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MORPHOMETRIC STUDY OF CERVICAL VERTEBRA OF A NIGERIAN POPULATION TOWARDS CORRECTING CERVICAL INSTABILITIES

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ABSTRACT

Objective: The understanding of the morphology of the cervical vertebra is important towards addressing cervical spine instabilities that may be faced by different racial populations. This study was aimed at evaluating the morphometry of C3 – C7 vertebra of a Nigerian population in order to provide a guide for correcting these instabilities during surgical operations of the cervical spine. **Materials and Methods:** With the aid of a digital vernier caliper, processed cervical bones of a total of 30 male adult cadavers were measured to the nearest 0.01mm. All linear measurements of the cervical vertebra were obtained and analyzed. All vertebras were fully ossified with no history of surgical spine operation. **Results:** The average values for all morphometric parameters of vertebral bodies were as follows; AVBH: 13.88mm, PVBH: 12.83mm, SVBW: 18.75mm, MVBW: 17.74mm, IVBW: 20.84mm. Mean values of pedicular measurements include; PH-L: 9.23mm, PH-R: 9.29mm, PW-L: 5.57mm, PW-R: 5.86mm. While the mean values of lamina measurements were; LH-L: 12.28mm, LH-R: 12.13mm, LL-L: 13.22mm, LL-R: 13.38mm, LT-L: 3.61mm and LT-R: 3.71mm. The dimensions of the C7 verterbra were significantly larger ($p < 0.05$) compared to other vertebra. In comparison to other racial populations, vertebral body height values in this present study were slightly lower compared to other studies, however, pedicle morphometric dimensions of this study were slightly higher. **Conclusion:** This study has been able to generate reference values for evaluating and treating cervical spine instabilities and determine the significance of the anatomic structures in cervical region in a Nigerian population.

KEYWORDS: Cervical, Instabilities, Pedicle, Vertebral, Lamina, Morphometry.

INTRODUCTION

The vertebral column in humans is a delicate, complex structure that serves two purposes: to protect the spinal cord and support the weight of the head, trunk, and limbs during the various activities of the skeleton and muscles attached to them.[1,2] The size, shape, and orientation of the vertebrae affect the vertebral column's strength and adaptability.[3] Due to a number of factors, such as prolonged sitting, hunching over, and squatting, Africans in their working years are at risk of developing acquired spinal conditions. Working tools are not often made in accordance with beneficial ergonomic principles in many regions of the continent. In addition, cervical spine instability from industrial accidents and exposure to occupational hazards are becoming more common.[4–6] Transpedicular screw fixation is one of the most widely used surgical procedures to treat these cervical instabilities.[7,8]

Spinal instabilities are commonly treated through a challenging surgical procedure called transpedicular screw fixation. This procedure was developed to treat the middle and lower cervical spine after traumatic lesions, but it is also crucial for simultaneous posterior decompression and reconstruction in the cervical spine.[9,10] The risk of catastrophic damage to the nearby neurovascular structures makes this surgical procedure technically challenging.[11,12]

An important tool in clinical practice, risk classification, diagnosis, and follow-up screening is anthropometry, which has been acknowledged for many years. Shape distortion abnormalities are frequently wrongly

categorized because there is no adequate quantitative anatomical diagnostic definition for acute conditions of the spine.[13] The most accurate method for extracting morphometric information from anatomical structures is direct measurement of specimens. Clinicians generally agree that cadavers offer the experience that is most similar to a real operating room in terms of texture and appearance. Because of this, surgeons are starting to rely more on metric values obtained from cadavers rather than information obtained from imaging-based studies.[14,15]

There is currently a dearth of precise quantitative anthropometric research in the Nigerian population that focuses on identifying preventable risk factors in order to provide information for the design of group-specific biomaterials and the design and establishment of individualized rehabilitation facilities. In-depth knowledge and comprehension of the spine's anatomical dimensions must be made available in order to address these issues. When available, reports on cadaveric studies are thought to be more accurate because, in addition to losing some of the final details of the bony structures due to imaging techniques, magnification and positioning cannot sufficiently capture individual variations in body proportions.[14,16] In order to better understand the cervical vertebra's morphometry in a population of Nigerian cadavers, this study set out to do so.

