ORIGINAL ARTICLE

NORMAL VALUES OF SKULL BASE ANGLES USING STANDARD AND MODIFIED MRI TECHNIQUE IN PAKISTANI POPULATION

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Background: Different techniques are used to measure skull base angle on sagittal images of MRI to diagnose platybasia and basilar kyphosis. Objective of this study was to determine the normal values of skull base angle using standard and modified methods of magnetic resonance imaging in Pakistani population. **Methods:** This cross-sectional, observational, descriptive study was conducted in Radiology Department, Wah Medical College, Wah Cantt. It comprised 700 subjects, including 336 females and 364 males (children and adults). Midline sagittal T1-weighted MR images were evaluated to measures the standard and modified skull base angles on Picture Archive and Communication System (PACS Links). All subjects underwent MR imaging on a 1.5 Tesla scanner, equipped with an 8-channel head coil. Data was collected on prescribed proforma and analysed using SPSS-23. **Results:** The standard MRI method gave a mean angle of 129.9±5.12° (range 108.1–148.3°) compared to mean angle of 121.3±5.06° (range 107.1–136.2°) obtained by the modified method; the difference of 8.6° between the mean angles given by these two methods is highly significant (p=0.002). **Conclusion:** Pakistani population has wider basal angle range as compared to the western population.

Keywords: MRI, Standard method, Modified method, Angular craniometry

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INTRODUCTION

Measurement of skull base angle is used for the diagnosis of platybasia and basilar kyphosis. Traditionally, basal angle measurements were based on plain skull images.[1,2] With the advent and generalization of MR imaging, traditional radiography method has been replaced and is rarely used. Modified MRI techniques produce lower basal angles than those reported by using traditional radiography.[1]

The size and shape of skull differs among different races. Differences occur in head shape, height of nasal root, jaw thickness, slope of forehead and size of brow ridge.[3] Skull base angle is not affected by change in the position of the patient. It is determined by extending a line across the anterior cranial fossa from the nasion to the tip of the dorsum sella and a second connecting line drawn along the posterior margin of the clivus.[4]

Increase in the angle beyond the normal range, leads to flattening of the skull base and is termed Platybasia[5]. Decrease in skull-base angle is known as basilar kyphosis. Basilar invagination and platybasia often appear together, in a variety of congenital craniofacial anomalies, such cleidocranial dysostosis, osteogenesis imperfecta, Arnold-Chiari malformation and in acquired disorders, such as rickets, osteomalacia, senile atrophy, hyperparathyroidism, Paget disease, trauma and local bone destruction.

As an isolated finding most patients are asymptomatic, and platybasia is not important clinically. No typical treatment is indicated unless there is compression or impingement of nerve roots or brain parenchyma. In some patients, posterior decompression, usually in conjunction with fusion of the skull to the upper cervical spine may be required.[5]

Most of the studies giving range of normal values for skull base angle are done on Western population.[6,7] The purpose of our study was to determine the normal range of skull base angle in our local population and compare it with other studies, using both standard and modified MRI techniques.

METHODOLOGY

This study was carried out in the Radiology Department of Wah Medical College, POF Hospital, Wah, from Apr to Nov 2021. T1-weighted sagittal images of the skull base of 700 consecutive cases were evaluated to measure the basal angle irrespective of the patient's age and gender. Cases with skull base tumours, infections, skull base fracture, congenital or acquired musculoskeletal dysplasia and craniovertebral assimilation abnormalities were excluded to determine a normalized standard.

Standard skull base angle was measured by taking the angle between the line ensuing from nasion and terminating at the centre of pituitary fossa and second line starting from the anterior margin of foramen magnum and ending at the centre of pituitary fossa as done by McGregor.[8] For measurement of modified skull base angles the landmarks provided by Keats and Cohen were used.[5,9]

