

Measurement of Subaxial Cervical Vertebral Height using Computed Tomography for Optimisation of Anterior Cervical Plate in North Indian Population

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ABSTRACT

Introduction: The morphometric analysis of subaxial cervical spine is of importance to improve the surgical outcome of the patients who undergo Anterior Cervical Discectomy and Fusion (ACDF) with anterior cervical plating. The morphometric values of cervical spine vary for from population to population and so does the size of the anterior cervical plate.

Aim: To analyse the average height of subaxial cervical spine and its implication in anterior cervical plating.

Materials and Methods: The present cross-sectional study included 70 patients who underwent Computed Tomography (CT) scan for evaluation of cervical spine between May 2021 to October 2021 in VMMC and Safdarjung Hospital, New Delhi. The height of subaxial cervical spine (from C3 to C7 vertebrae) was measured from superior most to inferior most bony part on the anterior surface of the corresponding cervical vertebrae in midsagittal section (A) and superior most to inferior most of the central cervical vertebral body in midsagittal section (B) using

Radiant viewer version 4.2.1 software. The Indian and imported anterior cervical plate, screw hole diameter and screw hole to plate edge were measured both on ventral and dorsal aspect with vernier caliper. The data was tabulated and mean, standard deviation and other variations were calculated.

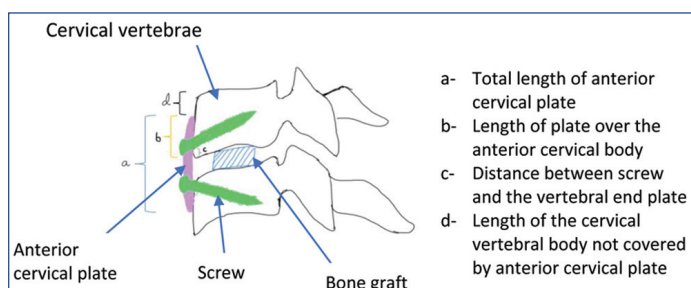
Results: The smallest vertebra was C5, A (11.62 ± 1.15 mm) and B (9.95 ± 1.35 mm). The vertebra C7 was the largest with measurements of A (14.07 ± 1.35 mm) and B (12.46 ± 1.29 mm). The total distance of cervical plate over the anterior cervical vertebral body measures 7.9 mm and 7.6 mm for imported and Indian implant, respectively. Considering the least cervical vertebral height of 9.95 ± 1.35 mm, the gap remaining from the adjacent disc after mounting imported and Indian implant was 2.05 ± 1.35 mm and 2.35 ± 1.35 mm, respectively.

Conclusion: The vertebra C7 was the largest vertebrae and C5 was the smallest. Thus, the Indian and imported anterior cervical plate leaves a gap of less than 5 mm from adjacent disc to plate at C3, C4, C5 and C6.

Keywords: Adjacent level disc ossification, Adjacent segment disease, Anterior cervical discectomy and fusion, Anterior cervical plate for indians

INTRODUCTION

The morphometric analysis of subaxial cervical spine is of importance to improve the surgical outcome of the patients who undergo ACDF with anterior cervical plating [1]. Since, the built of Indian patients is quite different from other population across the world, the morphometric values of cervical spine vary accordingly and so does the dimensions of anterior cervical plate [2,3]. During anterior discectomy and fusion, the proximity of the cervical plate less than 5 mm to the adjacent disc space is a serious risk factor for the development of anterior adjacent level ossification or Adjacent Segment Disease (ASD) [Table/Fig-1] [4-6]. Around 3% of patients per year developed ASD with new symptoms of radiculopathy and neck pain [7]. ASD is a common cause for revision cervical surgery following ACDF [7].



[Table/Fig-1]: Pictorial representation of Anterior Cervical Discectomy and Fusion (ACDF)

An appropriate length of anterior cervical plate should be used during ACDF based on the length of cervical vertebral body height [4]. No studies compared the subaxial cervical vertebral height with the anterior cervical plate. The present study was undertaken to analyse the average height of subaxial cervical spine and its implication in anterior cervical plating.

MATERIALS AND METHODS

A cross sectional study was done between April 2021 to November 2021 and the data for the study were collected from the patients who underwent CT scan between May 2021 to October 2021. Study was done in Spine unit, Central Institute of Orthopaedics, VMMC and Safdarjung Hospital, New Delhi, India. The Helsinki declaration was followed and respected throughout the study.

Inclusion criteria:

- Age: 20 to 45 years of age.
- Both males and females were included.
- Patients who underwent CT scan for evaluation of neck pain, polytrauma.

