NORMAL VALUES OF UPPER CRANIOFACIAL SKELETAL MEASUREMENTS OF THAI PATIENTS IN UDONTHANI HOSPITAL BASED ON COMPUTED TOMOGRAPHY

Khomdao BOONCHIT, M.D.[1]

ABSTRACT

This study was performed to establish normal values of the upper craniofacial skeleton of 1026 Thai patients in Udonthani hospital using CT scan. The samples were collected from july 2006 to july 2007, age ranging from newborn to 82 years. The measurement values were divided into four age groups, for those under the age of 1 year, 1 year, morethan 1 year upto 17 years and more than 17 years in the last category. No comparison between genders in this study, except in the subjects with the age of more than 24 years and these increase gradually to adult sizes. The size of these measurement increase rapidly to about 85 % of adult sizes by the age of 5 years and then increases gradually to adult sizes. The ability of Computed Tomography (CT scan) to identify bony and soft tissue features makes it particularly useful for the management of craniofacial disorders. The normal values of the upper craniofacial skeleton of Thai patients in Udonthani hospital are useful for the accurate diagnosis and reconstructive surgery planning of Thai patients in Udonthani and Northeastern Thailand.

INTRODUCTION

Knowledge of normal measurement values in the craniofacial region will help to improve diagnostic accuracy for presurgical reconstruction planning and postsurgical follow-up of patients of craniofacial anomalies such as orbital hypertelorism in Frontoethmoidal Encephalomeningocele, craniosynostosis syndrome, frontonasal dysplasia and facial clefts.

Current techniques in craniofacial surgery would benefit from objective (quantitative), as well as the current subjective (quanlitative) and radiographic assessment which are to be considered in the planning and execution of craniofacial bony reconstruction. Measurement of certain skeletal dimensions is essential for the accurate diagnosis and planning for reconstructive surgery.

Various methods have been used in the past to indirectly analyze the craniofacial region such as anthropometry[1] which is limited in its capacity to develop accurate normative standards for the craniofacial complex, because they are influenced by overlying soft tissues and is therefore unreliable in the assessment of the skull. Cephalometric radiography[2,3] and cephalometrics with multiplane and finite-element scaling analysis.[4] are inaccurate because of the enlargement and distortion of the image, structures overlapping, limited identifiable landmarks and positioning problems in the taking of the radiograph.

The other method is direct measurement in cadaveric skull.[6]

[1] Department of Radiology, Udonthani hospital, Udonthani 41000, Thailand

Quantitative CT measurement in the craniofacial region would be a useful adjunct to existing treatment methods, window setting, quality control and CT calibration error, partial-volumn effect, patient positioning, display/film distortions, spatial uniformity, resolution, scan noise and artifacts affect CT images.[7,8] However CT is now an established key modality in the diagnosis, surgical planning and follow up of craniofacial anomalies.[9] The intraobserver error, interobserver error and accuracy of CT linear measurements were all within acceptable limits (range, 0.4 to 0.9 mm.).[10] Three-dimentional CT of the craniofacial region was very accurate.[11]

The error of CT measurements of the upper craniofacial skeleton was within clinically acceptable limits (less than 5 percent) if the angle tilt was no more than ± 4 degree from 0 degree setting (baseline or orbitomeatal line).[12]

Normal values of craniofacial skeletal measurements are analyzed such as craniofacial anthropometry in Turkish population,[13] roentgen-cephalometric standards for a Swedish population,[14] growth of interorbital distance and skull thickness as observed in roetgenographic measurements,[15] bony interorbital distance,[16] CT in the evaluation of the orbit and the bony interorbital distance,[17] the study of normal interorbital distance of Oriental adults,[6] craniofacial skeletal measurements based on Computed Tomography.[12]

The purpose of this study was to provide normal values of the upper craniofacial region of Thai patients in Udonthani hospital taken from CT scans.

MATERIAL AND METHODS

The measurements in the present study were obtained from Thai population subjects of different ages who went to have CT scan in Udonthani hospital. The 1026 samples were collected from july 2006 to july 2007, ranging in age from newborn to 82 years.

CT scans in Udonthani hospital were obtained from an Elscint EXEL 2400 ELECT CT scanner. All patients were positioned by laser-light guiding for scanning in the orbitomeatal line. Head position was maintained with restraints and confirmed with a scan film.

