

Morphometry of Typical Cervical Vertebrae on Magnetic Resonance Imaging in Adult Bangladeshi People: A Cross-sectional Analytical Study

Maria Khan^{1*}, Mousomi Tahmina², Kaniz Fatima³, Nazia Binte Islam⁴, Isot Jahan⁵, Nafrina Islam Leeza⁶

¹Lecturer (Anatomy), Ibrahim Medical College, Segunbagicha, Dhaka, Bangladesh

²Assistant Professor (Anatomy), Green Life Medical College, Dhaka, Bangladesh

³Assistant Professor (CC) of Anatomy, Kumuduni Women's Medical College, Mirzapur, Tangail, Bangladesh

⁴Assistant Professor, Asgar Ali Medical College & Hospital, Gendaria, Dhaka, Bangladesh

⁵Lecturer of Anatomy, Green Life Medical College, Dhaka, Bangladesh

⁶Lecturer, Green Life Medical College, Dhaka, Bangladesh

DOI: <https://doi.org/10.36348/sijap.2024.v07i08.002>

Received: 07.09.2024 | Accepted: 15.10.2024 | Published: 21.10.2024

*Corresponding author: Maria Khan

Lecturer (Anatomy), Ibrahim Medical College, Segunbagicha, Dhaka, Bangladesh

Abstract

Background: Accurate knowledge of cervical vertebral morphometry is crucial for diagnosing pathological conditions and planning surgical interventions. However, data specific to the Bangladeshi population is lacking. **Objectives:** To determine the morphometric measurements of typical cervical vertebrae (C3-C6) on Magnetic Resonance Imaging (MRI) in adult Bangladeshi people and to analyze potential sex-based differences. **Methods:** This cross-sectional analytical study was conducted on 70 MRI scans (35 male, 35 female) of typical cervical vertebrae from adult Bangladeshi individuals. Various morphometric parameters were measured using 'Radiant DICOM Viewer' software. Statistical analysis was performed using SPSS version 22.0. **Results:** The sagittal diameter of the vertebral body was significantly larger in males compared to females for all measured vertebrae ($p < 0.001$). No significant differences were found between sexes in the height and transverse length of the vertebral body, anteroposterior and transverse lengths of the vertebral foramen, dimensions of foramen transversarium, superior articular facets, lamina, pedicle, and spinous process length ($p > 0.05$ for all). **Conclusion:** This study provides baseline morphometric data for typical cervical vertebrae in adult Bangladeshi individuals. The observed sexual dimorphism in sagittal vertebral body diameter and the lack of significant differences in other parameters contribute to our understanding of population-specific cervical spine anatomy. These findings may have implications for optimizing surgical techniques and implant designs for the Bangladeshi population.

Keywords: Cervical vertebrae, Morphometry, Magnetic Resonance Imaging, Bangladesh, Sexual dimorphism.

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INTRODUCTION

The cervical spine plays a critical role in supporting and mobilizing the head while protecting the spinal cord. Accurate knowledge of cervical vertebral anatomy and morphometry is essential for diagnosing pathological conditions and planning surgical interventions in this region [1]. While several studies have examined cervical vertebral morphometry in different populations, data specific to the Bangladeshi population is lacking [2,3].

Magnetic resonance imaging (MRI) has become the modality of choice for detailed evaluation of

the cervical spine due to its superior soft tissue contrast and multiplanar imaging capabilities [4]. MRI-based morphometric analysis can provide valuable data on vertebral dimensions that is relevant for spinal instrumentation and surgical approaches [5].

The typical cervical vertebrae (C3-C6) share common morphological features and are frequently involved in degenerative and traumatic conditions requiring surgical management [6]. Understanding the normal morphometric variations of these vertebrae in the local population is crucial for optimizing surgical outcomes.

This study aims to establish baseline morphometric data for typical cervical vertebrae in adult Bangladeshi individuals using MRI. The findings will contribute to the understanding of population-specific vertebral anatomy and may have implications for the design of implants and surgical techniques tailored to this population.

OBJECTIVES

1. To measure the sagittal diameter, height, and transverse length of the vertebral body of typical cervical vertebrae (C3-C6) on MRI in adult Bangladeshi people.
2. To determine the anteroposterior length and transverse length of the vertebral foramen of C3-C6 vertebrae.
3. To measure the height and width of the foramen transversarium, length and width of the superior articular facets, width and transverse length of the lamina, and length and width of the pedicle bilaterally for C3-C6 vertebrae.
4. To measure the length of the spinous process of C3-C6 vertebrae.
5. To compare the morphometric measurements between male and female subjects.

