International Journal of Anatomy and Research,
Int J Anat Res 2019, Vol 7(4.2):7105-12. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2019.315

Original Research Article

A MORPHOMETRIC STUDY OF BODY, LAMINA, SPINOUS PROCESS AND VERTEBRAL FORAMEN OF VERTEBRA PROMINENS (C7) IN NORTH INDIAN POPULATION: A CLINICO-ANATOMICAL APPROACH

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ABSTRACT

Introduction: Anatomical and morphometric aspects of seventh cervical vertebra are important for consideration of ventro-lateral approach in cervical spine surgery. Therefore, a detailed anatomical information of the dimensions of the vertebral elements is very important for successful surgical management in the degenerative, traumatic and neoplastic diseases of the cervical spine. Ethnic variations have also been reported in these dimensions and there have been no morphometric studies performed in this area in the North Indian population.

Materials and Methods: 60 dry Vertebra prominens vertebrae (C7) were obtained by maceration of the cadavers, made available for the purpose of dissection. Dimensions of vertebral body, lamina, spinous process and vertebral foramen of vertebra prominens(C7) were quantified for each vertebra. Morphological features included macroscopic appearance of Shape of vertebral foramen of vertebra prominens.

Results: The length (VBL), superior width(VBSW), inferior width(VBIW), anterior height(VBAH) and posterior height(VBPH) of vertebral body of vertebra prominens (C7) was 14.21±2.95mm, 25.17±3.45, 24.89±3.25mm, 11.72±1.88mm and 12.61±1.87mm respectively. Height(LH), length(LL) and width(LW) of lamina of were measured as 14.47±1.72 mm, 22.23±2.46mm and 3.74±0.46mm. Length of the spine of vertebra prominens was found to be 28.59±3.72mm. Maximum($width_{max}$) and minimum($width_{min}$) width of spine were 12.15±1.99mm and 6.22±1.53mm. Foramen diameter anteroposterior (FDAP) and transverse (FDT) was found to be 12.97±1.66mm and 22.85±2.46mm respectively.

Conclusion: Taking these measurements of vertebra prominens(C7) into consideration with combined effects of axial computed tomography, the diameters are valuable in correct estimation of spinal deformities and are of interest from anatomical, anthropological aspect and also from medicolegal point of view.

KEY WORDS: Lamina, Morphometry, Seventh cervical vertebra, Spine, Vertebra Prominens.

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Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research**
	ICV for 2016 90.30 — ISSN (E) 2321-4287 | ISSN (P) 2321-8967
	https://www.ijmhr.org/ijar.htm
	DOI-Prefix: https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2019.315	**Article Information**
	Received: 18 Sep 2019 — Accepted: 09 Oct 2019
	Peer Review: 18 Sep 2019 — Published (O): 05 Nov 2019
	Revised: None — Published (P): 05 Nov 2019

INTRODUCTION

Vertebra prominens is the common name for seventh cervical vertebra or C7, the largest and most inferior vertebra of the cervical region of the spine. Anatomical and morphometric aspects of vertebra prominens(C7) vertebra are

important for consideration of ventro-lateral approach in cervical spine surgery to save the life in those patients who are often the victims of polytrauma [1]. The vertebra prominens(C7) responsible for the palpable prominence at the dorsum of the neck [2]. The lower margin of the lateral surface of the body of the vertebra prominens sometimes bears, near its caudal border, at one or both the sides a fovea costalis or a costal pit. This is meant for the articulation with the head of first rib which is a well- developed cervical rib [3]. It is a separate and independent element in the embryo, also called as processus costarium usually more feebly developed than the posterior part, but is sometimes encountered movable, so called cervical rib in which case its length may vary greatly. It is grooved superiorly for anterior ramus of the cervical nerve [3,4]. The seventh cervical vertebra when it bears a pair of ribs, takes on the characters of first thoracic, on the other hand it may become like a sixth cervical, in the rarer cases when the first thoracic ribs are rudimentary.

