



# Evaluation of Skull Base Angle Using the Magnetic Resonance Imaging

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**Keywords:** Skull base angle; Platybasia; Craniometric; Magnetic Resonance Imaging (MRI); Normative data; Nepalese population; Cross-sectional study; Craniovertebral Junction (CVJ); Basilar invagination; Anatomical variation.

## Abstract

**Introduction:** The skull base angle, a critical anatomical and clinical parameter, plays a pivotal role in various medical disciplines, including neurology, otolaryngology, and maxillofacial surgery. Understanding the skull base angle involves examining the intricate anatomical relationships within the cranial base, which forms the floor of the cranial cavity and houses vital structures such as the brainstem, cranial nerves, and cerebral blood vessels.

**Methodology:** -A quantitative, cross-sectional research design was employed for this study. The research was conducted in the Radiology Department of Tribhuvan University Teaching Hospital (TUTH) over a period of three months. Data were collected from a sample size of 120 using a convenience sampling technique (non-probability sampling). Examinations were performed with the MAGNETOM Amira Siemens 1.5T MRI (Magnetic Resonance Imaging).

**Result:** -Using the MR imaging technique, our study determined that the mean skull base angle for the Nepalese population was 120° (SD=4.739, 95% CI) for males and 119° (SD=4.138, 95% CI) for females. The overall average skull base angle was found to be 119°. Statistical analysis revealed no significant difference between the angles for males and females.

**Conclusion:** This study found that the skull base angle could be measured with high accuracy and reliability, and no significant differences were detected between age groups or genders. To further refine these findings and develop a detailed nomogram for the Nepalese population, future research should encompass a larger and more ethnically diverse sample.

## Introduction

The head is primarily composed of the skull, which encases the brain along with its protective meninges in the cranial cavity. The sensory organs, such as the eyes and ears, are either situated within the skull bones or housed in cavities formed by them. The brain generates 12 pairs of cranial nerves, which exit

the brain through openings and gaps in the skull. While most of these cranial nerves are connected to structures in the head and neck, the 10th nerve also extends to the chest and abdominal regions [1].

The neurocranium is made up of the flat bones of the skull, also known as the cranial vault, along with the skull's base. It



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comprises eight bones: the frontal bone, occipital bone, ethmoid bone, sphenoid bone, and the paired parietal and temporal bones [2].

Platybasia is defined as the flattening of the skull base, indicated by an increased skull base angle. Traditionally, several techniques have been used in plain skull radiography to assess this angle, with the standard approach involving the measurement between a line drawn from the nasion to the center of the sella turcica and another line extending from the center of the sella turcica down along the posterior aspect of the clivus [3].

The basal angle, Boogaard's angle, and clival angle are commonly used in diagnosing craniometric angle malformations, typically assessed through radiography or cephalograms, and increasingly with MRI (Magnetic resonance imaging). Chiari malformation and basilar invagination are two primary clinical conditions linked to Craniovertebral Junction (CVJ) malformation [4]. Platybasia and hyperlordosis are often associated with basilar invagination. Due to the ease of accessing the anatomical bony landmarks needed for these angle measurements, these angles serve as reliable diagnostic tools for CVJ malformations [5].

Platybasia and basilar invagination often co-occur and can be found in various congenital craniofacial anomalies, such as osteogenesis imperfecta, craniocleidodysostosis, and Arnold-Chiari malformation. They can also develop in acquired conditions like Paget's disease, osteomalacia, rickets, senile atrophy, hyperparathyroidism, localized bone destruction, and trauma. Basilar invagination may present with clinical signs and symptoms of brainstem and upper cervical cord compression or disruptions in Cerebrospinal Fluid (CSF) circulation, potentially leading to hydrocephalus. However, when platybasia appears as an isolated finding, it is usually not clinically significant, and most patients remain asymptomatic [3].

Magnetic Resonance Imaging (MRI) has become one of the most powerful and adaptable diagnostic tools available to clinicians and researchers. Since MRI's commercial introduction, both its technology and clinical applications have advanced significantly. Innovations such as high-field magnets, advanced gradient systems, a variety of specialized radiofrequency coils, and improved computing technologies have greatly enhanced image resolution, quality, and examination speed [6].