This study aims to increase understanding of cervical spine anatomy and enable a better understanding of the quantitative anatomical basis of spine-related laboratory investigations and interpretations, the principles of spine biomechanics, ergonomics, physiotherapy, and rehabilitation based on the study population.

MATERIALS AND METHODS

This study was cross-sectional and descriptive. Selected morphometric parameters for C3 to C7 vertebrae from a total of 30 male cadavers of Nigerian descent were obtained after receiving ethical approval (UPH/CEREMAD/REC/MM84/045) from the University of Port Harcourt Research Ethics Committee. There were no bone disorders or injuries of any kind, and all of the vertebral bones were fully osseous. The cervical spine was exposed after these spines were exhumed and positioned in the prone position by dissecting through the neck muscles in accordance with Cunningham's manual of practical anatomy. The vertebral column was then removed from the body after being exposed to its full length. The spines were then scrubbed with brushes, de-fleshed, and disarticulated to allow for accurate measurement of each individual vertebra.

The spines were put together and held with a string that was passed in between the vertebral foramen and tied together after being brushed, easured, and recorded for each individual vertebra. The spines were then conserved.

A digital vernier caliper was used to help obtain all of the morphometric variables that were examined in this study. These morphometric variables consist of;

The anterior vertebral body height (AVBH) is the separation, anteriorly, between the central borders of the superior and inferior vertebral bodies in the sagittal plane.

The posterior vertebral body height (PVBH), measured on the back of the vertebra between the superior and inferior end plates, is the separation in the sagittal plane between the posterior borders of the superior and inferior vertebral bodies.

The superior vertebral body width (SVBW) is the separation in the transverse plane between the superior vertebra body's left and right borders.

MVBW, or middle vertebral body width, was the separation in the transverse plane between the middle vertebra's left and right borders.

The inferior vertebral body width (IVBW) is the separation between the inferior vertebral body's left and right borders in the transverse plane.

The pedicle height (PH) is the distance between the highest point on the superior surface and the lowest point on the inferior surface.

The transverse length of the pedicle, as measured from its lateral borders, is known as the pedicle width (PW).

The transverse distance separating the superior and inferior borders of the lamina is known as laminar height (LH).

Laminar length (LL): This was the measurement of how far the superior articular process' lateral border was from the spinous process along the lamina's transverse axis.

Laminar thickness (LT): This was determined to be the lamina's maximum measurable thickness.

Analysis based on statistics: Figures and tables were used to represent all data. There were applied descriptive statistics like mean, standard deviation, standard error, and variance. The obtained data were analyzed using the Statistical Package for Social Sciences (SPSS) version 23.0.

RESULTS

The superior vertebral body was observed to have a mean of 16.03mm while the mid vertebral body and the inferior vertebral body were seen to have a mean of 15.82mm and 18.20mm, respectively. Table 1 displays the morphometric characteristics of the C3 vertebra. The left pedicle width was observed to have a mean of

5.40mm, while the right pedicle width was observed to have a mean of 5.40mm. The left pedicle height was observed to have a mean of 8.46mm, while the right pedicle height was observed to have a mean of 8.36mm. The left and right laminae length had a mean of 13.66mm and 13.60mm, while the left and right laminae thickness had means of 3.43mm and 3.78mm. The left and right laminae height were observed to have mean values of 11.85mm and 11.57mm.

Table 1: Descriptive Statistics of Morphometric Parameters of C3 Vertebra.

