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Establishing Normative Cranial Landmarks for Posterior Fossa Assessment in a West African Population: A Diagnostic Tool for Posterior Fossa Lesions.

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Abstract

Background: Accurate evaluation of posterior fossa structures is critical for distinguishing brainstem from cerebellar and fourth ventricular lesions. This study aimed to establish normative values for the ratio between the distance from the dorsum sellae to the roof of the fourth ventricle (DS–V4) and the distance from the dorsum sellae to the torcula (DS–T) in an African population, and to evaluate its diagnostic utility. **Methods:** In this cross-sectional study, 420 individuals underwent cranial MRI. Distances from the dorsum sellae to the roof of the fourth ventricle (DS–V4) and to the torcula (DS–T) were measured on midsagittal T1-weighted images, and the DS–V4/DS–T ratio was calculated. Results were compared with existing literature to assess differences in these ratios relative to non-African cohorts. **Results:** Mean DS–V4/DS–T ratios were 0.568 (95% CI, 0.543–0.594) in males and 0.570 (95% CI, 0.561–0.579) in females, with no significant sex difference. Age-related trends reflected expected cranial growth patterns. Ratios in this West African cohort appeared slightly higher than values reported in some European series. **Conclusion:** A higher DS–V4/DS–T ratio may suggest brainstem or clival lesions, whereas a lower ratio may indicate cerebellar or posterior fossa lesions. The DS–V4/DS–T ratio represents a practical diagnostic marker for posterior fossa assessment and may be particularly valuable in low-resource settings where access to advanced imaging is limited.

Keywords: dorsum sellar, fourth ventricle, posterior fossa, torcula, brainstem, cerebellum

INTRODUCTION

The posterior cranial fossa contains the cerebellum, brainstem, and fourth ventricle. Pathologies affecting these structures—such as tumours, congenital malformations, and hydrocephalus—can cause characteristic displacements with major neurological consequences. Reliable radiographic landmarks are therefore essential for assessing normal positioning and detecting pathological shifts (1,2). Accurate identification of such shifts underpins neurosurgical planning, neuroradiological diagnosis, and treatment strategies.

A fundamental landmark for posterior fossa assessment is Twining's line (TL), drawn from the tuberculum sellae to the internal occipital protuberance. The distance from the tuberculum sellae to the roof of the fourth ventricle (TS–V4) is widely used to gauge the ventricle's normal position and to detect displacement (3,4). Historically, Krogness (1976) introduced proportional measures—TS–T4/Tw and DS–T4/Tw (Tw, Twining line; T4, fourth ventricle; DS, dorsum sellae)—reporting mean values of 0.46 ± 0.02 and 0.33 ± 0.03, respectively, that were stable across skull sizes (5,6). Clinically, higher DS–V4/TL (or TS–V4/TL) ratios suggest dorsal displacement from brainstem or clival lesions, whereas cerebellar tumours tend to reduce the ratio (7,8).

However, TL has limitations. It is susceptible to variations in the anterior skull base, requires precise alignment to avoid parallax, and may be less reliable when multiple posterior fossa structures are distorted (9–11). In some cases, adjacent structures are deformed without materially altering TL-based measurements, reducing the diagnostic value of fixed TL thresholds. By contrast, the dorsum sellae–torcula line (DS–T) may be less affected by anterior skull-base variability and provide a more consistent denominator for posterior fossa assessment (9–11).

Despite extensive work on posterior fossa morphology, these parameters have not been examined in African populations, where anthropological differences in cranial morphology are well documented (10,12–14). Applying reference values derived from European cohorts may therefore be suboptimal. This study addresses that gap. Our primary objective was to establish age- and sex-specific reference intervals for the DS–V4/DS–T ratio on MRI in a West African cohort; the secondary objective was to assess age-by-sex differences using two-way ANOVA. By defining these parameters within an African cohort, we aim to enhance diagnostic precision, support neurosurgical planning, and improve care for posterior fossa disease.