The spine of vertebra prominens is characterized by an especially long powerful, non-bifurcated processus spinous, which on palpation of the spine from above is usually the first to be distinctly felt; the vertebra is accordingly named the vertebra prominens. [3] Apophysomegaly and vertebra prominens is associated with acroparesthalgia and amyotrophy of the hand [5]. Clay-Shoveller's fracture of spinous process of seventh cervical is an obvious example of the appendicular fracture of the vertebrae which arise from a direct blow or indirect violent muscular action [6]. X-ray irradiation of the seventh cervical vertebra is also used in the treatment of psoriasis [7]. Intermittent neck pain is usually produced by cervical spondylosis due to degenerative disc diseases and also in patients with reversed cervical curvature which is usually associated again with neurological symptoms [8]. Surgical procedures like cervical laminoplasty or implantation of cervical spine instrumentation, require detailed anatomical information to avoid harming the patient [9].

Knowledge of morphometry of vertebral canal foramen is also important for understanding the pathology of certain diseases, to analyse the degree of spinal curvature on cervical spine and also for proper preoperative planning [10]. Thus anatomy of vertebra prominens (C7) is of high clinical importance to surgeons as a surgical procedure may be done through anterior or posterior cervical spine with gratifying results [8]. These are certain findings which may be of clinical interest to radiologists, neurologists, orthopaedic surgeons, which describes the anatomical details in the specimens of vertebra prominens(C7). It has also been observed that vertebral dimension differences exist amongst different races [9, 11]. Ethnic variations have also been reported in these dimensions in the present study and there have been no morphometric studies performed in this area in the North Indian population.

MATERIALS AND METHODS

60 Dry adult human vertebra prominens (C7) were obtained by maceration of the cadavers, made available for the purpose of dissection, in the department of anatomy, Government Medical College, Amritsar. The vertebrae were complete in all respects so as to give the correct measurements. All the vertebrae were thoroughly boiled, cleaned and labelled from 1-60. Morphometric dimensions of vertebral body, lamina, spinous process and vertebral foramen of vertebra prominens (C7) were quantified for each of the 60 specimens. (Table 1) [12-15]. All the measurements were made using a vernier caliper accurate to 0.1 mm. The values were statistically analysed and compared with other studies. (Table 2, 3, 4,5) Morphological features of C7 included macroscopic appearance of Shape of vertebral foramen [16]. (Table 6).

A representative set of surface dimensions of vertebra prominens were defined in the figure 1 and following morphometric dimensions of vertebral body, lamina, spinous process and vertebral foramen were made.

Vertebral body:

1. Vertebral Body length (VBL): It is the greatest anteroposterior diameter of the centrum of the body in sagittal plane and marked as VBL=AB. (Figure 1)

2. Vertebral body superior width (VBSW): It is the greatest transverse diameter of the centrum

of vertebral body and marked as VBSW=CD. (Figure 1)

3. Vertebral Body Inferior Width (VBIW): The diameter was measured as the transverse width of the base of inferior aspect of vertebral body and marked as VBIW= C'D'. (Figure 1)

4. Vertebral body Anterior height (VBAH): It is the maximum anterior vertebral body height on the superoanterior and inferoanterior point on the vertebral body and marked as VBAH= A'B'. (Figure 1)

5. Vertebral Body Posterior height (VBPH): It is the maximum vertebral body posterior height on the most superoposterior point and on most inferoposterior point on the vertebral body and marked as VBPH= A"B" (Figure 1)

Laminae:

6. Lamina Height (LH): It is the distance between the superior and inferior borders on the lamina and marked as LH=E'F' (Figure 1)

7. Lamina Length (LL): It is the distance between the spinous process and the lateral border of the superior articular process on the lamina and marked as LL=EF (Figure 1)

8. Lamina Width (LW): It is the maximum transverse width of the lamina and marked as LH=ef (Figure 1)

Spine:

9. Spine Length (SL): It is maximum anteroposterior diameter from the centre of superior margin of junction of two lamina upto posterior most end of the spine and was marked as SL=UV. (Figure 1)