Parameter	Mean ± S.D (mm)	S.E.M	Variance	Min (mm)	Max (mm)
AVBH (mm)	14.08 ± 2.53	0.47	6.42	8.30	19.33
PVBH (mm)	12.68 ± 3.14	0.59	9.88	6.82	19.71
SVBW (mm)	16.03 ± 3.45	0.66	11.95	10.09	22.30
MVBW (mm)	15.82 ± 2.64	0.50	7.00	12.01	21.74
IVBW (mm)	18.20 ± 2.44	0.47	5.96	13.53	25.16
PH-L (mm)	8.46 ± 1.51	0.28	2.30	5.13	10.67
PH-R (mm)	8.36 ± 1.51	0.28	2.29	4.02	10.25
PW-L (mm)	5.40 ± 1.45	0.27	2.12	3.27	9.32
PW-R (mm)	5.40 ± 1.14	0.21	1.31	4.04	8.69
LH-L (mm)	11.85 ± 1.91	0.36	3.67	7.30	15.17
LH-R (mm)	11.57 ± 1.86	0.35	3.49	6.50	15.96
LL-L (mm)	13.66 ± 1.95	0.37	3.83	10.24	18.73
LL-R (mm)	13.60 ± 2.05	0.38	4.23	9.59	18.75
LT-L (mm)	3.43 ± 0.86	0.16	0.74	1.53	5.11
LT-R (mm)	3.78 ± 1.28	0.24	1.66	1.51	5.99

Table 2 lists the morphometric characteristics of the C4 vertebra, including the superior vertebral body's mean measurement of 16.97mm, the midvertebral body's mean measurement of 16.38mm, and the inferior vertebral body's mean measurement of 18.88mm. The anterior vertebral body height was observed to have a mean of 13.23mm, whereas the posterior vertebral body height has a mean of 12.14mm. The left pedicle height was observed to be 8.08mm, while the right pedicle height was observed to be 8.53mm. The left pedicle width was observed to be 5.60mm, while the right pedicle width had a mean of 5.76mm. The left and right laminae length had a mean of 13.94mm and 13.24mm, and the left and right laminae thickness had means of 2.89mm and 3.20mm. The left and right laminae height were observed to have mean values of 10.94mm and 11.21mm.

Table 2: Descriptive Statistics of Morphometric Parameters of C4 Vertebra.

Parameter	Mean ± S.D (mm)	S.E.M	Variance	Min (mm)	Max (mm)
AVBH (mm)	13.23 ± 1.89	0.35	3.57	8.67	17.36
PVBH (mm)	12.14 ± 2.16	0.40	4.67	5.13	16.76
SVBW (mm)	16.97 ± 3.27	0.61	10.69	12.00	24.59
MVBW (mm)	16.38 ± 2.69	0.51	7.28	9.77	21.22
IVBW (mm)	18.88 ± 2.02	0.38	4.08	15.88	22.89
PH-L (mm)	8.08 ± 1.06	0.20	1.14	5.42	9.63
PH-R (mm)	8.53 ± 1.14	0.22	1.32	6.38	9.89
PW-L (mm)	5.60 ± 1.27	0.24	1.62	4.05	9.13
PW-R (mm)	5.76 ± 1.33	0.25	1.78	3.09	9.23
LH-L (mm)	10.94 ± 1.24	0.23	1.53	9.12	13.66
LH-R (mm)	11.21 ± 1.27	0.24	1.63	9.08	13.43
LL-L (mm)	13.94 ± 1.99	0.38	3.99	10.36	18.20
LL-R (mm)	13.24 ± 2.00	0.38	4.03	9.67	19.68
LT-L (mm)	2.89 ± 1.12	0.21	1.24	1.39	5.49
LT-R (mm)	3.20 ± 1.16	0.22	1.35	1.40	6.93

Table 3 displays the morphometric characteristics of the C5 vertebra, with the superior vertebral body having a mean of 17.81mm, the midvertebral body having a mean of 16.64mm, and the inferior vertebral body having a mean of 19.57mm. The anterior vertebral body height was observed to have a mean of 13.39mm, whereas the posterior vertebral body height has a mean of 12.27mm. The average left pedicle height was 8.65mm, while the average right pedicle height was 8.78mm. The average left pedicle width was 4.85mm, while the average right pedicle width was 5.33m. The left and right laminae length had means of 13.30mm and 14.17mm, the left and right laminae thickness had means of 3.51mm and 3.37mm, and the left and right laminae height were observed to have mean values of 11.09mm and 11.48mm, respectively.

