



Original Article

Evaluation of McNamara's analysis in South Indian (Tamil Nadu) children between 8–12 years of age using lateral cephalograms

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1. Introduction

The most common problem in any diagnostic system is to establish a range of normality. To determine an existing abnormality, it is essential to establish a normal range of values. In case of malocclusion, we must first establish a range of normality to detect the pathological abnormality. Lateral cephalometric radiograph has become an imperative tool in the orthodontic diagnosis and treatment planning which is a reliable and reproducible tool.¹ Cephalometric radiograph provides measurements that are unique for a person being investigated² and it is a valuable tool to predict growth changes.³

Growth is a continuous and sequential process in children with a unique pattern for each child. These developmental changes can influence the cephalometric standards. Evaluating children at an early stage, whose growth deviates from usual growth patterns helps to correct the problem by early orthodontic intervention during late deciduous or early mixed dentition.⁴ American Association of Orthodontics (AAO) suggests that orthodontic diagnosis in children should be done early and not later than 7 years of age.⁵

As genetics plays a major role in the development of facial pattern and dentition,⁶ differences in size, growth and shape occurs for different ethnic groups. Cephalometric norms are important and standard measurements which help to determine the extent of deviation from normality. Several studies have reported that the standard cephalometric measurements of one ethnic group should not be considered as normal and should not be applied for other ethnic group.^{7–9} Indian

children differ from western children in growth, development of dentition and maturation,¹⁰ so the cephalometric standards of different ethnic origins cannot be applied to Indian children.

As AAO states the importance of orthodontic check-up as early as 7 years of age and children commonly undergo orthodontic treatment at around 10–14 years of age,^{11–14} priority should be given to establish norms for the mixed dentition age group. Various cephalometric norms have been established for Indian adult populations and few norms have been established for children.

Though several cephalometric analysis exist, McNamara analysis is one which is not only sensitive to the position of the teeth but also to the cranial base structures.¹⁵ McNamara analysis has given values specific for growing children from 6 years of age and more importantly these are linear measurements than angular measurements. It can easily be explained to the patients and their parents. As no standard cephalometric norms have been previously established for McNamara's analysis in South Indian (Tamilnadu) children with mixed dentition, the following study is undertaken to evaluate cephalometric values using McNamara's analysis and to derive normative values for South Indian (Tamilnadu) children between 8–12 years of age. Hence, the present study was aimed to evaluate cephalometric values using McNamara's analysis in children between 8–12 years of age

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2. Materials and methods

2.1. Ethical approval

The study was conducted in the Department of Pediatric dentistry, Saveetha Dental College. The study was approved by the Institutional Scientific Research Board, Saveetha University (SR/STPG-14). The lateral cephalograms were taken for the children who reported to the outpatient of the Department of Pediatric Dentistry, Saveetha Dental College.

2.2. Selection criteria

- Sample size-150 children (75 boys and 75 girls).
- Age group- 8–12 years of age.
- Group I -8-10 years age.
- Group II-11–12 years of age.
- 30 Children were allocated to each age group (15 boys and 15 girls).

2.3. Inclusion criteria

- Children with nearing or established class I occlusion.
- Flush terminal plane or mesial step molar relationship in primary dentition.
- Overjet and overbite within normal limits.
- No crossbite or crowding.
- Family linkage of each subject was traced upto 3 generations.

2.4. Exclusion criteria

- Children with a history of systemic disease.
- Child's parents failed to give an informed consent.
- Families with intercaste marriages.

2.5. Materials

- PLANMECA PROMAX digital cephalostat
- FACAD SOFTWARE for cephalometric tracing and analysis

2.6. Radiographic technique

The lateral cephalograms of the selected children were taken in the Department of Radiology, Saveetha Dental College and Hospitals, Chennai. Same X-ray machine (PLANMECA PROMAX) was used to obtain all lateral cephalograms. The PLANMECA PROMAX utilizes a unique digital technology called as SCARA (Selectively Complaint Articulated Robot Arm) technology. The SCARA arm can be moved away or close to the patient for positioning while taking lateral cephalogram.

