ORIGINAL RESEARCH

# Determination of craniofacial relation among the subethnic Indian population: A modified approach – (Sagittal relation)

A Sumathi Felicita, Shyamala Chandrasekar, KK Shanthasundari

Department of Orthodontics, Saveetha Dental College, Chennai, Tamil Nadu, India

## ABSTRACT

**Aim**: To measure the linear cephalometric dimensions of anterior and posterior segments of the craniofacial complex sagittally, to establish ratios between different linear dimensions of sagittal segments and check for dimensional balance among the various segments in subjects with normal occlusion, pleasing profile and facial harmony.

**Setting and Sample Population**: Department of Orthodontics, Saveetha University. Lateral cephalograms of 120 subjects of both sexes in the age group of 17-28 years with normal occlusion belonging to Chennai, India

**Materials and Methods**: Linear dimensions of anterior and posterior segments of the craniofacial complex were measured sagittally with the posterior maxillary plane as a key reference plane. Ratios were established between the various parameters in the anterior and posterior region.

**Results**: A ratio of 1:1 was found to exist between the individual and aggregate sagittal segments of the craniofacial complex in both sexes. There was a statistically significant sexual dimorphism in the aggregate lengths($P$=0.028,$P$=0.005).However, the ratio between the anterior cranial floor and effective maxillary length was 2:3 and 5:8 and that between anterior cranial floor to effective mandibular length was 5:8 and 3:5 in females and males respectively. The difference in the above values was not statistically significant.

**Conclusion**: A dimensional balance was found to exist between the maxilla and mandible both at the dentoalveolar and skeletal level with a ratio of 1:1. There was also a dimensional balance between the posterior cranial floor and ramus width. However, there was no architectural balance between the anterior cranial floor and maxilla and mandible.

Received : 29-11-10
Review completed : 01-06-11
Accepted : 08-11-11

**Key words:** Aggregate length, anterior segment, posterior segment, ratio, sagittal parameters

Radiographic cephalometry is an important investigative tool available to clinicians and researchers. It is used for a wide variety of diagnostic and comparative procedures and its potential for research purpose seems limitless.

A variety of cephalometric analyses[1-11] have been described for different applications by ascertaining the dimensions of lines, angles and planes between anthropometric landmarks established by physical anthropologists and points selected by orthodontists. Their primary use is to provide a means of comparison of individual dentofacial characteristics with a population average in order to identify areas of specific deviation, as well as describe the spatial relationship between various parts of the craniofacial structures. These analyses which are based on linear and angular measurements have their inherent drawbacks due to anatomical variation and growth changes occurring in different anatomical landmarks and reference planes. Also, the values measured are compared with a population standard which has a wide range of values and may not reflect the true picture of the existing malocclusion.

To overcome these limitations of conventional analysis, establishment of ratios to assess the skeletal, dental and soft tissue relationships by comparing one segment of the craniofacial complex with other would be more appropriate. This will help ascertain discrepancy of one particular skeletal

Address for correspondence:
Dr. A. Sumathi Felicita
E-mail: felicitaa@rediffmail.com.

| Access this article online | |
|---|---|
| Quick Response Code: | Website: www.ijdr.in |
| | |
| | DOI: 10.4103/0970-9290.102210 |

component when compared to another without having to refer to a population standard.

This concept was envisaged by Enlow D.H *et al.*,[12] in their analysis of intrinsic facial form and growth in which the cephalometric evaluation for an individual is based on their own particular morphological and morphogenetic facial pattern without referring to statistical population standards. According to them there are four basis morphological concepts namely the concept of architectural equivalence, the concept of effective dimensions, the concept of aggregate balance and the concept of incremental balance.

According to the concept of architectural equivalence[12] a prescribed portion of each bone represents a direct architectural counterpart of some segment of another bone, even though their respective functions and other anatomic relationships are different. If any two such equivalents match, a dimensional balance is produced and morphological fit is provided. If the match does not occur, corresponding architectural imbalance result and affects not only their fit but that of other contiguous bones as well.

The concept of incremental balance[12] applies to increments of growth as well as to effective anatomical dimensions among the structural equivalents. If dimensional imbalance exists, an incremental balance can subsequently take place in such a way that dimensions are later brought into actual balance. Dimensional balance at an early age becomes upset by imbalanced growth increments.