MATERIALS AND METHODS

Study Design and Setting: This cross-sectional analytical study was conducted in the Department of Anatomy at Dhaka Medical College, Dhaka, from January to December 2020. MRI scans were collected from the Radiology and Imaging Department of the National Institute of Neurosciences and Hospital, Dhaka.

Study Population and Sample Size: A total of 70 MRI scans of cervical spines (35 male, 35 female) from adult Bangladeshi individuals were included in the study. The sample size was determined based on feasibility and resource constraints.

Inclusion Criteria:

- Age range: 18-60 years
- No history of cervical spine trauma or surgery
- No evidence of congenital anomalies or pathological conditions affecting cervical vertebrae

Exclusion Criteria:

- Presence of cervical spine fractures, tumors, or infections
- History of cervical spine surgery
- Congenital anomalies of the cervical spine
- Poor quality MRI scans

Ethical Considerations: The study protocol was approved by the Institutional Ethics Committee. Informed consent was obtained from all participants before including their MRI scans in the study.

MRI Protocol: All MRI scans were performed using a 1.5 Tesla MRI scanner (Siemens Magnetom Avanto, Erlangen, Germany). T1-weighted and T2-weighted sequences in sagittal and axial planes were obtained using standardized protocols for cervical spine imaging [7].

Morphometric Measurements: The following measurements were taken for each typical cervical vertebra (C3-C6) using the image measuring software 'Radiant DICOM Viewer':

1. Vertebral body: sagittal diameter, height, and transverse length
2. Vertebral foramen: anteroposterior length and transverse length
3. Foramen transversarium: height and width (bilateral)
4. Superior articular facets: length and width (bilateral)
5. Lamina: width and transverse length (bilateral)
6. Pedicle: length and width (bilateral)
7. Spinous process: length

All measurements were performed by two trained observers independently to ensure reliability. In case of discrepancies, a consensus was reached through discussion with a senior radiologist.

Statistical Analysis: Data were analyzed using Statistical Package for Social Sciences (SPSS) version 22.0. Descriptive statistics including mean, standard deviation, and range were calculated for all measurements. Comparison of measurements between males and females was performed using unpaired Student's t-test. A p-value < 0.05 was considered statistically significant.

Intra-observer and inter-observer reliability were assessed using intraclass correlation coefficients (ICC) for a subset of measurements [8].

Limitations: The study was conducted in a single center, which may limit the generalizability of the findings to the entire Bangladeshi population. Additionally, the exclusion of subjects with cervical spine pathologies was based on verbal inquiry and visual assessment of MRI scans, which may have missed some subtle abnormalities.

RESULTS

The study included 70 MRI scans of typical cervical vertebrae (C3-C6) from 35 male and 35 female adult Bangladeshi individuals. The morphometric measurements for various parameters are presented below:

1. Sagittal diameter of the vertebral body:

The mean sagittal diameter was significantly larger in males compared to females for all measured vertebrae ($p < 0.001$).

Table I: Sagittal diameter of the vertebral body (in mm)

Vertebra	Male (Mean ± SD)	Female (Mean ± SD)	p-value
C3	17.31 ± 1.51	14.62 ± 0.56	<0.001
C4	16.81 ± 1.52	14.02 ± 1.14	<0.001
C5	16.04 ± 1.71	13.95 ± 1.21	<0.001
C6	17.29 ± 1.81	13.94 ± 1.08	<0.001

2. Height of the vertebral body:

No significant differences were found between males and females in the mean height of the vertebral body.

Table II: Height of the vertebral body (in mm)

Vertebra	Male (Mean ± SD)	Female (Mean ± SD)	p-value
C3	11.11 ± 0.34	10.96 ± 0.81	0.310
C4	11.35 ± 0.29	11.48 ± 0.82	0.367
C5	11.63 ± 0.54	11.34 ± 0.69	0.052
C6	11.26 ± 0.41	11.09 ± 0.63	0.164

3. Transverse length of the vertebral body:

No significant differences were observed between males and females in the mean transverse length of the vertebral body.

