of cranial base angle after the age of 5, although there were wide individual variations that ranged from -7 to +10.

In subjects with skeletal Class III, permanent dentition groups showed statistically significant higher mean effective maxillary length (PNS-ApMax), more forward position of the maxilla according to A-Nv (FH), and SNA angle (in relation to the cranial base), and increased vertical position in relation to the cranial base (ANS-Na) when compared to mixed skeletal Class III dentition group. These findings elucidated that normal nasomaxillary complex growth could continue even with the presence of skeletal Class III discrepancy, and according to Enlow and Hans (20), the whole maxilla undergoes a

simultaneous process of primary displacement in an anterior and inferior direction as it grows posteriorly which justifies the increase in vertical dimension, antero-posterior lengthening and forward positioning, else the naso-maxillary complex completes most of its growth in the early mixed dentition stage, which is confirmed by suture closure around that stage. That is why it is recommended to treat patients with skeletal Class III, maxillary retrusion as early as possible, to get advantage of the responding sutures [78]. Findings of this study disagreed with those of Guyer et al (21) who stated that all maxillary linear measurements were significantly smaller than those of the control group. There was an agreement with Alexander et al (6) findings which revealed that the mid-facial growth was at its peak in the pre-pubertal stage, and that there was a considerable amount of mid-facial growth that occurred after the adolescent growth spurt, conversely Miyajima et al (22) stated that maxilla in Class III malocclusion maintains a constant position relative to the cranial base as the patient matures.

Upon permanent dentition comparison of both skeletal groups, skeletal Class III showed statistically significant higher mandibular base measurements, which agrees with Baccetti et al (5), Kuc-Mickalska and Baccetti (7), and Miyajima et al (22).

Mixed dentition group of skeletal Class III was compared to permanent group of the same class, and a statistically significant increase in all measurements of the permanent dentition group was noticed, ramal length, corpus length, effective length, antero-posterior position (B-Nv, SNB angle), except for tipping of mandibular base (MP/SN) which showed no statistically significant change. These findings are highly expected and agree with those of Guyer et al (21) Miyajima et al (22) Reyes et al (23), and with the normal mandibular growth pattern discussed by Enlow and Hans (20). On the other hand there was a disagreement concerning the stability of mandibular orientation with age. Baccetti et al (5) stated that there was an increase in the lower facial height that was accentuated by the eruption of second and third molars. The same finding was revealed by Wolfe at al (24), who found out that larger gonial and mandibular plane angles existed in Class III patients. Uchiyama (25) noted that Japanese patients with severe Class III malocclusion had an increased mandibular ramus, and total mandibular length associated with a more superiorly positioned glenoid fossa upon comparison with Caucasians, so with the increase in the mandibular ramus height, posterior facial height increased, and the anterior facial height relatively decreased. Enlow and Hans (20) stated that the Class III mandible is rotated forward in conjugation with an upward-backward middle cranial fossa rotation, and a vertically short nasal region, and that the mid-face is short relative to the vertical dimension of the ramus (or the ramus is long relative to the maxilla; either way), and that could explain why the class III face looks long.

Regarding the facial skeleton antero-posterior measurements, when comparing skeletal Class III groups with skeletal Class I in both mixed and permanent stages, it was found that skeletal Class III group showed lower ANB angle, A'-D', and A-B difference (FH), which agrees with the findings of Jacobson et al (26) who found a significant difference in the ANB angle between normal control group and Class III group, as well as Ellis and McNamara (1) who described Class III characters, and stated that one of the most important characters is prognathic mandible in relation to the maxilla.

When comparing permanent groups of skeletal Class I and skeletal class III, a statistically significant increase in retroclination of the mandibular incisors was noticed, there was an agreement with the findings of Alexander et al (6), Guyer et al (21), and Miyajima et al (22) who compared skeletal class III features with those of normal individuals, and noticed lingual tipping of lower incisors' crowns relative to their apical bases in class III cases.

On the other hand, when comparing the mixed and permanent dentition groups of skeletal Class III, it was found that the upper incisor inclination increased (U1/PP), and obtained a more anterior position. The fact that inclination of upper incisors increased with age in skeletal Class III individuals as a mean of compensation has also been supported by Alexander et al (6), and Guyer et al (21).