Table 3: **Descriptive Statistics of Morphometric Parameters of C5 Vertebra.**

Parameter	Mean ± S.D (mm)	S.E.M	Variance	Min (mm)	Max (mm)
AVBH (mm)	13.39 ± 1.76	0.32	3.09	9.04	16.25
PVBH (mm)	12.27 ± 2.80	0.51	7.85	6.68	19.59
SVBW (mm)	17.81 ± 3.23	0.60	10.44	13.93	26.51
MVBW (mm)	16.64 ± 2.91	0.54	8.47	12.25	23.61
IVBW (mm)	19.57 ± 2.26	0.42	5.13	15.91	22.94
PH-L (mm)	8.65 ± 1.14	0.21	1.32	6.30	11.12
PH-R (mm)	8.78 ± 0.91	0.17	0.83	7.16	10.38
PW-L (mm)	4.85 ± 1.26	0.23	1.62	3.13	8.26
PW-R (mm)	5.33 ± 0.99	0.18	0.98	3.72	8.25
LH-L (mm)	11.09 ± 1.77	0.32	3.15	8.00	15.31
LH-R (mm)	11.48 ± 1.96	0.36	3.86	8.07	15.10
LL-L (mm)	13.30 ± 2.11	0.39	4.48	7.57	18.20
LL-R (mm)	14.17 ± 3.27	0.60	10.74	9.55	25.34
LT-L (mm)	3.51 ± 2.01	0.37	4.06	1.65	12.60
LT-R (mm)	3.37 ± 0.94	0.17	0.89	1.45	4.98

Table 4 displays the morphometric characteristics of the C6 vertebra, with the superior vertebral body having a mean of 19.61mm, the midvertebral body having a mean of 18.18mm, and the inferior vertebral body having a mean of 12.71mm. The anterior vertebral body height was observed to have a mean of 13.92mm to the posterior vertebral body height, which has a mean of 13.03mm. The average left pedicle height was 9.69mm, while the average right pedicle height was 9.74mm. The average left pedicle width was 5.71mm, while the average right pedicle width was 6.17mm. The left and right laminae length had a mean of 12.96mm and 13.26mm, and the left and right laminae thickness had means of 3.43mm and 3.56mm. The left and right laminae height were observed to have mean values of 12.59mm and 12.10mm.

Table 4: Descriptive Statistics of Morphometric Parameters of C6 Vertebra.

Parameter	Mean ± S.D (mm)	S.E.M	Variance	Min (mm)	Max (mm)
AVBH (mm)	13.92 ± 1.85	0.34	3.45	8.93	17.31
PVBH (mm)	13.03 ± 1.77	0.33	3.15	9.11	15.80
SVBW (mm)	19.61 ± 3.46	0.63	12.01	14.75	28.02
MVBW (mm)	18.18 ± 3.47	0.63	12.07	13.12	26.80
IVBW (mm)	21.71 ± 3.21	0.58	10.32	17.12	29.90
PH-L (mm)	9.69 ± 1.43	0.26	2.07	5.25	13.18
PH-R (mm)	9.74 ± 1.43	0.26	2.04	6.18	12.91
PW-L (mm)	5.71 ± 1.19	0.21	1.42	3.29	8.21
PW-R (mm)	6.17 ± 0.92	0.16	0.84	4.30	7.71
LH-L (mm)	12.59 ± 1.83	0.33	3.35	9.45	16.50
LH-R (mm)	12.10 ± 2.62	0.48	6.82	8.15	16.19
LL-L (mm)	12.96 ± 1.63	0.27	2.66	8.38	16.82
LL-R (mm)	13.26 ± 2.99	0.54	8.96	9.18	25.70
LT-L (mm)	3.43 ± 1.00	0.18	1.00	2.12	5.71
LT-R (mm)	3.56 ± 1.14	0.20	1.30	1.77	6.82