10. Spine Width Maximum (SW): It is the maximum transverse width of the spine and marked as SW=XY. (Figure 1)

11. Spine Width Minimum (sw).: It is the minimum transverse width of the spine and marked as sw=xy. (Figure 1)

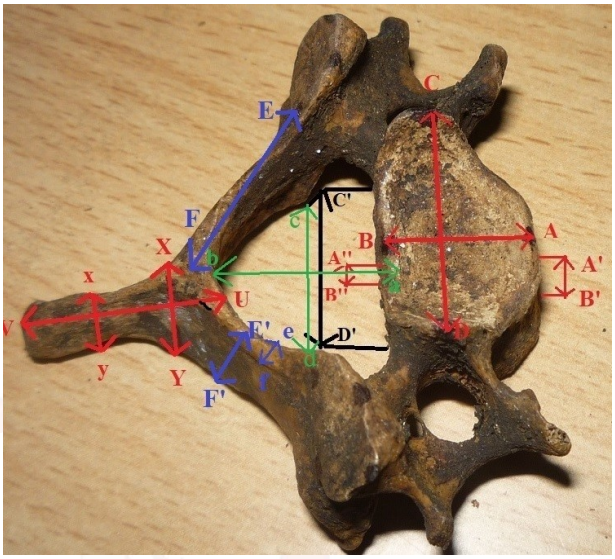
Vertebral Foramen

12. Foramen Diameter Anteroposterior (FDAP): It is the anteroposterior length of the vertebral canal from the centre of superior margin of the body to the beginning of spine and shown as FDAP=ab. (Figure 1)

13. Foramen Diameter Transverse (FDT): It is the greatest transverse diameter of vertebral canal and shown as FDT=cd. (Figure 1)

14. Morphological features of shape of vertebral foramen: It was observed Elliptical, Oval, Heart shaped and Circular.

Fig. 1: Superior View of Vertebra Prominens (C7) Showing the dimensions of Body, Lamina, Spine and Vertebral Foramen.



Vertebral Body length (VBL): AB, Vertebral body superior width (VBSW): CD, Vertebral Body Inferior Width (VBIW): C'D', Vertebral body Anterior height (VBAH): A'B', Vertebral Body Posterior height (VBPH): A"B", Lamina Height (LH): E'F', Lamina Length (LL): EF, Lamina Width (LW): ef, Spine Length (SL): UV, Spine Width Maximum (SW): XY, Spine Width Minimum (sw).: xy, Vertebral Foramen Diameter Anteroposterior (FDAP), Vertebral Foramen Diameter Transverse (FDT)

RESULTS

Vertebral Body: The present study showed the vertebral body length (VBL), vertebral body superior width (VBSW) and vertebral body inferior width (VBIW) of vertebra prominens (C7) vertebra to be 14.21±2.95mm, 25.17±3.45 and 24.89±3.25mm respectively. Vertebral body anterior height (VBAH) and vertebral body posterior height (VBPH) were 11.72±1.88mm and 12.61±1.87mm respectively. (Table 1)

Lamina: Lamina height (LH), length (LL) and width (LW) of vertebra prominens were measured as 14.47±1.72 mm, 22.23±2.46mm and 3.74±0.46mm respectively. (Table 1)

Spine: Length of the spine of vertebra prominens was found to be 28.59±3.72mm. Maximum width ($width_{max}$) and minimum width ($width_{min}$) of spine of vertebra prominens were 12.15±1.99mm and 6.22±1.53mm respectively. Mean width of spine $_{(max+max)}$ was 9.18±1.46mm.

(Table 1)

Vertebral Foramen: Foramen diameter antero-posterior (FDAP) was measured as 12.97±1.66mm & foramen diameter transverse (FDT) of vertebra prominens was measured as 22.85±2.46mm in the present study. (Table 1)

On the basis of macroscopic features of shape of vertebral foramen of seventh cervical vertebra, the most common shape was viewed as heart shape in 53.33% of cases followed by oval transverse in 36.66% of cases, U shape in 6.66% of cases and then circular in 3.33% of cases. (Table 6)

The results of parameters of vertebral body, lamina, spine and vertebral foramen of vertebral prominens (C7) are shown in (Table 1), the comparative data in (Table 2,3,4,5) and the results of macroscopic appearance of vertebral foramen are shown in (Table 6).

Table 1: The Results of The Measured Parameters of Vertebral Body, Lamina, Spinous Process and Vertebral Foramen of Vertebra Prominens (C7) in The Present Study.

