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Cervical Vertebrae at the Galloway Osteological Collection: A Morhphometric Study

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ABSTRACT

Background: Morphometric characteristics of typical cervical vertebrae have been studied across different populations and racial differences have been documented. Morphometry of typical cervical vertebrae are useful reference data for spine surgeons and radiologists in the safe management of patients with cervical spine disorders. Objective: The objective of this study was to determine the morphometric characteristics of typical cervical vertebrae (C3-C6). **Methods:** This was a cross sectional study of 404 typical cervical vertebrae retrieved from the Galloway osteological collection atMakerere University. Linear dimensions were measured using digital Vernier calipers. Data was summarized using descriptive statistics. Inferential statistics were performed using the independent sample t-test to determine differences between males and females. The level of significance was set at 0.05. **Results:** There was progressive increase in the transverse diameter of the vertebral bodies fromC3-C6. The mean transverse diameter of C3 was (22.1±1.5mm), C4 (22.7±1.65mm), C5 (23.6 ±1.5mm) and, C6 (24.7±1.75mm). There was progressive increase in the length of the laminae from C3-C6. Conversely, the pedicle width progressively reduced from C3-C6. The other linear dimensions measured did not show any logical trend. The transverse diameters of the vertebral body, pedicle width, and lamina dimensions were significantly greater in males than in females (P= 0.028, P= 0.001and P= 0.001 respectively). **Conclusion:** There is progressive increase in the morphometric dimensions of most parameters of the vertebrae from C3 to C6. Conversely the pedicle width progressively reduces from C3-C6. There are significant differences between males and females.

Keywords: *Morphometry, Cervical vertebrae, Diameter*

INTRODUCTION

Morphometric studies of typical cervical vertebrae have been conducted in different populations worldwide, and the majority of these studies highlight their importance in the development of vertebral column instrumentation.[1-3] Instrumentation of the vertebral column is used for the treatment of cervical instability, as well as for the decompression of neural structures.[4-7] Cervical spine morphometry varies from one population to another, where these may have implications for the actions of spinal column. [2,7-9]

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Established normal morphometry of typical cervical vertebrae for a specific population helps to guide spine surgeons, to select appropriate screw size for cervical spine instrumentation.[10-12]

Cervical spine surgeries have been associated with complications such as injuries to vertebral arteries, neural tissues, the oesphagus, and the airway.[13-15] There are numerous causes of these injuries however iatrogenic injuries are not uncommon.[14] For this reason spine surgeons agree that sound knowledge of the vertebral column anatomy is required to prevent most of these injuries.[2]

Several studies have been conducted on the morphology and morphometry of vertebral column bones at the Galloway osteological collection and in the Ugandan population, but most of these previous studies were focused on the thoracic and lumbar vertebrae and none had been done on typical cervical vertebrae.[16-18] Therefore this study set out to describe the morphometric characteristics of typical cervical

vertebrae in the Galloway dry bone collection at Makerere University, Uganda.

MATERIALS ANDMETHODS

One hundred one complete sets of typical cervical vertebrae (C3- C6) were retrieved from the Galloway dry bone collection at the Department of Anatomy, Makerere University in Uganda.
The Galloway Osteological Collection was established at the Department of Human Anatomy by Sir Alexander Galloway the first dean of Faculty of Medicine at Makerere University in 1947. By the early 1980's the collection had accumulated more than 500 complete human skeletons however some of them have degenerated over time. Most were unclaimed bodies mainly from East Africa. Also available is the age, sex and cause of death. The process was performed with permission from the police for academic purposes and research.
There were 150 complete sets of cervical vertebrae but only 101 were undamaged and were hence selected for this study. In total there were 404 vertebrae of which 316 were male and 88 female. The bones were carefully examined for completeness to ensure that only undamaged cervical vertebrae were utilized for the study and only adult bones age above 18 years were included in the study. Using a digital vernier caliper (draper) with 0.01 mm precision (Draper Expert 52427, Draper tools, Amazon, UK, accurate to 0.01mm).
Linear measurement of the vertebral elements of each vertebra was done by two independent observers at two separate sittings and an average of the two measurements was calculated and taken as the reading of interest. All linear measurements were performed using a digital vernier caliper (draper) with 0.01 mm precision (Draper Expert 52427, Draper tools, Amazon, UK).