These advancements have enabled highly detailed imaging across the body and brought sophisticated techniques like functional brain imaging, whole-body diffusion imaging, fiber tracking, and real-time cardiac imaging into routine clinical practice. Additionally, improvements in hardware and software have led to the creation of user-friendly, advanced viewing and processing tools, further enhancing diagnostic capabilities. As a result, MRI is now commonly used for a wide range of diagnostic procedures, providing clinicians with better information, reducing patient risk by avoiding radiation and invasive methods, and supporting improved diagnosis and treatment planning [6].

In MRI, how bright or dark an image looks are based on different principles than in CT scans. Instead of using x-rays, MRI uses radio waves and a magnetic field to see how tissues react. This reaction makes tissues show up in different shades of gray, bright, dark, or somewhere in between based on their molecular make-up. Different soft tissues will look different on an MRI because of this. Additionally, MRI allows us to adjust the radio-waves and magnetic fields to change how tissues appear, which

provides more flexibility. For example, water-rich tissues like Cerebrospinal Fluid (CSF) can be made to look either bright or dark on MRI images [6].

MRI gives detailed information about the body's tissues and their functions. However, there are situations where MRI might not be suitable or safe. For example, MRI cannot be used on patients with ferromagnetic metal in their bodies from accidents, job-related injuries, or surgical implants due to safety concerns. Most modern metal implants, like stents and orthopedic screws, are made from materials that are safe for MRI scans [7].

These results contribute valuable normative data to the understanding of cranial anatomy and can aid in clinical and surgical planning. The lack of significant sex-based differences highlights the need for individualized approaches in medical practice that do not necessarily rely on sex-specific anatomical variations. Future research could explore variations across different populations and investigate potential clinical implications of these findings in various medical and surgical contexts.

The purpose of this study is to determine skull base angle in adult population visiting a tertiary care hospital (TUTH) in Nepal.

## Objective

### General objective

Evaluation of skull base angle using magnetic resonance imaging

### Specific objective

- i. To correlate the skull basal angle with different age group populations
- ii. To correlate the skull basal angle with the age and gender of the participants.
- iii. To compare the findings of normal Nepalese population with the population of different countries.

## Materials & methods

### Study design

Quantitative, cross-sectional study.

### Research setting and population

This study was conducted in the Department of Radiology and Imaging at Tribhuvan University Teaching Hospital in Kathmandu, Nepal, over a period of three months from May to July 2024. It included 120 adult patients who underwent an MRI of the head and met the inclusion criteria, having consented to participate in the study.

### Inclusion criteria

Patients with various clinical conditions were recommended for an MRI of the head. The patients, who presented to the radiology department were diagnosed by the consultant radiologist as having normal studies.

### Exclusion criteria

#### Patients with brain tumors

Patients with clinical conditions that may be related to abnormal basal angles, such as Chiari malformations, Paget disease, osteomalacia, rickets, rheumatoid arthritis.

Patients with infection and trauma of the skull base were excluded from the study.

**Sampling method**

Convenience sampling technique i.e., non-probability sampling was used.

**Sample size**

Total number of patients who came in department to do MRI head and met our inclusion criteria during 3 months from May to July of data collection were included in the study i.e.120.

**Material used**

The Magnetom Amira Siemens 1.5T MRI, model number 10838610.

**Statistical analysis**

**Data collection method**

The 120 MRI examinations conducted in the Radiology and Imaging Department at Tribhuvan University Teaching Hospital (TUTH) were collected and evaluated over a period of three months. The MRI scans were performed using the MAGNETOM Amira Siemens 1.5T MRI scanner, following the standard protocol for MRI of the head. Patients were instructed to remain still during the scanning processing. The imaging protocol had sufficient slice to cover the entire brain from one temporal lobe to the other.

