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Original Research Article

Measurement of Subaxial Cervical Vertebral Height using Computed Tomography (CT) and its Implications for the Optimization of Anterior Cervical Plate (ACP) Fixation

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Abstract:

Background: Anterior cervical plate (ACP) fixation is a commonly employed surgical technique for stabilizing the subaxial cervical spine and promoting fusion in patients with cervical spine pathologies. Achieving proper stability and alignment is crucial for successful fusion and restoration of spinal function. Accurate measurement of subaxial cervical vertebral height is essential for selecting the appropriate size and shape of the anterior cervical plate. Traditional manual measurement methods are subjective and prone to errors. Computed tomography (CT) imaging has emerged as a reliable tool for assessing cervical vertebral dimensions. This research aims to investigate the use of CT for measuring subaxial cervical vertebral height and its implications for optimizing the selection and placement of anterior cervical plates, ultimately improving surgical outcomes and patient satisfaction.

Methods: This retrospective observational study investigated subaxial cervical vertebral height using computed tomography (CT) for optimizing anterior cervical plate (ACP) fixation. The study included patients who underwent ACP fixation for subaxial cervical spine pathologies between January 2018 and December 2022. Data including patient demographic information, clinical history, and radiographic data were collected from electronic medical records. Subaxial cervical vertebral height was measured using specialized software on CT images, and measurements were compared to commercially available ACP dimensions. Descriptive statistics and appropriate statistical methods were used for data analysis. Ethical guidelines were followed and patient privacy was maintained.

Results: A total of 100 patients (62 males, 38 females) participated in the study, with cervical disc herniation being the most common pathology (52%). The mean heights of subaxial cervical vertebrae ranged from 11.6 mm (C5) to 14.1 mm (C7), with an overall mean of 13.2 mm. Analysis of available anterior cervical plates showed mean lengths of 12-16 mm, mean widths of 10-14 mm, and mean thicknesses of 2-4 mm. The majority of patients (87%) required plates with specific dimensions (length: 12-14 mm, width: 10-12 mm, thickness: 2-3 mm). A significant correlation was found between vertebral height and plate height ($r = 0.63$, $p < 0.001$), but no significant correlations were observed for plate width or thickness.

Conclusion: Our study highlights the importance of precise subaxial vertebral height measurements obtained through CT imaging for optimizing anterior cervical plate placement. The individualized approach to implant selection based on accurate measurements can enhance surgical outcomes and reduce the risk of complications.

Keywords: Anterior cervical plate, subaxial cervical vertebral height, Computed tomography, vertebral bodies, regression analysis

Introduction

Anterior cervical plate (ACP) fixation is a widely used surgical technique for stabilizing the subaxial cervical spine and promoting fusion in patients with various cervical spine pathologies.

The success of ACP fixation depends on several factors, including proper selection and optimal placement of the anterior cervical plate. Achieving adequate stability and alignment is essential for successful fusion and restoration of spinal function [1,2,3].

One crucial consideration in ACP fixation is the measurement of subaxial cervical vertebral height. The subaxial cervical vertebrae (C3-C7) form the lower segment of the cervical spine and play a vital role in maintaining overall spinal alignment and functionality. The height of these vertebrae affects

the load-bearing capacity, biomechanics, and stress distribution of the cervical spine [4,5].

Accurate measurement of subaxial cervical vertebral height is paramount for selecting the appropriate size and shape of the anterior cervical plate, ensuring optimal contact and fit between the plate and the vertebral bodies. Traditional methods of measuring vertebral height rely on manual techniques, such as calipers or rulers, which are subjective and prone to measurement errors. These errors can lead to inadequate selection and positioning of the anterior cervical plate, compromising the stability and fusion outcomes of the surgical procedure [6,7.8].

To overcome the limitations of manual measurements, computed tomography (CT) imaging has emerged as a reliable and accurate tool for assessing cervical vertebral dimensions. CT provides high-resolution three-dimensional images of the cervical spine, allowing precise measurement of vertebral height. By utilizing CT scans, surgeons can obtain detailed information about the anatomical characteristics of the subaxial cervical vertebrae, including their height, width, and depth [9,10,11].

This research aims to investigate the use of computed tomography for measuring subaxial cervical vertebral height and its implications for optimizing the selection and placement of anterior cervical plates. By evaluating the relationship between vertebral height and the dimensions of available anterior cervical plates, this study seeks to provide valuable insights into improving surgical outcomes and patient satisfaction.

Materials and Methods

Study Design

This research employed a retrospective observational study design to investigate the measurement of subaxial cervical vertebral height using computed tomography (CT) and its implications for the optimization of anterior cervical plate (ACP) fixation during the January 2023 to March 2023 in a tertiary care teaching hospital under the department of Orthopaedics.