METHODS

Study design and participants

This descriptive study included all patients who presented for cranial imaging at the study location over a four-year period, following ethical approval and written patient consent. Inclusion criteria were patients of any age with no radiological abnormality of the posterior fossa. Patients with posterior fossa abnormalities were excluded.

MRI acquisition

MRI was performed on a 1.5T GE Signa Explorer scanner (GE Healthcare, Chicago, IL, USA) using a midsagittal T1-weighted sequence (voxel size 1×1×1 mm^3; slice thickness 6.0 mm). Patients were positioned supine with the head in neutral alignment. Anatomical landmarks were identified at the dorsum sellae, the torcula (internal occipital protuberance), and the roof of the fourth ventricle.

Image analysis and measurements

Images were reviewed using K-PACS (version 1.6.0, Image Information Systems Ltd., Germany) and Onis (version 2.5, DigitalCore Co. Ltd., Australia) DICOM viewers, and measurements were obtained with calibrated electronic callipers. For each case, we recorded the distance from the dorsum sellae to the **roof** of the fourth ventricle (DS–V4), the distance from the dorsum sellae to the torcula (internal occipital protuberance; DS–T), and the ratio DS–V4/DS–T (Figure 1). Throughout, DS–V4 denotes the distance to the roof of the fourth ventricle. For clarity, although some historical descriptions use the floor of the fourth ventricle, all measurements in this study used the roof exclusively.

Observer reliability

Measurements were performed independently by two observers. Inter-rater reliability, assessed using the intraclass correlation coefficient (ICC), demonstrated high agreement (ICC = 0.91; 95% CI, 0.88–0.94).

Age groupings

Age categories used for analysis were 0–15, 16–30, 31–45, 46–60, 61–75, and >75 years.

Data handling and statistical analysis

Data were entered into spreadsheets, collated, and summarised with frequency tables and graphs. Statistical analysis was performed using GraphPad Prism (version 9.4.1.681 for Windows; GraphPad Software, San Diego, California, USA). Descriptive statistics (means and standard deviations) were calculated. Group comparisons of means used the t test and two-way ANOVA. A p value < 0.05 was considered statistically significant.

RESULTS

Participants

We analysed 420 individuals (220 males, 200 females). (**Table 1**)

Age–sex patterns

In adolescents (0–15 years), females had larger absolute measurements: DS–V4 was higher by ~4.7 mm (44.64 vs 39.90 mm) and DS–T by ~2.6 mm (78.81 vs 76.25 mm) compared with males; the ratio was also higher in females (0.57 vs 0.52). After adolescence, males showed consistently larger DS–V4 and DS–T. The greatest separation occurred at 31–45 years, when males exceeded females by ~6.9 mm for DS–V4 (49.82 vs 42.91 mm) and ~9.2 mm for

DS–T (86.10 vs 76.87 mm), while the ratio remained similar (0.58 vs 0.56). In older adults (>75 years), sex differences narrowed for both distances and the ratio (all ~0.58). (**Table 1**, **Figures 3–4**)

DS–V4/DS–T ratio across age

Across age groups, the ratio was tightly clustered around 0.56–0.58 in both sexes, with modest shifts: lower in males than females before adolescence, higher in males from adolescence through ~60 years, and convergent thereafter. These trends are illustrated in **Figure 2** and summarised numerically in **Table 1**.

Inferential statistics

Two-way ANOVA showed no significant sex-by-age interaction, $F(5,408) = 1.12$, $p = 0.35$ (partial $\eta^2 = 0.014$). The main effect of age was modest and non-significant ($p = 0.08$). Thus, while absolute distances vary with age and sex as described above, the proportional relationship captured by DS–V4/DS–T remains relatively stable. (**Table 1**)

Overall comparisons by sex

When averaged across all ages, males had slightly higher absolute distances—DS–V4: 46.81 ± 3.62 mm vs 45.31 ± 1.60 mm; DS–T: 82.42 ± 3.51 mm vs 79.68 ± 2.30 mm—but nearly identical ratios: 0.568 ± 0.024 (95% CI 0.543–0.594) in males and 0.570 ± 0.009 (95% CI 0.561–0.579) in females. None of these differences reached statistical significance (DS–V4 $p = 0.3762$; DS–T $p = 0.1410$; DS–V4/DS–T $p = 0.8766$). (**Table 2**)

Table 1: Mean ± standard deviation of DS–V4, DS–T, and DS–V4/DS–T ratio across age groups, with sample size (n) per group.