**Table 1:** MRI head parameter.

TR	TE	SLICE	MATRIX	FOV	PHASE	GAP	NEX
550ms	15ms	5MM	256x256	210-230	A>P	20%	1

This data was collected at the main operating console in the MRI operating room of the Radiology Department at Teaching Hospital, Maharajgunj Medical Campus, Kathmandu, Nepal. The 16-channel head coil was used for the patients, and no parameters were changed during the scan.

**Data collection Tools**

A proforma was created to record the measurement of the skull base angle, and it was completed daily.

**Data entry and analysis**

The data collected were organized in an Excel spreadsheet and analyzed using IBM SPSS (Statistical Package for the Social Sciences) software version 26. Statistical analysis was performed to calculate the mean and standard deviation. The Kolmogorov-Smirnov test ( $p=0.012$ ) and Shapiro-Wilk test ( $p=0.021$ ) indicated that the data were not normally distributed. Consequently, the Spearman rank correlation test was used to evaluate the relationships between skull base angle, age, and gender, while the Mann-Whitney U test compared skull base angles across genders, and the Kruskal-Wallis H test assessed differences among age groups.

**Measurement level of skull base angle**

The angle was measured in a mid-sagittal Turbo Spin Echo (TSE) T1-weighted MRI image. This angle was defined by a line extending from the anterior cranial fossa to the tip of the dorsum sellae and another line drawn along the posterior margin of the clivus.

In the sagittal T1-weighted MRI image, the anterior cranial fossa was identified as the area stretching from the frontal bone to the sphenoid bone, characterized by the frontal lobes and the cribriform plate of the ethmoid bone. The dorsum sellae appeared as a prominent bony ridge at the posterior aspect of the sella turcica, while the clivus was seen as a sloped, smooth bony region extending posteriorly from the dorsum sellae towards the foramen magnum, providing the basis for measuring the skull base angle.

Syngo MR® Software package was used for angle measurement in MAGNETOM Amira.



**Figure 1:** Measuring Skull Base angle.



**Figure 2:** Measuring Skull Base angle.

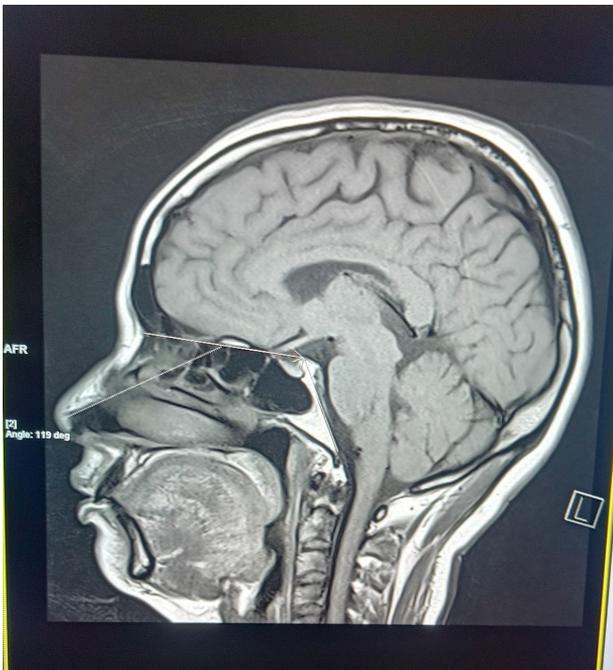


Figure 3: Measuring Skull Base angle.



Figure 4: Measuring skull base angle.

**Result**

**Gender wise distribution**

Table 2: Gender wise distribution.

Sex	Frequency	Percent
Male	55	45.8
Female	65	54.2
Total	120	100.0

A total of 120 patients were enrolled in the study, with female participants constituting 54.2% and male participants 45.8%, indicating a higher enrollment of females compared to males. Figure 1 illustrates this distribution with a pie diagram, showing 65 female participants and 55 male participants.