Exclusion criterias are asymmetric scans, syndrome and diseases affecting craniofacial skeleton such as congenital anomalies, orbital and sinus diseases, fracture or previous surgery. Rotation of the subject can be determined by the distance between each orbital rim, adjacent facial bones and skull.

The growth levels gradually stop at about 13 years of age in girls and 21 years of age in boys, similar to other areas of the upper face and midface.[16] Generally, facial growth changes minimally after late adolescence (17-20 years of age).[17] So the measurement values were divided into four age groups for those under 1 year of age, 1-year age categories, from more than 1 to 17 years, and then more than 17 years in the last category.

MEASUREMENTS

A series of five parameters (table1) was obtained from the CT scan of each subject. The measurements were performed in picture archiving, with bone window setting (window width 1500 H.U. and window level 200 H.U.) The process of measurements was performed by the author (twelve-year experienced radiologist).

TABLE 1 Computed Tomographic measurements of the Craniofacial Skeleton

Measurement	Description
1. Interorbital distance	The distance between bilateral dacryons (junction of the frontal, lacrimal and maxillary bones) (Fig.1)
2. Anterior interorbital distance	The distance between a point on each lacrimal bone representing the anterior end of the medial orbital wall. (Fig.1)
3. Mid interorbital distance	The distance between a point on each medial wall of the bony orbit (ethmoid bone) midway between the lacrimal bone and the base of the optic strut. (Fig.2)
4. Lateral orbital distance	The distance between the most anterior tip of each lateral orbital wall. (Fig.2)
5. Intertemporal distance	The distance between the most medial aspect of each temporalis groove. (Fig.3)

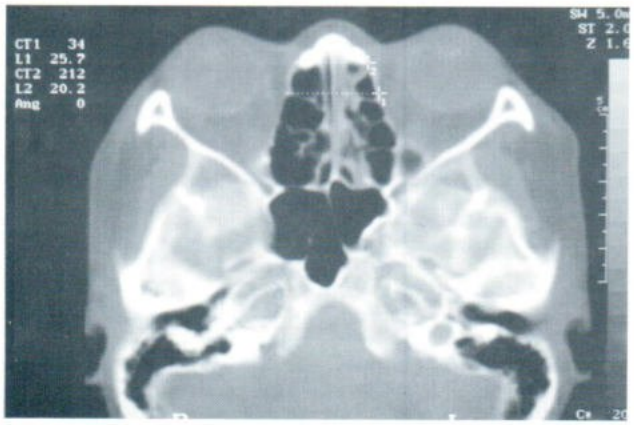

Fig. 1 1. Interorbital distance
2. Anterior interorbital distance

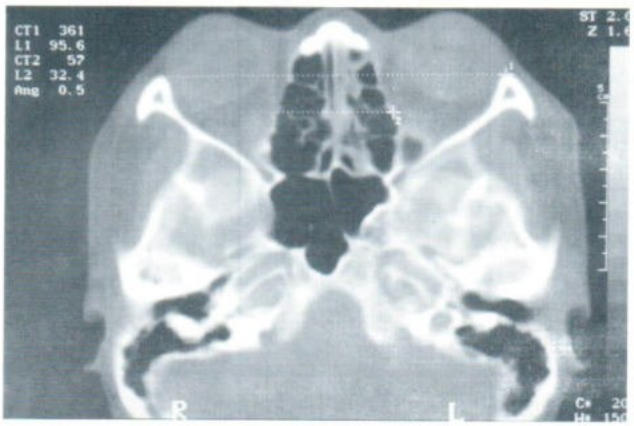

Fig.2 1. Lateral orbital distance
2. Mid interorbital distance

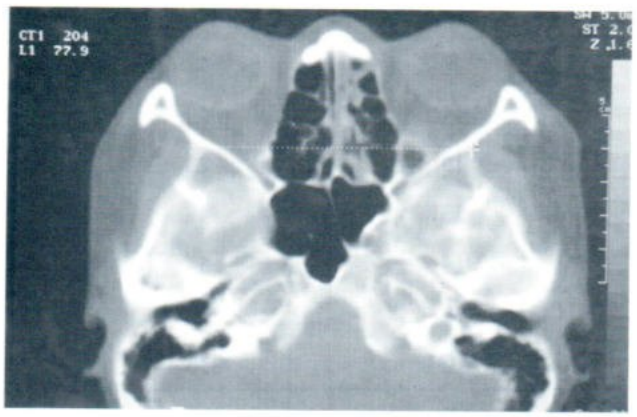

Fig.3 1. Intertemporal distance

ANALYSIS

The age and sex distribution of Thai patient population of this study is shower in Table2.