On comparing skeletal Class I mixed and permanent groups, there was a significant increase in the lower incisors inclination, so when the lower incisors in Class III didn't show a difference with age, this was considered a compensation, as they didn't follow the changes seen in skeletal Class I.

Permanent dentition group of skeletal Class III when compared to the permanent dentition group of skeletal Class I showed a statistically significant increase in upper lip thickness, angle of facial convexity and facial soft tissue angle. The thickness of upper lip differed among individuals and was not necessarily attained to the type of skeletal discrepancy (25, 27). Angle of facial convexity and facial axis angle were susceptible to increase due to the more anterior position of the soft tissue pogonion. Upper lip protrusion showed a significant decrease in relation to the E line, this was attainable to the forward chin position.

When comparing skeletal Class III mixed dentition group with permanent group , it was found that lower lip protrusion ( labrale inferius to esthetic line by Ricketts (17)) happened to increase with age in skeletal Class III individuals, alongside with upper lip thickness, angle of facial convexity, and soft tissue facial angle. This increase of lower lip protrusion is referred to the increase in mandibular overall size, thus the soft tissue would follow the bony profile, this agrees with what Miyajima et al (22) reported about Class III patients, that the underlying skeletal and dento-alveolar imbalances were reflected in the soft tissue profile, also Ngan et al (28) using six months treatment with maxillary expansion and protraction found that forward movement of the maxilla was accompanied by 50% to 70% forward movement of the soft tissue profile, similarly in the mandible, forward movement of the bony base is accompanied by lower lip protrusion. Though Subtelny

(29) offered a considerable body of evidence suggesting that different components of the soft tissue profile have differing rates and timing of growth and that all parts of the soft tissue profile usually don't grow in direct proportion to their apical bases.

The increase in upper lip thickness in skeletal Class III individuals with age could be justified by the increased muscle activity and strain to allow lip closure with this type of skeletal discrepancy. Facial angle showed an increase in its mean, which is due to the more anterior position of the chin (16). Angle of facial convexity showed an increase leading to a more concave profile but not as significant as that of facial angle, probably due to maxillary growth potentially causing a more anterior position of soft tissue subnasale, leading to a more acute angle of convexity.

Upper lip protrusion showed a statistically significant decrease, which was referred to the increased chin prominence, as the degree of prominence was measured in relation to a line connecting the tip of the nose with the most prominent part of the chin (soft tissue pogonion).

### *5.2. Postero-anterior cephalometric radiographic findings:*

When comparing skeletal Class I mixed dentition group with its equivalent skeletal Class III group, no statistically significant difference was observed. The same findings were observed upon comparing the permanent dentition groups.

Upon comparison of mixed dentition skeletal Class III group with the equivalent permanent group, results showed no statistically significant difference in the bizygomatic width, and the bimaxillary width, only bigonial width showed an increase. According to Hesby et al (30) maxillary transverse dimensions continued to change until early stages of growth and this was reflected in the change of bi-molar, bi-premolar widths of the maxillary arch, after this, very minor changes could be detected, which agrees with the findings of the current study. Though mandibular dimensions continued to change with bone deposition on the lateral sides of the rami of the mandible, and resorption of the medial sides [77]. This type of growth was exaggerated in cases of skeletal Class III with mandibular excess where all mandibular dimensions are larger than normal. According to Lux et al (31) about 84-91% of the bizygomatic, and mandibular transverse growth had been reached by the age of 7, and there is a deceleration of the intermolar width increase after the age of 7 provided that these findings were obtained from normal individuals. In the current study when comparing mixed and permanent dentition groups of skeletal Class I, it was found that bizygomatic and bigonial widths showed a statistically significant increase with aging.

## VI. Summary and Conclusion

- Mandibular antero-posterior dimensions were greater in skeletal Class III permanent dentition group than in skeletal Class I.
- Mandibular rotation didn't increase with age in skeletal Class III individuals.
- Maxillo-mandibular relation worsened with age in skeletal Class III individuals.
- Lower incisors of skeletal Class III individuals showed a more retroclined position when compared to those of skeletal Class I. Upper incisors' inclination increased in skeletal class III individuals with age.
- Concavity of the soft tissue profile increased with age with the mandibular forward movement.
- Transverse dimensions of the mandible of skeletal Class III individuals had no correlation with the antero-posterior discrepancy.
- Treatment of skeletal Class III cases is recommended in the early mixed dentition stage with big emphasis on the antero-posterior dimension.

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