S. No.	Parameters	Mean (mm)	Range (mm)	S.D
1	Vertebral Body length (VBL):	14.21	9.30-22.20	2.95
2	Vertebral body superior width (VBSW)	25.17	18.90-33.50	3.45
3	Vertebral Body Inferior Width (VBIW)	24.89	18.70-31.60	3.25
4	Vertebral body Anterior height (VBAH)	12.61	9.70-16.80	1.87
5	Vertebral Body Posterior height (VBPH)	11.72	7.90-16.30	1.88
6	Lamina Height (LH)	14.47	9.30-19.20	1.72
7	Lamina Length (LL)	22.23	16.20-28.40	2.46
8	Lamina Width (LW)	3.74	1.40-5.80	0.46
9	Spine Length (SL)	28.59	22.30-35.40	3.72
10	Spine Width Maximum (SW)	12.15	7.70-16.60	1.99
11	Spine Width Minimum (sw)	6.22	4.00-9.60	1.53
12	Mean width spine (max + max)	9.18	5.85-11.60	1.46
13	Foramen Diameter Anteroposterior (FDAP)	12.97	9.80-16.10	1.66
14	Foramen Diameter Transverse (FDT):	22.85	14.90-27.00	2.46

Table 2: Comparison of Vertebral Body Dimensions (Length-VBL, Superior Width-VBSW, Inferior Width-VBIW, Anterior Height-VBAH, Posterior Height-VBPH) of Vertebra Prominens From Previous Studies.

Worker & Year	Population	N	VBL	VBSW	VBIW	VBAH	VBPH
			Mean(mm) & S.D Range (mm)	Mean(mm) & S.D Range (mm)	Mean(mm) & S.D Range (mm)	Mean(mm) & S.D Range (mm)	Mean(mm) & S.D Range (mm)
Anderson 1883	Belfast	53	18.3 (14-19)	27.5 (23-30)	-	13 (12-14)	-
Cyriax 1920	London	88	-	29.24 (23-36)	-	13.44 (10-17)	-
Francis 1955	White Males	100	16.7±1.3 (14-21)	29.3±1.8 (26-34)	-	14.6±1.1 (12-17)	-
	White Females	27	14.9±1.2 (13-27)	26.2±1.8 (23-31)	-	13.2±1.2 (11-16)	-
	Negro Males	100	16.8±1.5 (14-21)	28.9±1.8 (23-35)	-	14.6±1.0 (12-17)	-
	Negro Females	57	15.2±1.2 (13-17)	25.9±1.7 (23-30)	-	13.2±1.0 (11-15)	-
Gilad & Nissan 1985	Israel	126	-	16.4±1.4	16.3±1.4	14.6±1.4	14.9±1.4
Bazaldua et al. 2011	Northeastern Mexico		17.42±1.33	23.44±3.48			
Prabavathy et al. 2017	Puducherry	350	16.12± 0.57	26.12 ±3.76		11.62± 0.37	
Present Study 2019	North Indians	60	14.21±2.95 (9.30-22.20)	25.17±3.45 (18.90-33.50)	24.89±3.25 (18.70-31.60)	11.72±1.88 (7.90-16.30)	12.61±1.87 (9.70-16.80)

Table 3: Comparison of Lamina Dimensions (Length-LH, Length-LL, Width-LW) Of Vertebra Prominens From Previous Studies.

Worker & Year	Population	N	Lamina Height	Lamina Length	Lamina Width
			Mean(mm) & S.D Range (mm)	Mean(mm) & S.D Range (mm)	Mean(mm) & S.D Range (mm)
Bazaldua et al. 2011	Northeastern Mexico	150	14.31±1.50 (11.73-16.75)	15.39±1.57 (13.26-18.19)	-
Prabavathy et al. 2017	Puducherry (South India)	350	13.52±0.49	24.08±0.80	-
Ensaf et al 2013	-	-	17.3±1.05	21.5±1.05	-
Parashar et al. 2014	Rajasthan	75	13.60±.669 13.58±.59	24.69±.54 24.63±.51	-
Present Study 2019	North Indian	60	14.47±1.72 (9.30-19.20)	22.23±2.46 (16.20-28.40)	3.74±0.46 (1.40-5.80)

Table 4: Comparison of Spine Dimensions (Length-SL, $Width_{max}$-SW, $Width_{min-}$ sw) of Vertebra Prominens From Previous Studies.