Considering the clinical usefulness of this concept of intrinsic facial form and growth, a lateral cephalometric study was undertaken to evaluate the sagittal and vertical skeletal relationships of the craniofacial complex among subjects with normal occlusion, pleasing profile and facial harmony. A craniofacial analysis based on ratios was developed for cephalometric evaluation of chosen subjects who belonged to the local population in Chennai.

India is a large country, its inhabitant being multiethnic.[13] Indian population has been largely divided into seven ethnic groups based on their anthropometric measurements, skin colour and language. Dravidians, one of the subethnic groups inhabit Southern India especially Tamil Nadu, Kerala, Andhra, Southern Bihar and coastal Orissa. The food, dietary habits and language differ and hence prevalence of malocclusion. Chennai, the capital of Tamil Nadu in India, is a cosmopolitan city. The native Chennai population however belongs to the Dravidian subethnic group with a distinct culture and Tamil as their mother tongue.

The aim of the present study was to
- To measure the sagittally linear cephalometric dimensions of anterior and posterior segments of cranial, nasomaxillary and mandibular complex in subjects with normal occlusion and pleasing profile and facial harmony
- To establish ratios between the sagittally linear dimensions of craniofacial segments
- To evaluate whether a dimensional balance exists between the different segments of the anatomic of the craniofacial complex.

The craniofacial relation established between the sagittal linear dimensions is reported in the present study.

## MATERIALS AND METHODS

The sample for the present study consists of 120 patients, 60 males and 60 females from the local population staying in Chennai city, within the age group ranging from 17 to 28 years with Tamil as a mother tongue.

The subjects were selected based on the following criteria.
- Clinically acceptable pleasing profile and with facial harmony and balance.
- Angle's class I molar and canine relation with minimal spacing, crowding or rotation.
- Normal overjet and overbite (less than 3 mm).
- Full complement of teeth except third molars with proper intercuspation.
- No history of trauma, surgical intervention or orthodontic treatment.
- No functional shift of the mandible during opening or closing.
- No temporomandibular joint dysfunction symptoms such as crepitus, clicking or pain.
- No systemic complaints.

The criteria were verified clinically and recorded in a proforma especially designed for the purpose. Clinical extraoral and intraoral photographs of all the subjects were taken. They were evaluated by two faculty members in the Department of orthodontics to confirm features of acceptable pleasing profile, facial harmony and normal occlusion.

In order to standardize the lateral cephalograms all of them were taken in the same cephalostat machine by a single operator with the head in natural posture.[14] Magnification error was determined by taping a piece of 19-gauge wire of length 3 cm over the temple region and actual length and radiographic length were compared and magnification obtained. The magnification factor was found to be 9.3. Since the subject-film distance, subject X-ray source distance, cephalostat, operator and X-ray film all were kept constant, magnification factor was not added to the cephalometric linear dimension.

The reference points used are given in Table 1 and Figure 1. The key reference planes were functional occlusal plane and

PM vertical [Figure 2]. SE point and FMS (frontomaxillary nasal suture) have been used in the construction of key reference plane. These landmarks were taken to overcome the problems encountered in the stability of nasion and sella during growth. During growth, remodeling at the floor and the posterior wall of the sella tursica results in downward and backward displacement of the sella whereas nasion can be displaced sagittally and vertically because of expansion and development of the maxillary sinus. According to Melsen,[15] FMN suture and SE point do not undergo any remodeling after childhood.

The PM vertical or the posterior maxillary plane[16] is a vertical plane from the sphenoethmiodal suture in the base of the cranium to the posterior surface of the maxillary tuberosity. This line differentiates the craniofacial components into an anterior and posterior component. Structures anterior to the PM line are the anterior cranial base, the nasomaxillary complex and corpus of the mandible. Structures posterior to this line consist of posterior cranial base, the pharynx and the ramus of the mandible.

Making use of the above reference points and planes linear dimensions of specific anatomic segments were measured parallel to the functional occlusal plane sagittally with PM vertical as the vertical reference line [Figure 2]. All measurements were performed by a single operator.

The various sagittal parameters measured and were given alphabetical and numerical code as given below [Table 2].