The following measurements were done:The antero-posterior diameter (APL) of the vertebra bodies whichwas measured as the distance from the posterior midline point between the right and left medial part of the uncinated processes to the anterior midline point between the right and left uncinated processes with reference to the junction of the laminae of spinal canal (figure 1 a).The anterior and posterior midline points of the vertebral body were marked with a pencil then a straight line was drawn to connect the two points followed by measuring the distance with a Vernier caliper.
The transverse diameter (TL) of the vertebral body was measured as the distance between the two lateral faces of the vertebral body at the medial portion of the vertebral body [Figure 1 b].
The vertebral body height (VBH) was measured as the distance between the superior and inferior borders of the vertebral body at the medial line running through the anterior face [Figure 1c].
The pedicle length (PL) was measured as the distance between the anterior limit of the superior articular facet and posterior limit of the vertebral body [Figure 2a].The Pedicle width (PW) was measured as the distance between superior and inferior border of pedicle [Figure 2b].
The lamina height (LH) was measured as the distance between the superior and inferior borders of the lamina [Figure 3a]. The lamina length (LL) was measured as the distance between the spinous process and lateral border of superior articular process [Figure 3b].
All data was entered directly into a standard computer spreadsheet and export to STATA version 12 for analysis. Data was summarized using descriptive statistics such as frequencies, mean and standard deviation. Inferential statistics were performed using the independent sample t-test to determine sex differences. The spearman's correlation was used to analyze the relationship between the right and the left pedicle and lamina. The level of significance was set at 0.05.
Permission to conduct the study was obtained from the Department of Anatomy- Makerere University. Ethical approval was obtained from Makerere University-School of Biomedical Sciences Higher degree Research and Ethics Committee (SBSHDREC).

RESULTS

The cervical vertebrae consisted of 79 male sets (316 vertebrae) and 22 female sets (88 vertebrae). Comparisons with reference to age could not be done because some skeletons had incomplete demographic data. The methods used to measure the dimensions of vertebrae in this study are similar to what has been used by several authors in different population groups.[2,19,20]
However the sample size in the previous studies were smaller than in the current study.
Vertebral body dimensions
The largest mean antero-posterior length (APL) was observed at C4 for both males and females; and the smallest was seen at C5 for males and at C3 for females. There was no significant difference in APL between males and females (p=0.062) (Table 1). The mean vertebral body transverse length (TL) was greatest at C6 in both males and females. The TL progressively increased from C3 to C6.There was significant difference in mean TL between males and

females (P= 0.028) (Table 1).The mean vertebral body height (VBH) progressively decreased from C3 to C5 and then increased at C6. The largest mean VBH was observed at C3 in both males and females, and the smallest height at C5 .There was no significant (P= 0.052) difference in mean vertebral height between males and female [Table 1].