The lateral cephalograms were obtained during a natural head-posture, in which the subjects looked at the reflection of their eyes in a mirror placed 5 feet in front of them after first tilting their head forward and backward with decreasing amplitude until a comfortable position of natural balance was found (Cooke and Wei)

The preview image was zoomed in for observation of all landmarks before the image is printed. PLANMECA's design the FOV (Field of View) of 11.8 in. h, which is required to view complete craniofacial complex. The image stored as either JPEG (Joint Photographic Experts Group) or TIFF (Tagged Image File Format)

2.7. Tracing and analysis of radiographs

FACAD software is developed by the Swedish company Ilexis AB in co-operation with the maxillofacial unit at the University Hospital in Linköping, Sweden. The soft copy of the cephalograms were converted into JPEG format and then transferred into FACAD (version 3.3.0.1) in

accordance with the manufacturer's instruction. The dentofacial relationships and McNamara analysis landmarks were already stored in FACAD software. The image was calibrated in real time measurement using the sensor head readings on the image. When point identification is difficult, the image was further enhanced. Measurements obtained from the digital tracing were recorded and tabulated (Figure 1)

3. Statistical analysis

Data was tabulated and entered in SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). Significance level is fixed as 5% ($\alpha = 0.05$).

Independent sample t-test- To compare the mean values between groups is applied.

Paired t-test - To compare mean values between measurements is applied.

Dahlberg value is calculated for extent of errors between measurements.

4. Results

Dahlberg's formula $ME = \sqrt{(\sum d^2)/2n}$ was used to determine method errors for both linear and angular measurements and it was applied in paired samples correlations between the repeated tracing to determine the significant correlations between two repeated measurements (Table 1). The correlations were found to be highly significant between the two repeated tracings ($p < 0.001$). The data was averaged considering the non-significant difference in the data recorded by the examiner and high correlation between the repeated tracings.

The cephalometric measurement data were categorized based on two different age groups to obtain specific and useful cephalometric values in mixed dentition phase of Tamilian children. Independent t-test was done to evaluate any significant variation in parameters between two age groups (Table 2). Independent sample t-test was done to compare mean values between genders among two age group to determine gender difference (Table 3). Relationship between mid facial length, mandibular length and lower anterior facial height is depicted in Table 4 with minimum and maximum range values for all the 3 parameters.

Table 1
Paired Sample Correlations between repeated tracing measurements.

S.No	Variables	N	Correlation	P-Value
1	A-NP-I A-NP-II	20	0.857	< 0.001**
2	Co-Gn-I Co-Gn-II	20	0.700	< 0.001**
3	Co-A-I Co-A-II	20	0.704	< 0.001**
4	Max-Mand diff-I Max-Mand diff-II	20	0.847	< 0.001**
5	LAFH-I LAFH-II	20	0.714	< 0.001**
6	Mandibular plane angle -I Mandibular plane angle -II	20	0.909	< 0.001**
7	Facial axis angle -I Facial axis angle -II	20	0.976	< 0.001**
8	Pog-NP-I Pog-NP-II	20	0.980	< 0.001**
9	Is-A-I Is-A-II	20	0.904	< 0.001**
10	Ii to A-Pog-I Ii to A-Pog-II	20	0.824	< 0.001**
11	Upper pharyngeal width-I Upper pharyngeal width-II	20	0.944	< 0.001**
12	Lower pharyngeal width-I Lower pharyngeal width-II	20	0.927	< 0.001**

I- 1st Tracing II- 2nd Tracing.

** Paired Sample t-test- $p < 0.001$ - Highly significant.

Table 2
Independent sample *t*-test to compare mean values between Age groups.