Table III: Transverse length of the vertebral body (in mm)

Vertebra	Male (Mean ± SD)	Female (Mean ± SD)	p-value
C3	22.78 ± 0.53	22.71 ± 0.31	0.406
C4	23.32 ± 0.36	23.41 ± 0.16	0.144
C5	26.21 ± 0.35	26.29 ± 0.26	0.273
C6	25.20 ± 0.57	25.10 ± 0.32	0.341

4. Anteroposterior length of the vertebral foramen:

No significant differences were found between males and females in the mean anteroposterior length of the vertebral foramen.

Table IV: Anteroposterior length of the vertebral foramen (in mm)

Vertebra	Male (Mean ± SD)	Female (Mean ± SD)	p-value
C3	12.58 ± 0.84	12.28 ± 0.61	0.094
C4	12.07 ± 1.14	11.60 ± 1.11	0.083
C5	12.48 ± 1.17	12.12 ± 0.95	0.163
C6	11.97 ± 1.09	11.92 ± 0.85	0.849

5. Transverse length of the vertebral foramen:

No significant differences were observed between males and females in the mean transverse length of the vertebral foramen.

Table V: Transverse length of the vertebral foramen (in mm)

Vertebra	Male (Mean ± SD)	Female (Mean ± SD)	p-value
C3	21.34 ± 0.73	21.63 ± 0.79	0.110
C4	21.73 ± 1.12	21.49 ± 0.97	0.352
C5	21.67 ± 0.88	21.44 ± 0.79	0.270
C6	21.29 ± 1.04	21.35 ± 0.91	0.801

Additional measurements for foramen transversarium, superior articular facets, lamina, pedicle, and spinous process length showed no significant differences between males and females.

compared to females. Other measured parameters did not show statistically significant differences between the sexes.

In summary, the study revealed significant sexual dimorphism in the sagittal diameter of the vertebral body, with males having larger dimensions

These findings provide baseline morphometric data for typical cervical vertebrae in the adult Bangladeshi population, which may have implications

for cervical spine surgery and implant design in this population.

DISCUSSION

This study provides comprehensive morphometric data on typical cervical vertebrae (C3-C6) in adult Bangladeshi individuals using MRI. The findings reveal important insights into the anatomical characteristics of the cervical spine in this population, with potential implications for clinical practice and surgical planning.

Sagittal Diameter of the Vertebral Body: Our study found significant sexual dimorphism in the sagittal diameter of the vertebral body, with males consistently showing larger dimensions than females across all measured vertebrae (C3-C6). This finding is consistent with previous studies in other populations, such as the work by Kar *et al.*, (2017) on an Indian population, which also reported significantly larger sagittal diameters in males [1]. The sexual dimorphism observed in our study may be attributed to general differences in body size and bone mass between males and females [2].

The mean sagittal diameters in our study (ranging from 16.04 to 17.31 mm in males and 13.94 to 14.62 mm in females) are comparable to those reported by Bazaldua *et al.*, (2011) in a northeastern Mexican population [3]. However, our values are slightly lower than those reported by Kathole *et al.*, (2012) in a Western Indian population [4]. These differences highlight the importance of population-specific data in understanding cervical spine morphometry.

Height and Transverse Length of the Vertebral Body: Interestingly, our study did not find significant differences between males and females in the height and transverse length of the vertebral body. This is in contrast to some previous studies, such as Prabavathy *et al.*, (2017), which reported sexual dimorphism in these parameters in an Indian population [5]. The lack of significant differences in our study may be due to population-specific characteristics or could be related to our sample size.

Vertebral Foramen Dimensions: The anteroposterior and transverse lengths of the vertebral foramen showed no significant differences between males and females in our study. This is consistent with findings by Prameela *et al.*, (2019) in a South Indian population [6]. The dimensions of the vertebral foramen are clinically important, as they relate to the available space for the spinal cord and can influence the risk of cervical myelopathy [7].

Foramen Transversarium and Articular Facets: Our measurements of the foramen transversarium and superior articular facets did not reveal significant sexual dimorphism. This is in line with findings by Polat *et al.*,

(2019) in a Turkish population [8]. However, it's worth noting that even small variations in these structures can have clinical significance, particularly in the context of vertebral artery injuries during cervical spine surgery [9].

Lamina and Pedicle Dimensions: The lack of significant differences in lamina and pedicle dimensions between males and females in our study is consistent with some previous reports [10]. However, it contrasts with others that have found sexual dimorphism in these parameters [11]. These structures are critical for surgical procedures, particularly for screw placement in cervical spine fixation [12].