SAS statistical procedures were used for all calculations. Statistical differences between group means were tested by the Student's t-test. Group means, standard deviations and 95 % confidence intervals for individual predicted values were calculated since the purpose of this study was to produce normative values (table 3 and 4). Test statistics associated with probabilities of 0.05 or less were considered significant, and all probability (p) values quoted were two sides.

RESULTS

TABLE 2 Sex Distribution of Study Population

Age Category	Males	Females	Total
0-3 mo	2	4	6
4-6 mo.	3	3	6
7-9 mo.	4	4	8
10-11 mo.	1	2	3
1 yr.	3	3	6
2 yr.	6	2	8
3 yr.	5	4	9
4 yr.	4	3	7
5 yr.	6	2	8
6 yr.	2	4	6
7 yr.	5	6	11
8 yr.	6	2	8
9 yr.	6	3	9
10 yr.	7	2	9
11 yr.	4	4	8
12 yr.	8	4	12
13 yr.	11	4	15
14 yr.	15	2	17
15 yr.	13	4	17
16 yr.	14	5	19
17 yr.	12	7	19
>17 yr.	435	330	765
Total	622	404	1026

TABLE 3 Means, Standard deviation and Ninety-Five Percent Confidence Intervals of interorbital distance, anterior interorbital distance and mid interorbital distance (mm.)

Age	Interorbital distance			Anterior interorbital distance			Mid interorbital distance		
categories	Mean	SD	95% CI	Mean	SD	95% CI	Mean	SD	95% CI
0-3 mo.	15.66	2.20	10.19-21.13	17.63	1.98	12.70-22.56	16.03	1.87	11.37-20.69
4-6 mo.	17.63	2.13	12.32-22.93	18.23	4.61	12.32-22.93	18.05	3.54	14.32-21.77
7-9 mo.	17.21	2.55	15.07-19.34	18.46	2.51	13.56-22.30	18.36	2.13	13.06-23.67
10-11 mo.	17.51	2.50	15.35-19.79	18.56	3.30	14.52	18.51	2.89	14.39-22.66
1 yr.	17.93	2.17	15.65-20.21	18.67	3.37	15.65-20.21	18.67	3.37	15.85-21.43
2 yr.	18.46	2.21	12.95-23.97	19.23	4.45	14.55-23.90	19.20	1.72	15.68-23.04
3 yr.	18.46	2.21	12.95-23.92	19.28	2.62	17.08-21.08	19.86	3.00	12.39-27.34
4 yr.	19.20	4.84	11.15-26.24	19.60	1.95	16.23-20.96	23.08	2.25	21.20-24.97
5 yr.	21.02	1.06	19.32-22.72	20.50	3.54	14.86-26.13	24.10	0.23	23.73-24.46
6 yr.	21.60	1.97	19.95-23.24	20.73	2.91	18.29-23.17	24.01	1.42	22.81-25.20
7 yr.	24.75	2.07	20.11-25.38	21.05	3.04	15.76-26.86	26.06	4.00	16.12-36.00
8 yr.	24.03	1.92	19.24-28.82	21.27	3.61	10.36-28.30	27.40	0.98	18.50-36.29
9 yr.	24.26	1.79	22.76-25.76	21.33	3.45	18.45-24.22	29.82	1.53	28.54-31.10
10 yr.	24.80	2.70	20.06-23.53	22.06	2.49	13.86-26.26	29.93	3.76	20.58-34.28
11 yr.	24.10	1.78	21.31-26.88	22.22	0.91	20.77-23.67	28.32	3.40	22.90-33.74
12 yr.	25.77	1.84	24.22-27.32	22.45	2.33	20.49-24.40	30.27	2.27	28.37-32.17
13 yr.	26.12	2.41	24.58-27.66	22.98	3.25	19.97-25.99	32.49	2.87	30.66-34.31
14 yr.	25.72	3.37	22.60-28.85	23.97	4.60	21.04-26.90	31.57	4.02	27.84-35.29
15 yr.	24.52	5.27	21.81-27.23	21.59	2.27	20.42-22.76	31.49	1.76	30.58-31.39
16 yr.	27.76	1.85	26.34-29.19	21.31	3.37	19.68-22.94	31.66	3.38	29.06-34.26
17 yr.	26.08	2.46	24.89-27.27	24.86	2.64	22.83-26.89	31.12	2.77	29.78-32.46
> 17 yr.	26.59	2.39	24.42-28.76	23.45	2.93	23.24-23.65	31.46	4.68	26.13-31.79