B1-B7- Individual segments in the anterior and posterior region

C1-C4-Aggregate length of anterior and posterior segment

**Table 1: The detailed description of the landmarks used in the study**

| Reference points | Description |
|---|---|
| SE point (Sphenoethmoidal) | Point determined by the intersection of the greater wing of the sphenoid and the cranial floor as seen in lateral head films. |
| FMS point (Frontomaxillarynasal suture) | Superiormost point of the suture at the articulation of the frontal, nasal bone and maxillary bone. |
| A point (Subspinale) | Point at the deepest midline concavity of the maxilla between the anterior nasal spine and prosthion. |
| B point (Supramentale) | Point at the deepest midline concavity on the mandibular symphysis between the infradentale and pogonion. |
| SPr point (Superior prosthion) | Point of contact of alveolar margin between the two maxillary central incisors. Represents the anterior limit of the maxillary dentoalveolar segment |
| IPr point (Inferior prosthion) | Point of contact between the alveolar process between the two central incisors of the mandible. Represents the anterior limit of the mandibular dentoalveolar segment. |
| ANS | The tip of the bony anterior nasal spine in the median plane |
| PNS | The intersection of a continuation of the anterior wall of the pterygopalatine fossa and the floor of the nose marking the dorsal limit of the maxilla |

**Table 2: The parameters used in the study**

| Code | Parameter |
|---|---|
| | Horizontal |
| B1 | Anterior cranial floor |
| B2 | Posterior cranial floor |
| B3 | Effective maxillary length at point A |
| B4 | Effective maxillary length at superior prosthion |
| B5 | Effective mandibular corpus length at inferior prosthion |
| B6 | Effective mandibular corpus length at point B |
| B7 | Ramus width |
| | Composite values |
| C1 | B3+B2 |
| C2 | B4+B2 |
| C3 | B5+B7 |
| C4 | B6+B7 |

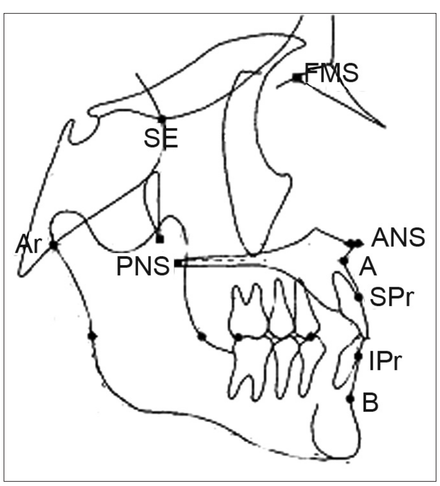



**Figure 1:** Showing the various landmarks used in the study.

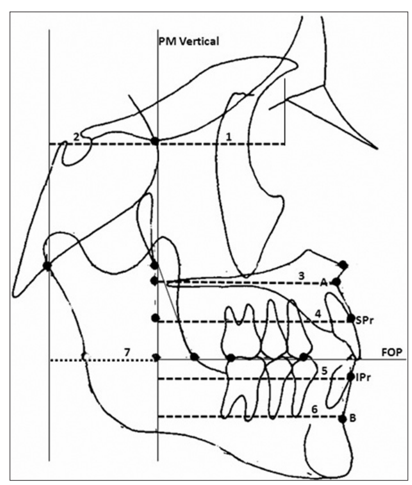



**Figure 2:** Showing the key reference planes and the various parameters used in the study. 1- Anterior cranial floor, 2-Posterior cranial floor, 3-Effective maxillary length at point A, 4-Effective maxillary length at superior prosthion, 5-Effective mandibular corpus length at inferior prosthion, 6-Effective mandibular corpus length at point B, 7-Ramus width, FOP- Functional occlusal plane.

The different parameters in the anterior region are anterior cranial floor, effective maxillary length at point A and superior prosthion and effective mandibular length at point B and inferior prosthion. The posterior region consists of the posterior cranial floor and ramus width [Figure 2]. All the parameters were measured parallel to the functional occlusal plane. It is to be noted that the entire length of maxilla or mandible was not taken into account to determine the length of the skeletal bases [Table 2 and Figure 2]. The effective maxillary length at point A is measured from point A to the PM vertical along the palatal plane. The effective mandibular length at point B is measured from point B to the PM vertical and is denotes the mandibular corpus length. Similar measurements are made at the superior and inferior prosthion.

The aggregate length in the maxilla consists of the aggregate length measured at point A and superior prosthion. The aggregate length at point A is the sum total of effective maxillary length at point A and the posterior cranial floor. The aggregate length at superior prosthion is the sum total of effective maxillary length at superior prosthion and the posterior cranial floor. Similarly the aggregate length in the mandible is measured at point B and inferior prosthion. The aggregate length at point B is measured between ramus width and effective mandibular length at point B and that at the inferior prosthion is measured between the inferior prosthion and ramus width [Table 2]. All measurements made at the point A and point B denotes skeletal characteristics and all measurements made at superior and inferior prosthion denote dentoalveolar characteristics.