Spinous Process Length: Our findings on spinous process length showed no significant sexual dimorphism, which is consistent with some previous studies [13]. However, the spinous process serves as an important attachment site for muscles and ligaments, and its dimensions can influence surgical approaches to the posterior cervical spine [14].

Clinical Implications: The morphometric data obtained in this study have several clinical implications. The sexual dimorphism observed in the sagittal diameter of the vertebral body suggests that gender-specific considerations may be necessary when designing cervical spine implants for the Bangladeshi population. The lack of significant differences in other parameters indicates that a more generalized approach may be suitable for other aspects of cervical spine instrumentation.

Furthermore, the data on vertebral foramen dimensions can aid in the assessment of cervical spinal stenosis, while the measurements of pedicle and lamina can guide the selection of appropriate screw sizes and trajectories in cervical spine fixation procedures [15].

Limitations and Future Directions: While this study provides valuable data, it has some limitations. The sample size, while adequate for preliminary analysis, could be expanded in future studies to increase statistical power. Additionally, the study was conducted at a single center, which may limit its generalizability to the entire Bangladeshi population.

Future research could explore age-related changes in cervical vertebrae morphometry, as well as investigate potential correlations between vertebral dimensions and other anthropometric measurements. Moreover, comparative studies with other South Asian populations could provide insights into regional variations in cervical spine anatomy.

In conclusion, this study provides the first comprehensive morphometric analysis of typical cervical vertebrae in the adult Bangladeshi population using MRI. The findings contribute to the understanding

of population-specific vertebral anatomy and may inform the development of tailored approaches to cervical spine surgery and implant design for this population.

CONCLUSION

This cross-sectional analytical study provides valuable morphometric data on typical cervical vertebrae (C3-C6) in adult Bangladeshi individuals using MRI. The key findings and conclusions of this study are:

1. **Sexual Dimorphism:** A significant difference was observed in the sagittal diameter of the vertebral body between males and females, with males consistently showing larger dimensions across all measured vertebrae (C3-C6). This finding highlights the importance of considering gender-specific factors in cervical spine interventions and implant design for the Bangladeshi population.
2. **Other Morphometric Parameters:** Interestingly, no significant differences were found between males and females in other measured parameters, including the height and transverse length of the vertebral body, dimensions of the vertebral foramen, foramen transversarium, superior articular facets, lamina, pedicle, and spinous process length. This suggests that a more generalized approach may be suitable for these aspects of cervical spine assessment and instrumentation.
3. **Population-Specific Data:** The morphometric measurements obtained in this study provide a baseline reference for the adult Bangladeshi population. These data contribute to the understanding of population-specific variations in cervical vertebrae anatomy, which is crucial for optimizing diagnostic and therapeutic approaches in spine care.
4. **Clinical Implications:** The detailed morphometric data presented in this study have important implications for various clinical applications, including:
 - Improved accuracy in the diagnosis of cervical spine pathologies
 - Enhanced planning and execution of cervical spine surgeries
 - Optimization of implant design and selection for the Bangladeshi population
 - Refinement of techniques for pedicle screw placement and other cervical spine instrumentation procedures
5. **Research Contribution:** This study addresses a significant gap in the literature by providing the first comprehensive morphometric analysis of typical cervical vertebrae in the Bangladeshi population using MRI. It sets a foundation for future research in this area and enables comparisons with other populations.

6. **Limitations and Future Directions:** While this study provides valuable insights, it also acknowledges limitations such as the single-center design and sample size. Future studies should aim to expand on these findings by:
 - Including larger, multi-center samples to enhance generalizability
 - Investigating age-related changes in cervical vertebrae morphometry
 - Exploring correlations between vertebral dimensions and other anthropometric measurements
 - Conducting comparative studies with other South Asian populations to identify regional variations

In conclusion, this study offers important morphometric data on typical cervical vertebrae in adult Bangladeshi individuals, revealing both similarities and differences compared to other populations. These findings have significant implications for clinical practice, surgical planning, and implant design in the context of cervical spine care for the Bangladeshi population. The data presented here serve as a valuable reference for clinicians, researchers, and biomedical engineers working in the field of spine care and should inform future research and clinical practice in Bangladesh and beyond.

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