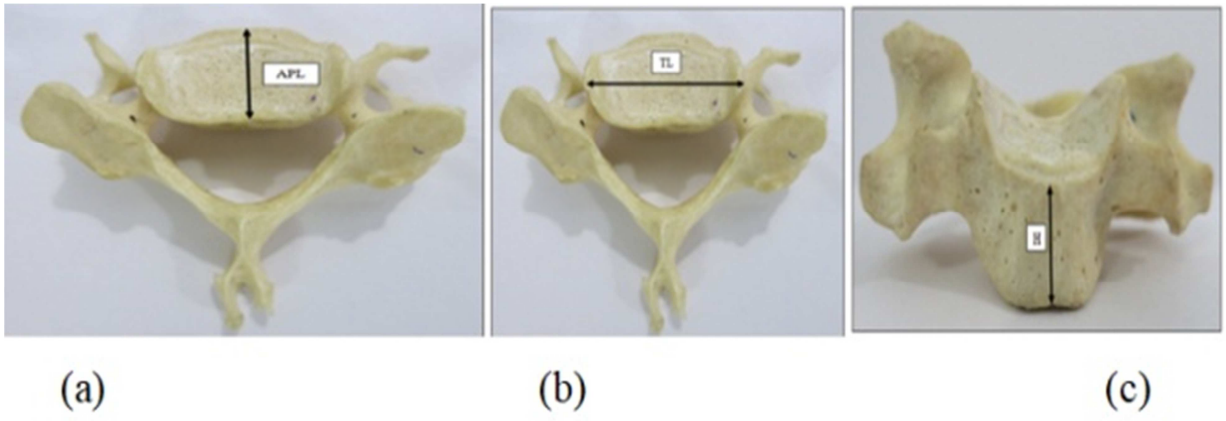

Figure 1: Reference points for measuring the Antero-Posterior diameter,Transverse diameter and Vertebral body height adapted from Mahto & Omar.[7]

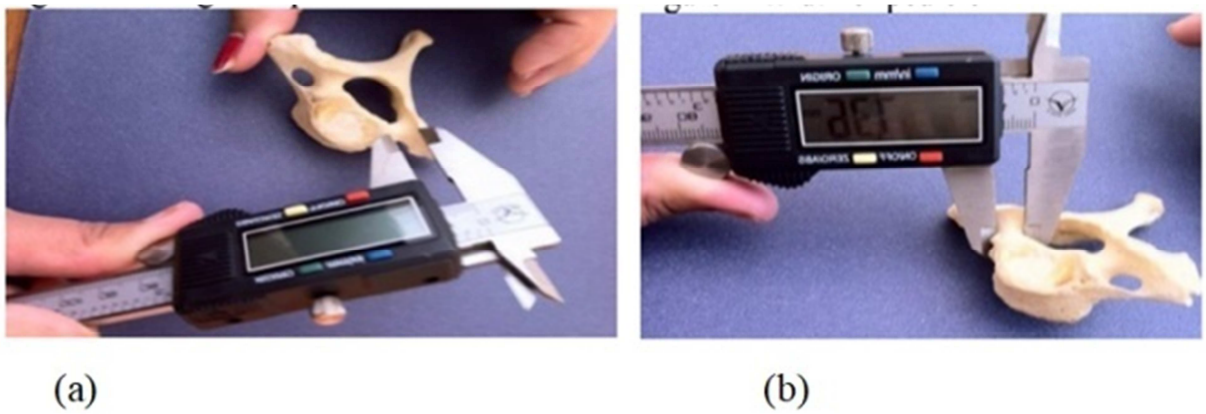

Figure 2: Reference ponts for measuring the length and width of the pedicle adapted from Parashar et al.[8]