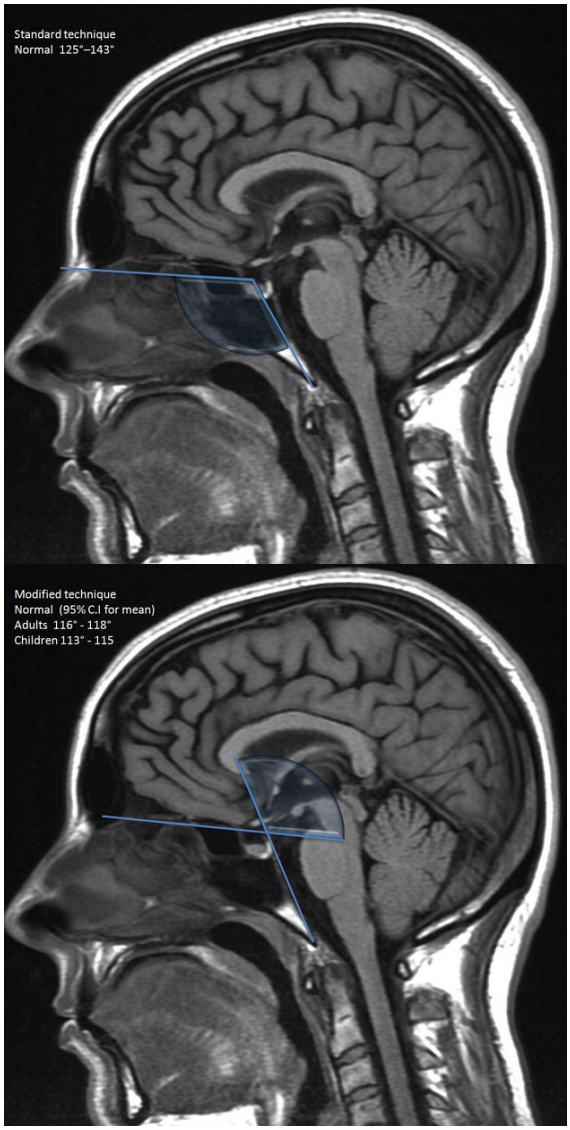

Figure-1: Measurement of skull base angle (Standard and Modified techniques)

Basic statistics were calculated for age and MRI angles of skull by two methods. Normal ranges with Mean±SE were reported. Correlations were calculated between the angles from the two methods. Paired *t*-test was used to test significance of difference between the mean angles of the two methods for all subjects as well as for female and male subjects. Two-way tables were made showing means for gender-by MRI methods, age groups (children *vs* adults) by MRI methods, and age groups by combination of method and gender. Unequal samples *t*-test was used to test the difference in angles of female and male subjects, children and adults of all subjects, and children and adults of the two gender classes.

Confidence interval and standard error of differences between two means for independent samples *t*-test were calculated. To test the effects of four combinations of gender and age groups considered as treatments on MRI angles measurement from the standard and modified methods, one way analysis of variance (ANOVA) was used.

RESULTS

The standard MRI method gave a mean angle of 129.9±5.12° (range: 108.1–148.3°) as compared to mean angle of 121.3±5.06° (range 107.1–136.2°) obtained by the modified method. The difference of 8.6° between the angles given by the two methods is highly significant using paired *t*-test. The 95% confidence interval for the mean difference was 8.5–8.9. Paired *t*-test also showed significant differences (8.7°) between the angles of the two MRI methods in females and in male subjects (p=0.002). (Table-1).

The angles of the two methods of MRI were very highly correlated (r=0.8430, 0.7649, and 0.8996 for all, female and male patients respectively) showing that the results of the modified method are as reliable as the standard method. The scatter plot and regression line of the angles of modified method on the angles of the standard method of the patients with a coefficient of determination (R^2 of 0.7715) also show close relationship between the reading of angles of the two MRI methods, because the regression model for modified method is explaining 77% of the variation in data from the standard method. (Figure-2).

Male subjects had lower angles than female subjects with difference highly significant in standard method and modified method. Differences in mean angles of children and adults were also highly significant with children having wider angles than adults. (Table-2).

Student's *t*-test for differences between children and adults showed that differences were significant in males and not significant in females in case of standard method. Showing that boys on the average had wider angles than men while the angle of girls were slightly wider than women and the difference between girls and women did not reach significant level in standard method based on unequal sample non-paired *t*-tests. (Table-3).

As children had wider angles than adults, we explored if there is a clear trend of angle with age or not, for this purpose a frequency table for different age groups was prepared and averages of the skull angles for the different age groups were calculated. The results for females and males are slightly different, especially in children and old age groups. It has implications for normal range of skull angles in our population. There should be separate recommendations for normal angle ranges of skull for boys, girls, men and women. (Table-4).