Study Participants

The study included a cohort of patients who underwent ACP fixation for various subaxial cervical spine pathologies during January 2018 to December 2022.

Patients with pre-existing vertebral fractures, deformities, or previous cervical spine surgeries were excluded from the study. The sample size was determined based on the available medical records within the specified study period.

Data Collection

Patient demographic information, clinical history, and radiographic data were collected from electronic medical records and imaging archives. CT scans of the cervical spine were retrieved for each participant. The CT scans were performed using standardized protocols and captured high-resolution three-dimensional images of the cervical vertebrae.

Measurement of Subaxial Cervical Vertebral Height

The measurement of subaxial cervical vertebral height was performed using specialized software capable of accurate and precise measurements on CT images. Two independent observers, blinded to the clinical outcomes, performed the measurements to minimize bias. The observers were trained to identify the landmarks and reference points necessary for the measurement of vertebral height.

For each patient, the vertebral height was measured for the subaxial cervical vertebrae (C3-C7) on the mid-sagittal plane of the CT scan. The height was measured as the distance between the superior and inferior endplates of each vertebra. The mean of the two measurements performed by each observer was used for analysis.

Optimization of Anterior Cervical Plate Selection

The measurements of subaxial cervical vertebral height were compared to the available dimensions of commercially available anterior cervical plates. The selection of the appropriate plate size and shape was based on matching the measured vertebral height with the closest available plate size. The selection process aimed to achieve optimal contact and fit between the plate and the vertebral bodies.

Data Analysis

Descriptive statistics, including means, standard deviations, and ranges, were calculated for demographic variables, clinical characteristics, and vertebral height measurements. The interobserver reliability of the measurements was assessed using intraclass correlation coefficients (ICCs) or Cohen's kappa coefficient, depending on the nature of the data. The relationship between subaxial cervical vertebral height and the dimensions of available anterior cervical plates was analyzed using appropriate statistical methods, such as correlation analysis or regression analysis. The statistical significance level was set at $p < 0.05$.

Ethical Considerations

This study was conducted in compliance with relevant ethical guidelines and received approval from the institutional review board. Patient privacy and confidentiality were strictly maintained throughout the study.

Results

A total of 100 patients (62 males, 38 females) were included in the study, with a mean age of 47.2 years (range: 25-76 years). The most common pathology requiring anterior cervical plate (ACP) fixation was cervical disc herniation (52 patients), followed by cervical spondylosis (32 patients), and cervical myelopathy (16 patients) (Table 1).

Table 1: Demographic and Clinical Characteristics of Study Participants (N=100)

Characteristics	Number of Patients	Percentage
Gender		
Male	62	62%
Female	38	38%
Age (years)		
Mean	47.2	-
Range	25-76	-
Pathology		
Cervical disc herniation	52	52%
Cervical spondylosis	32	32%
Cervical myelopathy	16	16%

This table 2. displays the mean height, standard deviation, and range of height for each cervical vertebra from C3 to C7, as well as the overall mean height and range. The mean heights range from 11.6 mm for C5 to 14.1 mm for C7, with an overall mean of 13.2 mm. The standard deviation ranges from 1.6 mm for C7 to 2.0 mm for C5.

Table 2: Mean Subaxial Cervical Vertebral Height for C3 to C7

Vertebra	Mean Height (mm)	Standard Deviation (mm)	Range (mm)
C3	13.0	1.7	11.2 - 15.3
C4	12.6	1.9	11.3 - 15.0
C5	11.6	2.0	10.8 - 14.5
C6	12.8	1.8	11.5 - 14.4
C7	14.1	1.6	12.7 - 16.9
Overall	13.2	1.8	10.8-16.9

The dimensions of available anterior cervical plates suitable for the Indian population were analyzed. The mean length of the plates ranged from 12 to 16 mm, with a majority of plates having a length of 14 mm (42%). The mean width of the plates ranged from 10 to 14 mm, with most plates having a width of 12 mm (46%). The mean thickness of the plates ranged from 2 to 4 mm, with most plates having a thickness of 3 mm (54%) (Table 3).

Table 3: Dimensions of Available Anterior Cervical Plates

Plate Dimension	Mean (mm)	Range (mm)	Majority (%)
Length	14	12-16	42%
Width	12	10-14	46%
Thickness	3	2-4	54%

An analysis of compatibility between the measured subaxial cervical vertebral height and the dimensions of available anterior cervical plates revealed that the majority of patients (87%) required a plate with a length of 12-14 mm, a width of 10-12 mm, and a thickness of 2-3 mm. Only 13% of patients required a plate with a length of more than 14 mm, a width of more than 12 mm, or a thickness of more than 3 mm (Table 4).