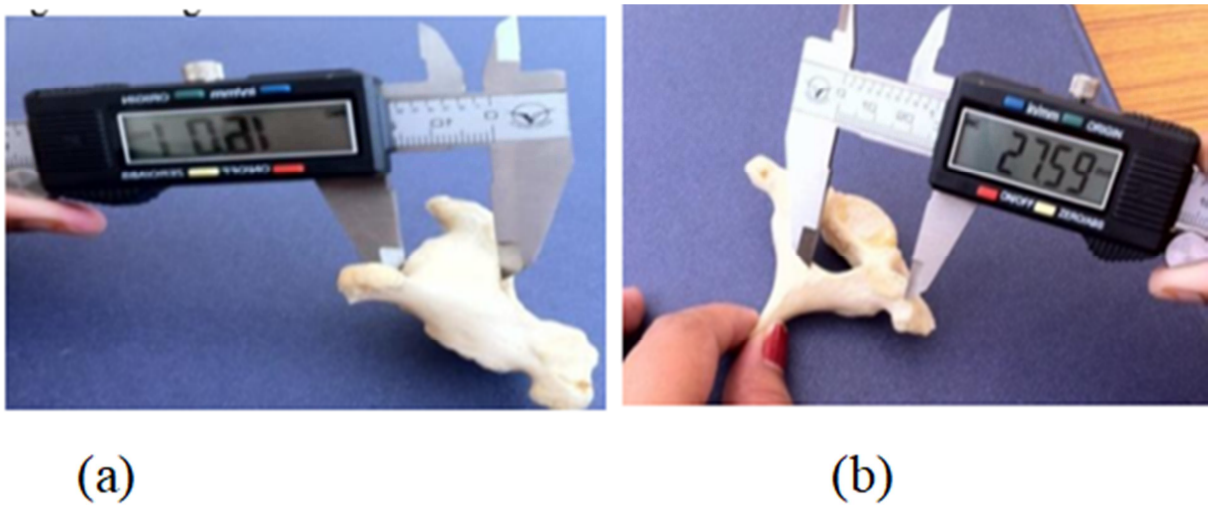

Figure 3: Reference points for measuring the height and length of the lamina adapted from Parashar et al.[8]

Pedicle dimensions

The mean pedicle length (PL) in the males decreased from C3 to C4 and then gradually increased from C5 to C6 bilaterally as summarized in Table 2.The greatest mean PL in the males was observed at C3 on the right and C6 on the left; while the smallest mean PL was at C4bilaterally [Table 2]. In the females, the mean PL decreased from C3 to C4 and then increased from C5 to C6. The greatest PL in the females was observed at C6 (right) and C3 (left); and the smallest at C4 bilaterally [Table 2]. There was no significant difference in PL between males and females (P=0.402).There was progressive decrease in mean pedicle width (PW) from C3 to C6 bilaterally in both sexes. There was significant (P = 0.001) difference between males and females [Table 2]. There was high correlation between the left and right pedicles (P = 0.001).

Table 1: Morphometric characteristics of vertebral bodies C3-C6.

Vertebra				Mean Transverse diameter (mm)			Mean Height (mm)		
	Male	Female	p-value	Male	Female	p-value	Male	Female	p-value
C3	15.4±1.4	14.9±1.4	0.181	22.3±1.4	21.9±1.6	0.355	12.2±3.2	11.3±1.6	0.236
C4	15.7±1.5	15.3±2.3	0.330	23.0±1.6	22.4±1.7	0.104	11.2±1.2	10.9±1.4	0.318
C5	15.2±1.4	14.9±2.2	0.448	23.8±1.5	23.4±1.5	0.295	10.7±1.2	10.5±1.1	0.398
C6	15.3±1.3	15.1±1.7	0.506	25.1±2.0	24.3±1.5	0.109	11.4±1.0	11.1±1.2	0.109
Overall	15.4±1.4	15.1±1.9	0.062	23.5±1.9	23.0±1.8	0.028	11.4±1.9	11.0±1.3	0.052

Table 2: Morphometric Characteristics of pedicles

Vertebrae (n= 101)		C3	C4	C5	C6	Overall
Right mean Pedicle Length(mm)	Male(n=79)	5.2±1.1	4.7±0.8	4.9±0.8	5.2±0.9	5.0±1.0
	Female(n=22)	5.2±0.9	4.9±0.8	5.1±0.7	5.3±0.8	5.1±.8
	p-value	0.967	0.530	0.209	0.504	0.242
Leftmean Pedicle Length (mm)	Male(n=79)	5.2±0.9	4.9±0.7	5.1±0.8	5.3±0.9	5.1±.8
	Female(n=22)	5.4±0.8	5.0±0.8	5.1±0.7	5.4±0.7	5.2±.8
	p-value	0.427	0.702	0.838	0.814	0.402
Right mean Pedicle Width (mm)	Male(n=79)	6.0±0.6	6.1±0.6	5.8±0.7	5.7±0.8	5.9±.7
	Female(n=22)	5.5±0.7	5.5±0.8	5.5±0.7	5.4±0.7	5.5±.7
	p-value	0.001	0.000	0.081	0.108	<0.000
Left mean Pedicle Width (mm)	Male(n=79)	6.1±0.6	6.1±0.7	5.8±0.7	5.8±0.8	5.9±.04
	Female(n=22)	5.6±0.8	5.6±0.6	5.5±0.8	5.5±0.6	5.5±.07
	p-value	0.003	0.001	0.040	0.162	<0.000