Table-1: Results of paired *t*-test for the angles of standard and modified MRI

Subjects	Angle given by		Mean difference (95% CI)	*t*	*p*
	Standard method	Modified method			
Over all (n=700)	129.9±5.1°	121.3±5.06°	8.6° (8.5, 8.9)	91.97	0.002
Female (n=336)	130.7±5.0°	122.0±4.7°	8.7° (8.4, 8.9)	59.60	0.001
Male (n=364)	129.2±5.1°	120.5±5.3°	8.7° (8.4, 8.9)	70.04	0.001

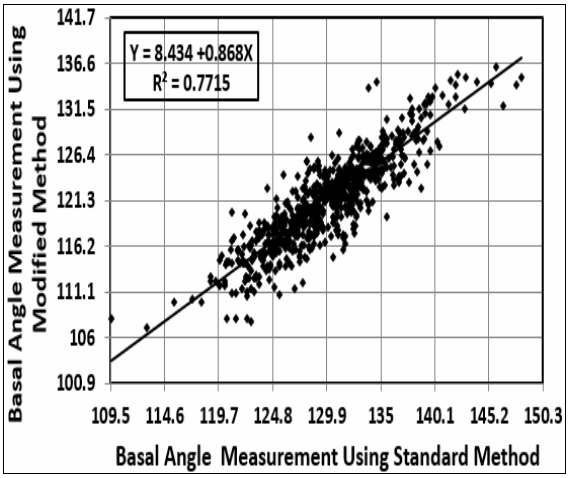

Figure-2: Relationship of basal angle measurement by standard and modified methods of MRI

Table-2: Mean angle of MRI for two-way tables, method by gender and method by age-category

Gender	Gender			Age categories		
	Female (n=336)	Male (n=364)	Difference	Children (n=96)	Adults (n=604)	Difference
Standard	130.7	129.2	1.5*	132.3	129.6	2.7*
Modified	122.0	120.5	1.5*	124.1	120.8	3.3*

*p<0.01

Table-3: MRI angle of gender and age categories using standard and modified method

	Number		Standard			Modified		
	Female	Male	Female	Male	Diff.	Female	Male	Diff.
			Angles of MRI in Degrees					
Children	41	55	131.64	132.78	-1.15	123.40	124.55	-1.15
Adults	295	309	130.56	128.58	1.98	121.85	119.81	2.04
Diff.			1.08	4.20		1.55	5.54	

Table-4: Averages of the skull angles for the different age groups

Age (Years)	Female			Male		
	n	Standard (degrees)	Modified (degrees)	n	Standard (degrees)	Modified (degrees)
1–14	41	131.64	123.40	55	132.78	124.55
15–24	41	130.49	122.42	35	128.83	120.72
25–34	44	129.78	121.41	25	127.80	119.11
35–44	42	131.41	123.41	32	128.94	120.20
45–54	70	130.81	121.45	55	129.27	120.35
55–64	41	129.60	120.37	77	128.02	119.15
65–74	35	130.13	121.51	51	128.26	119.77
75–84	19	132.17	123.16	29	129.37	120.03
85–91	2	134.40	124.90	5	128.42	117.88

DISCUSSION

This study documents and compares the normal range and mean of skull base angle by both the Standard and Modified MRI methods for both genders and different age groups. A mean basal angle of 129.9±5.1° obtained by standard method and a mean basal angle of 121.3±5.06° obtained by the modified method may be considered normal. Angles greater than the given values may be associated with clinical diagnosis of platybasia. However further research is mandatory.

Koenigsberg[11] retrospectively studied midline sagittal images of 200 adults and 50 children using both the standard and modified methods. They reported mean angles of 129±6° for adults and mean angles of 127±5° for children with the standard MRI technique, and the modified technique gave values of 117±6° for adults and 114±5° for children. The modified method gave values significantly lower than those of standard MR imaging and traditional radiography. A study similar to our study was conducted in Thai population[12] involving 200 adults and 50 children and found Modified MRI basal angle range of 100.5–130° for adults and 102–130.5° for children. Their mean basal angle was 121.65±5.1° and they found no statistically significant difference between male and female subjects or between children and adults. Botelho[13] and Ferreira[14] in their studies of angular craniometry on craniocervical junction malformation found a mean basal angle of 118.71±7.11° and a range of 107–132°. They suggested a diagnosis of platybsia when the basal angle exceeds 133° and found that an enlarged BA was associated with a more acute Clivus canal angle and larger Boogards angle. In recent studies[15–18] it was further discussed that Clivopalate angle gives complementary information to clivoaxial and clivodens angle.

CONCLUSION

Pakistani population has wider skull base angle as compared to the western population. Modified MR imaging technique provides a better tool to evaluate platybasia and basilar kyphosis. Our observed values may be used as a guide for the potential range of normal skull base angles in Pakistani population.

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HBA: Drafting and reviewing **RA:** Analysis and interpretation **KI:** Drafting and reviewing

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