The superior vertebral body was observed to have a mean of 23.31mm while the mid vertebral body was seen and the inferior vertebral body had a mean of 21.66mm and 25.86mm, respectively. Table 5 displays the morphometric characteristics of the C7 vertebra. The left pedicle height was observed to have a mean of 11 point 29 mm, while the right pedicle height was observed to have a mean of 11.02 mm. The left pedicle width was observed to have a mean of 6.28mm, while the right pedicle width had a mean of 6.66mm. The left and right laminae were measured to have a mean height of 14.94mm and a mean thickness of 4.78mm, respectively. The left and right laminae were measured to have a mean length of 12.22mm and a mean thickness of 4.65mm.

Table 5: Descriptive Statistics of Morphometric Parameters of C7 Vertebra.

Parameter	Mean ± S.D (mm)	S.E.M	Variance	Min (mm)	Max (mm)
AVBH (mm)	14.76 ± 1.74	0.32	3.03	10.50	17.74
PVBH (mm)	14.05 ± 1.93	0.35	3.75	9.70	17.41
SVBW (mm)	23.31 ± 2.99	0.55	8.96	17.41	30.42

MVBW (mm)	21.66 ± 3.41	0.63	11.66	16.04	27.74
IVBW (mm)	25.86 ± 2.94	0.54	8.69	19.72	32.59
PH-L (mm)	11.29 ± 1.26	0.23	1.60	8.67	14.28
PH-R (mm)	11.02 ± 1.30	0.24	1.70	9.05	15.39
PW-L (mm)	6.28 ± 0.89	0.16	0.80	4.36	8.92
PW-R (mm)	6.66 ± 1.14	0.21	1.30	4.39	8.29
LH-L (mm)	14.94 ± 1.83	0.34	3.38	11.29	20.14
LH-R (mm)	14.30 ± 2.10	0.39	4.45	9.04	18.39
LL-L (mm)	12.22 ± 1.83	0.34	3.38	8.55	15.43
LL-R (mm)	12.65 ± 2.02	0.37	4.08	8.41	17.77
LT-L (mm)	4.78 ± 1.32	0.24	1.74	3.08	7.03
LT-R (mm)	4.63 ± 1.11	0.20	1.25	2.23	7.30

DISCUSSIONS

The cervical spine has distinct kinematic characteristics and is a complicated three-dimensional structure. When assessing clinical cases of cervical instability, which may call for surgical intervention, it is crucial to comprehend the normal biomechanical characteristics of the cervical spine.[17]

Spinal instabilities are commonly treated through a difficult surgical procedure called transpedicular screw fixation. In addition to being crucial for simultaneous posterior decompression and reconstruction in the cervical spine, this procedure was developed to treat the unstable cervical spine following traumatic lesions of the middle and lower cervical spine.[9,10] The risk of catastrophic damage to the nearby neurovascular structures makes this surgical procedure technically challenging.[11,12]

For Caucasian and Mongoloid populations, relevant anatomical studies on human cadavers have revealed details about the cervical spine and trans-pedicle anatomy, including landmarks for screw insertion and determination of screw size.[18–22] To produce data for a specific Negroid population, this study examined the morphometry of the cervical vertebrae (C3–C7) of Nigerian cadavers.