Lamina dimensions

The mean lamina length (LL) progressively increased from C3 to C6 bilaterally in the males as shown in Table 3.In females the rights mean LL progressively increased from C3 to C6, conversely mean left LL in females was largest at C3 and smallest at C4. The difference in LL between males and females was significant on the right (p <0.001) and non-significant on the left (p=0.399). The mean lamina height (LH) progressively increased from C3 to C6 bilaterally in both males and females. There was significant difference in left LH between males and female (P= 0.022), but there was no significant sex difference in the right LH [Table 3]. There was significant similarities between the right and left lamina (r= 0.86, P= 0.001).

DISCUSSION

In this study we measured the linear dimensions of dry typical cervical vertebrae at the Galloway osteological collection at Makerere University in Uganda. The transverse diameter of vertebral bodies, and lamina length were found to be larger at C6 and smallest at C3.

Conversely the pedicle width progressively reduced from C3 to C6. The other linear dimensions did not show any logical trend. Most of the linear dimensions of the vertebral elements were significantly larger in males than females. The procedures used for linear dimensions in this study have been used by other investigators therefore we feel that our results are comparable with what has been reported in literature.

In this study the mean APL of the vertebral body was slightly larger than what was reported in an Indian population, and was shorter than what was reported in Mexicans.[2,19,20] The mean transverse diameter (TD) was larger than what was reported by some authors.[2,19,20] The mean vertebral body height (VBH) was larger in comparison to what was reported in Chinese Singaporeans population,[10-12] and was slightly less than what was reported in Indians.[2,19,20] Such variations emphasize the need to take into account the racial differences during surgical procedures. In the current study the mean VBH and TL were significantly larger in males than in females. These sex difference findings are similar with what was reported in Caucasians and Indians.[19,21] Knowing the mean APL of a population can serve as a rough guide for spine surgeons and procurement officers with regard to locally specifications for anterior cervical instrumentation.

Table 3: Morphometric characteristics of lamina

Vertebrae (n= 101)	Variables	C3	C4	C5	C6	Overall
Right mean Lamina Length (mm)	Male(n=79)	23.3±1.4	24.20±1.5	25.1±1.5	25.7±1.7	24.6±1.8
	Female(n=22)	22.6±1.5	23.50±1.4	24.1±1.5	24.7±1.8	23.7±1.7
	p-value	0.045	0.051	0.006	0.017	0.000
Left mean Lamina Length (mm)	Male(n=79)	23.4±1.4	24.29±1.4	25.1±1.6	25.7±1.6	24.6±1.7
	Female(n=22)	25.7±1.5	22.99±1.5	23.7±1.8	24.5±2.1	24.2±8.0
	p-value	0.204	0.000	0.000	0.005	0.399
Right mean Lamina Height (mm)	Male(n=79)	10.0±1.2	9.91±1.2	10.5±1.1	11.4±1.3	10.4±1.3
	Female(n=22)	9.4±1.5	9.44±1.5	10.3±1.9	11.4±1.9	10.1±1.9
	p-value	0.070	0.121	0.516	0.958	0.104
Left mean Lamina Height (mm)	Male(n=79)	9.8±1.1	9.73±1.2	10.3±1.1	11.4±1.3	10.3±1.3
	Female(n=22)	9.2±1.3	9.37±1.6	9.9±1.7	11.2±1.8	9.9±1.8
	p-value	0.023	0.234	0.181	0.535	0.022