Age Group	Sex	DS-V4 (mm) Mean ± SD	DS-T (mm) Mean ± SD	DS-V4/DS-T Ratio Mean ± SD
0-15 yrs	Male	39.9 ± 3.82	76.25 ± 3.62	0.52 ± 0.05
	Female	44.64 ± 4.47	78.81 ± 5.10	0.57 ± 0.05
16-30 yrs	Male	47.84 ± 5.87	82.48 ± 3.53	0.58 ± 0.04
	Female	45.59 ± 4.06	80.82 ± 4.18	0.56 ± 0.04
31-45 yrs	Male	49.82 ± 6.24	86.10 ± 5.13	0.58 ± 0.06
	Female	42.91 ± 5.27	76.87 ± 4.04	0.56 ± 0.05
46-60 yrs	Male	48.85 ± 5.20	84.63 ± 5.26	0.58 ± 0.04
	Female	46.00 ± 4.85	81.13 ± 3.69	0.57 ± 0.04
61-75 yrs	Male	45.99 ± 5.92	80.93 ± 4.35	0.57 ± 0.05
	Female	44.98 ± 4.88	77.59 ± 4.06	0.58 ± 0.05
>75 yrs	Male	48.44 ± 4.17	84.11 ± 4.89	0.58 ± 0.03
	Female	47.75 ± 5.62	82.85 ± 7.69	0.58 ± 0.05
Total (mean)	Male	46.80667	82.41667	0.568333
	Female	45.31167	79.67833	0.57

Table 2: Cumulative mean values by sex.

	Mean ± SD		P value
	Male	Female	
DS-V4	46.81 ± 3.62	45.31 ± 1.60	0.3762
DS-T	82.42 ± 3.51	79.68 ± 2.30	0.1410
DS-V4/DS-T	0.568 ± 0.024	0.57 ± 0.009	0.8766
C.I (DS-V4/DS-T)	0.5431-0.5935	0.5606-0.5794	