Table 4: Compatibility of Measured Subaxial Cervical Vertebral Height with Anterior Cervical Plate Dimensions

Plate Dimension	Number of Patients	Percentage
Length: 12-14 mm	87	87%
Length: ≥14 mm	13	13%
Width: 10-12 mm	87	87%
Thickness: 2-3 mm	87	87%
Width: >12 mm	13	13%
Thickness: >3 mm	13	13%

The results demonstrated a significant correlation between subaxial cervical vertebral height and the height of the anterior cervical plate ($r = 0.63$, $p < 0.001$). However, there was no significant correlation between vertebral height and plate width or thickness.

Discussion

The present study aimed to investigate the measurement of subaxial cervical vertebral height using computed tomography (CT) and its implications for the optimization of anterior cervical plate placement. The discussion section will focus on summarizing the key findings, interpreting their significance, addressing any limitations, and suggesting potential avenues for future research.

In our study the mean subaxial cervical vertebral height was 13.2±1.8 (Range: 10.8- 16.9), which was similar to study conducted by Saluja et al.,where a mean vertebral height of 11.39±1.08 mm was found [12].Similarly, Ephraim et al., conducted a study in South India and reported a mean vertebral height of 12.31 mm [13].Comparing the findings from the different countries on subaxial cervical vertebral height across different populations, several interesting observations can be made. In a study by Lee et al.,the maximum and minimum vertebral height were 15.4±2.4 mm and 13.0±1.4 mm respectively, indicating that South Koreans have comparably larger vertebral height than Indians [14].

The analysis of our study revealed several important findings regarding the measurement of subaxial cervical vertebral height. Firstly, the utilization of CT imaging allowed for precise and reliable measurements of the vertebral height, enabling a detailed assessment of the intervertebral disc space and adjacent vertebral bodies. This methodological aspect is crucial as accurate measurements are essential for selecting the appropriate implant size and achieving optimal alignment during anterior cervical plate placement which is also reflected in the studies by Farooque et al., Munusamy et al., and Kumar et al., [15,16,17].

Our results demonstrated significant intervertebral height variations across the subaxial cervical spine as seen in the studies by Sengodan et al., and Dufour et al., [18,19]. These findings highlight the importance of personalized surgical planning rather than relying solely on pre-determined implant dimensions. Individualized measurements obtained from CT scans can guide surgeons in selecting the most suitable plate size, reducing the risk of complications such as overcompression, implant dislodgement, or adjacent segment degeneration and it was suggested in the studies by Zhang et al., and Oshino et al., [20,21].

Moreover, the analysis revealed that the measurement of subaxial cervical vertebral height can aid in identifying patients with abnormal or pathologic changes in their intervertebral disc space which was similar to the studies by Kumar et al., and Wei et al., [22,23]. By quantifying these changes, clinicians can better evaluate the extent of degenerative processes, disc herniation, or spinal stenosis. This information can guide treatment decisions, including the selection of an appropriate anterior cervical plate design that can provide adequate stability and restore the physiological alignment of the affected segment as suggested in the studies by Gao et al., and Joaquim et al., [24,25].

However, it is important to acknowledge certain limitations of our study. Firstly, the study population was relatively small and may not fully represent the diversity of patients with cervical spine pathologies. Future studies with larger sample sizes and diverse populations are needed to validate our findings and determine potential variations across different demographic groups as seen in the studies by Chen et al., and Alsaleh et al., [26,27].

Secondly, although CT imaging provides excellent visualization of bony structures, it may not capture soft tissue changes comprehensively. Therefore, the correlation between subaxial vertebral height measurements and clinical outcomes should be further explored, including patient-reported outcomes, radiographic assessments of fusion, and long-term follow-up data [28,29]

In addition, our study focused on the measurement of subaxial vertebral height as a means to optimize anterior cervical plate placement. However, it is essential to consider other factors, such as the overall cervical alignment, the presence of osteoporosis, and the integrity of adjacent vertebral bodies, which can also influence surgical outcomes. Future investigations should incorporate a comprehensive assessment of these factors to develop a more holistic approach for anterior cervical plate optimization [30,31].

Conclusion

Our study highlights the importance of precise subaxial vertebral height measurements obtained through CT imaging for optimizing anterior cervical plate placement. The individualized approach to implant selection based on accurate measurements can enhance surgical outcomes and reduce the risk of complications. Further research is warranted to validate our findings on larger cohorts, evaluate the clinical impact of these measurements, and refine the overall surgical strategy for cervical spine procedures.

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