The measurements thus obtained were entered in a form analysis sheet and tabulated. In order to evaluate whether a dimensional balance existed between the different anatomical segments, ratios were determined between the different segments for males and females separately. The values were subjected to statistical evaluation to check for sexual dimorphism between males and females for the various ratios established.

In order to evaluate intra examiner variability in measurements 10 cephalograms (five each from males and females) were randomly selected and retraced after 3-week interval. The values were subjected to statistical evaluation.

## Statistical analysis

Intraoperator error was determined by Dahlberg's method of error determination. The mean values of the individual ratios of the segments were calculated. Independent 't' test was done to assess the level of significance for sexual dimorphism. A "*P*" value < 0.05 is 95% significant, "*P*" value <0.01 is 99% significant and a "*P*" value < 0.001 is 99.9% significant. The results obtained from the statistical evaluation were tabulated in Table 3 and graphically represented in Graphs 1-7.

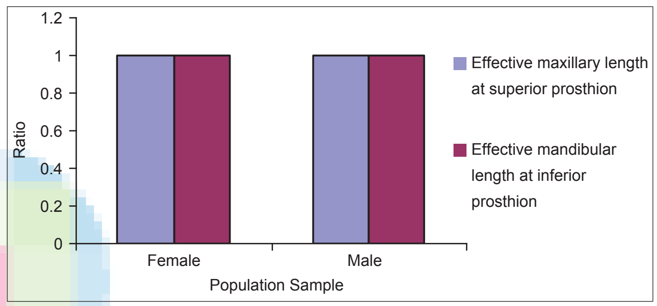
## RESULTS

Table 3 shows the ratios calculated from the various parameters (designated by alphabetical code) among males and females and their level of significance.

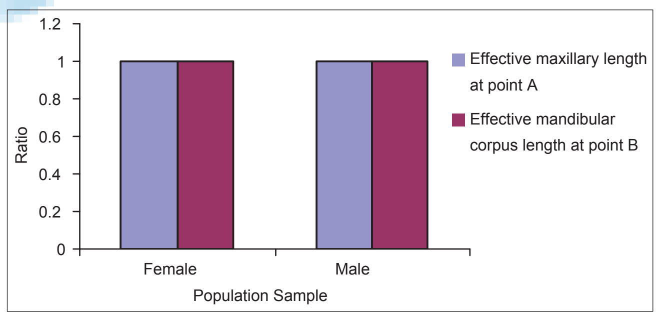
The statistical evaluation of intra operator error showed that the "r" value is in the range of 0.000689-0.0792. This value indicates that the evaluation by the operator is consistent. "r" value nearing 1 indicates inconsistency.

Horizontal evaluation of the craniofacial complex shows that the ratio between the effective maxillary length at the superior prosthion (B4) to the effective mandibular corpus length at the inferior prosthion (B5) was found to be 1.02318:1 (1:1) in females and 1.00418:1 (1:1) in males [Table 3 and Graph 1].

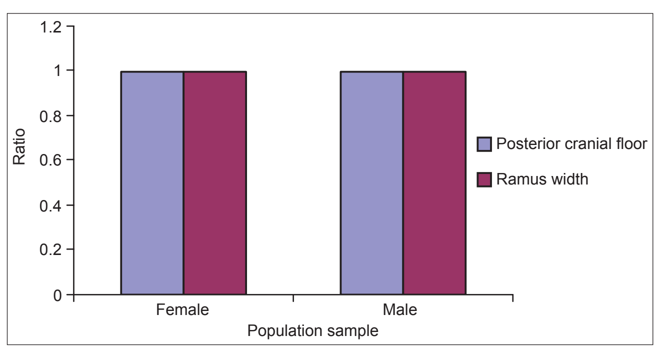
A ratio of 0.95448:1 (1:1) in females and 0.93573:1(1:1) in




**Graph 1:** Effective maxillary length at superior prosthion : Effective mandibular length at inferior prosthion




**Graph 2:** Effective maxillary length at point A : Effective mandibular corpus length at point B




**Graph 3:** Posterior cranial floor : Ramus width

males was noted between the effective maxillary length at point A (B3) to the mandibular corpus length at point B (B6) [Table 3 and Graph 2].