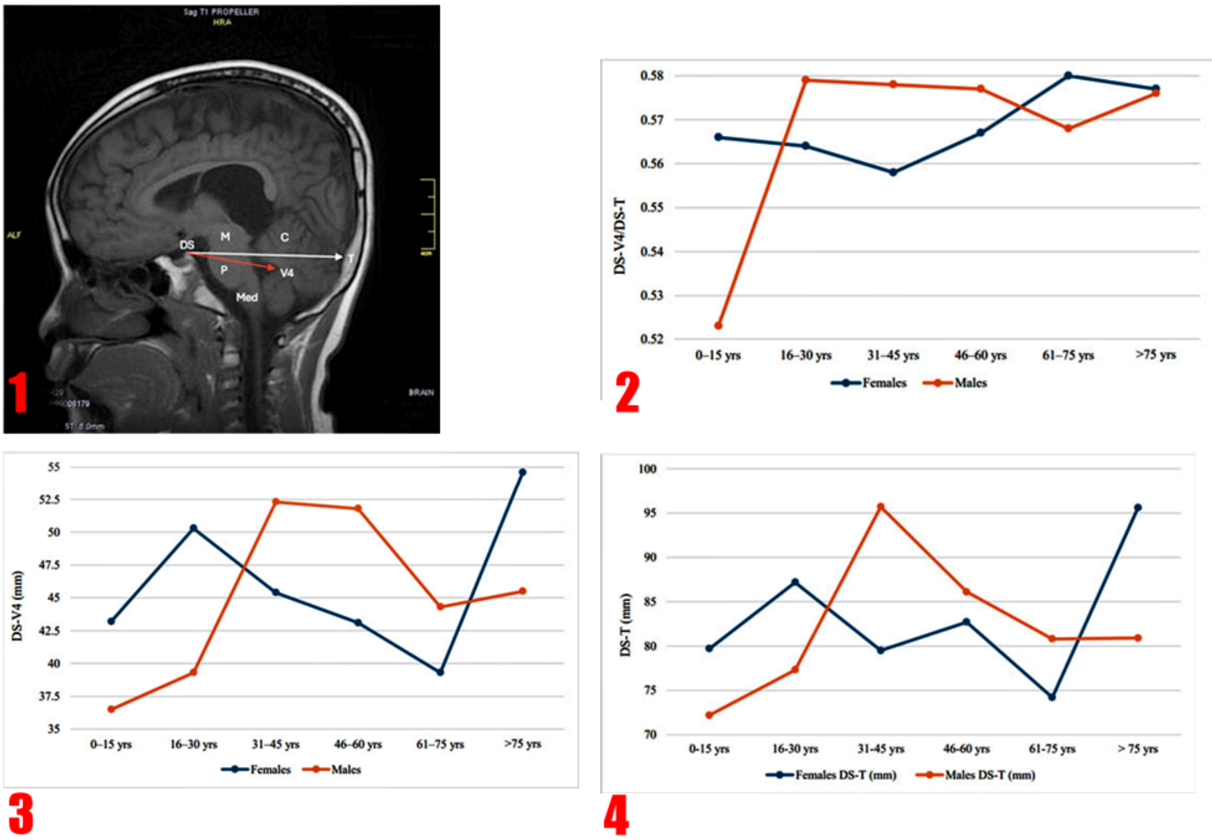

Figure 1-4: Figure 1: Sagittal T1W MRI showing measurements from the dorsum sella (DS) to the torcula (T) (DS-T) (white arrow) and from the dorsum sella to the roof of the fourth ventricle (V4) (DS-V4) (red arrow). (M-midbrain; P-pons; Med-medulla; C-cerebellum). Figure 2: DS-V4/DS-T values by sex. Figure 3: Comparison of the trend in DS-V4 with age between males and females. Figure 4: Comparison of the trend in DS-T with age between males and females.

DISCUSSION

DS–V4 and DS–T measurements followed a consistent pattern: females showed slightly higher values in pre-adolescence (0–15 years), whereas males had higher values thereafter, with the greatest separation at 31–45 years. These trends accord with established cranial growth dynamics (15–17). Earlier skeletal maturity in females likely explains their initially larger DS–V4 and DS–T values, while post-pubertal skull-base expansion in males accounts for the subsequent increase (18). This is congruent with prior work indicating continued male cranial base growth beyond puberty, in contrast to earlier female maturation (18–22).

Although males had slightly larger absolute distances, the DS–V4/DS–T ratio was similar—0.568 for males and 0.570 for females—with overlapping confidence intervals. The absence of statistically significant differences ($p > 0.05$) indicates that the ratio is effectively sex-independent and suitable as a universal reference parameter for posterior fossa assessment (8,23). This supports its use as a stable marker of normal fourth-ventricular position, largely unaffected by sex-related anatomical variation.

Differentiating brainstem lesions from fourth-ventricular or cerebellar tumours remains a central challenge in posterior fossa imaging. The DS–V4/DS–T ratio provides a pragmatic aid: values above the normal range (0.568 ± 0.024 in males; 0.570 ± 0.009 in females) suggest dorsal displacement from brainstem or clival pathology (e.g., pontine gliomas, tectal plate tumours), whereas values below the range suggest anterior displacement due to posterior fossa masses (e.g., medulloblastomas, cerebellopontine angle tumours) (7,24). Ambiguity may arise with interface tumours (e.g., ependymomas, exophytic gliomas), which can exert both dorsal and anterior effects, yielding intermediate or borderline ratios; in such cases, ancillary imaging features (ventricular distortion patterns, MRI signal characteristics) remain essential (25). By establishing population-specific normative values, the present study supplies reference thresholds that can improve diagnostic confidence when ratios are borderline and better inform surgical planning.