SD = standard deviation, CI = confidence interval for individual predicted values

TABLE 4 Means, Standard deviation and Ninety-Five Percent Confidence Intervals of Lateral orbital distance and intertemporal distance (mm.)

Age categories	Lateral orbital distance			Intertemporal distance		
	Mean	SD	95% CI	Mean	SD	95% CI
0-3 mo.	65.32	4.90	54.18-72.19	61.16	0.25	60.54-61.79
4-6 mo.	68.36	3.83	58.82-77.90	68.26	5.25	59.28-77.25
7-9 mo.	67.86	7.34	49.60-86.12	67.46	6.73	50.72-84.20
10-11 mo.	72.05	7.07	58.67-82.63	67.69	6.01	56.52-78.87
1 yr.	73.45	6.81	67.75-79.14	67.93	6.70	62.33-73.54
2 yr.	73.60	8.44	64.73-83.46	66.30	4.45	56.38-76.21
3 yr.	78.50	4.44	67.46-89.53	68.56	3.62	59.56-77.57
4 yr.	82.16	3.87	78.92-85.40	69.66	6.00	57.30-82.02
5 yr.	82.35	1.23	80.37-84.32	72.60	3.59	66.88-78.31
6 yr.	84.81	3.54	81.85-87.77	73.08	3.67	69.84-76.32
7 yr.	86.86	0.40	85.86-87.87	73.83	5.04	69.62-78.05
8 yr.	89.77	2.02	67.79-84.55	76.17	5.26	67.79-84.55
9 yr.	89.86	1.70	85.63-94.09	76.72	4.48	72.97-80.47
10 yr.	90.51	2.43	88.47-92.55	73.73	3.32	65.46-82.00
11 yr.	91.50	4.24	73.38-109.61	77.10	3.67	64.04-90.18
12 yr.	90.88	8.04	79.41-102.34	77.07	3.11	74.18-79.95
13 yr.	92.68	3.89	89.08-96.28	78.81	4.31	76.07-81.55
14 yr.	92.82	1.97	91.16-94.48	80.33	3.17	77.67-82.99
15 yr.	97.04	3.68	95.15-98.94	80.27	3.87	78.27-82.26
16 yr.	98.06	4.98	94.23-101.89	81.31	4.59	77.77-84.84
17 yr.	95.57	4.70	93.30-97.83	79.74	5.23	77.22-82.27
>17 yr.	96.45	6.20	96.01-96.88	79.14	4.34	78.84-79.44

SD = standard deviation, CI = confidence interval for individual predicted values

DISCUSSION

1026 Thai patient population who went to have CT scan in Udonthani hospital ranging in age from newborn to 82 years from july 2006 to july 2007 and five parameters of the upper craniofacial skeleton were measured. These distances change with age which were verified in the present study (table3 and 4). The overall size of them reaches about 85 % of adult sizes by the age of 5 years and then increases gradually to adult. No comparison between males and females within each age study group of newborn, children to late adolescence because female patients in this study may have been too small. The patient ages more than 24 years old were compared between genders with also comparison between these data and the report of Mafee MF et al. (1986)[17](table 5).

TABLE 5 CT evaluation of the interorbital distance in adults (age>24 years)(mm.)