During anterior cervical reconstructions, surgeons require the APL and TL of the vertebral bodies to perform corpectomies and fix bi-cortical screws.[22] The APL guides surgeon on the approximate distance between the anterior and posterior longitudinal ligaments. It also can give a rough estimation of the antero-posterior thickness of the strut graft. The TL can give guidance on how far lateral the surgeon should venture without injuring the vertebral arteries. The anterior cervical approach is used for vertebrae from C3 to T1.[6,23]The anterior approach for decompression of the cervical spinal cord and nerve roots is widely used for spondylotic, neoplastic, infective or post-traumatic conditions and procedures range from corpoctemy, hemicorpectomy and fusion and depending on the indication.[22,24] Anterior plate fixation has been advocated to ensure immediate stabilization, improve the union rate and decrease the need for external immobilization.[14,25] The anterior approach to the cervical spinehas been associated with complications which include vertebral artery injuries, neural tissue injury, esophageal injury and, airway structural injury.[14,15,26,27] For this reason spine surgeons agree that sound knowledge of the vertebral column anatomy is required to prevent most of these injuries.[2]

In this study the pedicle width progressively decreased from C3 to C6. Conversely the pedicle length (PL) decreased from C3 to C4 and then increased from C3 to C6. The length and width of the pedicles are very important parameters for the selection of screw sizes for placement during transpedicular fixation surgery. The mean PL was shorter in this study than what was reported in Rajasthan, India,[28] but it was slightly larger than what was reported in the Mexican population.[2] The PW in this study was larger than what was reported in Mexican and Indian population respectively. The mean pedicle width was significantly larger in males than in females (P= 0.001). The sex difference in this study corroborates with the findings of Zhuang et al in a Chinese population.[29]

The dimensions of pedicles are very useful for trans-pedicular fixation procedures of the thoracic and lumbar spine.[30-32] Some surgeons have even ventured in pedicle screw fixation of C3-C6 but this has been associated with considerable neurological and vascular complication rates owing of the small dimensions of these typical cervical vertebrae, especially if done without intra-operative imaging.[13,33,34] Most surgeons instead prefer using lateral mass screws for C3-C6 because of the relatively strong and stable fixation and lower complication rates. In the Spine Unit at our national referral hospital, surgeons prefer using lateral mass screw fixation because all surgery is performed using a free technique without imaging guidance.

In this study the mean lamina length was larger than what was reported in a Mexican population,[2] and was larger than what was observed in the Rajasthan population in India.[8] The mean lamina height in this study was less than what was reported in the Mexican and Indian population.[2]

In the current study, laminar dimensions were larger in the males than females and this finding is not different from studies from other racial groups.[35] The mean lamina length in our is larger than what was reported in

the Mexican and Indian populations.[2,8] Variations in the lamina dimensions among different ethnic and sex groups may be related to genetic, racial, postural and, occupational factors.[7] Knowledge of the average dimensions of the laminae in a given population may guide surgeons on the most appropriate surgical procedures to perform depending on the indication. The length and height of the lamina are useful in guiding spine surgeons during laminoplasty procedures for multiple level cervical spine canal stenosis. Another technique that has been used in the treatment of cervical spine instability is trans-laminar screw fixation. Translaminar screw placement is simple and, is not limited by the position of the vertebral artery in the transverse foramen, and thereby, may be applicable to a wider number of patients. Despite its wide use,[35] some authors have recommended caution in its use in certain racial groups. In a CT scan study to measure the dimensions of cervical laminae in an Asian population, the authors advised caution in using trans-laminar screw fixation because of the small laminar dimensions.[36] Pre-operative CT scans are recommended to determine the dimensions of the laminae as a guide to appropriate screw sizes. This surgical technique is used for the treatment of the cervical spondylotic myelopathy.[8]

CONCLUSION

Overall there is an increase in the linear dimensions of the typical cervical vertebra from C3-C6. The length of the lamina and the transverse diameter of vertebral body increase as they descend the cervical column from C3 to C6. Conversely pedicle width decreases progressively from C3 to C6.Most of the linear dimensions of vertebral elements of typical cervical vertebrae in this study are significantly larger in males than in females. These findings provide reference data for our local setting that may be of value in pre-operative planning for the safe management of patients with cervical spinal disorders. There is need to conduct CT scan studies to compare different methods of studying the vertebral morphometry.