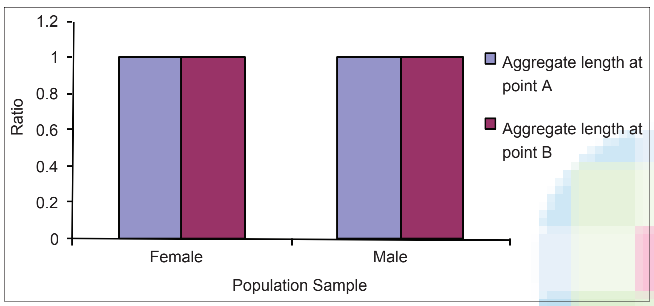
Evaluation of the dimensional relationship in the posterior segments revealed that the ratio between the posterior cranial floor (B2) and ramus width (B7) is 1.05942:1(1:1) in females and 1.07189:1(1:1) in the males [Table 3 and Graph 3].

The ratio between the aggregate maxillary length at point A (C1) and the aggregate mandibular length at point B (C4) was found to be 1.02544:1 (1:1) in females and 0.98807:1(1:1) in males. The difference between the males and females ratios was statistical significant at a level of 95% ($P$=0.028) [Table 3 and Graph 4]. Similarly the ratio between the aggregate maxillary length at the superior prosthion (C2) to the aggregate mandibular length at the inferior prosthion (C3) was found to be 1.03148:1 (1:1) in females and 0.98201:1(1:1) in males. The difference in the ratio being statistically significant at a level of 99% ($P$=0.005) [Table 3 and Graph 5].

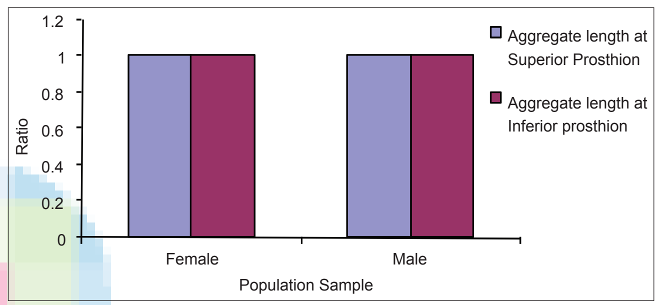
A statistically significant sexual dimorphism was noted between the aggregate length (combined anterior and posterior segments) between males and females though individually there was no statistical difference between both sexes. The ratio was less in males compared to females {0.988:1 and 1.025:1 for skeletal and 0.98:1 and 1.031:1 for dentoalveolar} [Table 3].

The ratio between the anterior cranial floor (B1) and effective maxillary length at point A (B3) is 0.66241:1 (2:3) in females and 0.63425:1 (5:8) in males [Table 3 and Graph 6].

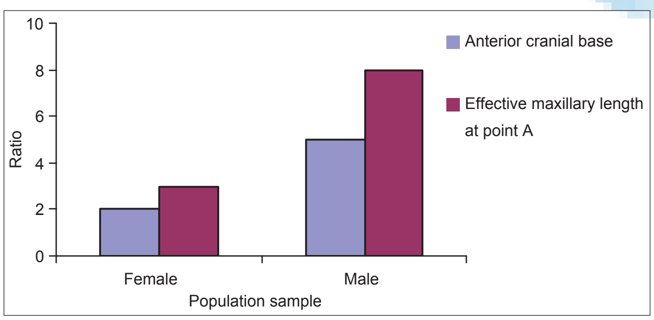
The ratio between the anterior cranial floor (B1) and mandibular corpus length at point B (B6) is 0.63315:1 (5:8) in females and 0.59591:1 (3:5) in males [Table 3 and Graph 7].