	Number of patients	Minimum		Maximum		Mean	
		Male	Female	Male	Female	Male	Female
Mafee MF et al.	400	22.9	22.9	32.1	32.0	26.7	25.6
Udonthani hospital	724	20.60	19.20	35.60	31.40	27.14	25.87

In 1992, Waitzman et.al 18 retrospectively define normal values for a series of craniofacial measurements. (table 6)

TABLE 6 Means and standard deviations of the orbital region (mm.)

	Age categories	Number of patients	Anterior interorbital distance	Mid interorbital distance	Lateral orbital distance	Intertemporal distance
Waitzman et al.	17 yr.	16	23.8±1.7	27.5±2.3	95.3±5.9	78.7±6.1
Udonthani hospital	17 yr.	19	24.86±2.64	31.12±2.77	95.57±4.70	79.74±5.23

The discrepancies between different studies may be the result of differences in race and population size used. The error of CT measurements is patient positioning. I suggest that the normal values of the upper craniofacial skeleton depend on age, sex and race which in my study, they are useful for the accurate diagnosis and reconstructive surgery planning of Thai patients in Udonthani and Northeasten Thailand.

REFERENCES

1. Farkas LG. Anthropometry of the head and face in medicine. New York:Elsevier,1981.
2. Broadbent B. A new X-ray technique and its application to orthodontia. Angle Orthod. 1931; 1:45.
3. Moyers RE., Bookstein FL. The inappropriateness of conventional cephalometrics. Am J Orthod 1979;75:599-617.
4. Grayson BH, McCarthy JG, Bookstein F. Analysis of craniofacial asymmetry by multiplane cephalometry. Am J Orthod 1983; 84: 217-24.
5. Richtsmeier J. Comparative study of normal, rouzon, and Apert craniofacial morphology using fine element scaling analysis. Am J Phys Anthropol 1987; 74: 473-93.
6. Nond Rojvachiranonda, Taom Bunaprasert, Prachya Maglin, Thawatchai Watanakajorn. The study of normal interorbital distances of oriental adults:a preliminary report. Chula Med J 1998; 42(10): 945-52.
7. McCullough EC. Factors affecting the use of quantitative information from a CT scanner. Radiology 197; 124: 99-107.
8. Baxter BS, Sorenson JA. Factors affecting the measurement of size and CT number in computed tomography. Invest Radiol 1981;16:337-41.
9. Becker M. Computed tomography in the evaluation of the craniofacial malformations. In: Converse JM, McCarthy J, Wood-Smith D, eds. Symposium on diagnosis and treatment of craniofacial anomalies. Vol 20. St. Louis: Mosby, 1979; 182.
10. Christiansen EL, Thompson JR, Kopp S. Intra - and interobserver variability and accuracy in the determination of linear and angular measurements in computed tomography. An in vitro and in situ study of human mandibles. Acta Odonto Scand 1986; 44: 221-9.
11. Matterson SR, Bechtold W, Philips , Staab E. A method for three-dimentional image reformation for quantitative cephalometric analysis. J Oral Maxillofac Surg 1989; 47: 1053-61.
12. Waitzman AA, Posnick JC, Armstrong DC, Pron GE. Craniofacial skeletal measurements based on computed tomography: Part I. Accuracy and reproducibility. Cleft Palate -Craniofacial J 1992; 29: 112-7.
13. Evereklioglu C, et al. Craniofacial Anthropometry in a Turkish Population. Cleft Palate -Craniofacial J 2002; 39: 208-18.
14. Thilander B, Persson M, Adolfsson U. Roentgen-cephalometric standards for a Swedish population. Eur J Orthod 2005; 27: 370-89.
15. Hansman CF. Growth of interorbital distance and skull thickness is observed in roentgenographic measurements. Radiology 1996; 86: 87-96.
16. Costaras M, Pruzansky S, Broadbent BH Jr. Bony interorbital distance (BIOD), head size, and level of the cribiform plate relative to orbital height: 1. Normal standarcs for age and sex. J Craniofac Genet Dev Biol 1982; 2: 5-18.
17. Mafee MF, et al. CT in the evaluation of the orbit and the bony interorbital distance. Am J Neuroradiol 1986; 7: 265-9.
18. Waitzman AA, Posnick JC, Armstrong DC, Pron GE. Craniofacial skeletal measurements based on computed tomography: Part II. Normal values and growth trends. Cleft Palate-Craniofacial J 1992;29:118-28.