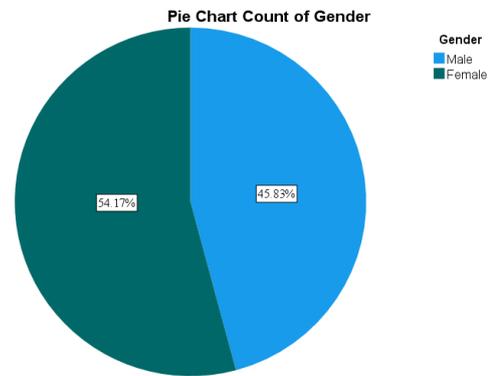


Figure 5: Pie diagram showing distribution of male and female.

**Age distribution**

Table 3: Age distribution.

	N	Minimum	Maximum	Mean	Std. Deviation
Age	120	13	84	44.66	18.538

A total of 120 participants had a mean age of 44 years, with a standard deviation of 18 years. The minimum age reported was 13 years, and the maximum age reported was 84 years.

**Gender distribution of skull base angle**

Table 4: Gender distribution of skull base angle.

	Gender	N	Minimum	Maximum	Mean	Std. Deviation
Skull base angle	Male	55	111	132	120.05	4.739
	Female	65	113	131	119.86	4.139

Table 3 showed that the mean skull base angle among males was 120.05 degrees, with a standard deviation of 4.739. The minimum skull base angle was 111 degrees, and the maximum was 132 degrees. Similarly, among females, the mean skull base angle was 119.92 degrees, with a standard deviation of 4.013. The minimum skull base angle was 113 degrees, and the maximum was 131 degrees.

**Skull base angle**

Table 5: Skull base angle.

	N	Mini-mum	Maximum	Mean	Std. Devia-tion
Angle	120	111	132	119.95	4.406

The minimum angle observed in the patients was 111 degrees, while the maximum angle was 132 degrees. The mean angle was 119.85 degrees, with a standard deviation of  $\pm 4.334$  degrees.

**Age interval distribution**

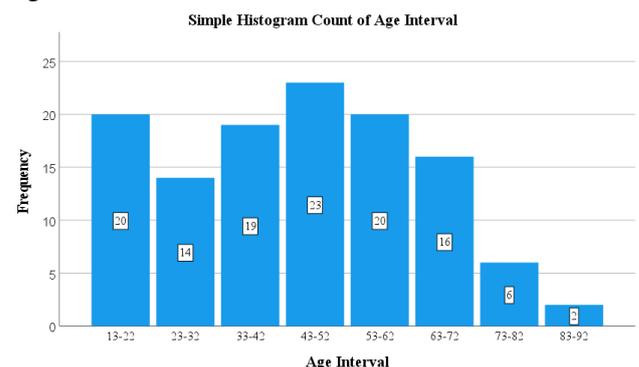


Figure 6: Age interval distribution.

Figure 7 illustrates the age distribution of participants. There were 20 individuals aged between 13 and 22, 14 participants aged between 23 and 32, 19 participants aged between 33 and 42, 23 participants aged between 43 and 52, 20 participants aged between 53 and 62, 16 participants aged between 63 and 72, 6 participants aged between 73 and 82, and 2 participants aged between 83 and 92.

**Test of normality**

The results of the normality tests show that the Kolmogorov-Smirnov statistic is 0.18 and the Shapiro-Wilk statistic is 0.019, both of which are below the reference value of 0.05. Therefore, we reject the null hypothesis in both tests, concluding that the data do not follow a normal distribution.

**Correlation between skull base angle with age and gender of participants with Spearman rank correlation test**

**Table 6:** Spearman’s rho correlation of age and skull base angle.

Variables	Spear-man’rho	p-value
Skull base Angle	-.060	.516

Spearman’s rank correlation analysis revealed a coefficient of -0.060, indicating a very weak negative correlation between age and skull base angle. With a p-value of 0.516, which exceeds the 0.05 significance level, we fail to reject the null hypothesis. Thus, there is no statistically significant correlation between age and skull base angle in this sample.