Exclusion criteria:

- Age below 20 years and above 45 years.
- Previous cervical spine surgery
- Deformity of the cervical spine
- Trauma, degenerative disease, tumour, Infection and inflammatory disease of the cervical spine

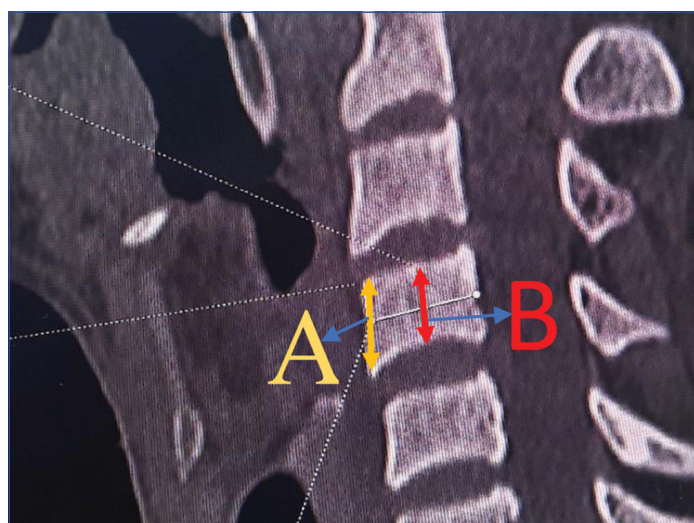
Sample size calculation: The study of Ephraim VR et al., observed that the mean height was 12.31±1.58 mm [8]. Taking this value as reference, the minimum sample size required with 3% margin of error and 5% level of significance.

$$\text{The formula used was } n = \frac{\sigma^2 Z^2}{d^2}$$

=70.4 (approximately, 71 cervical vertebrae)

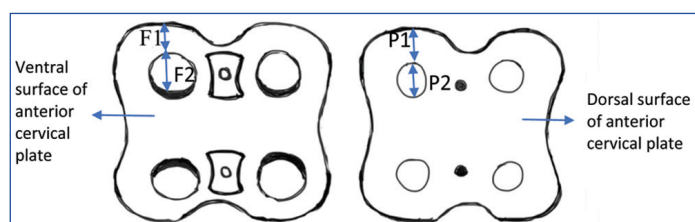
Study Procedure

The data was collected from the Radiology Department, Safdarjung hospital, New Delhi who underwent CT scan for evaluation of neck pain or polytrauma. The height of subaxial cervical spine (From C3 to C7 vertebrae) was measured from superior most to inferior most bony part on the anterior surface of the corresponding cervical vertebrae in midsagittal section (A) and superior most to inferior most of the central cervical vertebral body in midsagittal section (B) using Radiant viewer version 4.2.1 software [Table/Fig-2]. The data were tabulated and mean, SD and other variations were calculated.



[Table/Fig-2]: Yellow colour line represents the height of cervical vertebrae at anterior surface in midsagittal section; a), Red colour line represents the height of cervical vertebrae at center in midsagittal section (b).

The Indian (Shakti Orthopaedics Industries Private Limited) and imported (Medtronic Atlantis vision elite anterior cervical plate system) anterior cervical plates were used into study. Implants screw hole diameter (F2 and P2) and screw hole to plate edge (F1 and P1) were measured both on ventral and dorsal aspect with vernier caliper [Table/Fig-3]. All these data was used to analyse the dimensions of the anterior cervical plate required for the Indian population in general.



[Table/Fig-3]: Diagrammatic representation of ventral and dorsal surface of anterior cervical plate showing the measurement of screw hole diameter (F2&P2) and screw hole to plate edge distance (F1&P1).

STATISTICAL ANALYSIS

Categorical variables were presented in number and percentage (%) and continuous variables were presented as Mean±SD. The data was entered in MS Excel spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0

RESULTS

A study of 70 patients, consisting of 350 subaxial cervical vertebrae was done. All of them were native Indians, residing in and around Delhi, North India. Patients were aged between 21-43 years,

the mean age being 36.5 years with slight male predominance, 46 patients (65.71%). The mean height of cervical vertebrae at each level and the standard deviation were given in [Table/Fig-4]. The smallest vertebral height was C5, A (11.62±1.15 mm) and B (9.95±1.35 mm). C7 was the largest, measurements of A (14.07±1.35 mm) and B (12.46±1.29 mm).

Cervical vertebral level	Height of cervical vertebral body on the anterior surface in the midline (A) (Mean±SD)	Height of cervical vertebral body at the centre (B) (Mean±SD)
C3	13.29±1.3 mm	11.2±1.41 mm
C4	12.4±1.22 mm	10.5±1.36 mm
C5	11.62±1.15 mm	9.95±1.35 mm
C6	12.36±1.4 mm	10.62±1.33 mm
C7	14.07±1.35 mm	12.46±1.29 mm

[Table/Fig-4]: Mean height and standard deviation of cervical vertebrae of Indian population.

Indian anterior cervical plate had a screw hole diameter (F2) of 5.5 mm and the screw hole to plate edge distance (F1) of 1.6 mm on ventral surface. On dorsal surface, the screw hole diameter (P2) was 4.5 mm and the screw hole to plate edge distance (P1) was 2.1 mm. Accordingly, the total distance from the screw hole to the edge of the plate was 7.1 mm on ventral surface and 6.6 mm on dorsal surface. Considering, 1 mm of bone to be left behind from the anteroinferior and anterosuperior margin of superior and inferior cervical vertebral body respectively for screw insertion, then the total distance of cervical plate over the anterior cervical vertebral body measures 7.6 mm.

