

Vertebral Morphometric Evaluation of Stress in Modern Pediatric Patients

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INTRODUCTION

Multiple indicators of growth disruption have been implemented in evaluating systemic stress in past populations. The phenomenon of catch-up growth, however, can confound these interpretations. Researchers have thus utilized skeletal elements that cease growth during childhood relative to those that continue growth into adulthood to investigate lifetime stress. Vertebral neural canal (VNC) dimensions are fully formed by late childhood (approximately nine years old) while the vertebral bodies continue growth into adulthood.¹ Prior studies have utilized the anterior-posterior (AP) and transverse (TR) measurements of the VNC in adults relative to stature at age of death to identify "stunting" and evaluate childhood stress resulting in growth disruption.^{2,3} These morphometrics have been shown to be independent of age, sex, body size and ethnicity in adults.²

For this study, access to the health history of known age pediatric individuals is crucial to evaluating the developmental variation within vertebral morphometrics used to investigate stress and growth disruptions in past populations. Chronic illnesses in this population were used as a proxy for any environmental or health stressor that may have affected youth in past populations. This study seeks to evaluate the effect of chronic versus acute conditions on VNC growth in two age subsets of a pediatric population: less than nine years old and greater than nine years old. It is expected that individuals less than nine years old with chronic illnesses will display stunted VNC when compared to similar age individuals with acute illnesses.

MATERIALS & METHODS

- Using computed tomography (CT) with and without contrast, 40 pediatric cases were evaluated for antero-posterior (AP) and transverse (TR) VNC measurements. Two cases were deemed unreadable due to patient movement and metal artifacts leaving a total of 38 individuals ranging from ages 4 to 15 years old.

- Scans were obtained for reasons unrelated to this project and ordered by a physician. Full IRB approval was granted for access to these anonymized data.

- Using Osirix software, Dicom transverse sections were used to measure AP and TR dimensions for each patient for T10, T11, and T12 following Clark and colleagues² (see Figure 1). Approximate level within VNC was chosen based on triangulation in sagittal and coronal planes of the same patient via Osirix (see Figure 2). Each measurement was performed three times for each vertebral level in order to reduce error (see Figure 3).

- Patients were then divided by age into two groups: <9 years old (yo) and >9 years old. After reviewing brief medical histories and diagnostic justifications for performing a CT scan, these were further divided by chronic versus acute conditions.

- Group A: <9 yo Acute conditions
- Group B: <9 yo Chronic conditions
- Group C: >9 yo Acute conditions
- Group D: >9 yo Chronic conditions

- Two-tailed T tests were performed to test the differences between AP and TR means for each vertebral level between chronic and acute individuals within each age group.

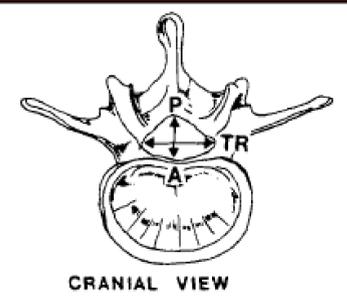


Figure 1: AP and TR measurements from Clark and colleagues.²

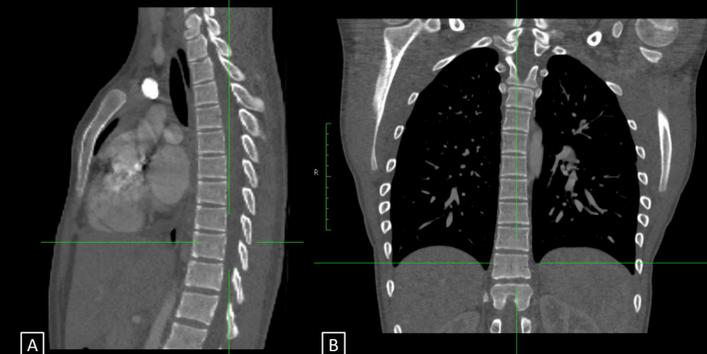


Figure 2: Positional lines (green) used to triangulate and estimate approximately constant level of VNC between patients at each thoracic vertebrae. A) Sagittal. B) Coronal

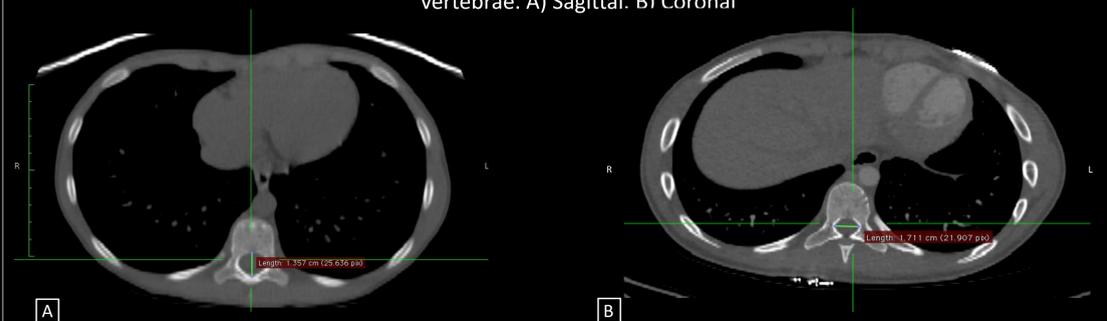


Figure 3: Dicom images at T10 showing positional lines (thin green) as well as the Osirix measurement (bold green line). A) AP from posterior vertebral body to anterior border of spinous process. This image is from a patient in Group A. B) TR measurement from widest point between pedicles. Image from a patient in Group D.

