



Original Research Article

Morphometry of foramen transversarium of cervical vertebrae and its clinical significance in South Indian population

Prabavathy G^{1,*}, Sadeesh T¹, Jayaganesh J²¹Dept. of Anatomy, Mahatma Gandhi Medical College & Research Institute, Sri Balaji Vidyapeeth, Pillaiyarkuppam, Puducherry, India²Tindivanam Government Hospital, Tamil Nadu, India

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ABSTRACT

Background: Literature shows multiple variations within the foramen transversarium of the cervical vertebrae.**Aim:** To study the morphometry of foramen transversarium of the cervical vertebrae on both sides.**Materials and Methods:** The foramen transversarium of three-hundred-fifty dry human cervical vertebrae of unknown age and sex was studied. The dimensions of the main foramen and the incidence of accessory foramen transversarium were measured and tabulated.**Results:** Among 350 vertebrae studied, the accessory foramina were noted in 66 (19%) vertebrae. On 21 (6%) vertebrae the accessory foramen was noted on both sides of the vertebra and in the remaining 45 (13%), it was observed on one side. When observing unilateral cases, 30 were present on the right side and 15 were on the left side. In both unilateral and bilateral cases, the increased incidence of accessory foramina was noted more in the C6 vertebra. A significant increase in the diameter of the foramen transversarium was observed on the left side of all vertebrae studied.**Conclusion:** Successful surgical management in degenerative, traumatic, and neoplastic diseases of the cervical spine needs well-detailed knowledge of the anatomy of the cervical spinal column.**Key Messages:** In our study, we found a noted increase in the incidence of accessory foramen transversarium. These morphometric parameters will be added data and can serve as a helpful guide while performing various surgeries of the neck region and for proper interpretation of X-rays and CT scan.© This is an open access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1. Introduction

The cervical part of vertebral column shows a convex ventral curvature (secondary curve) when the infant learns to erect its head. The cervical region contains seven vertebrae with foramen transversarium (FT) in the transverse process, which is the main characteristic feature. Among them, C3 to C6, bear common features termed as typical vertebrae. C1 and C2 are atypical cervical vertebrae which possess specific features for its identity. The foramen transversarium may be double or absent in C7, on one or either sides, which bears its uniqueness.

The cervical vertebra in its transverse process contains the anterior and posterior roots that end as anterior and posterior tubercles laterally. The part of bone formed by the roots, which lies lateral to the foramen, is known as the costotransverse bar. The vestigial part of costal elements attached to the body and the proper transverse process of the vertebra forms the foramen. In all cervical vertebra except C7, the vertebral artery, vein, and sympathetic fibers from inferior cervical sympathetic ganglion pass through the foramen. Only the vertebral vein passes through C7.¹

At each vertebra level, the appearance of foramen transversarium varies, which in turn indirectly related to the course of the vertebral artery, results in distortion in those conditions. The variations of foramen transversarium

* Corresponding author.

E-mail address: prabajai1986@yahoo.com (Prabavathy G).

are either due to embryological basis or related to the variation of the course of the vertebral artery. Earlier studies have published that the vertebral artery enters the foramen transversarium of the C6 vertebra in 88% of cases, C5 in 7%, and passes through the C7 vertebra in 5% of cases.² Literature showed incidence of double FT in 1.5% to 23%. The incidence of accessory foramen transversarium has been mentioned more in C5 & C6 vertebrae in skeletons and cadavers.³ When the FT is divided by a bony or fibrous partition, the smaller posterior part is called the accessory FT.⁴

The vertebral artery is responsible for the blood supply to the brain and also to the inner ear, thereby results in neurological symptoms and hearing disturbances, when it gets compressed while passing through the foramen.⁵

The surgical anatomy of the cervical spine is important in extensive surgical procedures like screw fixation. Studies have reported that the osseous and vascular variations of the cervical spine may lead to the risk of the vertebral artery during the surgical procedures.⁶ Some portion of the primitive dorsal aorta may not regress along with the two intersegmental arteries which connect the vertebral artery, leads to duplication and double origin of the vertebral artery.⁷ Successful surgical management in degenerative, traumatic, and neoplastic diseases of the cervical spine requires well-detailed knowledge in the anatomy of the cervical spinal column.⁸

This morphological knowledge of the cervical spinal column is important to correlate the incidence, variation, and its clinical importance of accessory foramen transversarium for orthopedic surgeons, neurosurgeons, and radiologists to avoid misdiagnosis in their clinical practice. Thus, the present anatomic study was undertaken to obtain detailed anatomical data on the foramen transversarium of the cervical vertebrae.

2. Materials and Methods

The present study was conducted after getting approval from the Institutional Ethics committee, in the department of Anatomy. Three-hundred-fifty dry human cervical vertebrae of unknown age and sex were utilized for this study. Complete intact vertebrae only were taken into consideration for the study. Vertebra which was damaged, incompletely formed, and with any signs of previous injuries were excluded from the study.

For each cervical vertebra, the foramen transversarium was studied and the following parameters were noted for the present study. 1. The highest diameter of foramen transversarium on the right and left side. 2. Incidence of accessory foramen 3. Absence of foramen. The diameters were measured by using Digital Vernier caliper. In the case of a vertebra with two foramina, we considered smaller foramen as accessory foramen transversarium and larger foramen as main FT.

2.1. Statistical analysis

The data obtained were analyzed using software SPSS 20. A comparison of the diameter of the foramen transversarium on both sides was analyzed using the Student 't' test. $P < 0.05$ was considered statistically significant.