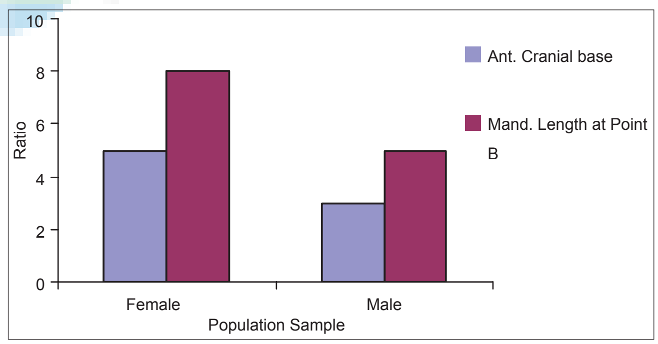

**Graph 4:** Aggregate length at point A : Aggregate length at point B




**Graph 5:** Aggregate length at superior prosthion : Aggregate length at inferior prosthion




**Graph 6:** Anterior cranial base : Effective maxillary length at point A




**Graph 7:** Anterior cranial base : Effective mandibular length at point B

**Table 3: The ratios of the various sagittal parameters studied**

| Parameter | Female | | Male | | Significance |
|---|---|---|---|---|---|
| | Mean | Ratio | Mean | Ratio | |
| Horizontal | | | | | |
| B4:B5 | 1.02318:1 | 1:1 | 1.00418:1 | 1:1 | .179NS |
| B3:B6 | 0.95448:1 | 1:1 | 0.93573:1 | 1:1 | .387NS |
| B2:B7 | 1.05942:1 | 1:1 | 1.07189:1 | 1:1 | .662NS |
| C1:C4 | 1.02544:1 | 1.025:1 | 0.98807:1 | 1:1 | .028 Significant |
| C2:C3 | 1.03148:1 | 1.03:1 | 0.98201:1 | 1:1 | .005 Significant |
| B1:B3 | 0.66241:1 | 2:3 | 0.63425:1 | 5:8 | .106NS |
| B1:B6 | 0.63315:1 | 5:8 | 0.59591:1 | 3:5 | .132NS |

*P*-value < 0.01 – significance of 99%. *P*-value < 0.05 – significance of 95%

## DISCUSSION

The rationale behind this analysis is that that if planes are constructed so that the activities of growth and remodelling fields are directly represented, a built in and morphologically natural set of standard is identifiable for meaningful evaluation of overall craniofacial form and pattern. Also, a given bone or part of a bone is compared with another specific segment within the complex craniofacial assembly without reference to population norms .If they exactly match or nearly so a dimensional balance exists between them. If one is either short or long, the resulting imbalance can produce a protrusion or retrusion of the face affecting the profile.[12]

The results obtained in the present study are expressed as ratios between the various segments to determine the dimensional balance among the different segments. Horizontal evaluation of effective maxillary length at point A and effective mandibular length at point B revealed a ratio of 0.95448:1 (1:1) in females and 0.93573:1(1:1) in males. Similarly a ratio of 1.02318:1(1:1) and 1.00418:1 (1:1) was found to exist between effective maxillary length at superior prosthion and effective mandibular length at inferior prosthion in females and males respectively. These observations indicate a dimensional balance between maxillary and mandibular effective length at both the apical base level and the dentoalveolar level.

A dimensional relationship was found to exist between posterior cranial floor and ramus with a ratio of 1.05942:1(1:1) and 1.07189: 1(1:1) in females and males, respectively. This confirms the concept of architectural equivalence between the anatomical segments in both sexes in the posterior segment.

Evaluation of aggregate length of maxilla at point A compared with aggregate length of mandible at point B and also aggregate length of maxilla at superior prosthion compared with aggregate length of mandible at inferior prosthion revealed that the aggregate length of maxilla and mandible are in dimensional balance in both males and females as with a ratio of 1:1 in both males and females.

However, a statistically significant sexual dimorphism was noted in the aggregate length between the maxilla and mandible in males and females though the individual segments anteriorly and posteriorly did not show any sexual dimorphism. This is an interesting observation which indicates that there is a dimensional difference between males and females in the aggregate maxillary and mandibular length at the skeletal and dentoalveolar level point A. The ratio was less in males compared to females. This, however, was not revealed in their individual skeletal base lengths possibly because the difference in the individual lengths between males and females was minimal and was not expressed in the ratio.

An attempt was made in this study to establish a ratio between anterior cranial floor and effective maxillary length at point A. The ratio was 0.66241:1 (2:3) in females and 0.63425:1 (5: 8) in males. Similarly, the ratio between anterior cranial floor and effective mandibular length at point B was found to 0.63315:1 (5:8) and 0.59591:1(3:5). This finding indicates that anterior cranial floor is not in structural or architectural balance with the maxilla or the mandible.

It is thus evident from the above discussion that there is a structural balance between all the anatomical segments of the craniofacial complex with a ratio of 1:1 except that between the anterior cranial floor and maxilla and mandible in both sexes in subjects with normal occlusion, pleasing profile, facial harmony belonging to the local Chennai population and confirms the principle of architectural equivalence.

Based on the concept of architectural equivalence Enlow, Kuroda, Takayuki and Lewis[16,17] described a procedure for evaluation of growth, craniofacial form and pattern. Comparing the dimensional relationship and growth changes of the basic anatomical parts the craniofacial form and growth pattern was evaluated.