RESULTS & DISCUSSION

AP and TR thoracic VNC measurements were expected to vary with respect to age as well as chronic versus acute conditions. Group B patients appear to have experienced stunted growth in both AP and TR dimensions when compared to Group A although neither is statistically significant (see Table 1A). An interval plot demonstrates TR measurements from T10 and T11 are greater in Group A than in Group B; T12 does not display this trend (Group A < Group B) (see Figure 4A). AP measurements compared between these groups are also not significant, however interval plots demonstrate the same trend. Meanwhile, patients greater than 9 years old demonstrate less variation in VNC dimensions as growth has ceased in this element. T-tests indicate there is no statistical difference in the AP or TR measurements at all vertebral levels between Group C and Group D (see Table 1B). An interval plot of TR means at each vertebral level demonstrates the similarity of averages between Group C and D (See Figure 4B). For both age subsets, AP and TR dimensions increased from T10 through T12 consistent with normal vertebral growth.

Previous studies found smaller VNC size to be associated with younger age at death in bioarchaeological populations.^{2,3} T10 and T11 appear to be most affected by environmental stressors.^{2,3} Due to the early age of growth completion for the VNC, stress episodes in youth may be identified, and the effects on later life health appear to be significant. The differences of means for VNC in this pediatric patients under age 9 support the effects of chronic illnesses resulting in stunted dimensions compared to those in the same age group. After growth completion at age 9, there is less variation between patients despite designation of chronic or acute illness; this suggests onset of illness to have occurred post-VNC completion.

Table 1: Two – tailed T test results at 95% confidence interval for each vertebral level and dimension. A) Comparing means for Groups A and B (<9 years old). B) Comparing means for Groups C and D (> 9 years old).

	N	T10 AP			T10 TR			T11 AP			T11 TR			T12 AP			T12 TR		
		Mean (cm)	S.D.	p-value															
Group A	7	1.590	0.178		1.774	0.093		1.721	0.103		1.875	0.121		1.763	0.246		2.088	0.310	
Group B	9	1.484	0.212	0.296	1.620	0.207	0.140	1.558	0.249	0.102	1.753	0.243	0.216	1.723	0.260	0.402	1.967	0.183	0.839
Group C	11	1.537	0.092		1.758	0.135		1.648	0.142		1.894	0.182		1.803	0.136		2.177	0.135	
Group D	11	1.532	0.161	0.931	1.786	0.115	0.608	1.682	0.198	0.655	1.890	0.173	0.965	1.792	0.175	0.873	2.190	0.151	0.834

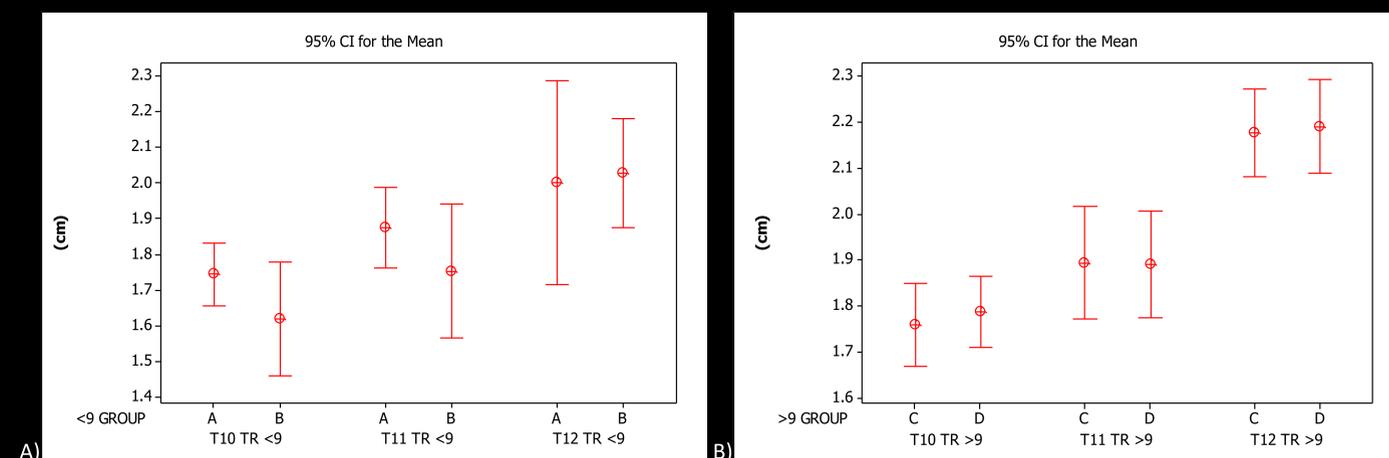


Figure 4: Interval plots for all TR measurements at T10, T11 and T12. A) Under 9 years old with acute diagnoses (1) show higher means for T10 and T11 than the under 9 years old chronic patients (2). T12 does not demonstrate this trend. B) Means between over 9 years old acute diagnoses (3) and over 9 years old chronic diagnoses (4) are not statistically different as expected.

CONCLUSIONS

This study demonstrates the detrimental effect of chronic illnesses experienced during growth of VNC in a pediatric population. Using VNC dimensions to identify early life stress periods that are not confounded by catch-up growth aides bioarchaeologists in assessing the health of adults in a population and risk of early mortality. For this study, a larger sample size may have resulted in statistically significant results although the trends are consistent with previous studies completed in adults. Limitations include the briefness of health records provided which lacked information on length or onset of conditions; also, physician read CT results were not included. Future research for this population includes a comparison between VNC and stature, as well as including additional patients.

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