Worker & Year	Population	N	Spine Length	Spine Width		
			Mean(mm) & S.D Range (mm)	$Width_{max.}$ Range (mm)	$Width_{min.}$ Range (mm)	$Mean_{(max+max)}$ Range (mm)
Bazaldua et al. 2011	Northeastern Mexico		29.12±5.86	-	-	-
Parashar et al. 2014	Rajasthan	75	22.10±2.02	-	-	-
Prabavathy et al. 2017	Puducherry	350	22.78±2.03	-	-	-
Present Study 2019	North Indian	60	28.59±3.72 22.30-35.40	12.15±1.99 (7.70-16.60)	6.22±1.53 (4.00-9.60)	9.18±1.46 (5.85-11.60)

Table 5: Comparison of Vertebral Foramen Dimensions (Anteroposterior-FDAP, Transverse-FDT) of Vertebra Prominens From Previous Studies.

Worker & Year	Population	N	FDAP		FDT	
			Mean(mm) & S.D	Range (mm)	Mean(mm) & S.D	Range (mm)
Francis 1955	White Males	100	15.5±1.5	Dec-19	25.6±1.6	23-30
	White Females	27	14.4±1.4	Nov-16	24.4±1.4	22-27
	Negro Males	100	15.5±1.4	13-19	25.5±1.3	22-30
	Negro Females	57	14.3±1.1	Dec-16	24.4±1.3	22-28
Present Study 2019	North Indians	60	12.97±1.66	9.80-16.10	22.85±2.46	14.90-27.00

Table 6: Incidence Of Shape Of Vertebral Foramen Of Vertebra Prominens in the Present study.

Worker	Year	Population	N	Shape of Spinal canal	N	%
Present Study	2019	North Indians	60	Heart Shape	16	53.33
				Oval Tr.	11	36.66
				U-Shape	2	6.66
				Circular	1	3.33

DISCUSSION

The dimensions and relations of spinal bony segments in mid-sagittal plane are of importance [13]. In injuries involving the anterior column of the spine i.e. concerning with vertebral bodies and intervertebral disc, the pioneering work of Smith and Robinson & Cloward in anterior removal of cervical disc and fusion is commonly performed procedure today [1]. The vertebral body of vertebra Prominens (C7) was measured for the parameters like vertebral body length (VBL), vertebral body superior width (VBSW), vertebral body inferior width(VBIW), vertebral body anterior height (VBAH) and vertebral body posterior height (VBPH). These measurements serve as an Anthropometric reference for Mathematical modelling, Anatomical and Biomechanical studies of Human spine [13].

The anteroposterior diameter of the vertebral bodies is an important parameter for the anterior fixation of bicortical screws. It is

evident from Table 2 that VBL of vertebra Prominens (C7) in the present study was 14.21mm and found to be less as compared to work done by Anderson, [17] Francis in White and Negro Males [12], Bazaldua et al. [18] and Prabavathy et al. [19], but values stand equivalent to Francis in White females and Negro females [12]. It is interpreted from Table 2 that VBSW and VBIW of vertebra Prominens in the present study was 25.17mm and 24.89mm respectively which were found to be more as compared to the findings of Gilad & Nissan [13] in Israel population who reported these to be 16.4mm and 16.3mm respectively. However, VBSW was slightly less as compared to the work done by Anderson, [17], Cyriax [20] and Francis [12] and concurs with the findings of Prabavathy et al [19]. It is understood from Table 2 that VBAH of vertebra Prominens in the present study was found to be 11.72 mm which was slightly less as compared with Anderson [17], Cyriax [20] and Francis in White and Negro Females [12] and supports the results given by Prabavathy et al. [19] Francis reported VBAH as 14.6mm in White and Negro Males [12] and Gilad & Nissan [13] also reported this to be 14.6 mm in Israel population. Whereas VBPH of vertebra Prominens was 12.61mm which was less than reported by Gilad & Nissan who found this to be 14.9mm in Israel population. [13] Not much data for VBIW and VBPH is available in the accessible literature. The subject of cervical rib is one which concerns the general practitioners, because the patient consults when the symptoms appear. Adson presented that scalenus anticus muscle and width of its attachment were the principle factors in causing the symptoms with the cervical rib. Thus scalenus anticus along with cervical rib is severed to relieve from the symptoms [21].

Vertebra prominens (C7) laminae play an important role in the maintenance of cervical spine stability[22]. Cervical laminoplasty is a surgical procedure frequently used for the treatment of cervical spondylotic myelopathy [23], resection of spinal medulla tumours and ossified posterior longitudinal ligament [24].