Enlow *et al*,[17] analysed head films of 137 class I untreated individuals at various ages and found that some class I individuals had a protrusive maxillary A point relative to B point and others had protrusive mandibular B point relative to A point. In their subsequent study they reported that intrinsic craniofacial compensations between the regional anatomic counterparts can have neutral effect, a maxillary protrusive effect or a mandibular retrusive effect.

A cephalometric analysis of craniofacial pattern was undertaken by Donald H. Enlow, Charles Pfister, Elisha Richardson and Takayuki Kuroda[18] for 180 class I black and caucasian individuals who were in their deciduous or mixed dentition stage of development.

A similar study was undertaken by Trouten JC, Donald H Enlow, Rabine M, Phelps AE, and Swedlow[19] to evaluate craniofacial pattern underlying anterior deep bite and open bite.

Mohandas Bhatt and Enlow DH[20] observed that structural factors contribute towards maxillary/mandibular protrusion or retrusion. They reported that depending upon the character and magnitude of the regional relationship and intrinsic compensatory growth, class I and II malocclusions are characterized either as type A or type B based on whether point A or point B is protrusive relative to the other along the occlusal plane.

Moyers, Bookstein, Hunter[21] evaluated cephalometric measurements based on the data derived from the university of Michigian growth study for both sexes from 4 to 18 years of age for profile and vertical analysis based on a similar analysis. They established a structural balance of anatomical segments between maxilla, mandibular corpus, ramus and posterior cranial base. Moyer also reported that facial proportions change with age with significant sexual differences.

Dale. J[22] subsequently evolved a proportional facial analysis based on this analysis, basically for classification of facial pattern. The proportional facial analysis clearly describes the multifactorial anatomic basis for malocclusion and explains the way in which compensations may occur to prevent or minimize a discrepancy.

Cevidanes LH *et al*[23] evaluated the cephaometric changes in 28 Brazilian children treated with Frankel regulator II using a simplified version of this analysis.

Di Paolo *et al*[24] in their quadrilateral analysis have also reported that in a balanced facial pattern a ratio of 1:1 exists between the maxillary base length and mandibular base length as noted in the present study although the landmarks used were different.

Schwarz[25] taking into account different anatomic landmarks for measurement established a ratio of 20:21 between the anterior cranial floor and mandible.

An account of individual combination of anatomical and developmental relationship that produce the craniofacial pattern in the subjects studied through this analysis will be of great clinical relevance and importance in diagnosis, treatment planning and treatment evaluation without reference to population standards or norms.

### Clinical application of the study

The advantage of this analysis is that all dimensional effects are determined solely by a comparison of each bony part with its various anatomical segments with no need for reference to population standards. Numerical values for the dimensions and angular relationship involved are irrelevant and any comparison of a bone's length in mm with a statistical standard becomes meaningless. The purpose is to determine simply whether any given bony part is horizontally or vertically long or short relative to its particular corresponding equivalent. This information in turn is used to determine how that bone contributes to the skeletal and dental basis for class I, II or III status.

It can serve as an efficient tool in diagnosis and treatment planning for class II, class III tendencies. To identify which of the skeletal base is at fault the ratio between anterior cranial base with that of maxilla and mandible can be considered for guidance. Relative increase or decrease in the dimensions of the anatomic segments can be analysed based on ratios to determine the anatomic basis for skeletal malocclusion. Combined with vertical parameters it can be used in the evaluation of deep bite or open bite malocclusion. A deviation in the normal ratio of 1:1 indicates a skeletal imbalance.

In growing patients it can be effectively used to evaluate the area of discrepancy and determine whether orthodontic/ orthopedic intervention is required to correct sagittal discrepancy depending on the growth status of the particular patient.

The above analysis is clinically relevant for evaluation of craniofacial, skeletal and dentoalveolar profiles to determine the structural and architectural balance or imbalance of the craniofacial complex and to localize and quantify skeletal contribution in malocclusion without reference to population norms.

## CONCLUSION

Thus, a structural and dimensional balance exists between the different anatomic segments in the anterior and posterior region with the ratio of 1:1 between their individual length and aggregate length except that between the anterior cranial floor and maxillary and mandibular length.