The average values for all morphometric parameters of the C3–C7 vertebral bodies in this study were as follows: AVBH: 13.88mm, PVBH: 12.83mm, SVBW: 18.75mm, MVBW: 17.74mm, IVBW: 20.84mm. The average pedicular measurements are as follows: PH-L: 9.23mm, PH-R: 9.29mm, PW-L: 5.57mm, and PW-R: 5.86mm. While the average lamina measurements were as follows: LH-L: 12.28mm; LH-R: 12.13mm; LL-L: 13.22mm; LL-R: 13.38mm; LT-L: 3.61mm; and LT-R: 3.71mm. Comparing the C7 vertebra's linear measurements to those of the other C3–C6 vertebra, the C7 vertebra's measurements were significantly higher. Results from studies related to this one conducted by Bazaldua-Cruz et al.[23] as well as Polat et al.[24] agreed with the findings of the current study. This is because the seventh cervical vertebra has different morphology in that it has relatively larger pedicles.[25]

According to the findings of this study, Bazaldua-Cruz et al. Prameela et al., and.[24] According to,[26] the C3, C4, and C5 vertebrae share some morphometric characteristics. The pedicle morphometric dimensions of this study were slightly larger than those of the studies mentioned above, but the vertebral body height values were slightly lower than those of the other studies. Laminar measurements of the C3, C4, and C5 vertebra in this study revealed that there were minor differences between them and those of studies conducted by Bazualdua-Cruz et al. Suleja et al. and.[23],[27] The best way to explain these differences is to say that they depend on a number of variables, including the race or ethnicity, gender, genetics, and occupational lifestyles of the different study populations. Prabhavathy and others.[28] stated that these factors have the potential to influence how the vertebral body develops, and as a result, how these human populations differ morphometrically.

Additionally, the size (length or diameter) of a screw is chosen during transpedicular fixation surgery using the morphometry of the cervical vertebrae pedicle. When performing cervical laminoplasty or laminectomy to remove tumor and for canal decompression for ossified posterior longitudinal ligament, the laminar dimension that contribute to cervical spine stability are crucial to be understood. [23,28] In this study, the left and right sides of the C3-C6 vertebra had mean laminar heights of about 11mm, respectively. The C3-C6 vertebra's left and right sides had respective mean laminar lengths of 13.47mm and 13.57mm. In Suleja and colleagues' studies.[27] as well as Polat et al.,[24] laminar morphometric dimensions of the C3–C6 vertebra were reported to vary by race. Suleja and colleagues,[27] reported that the right and left laminar heights were about 10mm and 10mm, respectively, and that the mean lengths of the right and left laminae were 14mm and 14mm, respectively. As opposed to this, Polat et al. According to.[24] their right and left laminar heights were 9 mm and 9 mm, respectively, while their right and left laminar lengths were about 13 mm, respectively.

Limitations

The ethical problems with vertebral bone extraction in Nigerian medical schools resulted in a small overall

sample size. Another is that there weren't many female cadavers available for the data collection.

CONCLUSION

We can state categorically that this study has provided an anatomical insight into the morphometry of the cervical (C3-C7) vertebra because it is arguably the best study to have been conducted in a Nigerian population. For neurosurgeons, radiologists, or clinicians, this knowledge of cervical vertebrae anthropometry will be essential information. It will also help surgeons perform cervical operations more successfully. Last but not least, the information gleaned from this study can be used as a benchmark for assessing pathologic changes and assessing the importance of anatomical structures in the cervical region in a Nigerian population, or more broadly, an African population.

Main points

There were no significant differences in the linear measurements of the vertebral body, pedicle and lamina of the cervical vertebra (C3-C5) in this study.

The vertebral body width values of C6 were higher compared to that of the C3, C4 and C5 vertebra.

All linear parameters of the vertebral body, pedicle and lamina of the seventh cervical (C7) vertebra were much higher than the other cervical vertebra.

Declaration of interests

All authors declare that there is no conflict of interest.

Author contributions

All the authors took part in the study conceptualization, design, actualization, analysis and write-up; they also read and agreed to the final manuscript.

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