Whereas imported anterior cervical plate had a screw hole diameter (F2) of 4.9 mm and the screw hole to plate edge distance (F1) of 2.1 mm on ventral surface. On dorsal surface, the screw hole diameter (P2) was 4.6 mm and the screw hole to plate edge distance was 2.3 mm. Subsequently, the total distance of the imported cervical plate over the anterior cervical vertebral body measured 7.9 mm.

Considering the least cervical vertebral height of 9.95±1.35 mm, the gap remaining from the adjacent disc after mounting imported and Indian implant was 2.05±1.35 mm and 2.35±1.35 mm, respectively.

DISCUSSION

In the present study, the height represented by A was the actual height of the cervical vertebrae on the anterior surface in the midline before osteotomy of the inferior lip of the vertebral body whereas the height B represents the height of the central cervical vertebrae in the midline. During the procedure of ACDF, the inferior lip of cervical vertebrae at the anteroinferior surface was removed by burring or cutting with rongeur, consequently, the height on the anterior surface of cervical vertebrae in midline after osteotomy corresponds to the height of central cervical vertebrae in the midline [9].

In the present study, the least subaxial cervical vertebral height was seen at the level of C5 cervical body (9.95±1.35 mm) and maximum at C7 cervical vertebral body (12.46±1.29 mm). This was compared with other studies, South Indians (Ephraim VR et al., 2016), Indian (Saluja S et al., 2015), Nigerians (Adeleke AA et al., 2020), Americans (Ezra D et al., 2017) and South Koreans (Lee DH et al., 2013) presented higher values than the present study [Table/Fig-5] [8,10-13]. The present study shows north Indian population have a smaller cervical vertebral height.

Sr. No.	Author's name and year	Place of study	Number of subaxial cervical vertebrae	Parameter assessed	Conclusion
1.	Lee DH et al., 2013 [13]	South Korea	250	Maximum vertebral height was (15.4±2.4 mm) Minimum vertebral height was (13.±1.4 mm)	South Koreans have comparably larger vertebral height than Indians.

2.	Saluja S et al., 2015 [10]	India	203	Mean vertebral height (11.39±1.08 mm)	The study was comparable with the present study.
3.	Ephraim VR et al., 2016 [8]	South India	50	Mean vertebral height (12.31 mm)	South Indians having marginally larger vertebrae than North Indians.
4.	Ezra D, et al., 2017 [12]	Israel	1385	African-American, Maximum and minimum vertebral height at C7 (13.64±1.34 mm) and C6 (11.44±1.66 mm), respectively. European-American, maximum and minimum vertebral height at C7 (13.81±1.81 mm) and C6 (12.16±1.62 mm), respectively.	African-Americans and European-Americans have significantly larger vertebrae.
5.	Adeleke AA et al., 2020 [11]	Nigeria	80	Maximum vertebral height at C7 (13.71±3.09 mm) Minimum vertebral height at C3 (10.76±2.16)	Nigerians have larger vertebral height compared to Indians.
6.	Present study	North India	350	Maximum vertebral height at C7 (12.46±1.29 mm) and Minimum vertebral height at C5 (9.95±1.35 mm)	North Indians have the least cervical vertebral height on comparing the above studies.

[Table/Fig-5]: Comparison of vertebral heights in subaxial cervical vertebrae with previous literature [8,10-13].

As per the present study, the length of the imported and Indian standard cervical plate on the anterior surface of the cervical vertebral body measures 7.9 mm and 7.6 mm. To prevent adjacent level disc degeneration, there should be a minimum gap of 5 mm from the cervical plate end to the adjacent level disc [13]. Considering the least cervical vertebral height of 9.95±1.35 mm, the gap remaining from the adjacent disc after mounting imported and Indian implant was 2.05±1.35 mm and 2.35±1.35 mm, respectively. According to the present study findings, the remaining distance from the end of the plate to the adjacent disc was less than 5 mm at C3, C4, C5 and C6.

Park JB et al., did a study concluding that the presence of any ossification in the adjacent disc on postoperative ACDF follow-up radiograph during the initial 12 months has a higher chance of progression to advanced ossification by 24 months, which was significantly more when the plate to disc distance was <5 mm [4]. Lee DH et al., did a study concluding that placement of anterior cervical plate nearer to the adjacent level disc during ACDF appear to induce the formation of adjacent level ossification development [13]. The ASD is a consequence of soft tissue injury due to excessive

dissection along the anterior longitudinal ligament or improper placement of an anterior cervical plate and the plate distance from the adjacent disc is less than 5 mm [14].

Limitation(s)

The limitations were small sample size, single centre study and one locality of population. Further studies are required in various parts of the country.

CONCLUSION(S)

The cervical vertebrae C5 was the smallest vertebrae and C7 was the largest. Both Indian and imported anterior cervical plate leaves a gap of less than 5 mm from adjacent disc to plate at C3, C4, C5 and C6. The operating surgeon should carefully scrutinise the preoperative radiographic images for assessment of cervical vertebral height and intraoperatively crosscheck with c-arm images. The other options of implantation and approaches to be kept ready like stand-alone cages/cervical disc arthroplasty or posterior approach with instrumentation. Further biomechanical studies are required to decrease the implant and screw hole size.

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