Variables	Age group	N	Mean	Std. Dev	t-Value	P-Value
A-NP	8–10 yrs	90	.124	3.3752	1.167	0.245
	11–12 yrs	60	-.510	3.0804		
Co-Gn	8–10 yrs	90	105.232	14.8211	2.416	0.017 [*]
	11–12 yrs	60	110.908	12.9332		
Co-A	8–10 yrs	90	84.544	12.9043	2.205	0.029 [*]
	11–12 yrs	60	88.972	10.6186		
Max-Mand difference	8–10 yrs	90	21.124	4.7207	1.074	0.285
	11–12 yrs	60	21.942	4.3225		
LAFH	8–10 yrs	90	57.638	8.6486	2.251	0.026 [*]
	11–12 yrs	60	60.673	7.1719		
Mandibular plane angle	8–10 yrs	90	25.668	4.4378	1.687	0.094
	11–12 yrs	60	26.950	4.7411		
Facial axis angle	8–10 yrs	90	89.977	3.8035	0.304	0.761
	11–12 yrs	60	89.778	4.0684		
Pog-NP	8–10 yrs	90	-4.412	6.0819	2.871	0.005 [*]
	11–12 yrs	60	-7.130	5.0117		
Is - A	8–10 yrs	90	5.843	2.9010	0.557	0.579
	11–12 yrs	60	5.592	2.3990		
Ii to A-Pog	8–10 yrs	90	4.510	2.3568	0.004	0.996
	11–12 yrs	60	4.508	2.1181		
Upper pharyngeal width	8–10 yrs	90	11.764	3.0691	1.584	0.115
	11–12 yrs	60	12.617	3.4524		
Lower pharyngeal width	8–10 yrs	90	8.248	2.7309	3.099	0.002 [*]
	11–12 yrs	60	9.627	2.5752		

* Independent Sample *t*-test- $p < 0.05$ - Significant.

5. Discussion

The purpose of this study was to evaluate cephalometric values using McNamara's analysis for South Indian (Tamilnadu) children between 8–12 years of age. As diversity in the craniofacial structures exists among children in different population, different ethnic origin and at different age group, it was thought that evaluating cephalometric values for Tamil children in this age group is essential. It also would aid in orthodontic diagnosis and treatment planning. The study evaluated 12 parameters (10 linear and 2 angular) in a group of Tamil children with acceptable facial profile and occlusion.

This is one of the first study to evaluate cephalometric values using McNamara's analysis for Tamilian children between 8–12 years of age. The entire cephalometric tracing and analysis was carried out by a single examiner. To determine the intra-observer reliability, 20 random cephalograms was re-traced after a week. The methodological error was calculated using Dalhberg formula There was a high correlation between the two tracings (Table 1). The values did not exceed beyond 1 mm for linear measurements and 0.5° for angular measurements.

5.1. Difference in age groups

Significant difference was present for the variables relating the mandible to cranial base (Pog-NP), maxilla and mandible (Co-Gn, Co-A, LAFH) and the lower pharyngeal airway.

5.2. Linear measurements

5.2.1. Nasion perpendicular to point A (A-NP)

The study revealed that there was no statistically significant difference in mean A-NP values between the two groups ($p > 0.05$). The mean A-NP value for Group I children is 0.124 ± 3.3 , and group II Children is -0.51 ± 3.0 . Interestingly Group I Children showed positive values and the Group II Children showed negative values The results indicated that the maxilla is slightly retrusive in Group II children than the Group I children. However, the result was not statistically significant. The result was similar to the study done in 12 year old Cauassian and Chinese children.¹⁴ However, the Kannada based Bunt and Brahmin children exhibited more protrusive maxilla, which is

contradictory to our results.¹⁶

5.2.2. Effective mandibular length (Co-Gn)

Effective mandibular length indicates a small or a large mandible. McNamara JA had given average measurements with respect to different age ranging from a minimum of 98 ± 3.4 mm to a maximum of 130 ± 4.6 mm. An increase will indicate a class III malocclusion and decrease will indicate a class II malocclusion. In the present study, mandibular length was significantly greater in group II children (110.90 ± 12.9) than the group I children (105.23 ± 14.8).

5.2.3. Effective midfacial length (Co-A)

Effective midfacial length is not the actual anatomic length of the maxilla. It represents the relationship of the maxilla relative to the cranial base. A greater value will indicate a protrusive maxillary skeletal base and a lower value will indicate a retrognathic maxilla respectively. In the current study, there was a significant difference in the midfacial length between the groups ($p < 0.05$), indicating a more protrusive maxilla in group II children (88.97 ± 10.6). The mean value of the present study was similar to the values given by Wu J on 12 year old Chinese children.

5.2.4. Maxillomandibular differential

The maxillomandibular differential can be estimated by subtracting effective midfacial length from the mandibular length. This measurement is emphasizing on the geometric relationship of the jaws and should not be related to the age of the children. The mean maxillomandibular differential values for both the groups was 21.9 ± 4.3 . Average measurements reported by McNamara JA for maxillo-mandibular differential in ideal cases were 20 mm (which is small), 25–27 mm (which is medium), 30–33 mm (which is large). In the present study the values fall under small maxillomandibular differential.