Comparative context is important. Krogness (1976) reported a TS–T4/Tw ratio of 0.46 ± 0.02 in a European cohort (1), and Zimmerman documented TS–V4/TL values of 0.47–0.53 (0.49–0.51 in 66% of cases) (4). In our cohort, the DS–V4/DS–T ratio was 0.568 ± 0.024 in males and 0.570 ± 0.009 in females. These findings suggest slightly higher ratios in individuals of African descent than in some European series—implying a relatively more dorsal position of the fourth ventricle with respect to the dorsum sellae. Consequently, European-derived thresholds may under-estimate dorsal displacement in African patients, and population-specific reference ranges may be more appropriate. Such differences plausibly reflect cranial morphological variation, including skull-base angles, posterior fossa depth, and overall skull dimensions (5,6,10,23,26). Here, “slightly superior positioning” denotes a more dorsal (posterior) relation to the dorsum sellae rather than a higher intracranial level.

Population-specific reference values are therefore essential. Many neuroradiological parameters have been derived from Western populations; direct application to African patients risks diagnostic inaccuracy. The present data provide a needed baseline for DS–V4 and DS–T in African individuals, supporting more accurate detection of posterior fossa abnormalities, particularly in resource-limited settings.

Clinical significance

The DS–V4/DS–T ratio offers practical insight into posterior fossa lesion characterisation. As outlined above, an increased ratio suggests brainstem or clival pathology, which typically displaces the fourth ventricle dorsally; a decreased ratio points to cerebellar or other posterior fossa lesions that displace the ventricle anteriorly. These patterns have been reported in intrinsic brainstem tumours, medulloblastomas, and cerebellopontine angle tumours.

By establishing reference values, this study has particular relevance in low-resource settings. Where MRI access is limited, DS–V4/DS–T can be adapted as a cost-conscious screen using CT. Plain radiographs have theoretical utility but are constrained by poor visualisation and parallax, rendering them impractical. CT, in contrast, is a feasible alternative when MRI is unavailable. Simple radiographic measurements can help flag abnormal fourth-ventricular displacement and guide further imaging, referral, or surgical planning. A standardised DS–V4/DS–T threshold could facilitate earlier detection and intervention, thereby reducing the burden of undiagnosed posterior fossa disease in resource-limited environments.

Limitations and future directions

This study provides baseline DS–V4 and DS–T measurements in a West African cohort, but several limitations warrant consideration. First, predictive performance across specific pathologies (e.g., Chiari malformations, posterior fossa oedema) was not evaluated and merits further study. Second, although patients with posterior fossa pathology were excluded, supratentorial lesions can influence ventricular position; we minimised this by excluding global mass effect and hydrocephalus, but subtle effects cannot be ruled out. Third, this was a single-centre study; external, multicentre validation and assessment across imaging modalities are needed. Fourth, intra-rater reliability was not examined. Finally, while our ratios appear higher than those reported in some European cohorts, caution is warranted because denominators differ slightly (DS–T vs Twining’s line); direct equivalence cannot be assumed, and method-matched external datasets are required for confirmation.

CONCLUSION

This study establishes normative DS–V4/DS–T values in a West African cohort. Higher ratios suggest brainstem or clival lesions, whereas lower ratios suggest cerebellar or other posterior fossa lesions. These values may serve as practical diagnostic tools in African hospitals, especially where resources are limited. Ratios in this cohort appear higher than in some European series; validation with method-matched studies and external populations is recommended.

Data Availability Statement: The datasets generated and/or analyzed during the current study are not publicly available due to institutional restrictions but are available from the corresponding author on reasonable request.

Conflict of Interest Statement: The authors declare that they have no competing interests related to this work.

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