This analysis is based on the establishment of ratios and can be an important clinical tool to evaluate the sagittal structural balance or imbalance of the craniofacial complex and to localize the area of discrepancy without referring to population norms. It is a valuable adjunct for treatment planning and evaluation along with other dentoalveolar and soft tissue profile considerations.

## REFERENCES


1. Steiner CC. Cephalometrics for you and me. Am J Ortod 1953;39: 729-55.
2. Downs WB. Variation in facial relationship: Their significance in treatment and prognosis. Am J Orthod 1948;34:812-84.
3. Ricketts RM, Bench RW, Gugino CF, Hilgers JJ, Schulhof R. Bioprogressive therapy. Rocky Mountain Orthodontics, Denver; 1979.
4. Burstone CJ, James RB, Legan H, Murphy GA, Norton LA. Cephalometrics for orthognathic surgery. J Oral Surg 1978;36:269-77.
5. Holdaway RA. A soft tissue cephalometric analysis and its use in orthodontic treatment planning: Part I: Am J Orthod 1983;84:1-28.
6. McNamara JA. A method of cephalometric evaluation. Am J Orthod 1984;86:449-69.
7. Brodie Allan G. Appraisal of present concepts in orthodontia. Angle Orthod 1950;20:24-38.
8. Sassouni V. A roentgenocephalometric analysis of cephalofacialdental relationships. Am J Orthod 1955;41:735-64.
9. Bimler HP. Bimler Therapy, Part I: Bimler cephalometric analysis. J Clin Orthod 1985;19:501-23.
10. Bimler HP. A roentgenoscopic method of analyzing the facial correlations. Trans Eur Orthod Soc 1957. p. 241-53.
11. Salzmann JA. Orthodontics practice and technics. J.B, Lippincott Company; 1957.
12. Enlow D, Moyers RE, Hunter WS, McNamara JA Jr. A procedure for the analysis of intrinsic form and growth: An equivalent-balance concept.

Am J Orthod 1969;56:6-22.
13. Kharbanda OP. What is the prevalence of malocclusion in India? Do we know Orthodontic treatment needs of our country? J Indian Orthod Soc 1993;32:33-41.
14. Moorrees CF, Kean MR. Natural head position: A basic consideration in the interpretation of cephalometric radiographs. Am J Phys Anthrop 1958;16:213-34.
15. Melsen. The cranial base. Acta Odontol Scand 1974;32:S62. as cited in Franchi L, Baccetti T, McNamara JA Jr. Treatment and post treatment effects of acrylic Herbst appliance therapy. Am J Orthod 1999;115:429-38.
16. Enlow D, Kuroda T, Lewis A. The morphological and morphogenetic basis for craniofacial form and pattern. Angle Orthod 1971a;41:161-88.
17. Enlow DH, Kuroda T, Lewis AB. Intrinsic craniofacial compensations. Angle Orthod 1971b;41:271-85.
18. Enlow DH, Pfister C, Richardson E, Kuroda T. An analysis of Black and Caucasian Craniofacial pattern. Angle Orthod 1982;52:279-87.
19. Trouten, Enlow, Rabine, Phelps, Swedlow. Morphologic characteristics in deep bite and open bite. Angle Orthod 1983;53:192-211.
20. Bhatt M, Enlow D. Facial variations related to head form types. Angle Orthdont 1985;55:269-80.
21. Moyer RE. Handbook of Orthodontics. 4th ed. Year book of Medical publishers.
22. Dale J. Orthodontics: Current principle and techniques. In: Graber TM, Vanarsdall RL, Vig KW, Editors, 4th ed. Maryland Heights, Westline Industrial Drive, St.Louis: Missouri: Elsevier Mobsy Inc; 2005. p. 414.
23. Cevidanes LH, Franco AA, Scanavini MA, Vigorito JW, Enlow DH, Proffit WR. Clinical outcomes of Fränkel appliance therapy assessed with a counterpart analysis. Am J Orthod Dentofacial Orthop. 2003; 123:379-87.
24. Di Paolo RJ. The quadrilateral analysis, cephalometric analysis of the lower face. J Clin Orthod 1969;3:523-30.
25. Schwarz. Roentgenostatics: A practical evaluation of the x-ray head plate. Am J Orthod 1961;47:561-85.

**How to cite this article:** Felicita AS, Chandrasekar S, Shanthasundari KK. Determination of craniofacial relation among the subethnic Indian population: A modified approach - (Sagittal relation). Indian J Dent Res 2012;23:305-12.

**Source of Support:** Nil, **Conflict of Interest:** None declared.