5.2.5. Lower anterior facial height (LAFH)

Lower anterior facial height is measured from anterior nasal spine to menton and this measurement increases with age. In the present study, there was a significant difference in LAFH between the different groups ($p < 0.05$), clearly indicating that, the growing children exhibit a higher LAFH.

The mean value of the present study was slightly lower than the values of Chinese and Kannada population, indicating a posterior positioning of menton in Tamilian children.^{14,16} The increase or decrease in LAFH has an effect on the horizontal growth pattern of the mandible.¹⁵

5.3. Mandible to the cranial base

5.3.1. Pogonion to Nasion perpendicular (P-NP)

This determines the anterior or posterior positioning of mandible to the cranial base. In the current study, there was significant difference in the position of pogonion relative to the cranial base between the groups ($p < 0.05$). Though there was a significant difference between the two age groups, the pogonion was posteriorly positioned in both the groups in relation to the cranial base. This result is similar to the findings of Bhat M done in kannada children and of Wu J in Chinese children.

5.4. Dentition

5.4.1. Upper incisor to point A

It represents the relationship of upper incisors to the maxilla. An increased value indicates proclined incisors and decreased value indicates retroclined incisors. There was no significant difference between the two groups ($p > 0.05$). McNamara JA had given values for different age groups, with values ranging between -2.1 and 1.3. But in the present study, the mean value ranges between 5.5 and 5.8,

Table 3
Independent samples *t*-test to compare mean values between genders among 8–10 and 11–12 years old children.

Age	Variables	Gender	N	Mean	Std. Dev	t-Value	P-Value
8–10Years	A-NP	Male	45	.469	2.7992	0.968	0.336
		Female	45	-.220	3.8684		
	Co-Gn	Male	45	106.436	13.4813	0.768	0.444
		Female	45	104.029	16.1125		
	Co-A	Male	45	85.407	10.8074	0.632	0.529
		Female	45	83.682	14.7819		
	Max-Mand difference	Male	45	21.027	4.9444	0.195	0.846
		Female	45	21.222	4.5399		
	LAFH	Male	45	57.693	8.2788	0.061	0.952
		Female	45	57.582	9.0967		
	Mandibular plane angle	Male	45	25.496	4.5466	0.366	0.715
		Female	45	25.840	4.3708		
	Facial axis angle	Male	45	90.211	3.4737	0.583	0.562
		Female	45	89.742	4.1330		
	Pog-NP	Male	45	-4.302	5.4550	0.171	0.865
		Female	45	-4.522	6.7111		
	Is - A	Male	45	6.096	3.0464	0.823	0.413
		Female	45	5.591	2.7590		
	Ii to A-Pog	Male	45	4.678	2.2085	0.673	0.503
		Female	45	4.342	2.5099		
	Upper pharyngeal airway	Male	45	12.282	2.7035	1.615	0.110
		Female	45	11.247	3.3461		
	Lower pharyngeal airway	Male	45	8.409	2.5651	0.558	0.579
		Female	45	8.087	2.9072		
11–12 Years	A-NP	Male	30	-.810	2.6853	0.752	0.455
		Female	30	-.210	3.4508		
	Co-Gn	Male	30	110.753	12.4943	0.092	0.927
		Female	30	111.063	13.5702		
	Co-A	Male	30	89.333	10.3514	0.262	0.794
		Female	30	88.610	11.0443		
	Max-Mand difference	Male	30	21.417	3.9669	0.940	0.351
		Female	30	22.467	4.6589		
	LAFH	Male	30	61.193	7.4891	0.558	0.579
		Female	30	60.153	6.9281		
	Mandibular plane angle	Male	30	26.307	4.7522	1.052	0.297
		Female	30	27.593	4.7215		
	Facial axis angle	Male	30	89.693	4.4167	0.160	0.873
		Female	30	89.863	3.7620		
	Pog-NP	Male	30	-7.997	5.1686	1.349	0.183
		Female	30	-6.263	4.7781		
	Is - A	Male	30	5.610	2.4914	0.059	0.953
		Female	30	5.573	2.3455		
	Ii to A-Pog	Male	30	4.483	2.3364	0.091	0.928
		Female	30	4.533	1.9152		
	Upper pharyngeal airway	Male	30	12.617	3.6098	0.000	1.000
		Female	30	12.617	3.3495		
	Lower pharyngeal airway	Male	30	9.493	2.4371	0.398	0.692
		Female	30	9.760	2.7416		

*Independent Sample *t*-Test- *p* < 0.05- Significant.