The dimensions of the laminae have not been extensively studied previously. As depicted from Table 3 that the lamina Height (LH) in the present study was 14.47mm which supports the results given by Bazaldua et al. [18] Parashar et al. [25] Prabavathy et al. [19]. However, Ensaf et al. found this to be 17.3mm. [26] Whereas the lamina Length (LL) in the present study was 22.23mm and found to be slightly less than Parashar et al., [25] Prabavathy et al., [19] more than Bazaldua et al. [18] and concurs with the findings of Ensaf et al. [26] Lamina Width (LW) in the present study was 3.74mm. however no comparable anatomic data was found regarding lamina width in the available accessible literature.

Duplicated spinous process in the vertebra prominens (7) may be associated with other congenital anomalies [27]. Fracture of spinous process of seventh cervical vertebra is also common [28]. Halifax clamps are inserted posteriorly with fusion provide good stabilisation in these patients [29]. These finding may be of clinical interest to radiologists, neurologists, surgeons, anthropologists and forensic personnel. Spine of vertebra Prominens was measured for length and maximum & minimum width. (Table 4) In the present study the length of the spine of vertebra Prominens (C7) was found to be 28.59 mm which supports the findings of Bazaldua et al. [18] who also found spine length to be 29.12mm in Mexican population. However, SL was found to be more than the results given by Parashar et al. [25] and Prabhavathy et al. [19] It is also predicted from Table 4 that the maximum width of spine of vertebra Prominens was found to be 12.15mm and the minimum width of spine was 6.22mm in the present study and mean of maximum and minimum width of spine was 9.18mm. However not much quantitative anatomic data was available in accessible literature. Cervical spine anatomy is also useful for eosinophilic granuloma & histiocytosis-X of cervical spine with restricted range of motion or torticollis and neurological symptoms [30].

There exists a direct correlation between the dimensions of vertebral foramen and associated consequences after trauma. Vertebral foramen diameters are important to analyse the degree of spinal curvature on cervical spine and a geometric cord is constructed, which is used as an index of degree of curvature that seems to relate to postoperative clinical outcome in

myelopathic patients [10]. Detailed knowledge of morphometry of vertebral foramen is critical for understanding the pathology of certain diseases and also for proper preoperative planning. It was measured for foramen diameter anteroposterior (FDAP) and foramen diameter transverse (FDT). A glance at the Table 5 reveals that the findings of FDAP and FDT of the present study was slightly less to Francis [12].

Not much quantitative anatomic data was available in accessible literature regarding the shape of spinal canal. However Table 6 depicts that in the present study the most common shape was found to be heart shape in 53.33% of cases., Oval Tr. 36.66, U-Shape6.66, Circular3.33. In hyperextension injury the spinal cord gets damaged and causes narrowing of spinal canal. The cord also gets compressed between protruding discs, osteophytic spurs calcified and hypertrophic ligaments which may lead to central infarction of the cord [31].

CONCLUSION

The slight variations in the measured parameters in the present study may be explained due to racial factors, living habits, native place or different environmental conditions but these must be taken into consideration during surgical procedures to avoid the risk of damaging important neurovascular structures during cervical spine surgeries. The knowledge about the morphometry of vertebral bodies, lamina, spinal processes and vertebral foramen of vertebra prominens (C7) is useful for surgeons who perform anterior cervical reconstructions using plate fixation, anterior fixation of bicortical screws or Cervical laminoplasty. The dimensions of vertebral foramen in the present study are being reported for the first time and considered as a novel data. These results emphasize the importance of preoperative computed tomography and conventional radiography of each patient in planning a surgical procedure and selecting the appropriate size of the instruments, thus avoiding possible postoperative complication related to implants. The study may also be helpful for anthropologists and forensic experts in knowing the racial differences.

Conflicts of Interests: **None**

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How to cite this article:

Monika Lalit, Sanjay Piplani, Jagdev S Kullar, Anupama Mahajan. A MORPHOMETRIC STUDY OF BODY, LAMINA, SPINOUS PROCESS AND VERTEBRAL FORAMEN OF VERTEBRA PROMINENS (C7) IN NORTH INDIAN POPULATION: A CLINICO-ANATOMICAL APPROACH. Int J Anat Res 2019;7(4.2):7105-7112. **DOI:** 10.16965/ijar.2019.315