**Mann-Whitney U Test for gender (male and female)**

**Table 7:** Mann-Whitney U Test of skull base angle and gender.

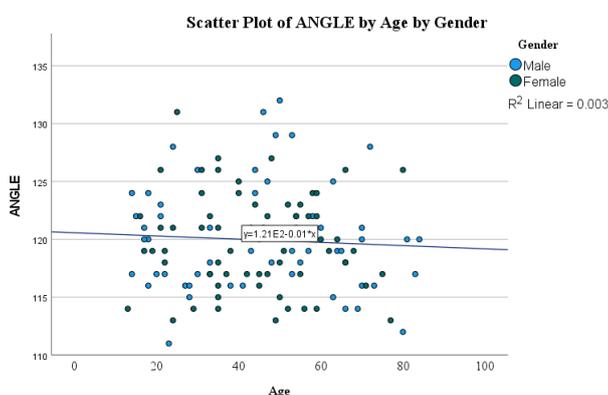
Variables	Mann-Whitney U	p-value
Skull Base Angle	-.121	.903

The Mann-Whitney U test produced a Z value of -0.121 and a p-value of 0.903, well above the 0.05 significance level. Thus, we fail to reject the null hypothesis, indicating no statistically significant difference in skull base angle between males and females.

**Kruskal-Wallis H Test for different age group**

**Table 8:** Kruskal-Wallis H Test for different age group.

Kruskal-Wallis H	Df	Asymp. Sig.
5.953	7	.545



**Figure 7:** Scatter plot of skull base angle and age of male and female.

Due to the non-normal distribution of the data, a non-parametric test was used to evaluate the relationship between skull base angle and different age intervals. The Kruskal-Wallis H test resulted in a p-value of .545, which is greater than the significance level of 0.05. Therefore, we fail to reject the null hypothesis. This indicates that there is no statistically significant difference in skull base angle across the different age intervals.

**Discussion**

Using the MR imaging technique, the mean skull base angle in the Nepalese population was found to be 119° (SD=4.406, 95% CI).

Using the MR imaging technique, the mean skull base angle for the Nepalese population was found to be 120° (SD=4.739, 95% CI) for males and 119° (SD=4.138, 95% CI) for females. There was no statistically significant difference between males and females. With the p-value of 0.516, we also found that there is no statistically significant difference between the skull base angle and age.

Konigsberg suggested that normal values for the mean skull base angle in adults range from 105° to 127°. Consistent with this hypothesis, our study found that the basal angle ranged from 111° to 132° [8].

In comparing the mean skull base angles across different populations, Thai adults have a mean angle of 115° (SD=5.7, 95% CI=114.2°–115.8°), while the Nepalese population exhibits a mean angle of 119.85°. This results in a mean difference of 4.85° between the two populations, with the Nepalese population having a larger mean skull base angle compared to the Thai population [3].

The mean skull base angle measured in the Western population by Konigsberg et al. was 117° (SD=6, 95% CI=116°–118°), while in the Nepalese population, the mean skull base angle was found to be 119° (SD=4.334, 95% CI). This results in a mean difference of 2° between the two populations, with the Nepalese population having a larger mean skull base angle compared to the Western population [3].

The mean basal angle in the South Indian population was 113° (males: 113°±5°, females: 114°±4°), whereas the skull base angle in the Nepalese population was found to be 120° (SD=4.739, 95% CI) for males and 119° (SD=4.080, 95% CI) for females. This indicates a mean difference of 7° between the Nepalese males and South Indian males, and a mean difference of 5° between the Nepalese females and South Indian females, with the Nepalese population exhibiting a larger mean skull base angle compared to the South Indian population [5].

The mean basal angle reported in a different study was 127.89° (SD=6.4), whereas in our research, the mean skull base angle for the Nepalese population was found to be 119° (SD=4.334, 95% CI). This difference may be due to the selection of small sample size in his/her study compared to ours [9].

**Conclusion**

This study found that the skull base angle could be measured with high accuracy and reliability, and no significant differences were detected between age groups or genders. To further refine these findings and develop a detailed nomogram for the Nepalese population, future research should encompass a larger and more ethnically diverse sample.

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**Author declarations****Conflict of interest**

The authors declare no conflict of interest.

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