Table 4
Relationship between mid facial length, mandibular length and lower anterior facial height.

Co-A Level	N	Co-Gn		LAFH	
		Minimum	Maximum	Minimum	Maximum
60 - 70	12	80.7	95.4	45.0	54.0
70 - 80	36	87.5	108.3	45.5	61.1
80 - 90	47	94.8	123.7	47.1	72.0
90 - 100	34	106.4	124.6	52.9	72.4
100 - 110	17	122.2	140.2	60.0	77.3
110 - 120	4	110.7	143.5	68.9	84.1
Total	150	58.0	143.5	32.8	84.1

indicating more forwardly placed incisors than the Caucasian children. Chinese male children expressed more proclined incisors than Tamilian male children.¹⁴

5.4.2. Lower incisor to A-Pog line

It usually relates the position of lower incisors to A-pog line.

Average value is 1-3 mm. An increase will indicate proclination and a decrease will indicate retroclination. The current study indicates that there was no significant difference in Lower incisor to A-Pog line (*p* < 0.05). But both the groups of children exhibited proclination of lower incisors relative to the cranial base than the values given by McNamara JA. Wu J had stated that Chinese boys exhibited more proclination of lower incisor (6.26 ± 2.25) than Chinese girls (2.53 ± 2.36), but there was no gender difference in our study.

5.5. Airway analysis

5.5.1. Upper pharynx

Pharyngeal width measurement is done to determine the patency of airway. Upper pharyngeal width is measured from a point on the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall. Upper pharyngeal width of 5 mm or less indicates an apparent airway obstruction.¹⁵ In the present study, the upper pharyngeal width was 11–12 in both the groups, indicating a patent upper airway. The values increase as the age advances.

5.5.2. Lower pharynx

It is measured from the intersection of the posterior border of the tongue and the inferior border mandible to the closest point on the posterior pharyngeal wall. The value does not increase with age and the values range between 10 and 12 mm.¹⁵ But in the present study there was significant variation in the mean value of lower pharyngeal width between both the groups ($p < 0.05$) and the values range between 8–10 mm. So it can be considered as a patent airway in both the groups.

5.6. Angular measurements

5.6.1. Facial axis angle

It is also termed as facial axis angle of Ricketts. This value measures the direction of growth of the chin, either horizontally or vertically, which eventually indicated the growth of jaws. If the value deviates from 90° to the cranial base, it indicates either horizontal or vertical facial development. If the value is acute, indicative of horizontal growth pattern and if the value is obtuse, indicative of vertical growth pattern. There was no significant difference in the facial axis values between the groups ($p > 0.05$). According to McNamara, the ideal facial axis value should be 90° and it should not increase with age. The results of the present study also gave a similar value and it is in agreement with the study done by Bhat M in Kannada population.

5.6.2. Mandibular plane angle

The FMA refers to the steepness of the mandibular plane when compared to the cranial base by Frankfort plane and it refers to forward or downward growth of jaws. Higher values indicate a vertical growth pattern and lower values indicate a horizontal growth pattern. In the present study there was no significant difference in the mandibular plane angle and the mean value ranges between 25°–26.5°. The result is in agreement with the original values of McNamara and supports the study done by Bhat M on Kannada population but contradictory to the findings of Wu J on Chinese females, where they exhibited more horizontal growth pattern (22°).

5.7. Gender differences

There were no statistically significant gender differences among the children for any of the variables (Table 4). This result is contradictory with the results of an earlier study, which stated that there was a significant gender difference in certain measurements.^{14,16}

5.8. Relationship of midfacial length, mandibular length and Lower anterior facial height

A geometric relationship between the maxilla and mandible was

established by McNamara JA based on the relationship between the midfacial length, mandibular length and lower anterior facial height. A similar relationship was determined in the present study and depicted in Table 8.

6. Conclusion

- These values can be used in Tamilian children irrespective of gender, because there is no statistically significant gender difference.
- Both maxilla and mandible is slightly retrusive in Tamilian children.
- Both the upper and lower incisors are proclined in Tamilian children.
- Presence of patent upper and lower airway.

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