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REFERENCES

1. Gupta R, Kapoor K, Sharma A, Kochhar S, Garg R. Morphometry of typical cervical vertebrae on dry bones and CT scan and its implications in transpedicular screw placement surgery. Surgical and Radiologic Anatomy. 2013;35(3):181-9.
2. Bazaldua C, Gonzalez L, Gomez S, Villarreal S, Velazquez G, Sanchez U. Morphometric study of cervical vertebrae C3-C7 in a population from northeastern Mexico. Int J Morphol. 2011;29(2):325-30.
3. Banerjee PS, Roychoudhury A, Karmakar SK. Morphometric analysis of the cervical spine of Indian population by using computerized tomography. Journal of Medical & Allied Sciences. 2012;2(2):66.
4. Hong JT, Sung JH, Son BC, Lee SW, Park CK. Significance of laminar screw fixation in the subaxial cervical spine. Spine. 2008;33(16):1739-43.
5. Jones EL, Heller JG, Silcox DH, Hutton WC. Cervical pedicle screws versus lateral mass screws: anatomic feasibility and biomechanical comparison. Spine. 1997;22(9):977-82.
6. Kwon BK, Song F, Morrison WB, Grauer JN, Beiner JM, Vaccaro AR, et al. Morphologic evaluation of cervical spine anatomy with computed tomography: anterior cervical plate fixation considerations. Clinical Spine Surgery. 2004;17(2):102-7.
7. Mahto AK, Omar S. Clinico-anatomical approach for instrumentation of the cervical spine: a morphometric study on typical cervical vertebrae. Int J Sci Stud. 2015;3:143-5.
8. Parashar R, Saxena D, Chauhan S, Arora R, Joshi A. A Morphometric study of pedicle, lamina& Spinous process of C3-C7 Vertebrae in Rajasthan Population. Int J Res Med. 2014;3(4):140-5.
9. Ogeng'o J. Editorial: Clinical Significance of Anatomical Variations. Anatomy Journal of Africa. 2013;2(1):57-60.
10. Tossel G. Dimensions of the cervical spinal canal in the South African Negroid population: University of Pretoria; 2007.
11. Tan S, Teo E, Chua H. Quantitative three-dimensional anatomy of cervical, thoracic and lumbar vertebrae of Chinese Singaporeans. European Spine Journal. 2004;13(2):137-46.
12. Roopnarian A. Ethnic variations of selected cervical spine radiographic parameters of males in KwaZulu-Natal 2011.
13. Abumi K, Shono Y, Ito M, Taneichi H, Kotani Y, Kaneda K. Complications of pedicle screw fixation in reconstructive surgery of the cervical spine. Spine. 2000;25(8):962-9.
14. Mwaka E, Nyati M, Orwotho N, Mugarura R. Oesophageal perforation in anterior cervical spine plating: A Case report. East and Central African Journal of Surgery. 2011;16(3).
15. Neo M, Fujibayashi S, Miyata M, Takemoto M, Nakamura T. Vertebral artery injury during cervical spine surgery: a survey of more than 5600 operations. Spine. 2008;33(7):779-85.
16. Luboga S. Supernumerary lumbar vertebrae in human skeletons at the Galloway Osteological Collection of Makerere University, Kampala. East African medical journal. 2000;77(1):16-9.
17. Manyama M. Diameters of the lumbar vertebral canal in adult skeletons at the Galloway osteological collection museum of Makerere university. 2005.
18. Bukenya M. The vertebral column in humans and selected non-human primates and the functional structure of its transitional elements: University of Cape Town; 2000.
19. Saluja S, Patil S, Vasudeva N. Morphometric Analysis of Sub-axial Cervical Vertebrae and Its Surgical Implications. Journal of clinical and diagnostic research: JCDR. 2015;9(11):AC01.
20. Singh S, Balakrishnan M. Morphometric study of cervical spine vertebrae in eastern region Nepalese population. Health Renaissance. 2014;11(3):224-8.
21. Rozendaal AS. Estimating sex from the seven cervical vertebrae: an analysis of White European skeletal populations. 2016.
22. Abuzayed B, Tutunculer B, Kucukyuruk B, Tuzgen S. Anatomic basis of anterior and posterior instrumentation of the spine:

morphometric study. Surgical and radiologic anatomy. 2010;32(1):75-85.
23. Southwick WO, Robinson RA. Surgical approaches to the vertebral bodies in the cervical and lumbar regions. JBJS. 1957;39(3):631-44.
24. Mobbs RJ, Rao P, Chandran NK. Anterior cervical discectomy and fusion: analysis of surgical outcome with and without plating. Journal of clinical neuroscience. 2007;14(7):639-42.
25. Caspar W, Pitzen T, Papavero L, Geisler FH, Johnson TA. Anterior cervical plating for the treatment of neoplasms in the cervical vertebrae. Journal of Neurosurgery: Spine. 1999;90(1):27-34.
26. Beutler WJ, Sweeney CA, Connolly PJ. Recurrent laryngeal nerve injury with anterior cervical spine surgery: risk with laterality of surgical approach. Spine. 2001;26(12):1337-42.
27. Smith M, Emery S, Dudley A, Murray K, Leventhal M. Vertebral artery injury during anterior decompression of the cervical spine. A retrospective review of ten patients. Bone & Joint Journal. 1993;75(3):410-5.
28. Parashar R, Saxena D, Chauhan S, Arora R, Joshi A. Morphometric study of pedicle, lamina and spinous process of C3-C7 vertebrae in Rajasthan population. Int J Res Med. 2014;3:140-5.
29. Zhuang Z, Chen Y, Han H, Cai S, Wang X, Qi W, et al. Thoracic pedicle morphometry in different body height population: a three-dimensional study using reformatted computed tomography. Spine. 2011;36(24):E1547-E54.
30. y Fluoroscopía PMMT. Morphometry of pedicle and vertebral body in a Mexican population by CT and Fluroscopy. Int j morphol. 2009;27(4):1299-303.
31. Yukawa Y, Kato F, Ito K, Horie Y, Hida T, Nakashima H, et al. Placement and complications of cervical pedicle screws in 144 cervical trauma patients using pedicle axis view techniques by fluoroscope. European spine journal. 2009;18(9):1293-9.
32. Abumi K, Itoh H, Taneichi H, Kaneda K. Transpedicular screw fixation for traumatic lesions of the middle and lower cervical spine: description of the techniques and preliminary report. Clinical Spine Surgery. 1994;7(1):19-28.
33. Roy-Camille R, Mazel C, Saillant G, Benazet J. Rationale and techniques of internal fixation in trauma of the cervical spine. Spinal Trauma Philadelphia: JB Lippincott. 1991:163-91.
34. Ludwig SC, Kramer DL, Balderston RA, Vaccaro AR, Foley KF, Albert TJ. Placement of pedicle screws in the human cadaveric cervical spine: comparative accuracy of three techniques. Spine. 2000;25(13):1655-67.
35. Ji GY, Oh CH, Park SH, Kurniawan F, Lee J, Jeon JK, et al. Feasibility of translaminar screw placement in Korean population: morphometric analysis of cervical spine. Yonsei medical journal. 2015;56(1):159-66.
36. Yusof MI, Shamsi SSM. Translaminar screw fixation of the cervical spine in Asian population: feasibility and safety consideration based on computerized tomographic measurements. Surgical and radiologic anatomy. 2012;34(3):203-7.

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