3. Results

Among 350 vertebrae studied, the accessory foramina were noted in 66 (19%) vertebrae. On 21 (6%) vertebrae the accessory foramen was observed on both sides of the vertebra and in the remaining 45 (13%), it was observed on one side. Among the unilateral cases, 30 were present on the right side and 15 were on the left side. In both unilateral and bilateral cases, the increased incidence of accessory foramina was noted more in the C6 vertebra. Compared to the main foramen, the accessory foramen transversarium was smaller in all cases (Figure 1). No variations were observed in C1 and C2. The incidence of triple foramen was not noted.

The mean diameter and standard deviation of foramen transversarium from C1 to C7 were compared on both sides. After intercomparison, the p-value was found to be < 0.001 ($p < 0.05$) in all cases, which was statistically significant [Table 1]. Hence, a significant increase in the diameter of the foramen transversarium was observed on the left side of all vertebrae studied.

4. Discussion

The formation and variation of foramen transversarium are indirectly related to variations in its presence and course of the vertebral artery. Absence and narrowing of the foramen transversarium also could indirectly indicates the absence and narrowness of the vessels of the vertebral artery respectively.

Among the 480 vertebrae studied, Taitz et al² reported the incidence of accessory foramina in 7% (34) of cases. Das Srijit et al⁹ studied 132 cervical vertebrae and reported incidence in 1.5% (2). Murlimanju et al¹⁰ reported 1.6% (6) incidence of accessory foramina in 363 specimens. In the present study, we noted an increased incidence of 19% (66), among the 350 vertebrae studied.

Taitz et al² observed the variability of foramen transversarium is more in the seventh cervical spine. El Shaarawy et al¹¹ reported that especially in C6, there is increased incidence of the accessory foramina transversaria. In the present study, the increased incidence of accessory foramina was identified more in the C6 vertebra in all cases.

Taitz et al² reported that only 6 vertebrae had foramen transversarium of equal size, while the others had foramina of very small dimensions. They also reported absent foramen in 4 cases and triple foramina transversaria in one vertebra.

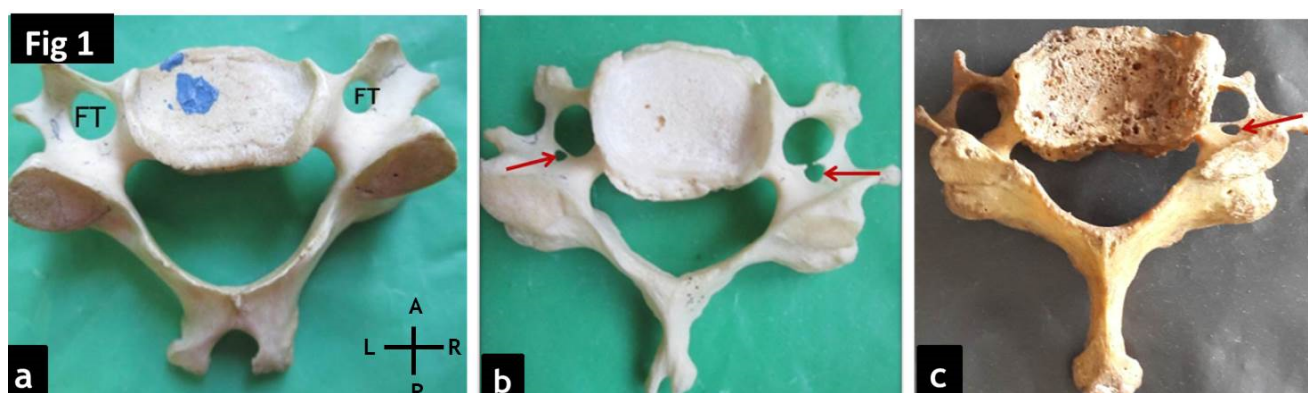


Fig. 1: Superior view: a) Typical cervical vertebra with foramen transversarium on both sides b) Typical cervical vertebra showing bilateral FT c) Cervical vertebra showing unilateral FT on right side

Table 1: Diameter of foramen transversarium of cervical vertebrae (C1-C7) on both sides.

Diameter of foramen transversarium (mm)	Right (n=350) Mean \pm SD	Left(n=350) Mean \pm SD	p-value
C1	6.57 \pm 0.73	6.85 \pm 0.58	<0.001*
C2	5.56 \pm 0.19	6.39 \pm 1.22	<0.001*
C3	4.89 \pm 0.21	5.19 \pm 0.15	<0.001*
C4	6.01 \pm 0.16	6.40 \pm 0.21	<0.001*
C5	6.33 \pm 0.17	6.69 \pm 0.16	<0.001*
C6	6.37 \pm 0.20	6.44 \pm 0.15	<0.001*
C7	6.28 \pm 1.03	6.68 \pm 0.16	<0.001*

*p<0.05 is considered statistically significant, SD- Standard Deviation - Student 't' test

Muralimanju et al¹⁰ observed that the accessory foramina were smaller than the usual foramina. They also reported double foramina in 1.4% (5) and triple foramina in 0.3% (1) of cases. In our study, we also observed, compared to the main foramen, the accessory foramen transversarium was smaller in all cases. The incidence of triple foramen was not noted.

Murlimanju et al¹⁰ reported the presence of accessory foramen on one side is more common than both sides. In the present study, in 21 (6%) vertebrae the accessory foramen was observed on both sides of the vertebra, and in the remaining 45 (13%), it was observed on one side. Among the presence of foramen on one side, 30 were present on the right side and 15 were on the left side.

We noted an increased diameter of a foramen in the C1 vertebra, more on the left side in the present study. The maximum diameter of C1 could be due to the largest calibre of the vertebral artery at the level of the C1. Since the vertebral artery within the foramen transversarium did not have constant caliber during its course, as reported by Cavder et al.¹² Cavder reported that the artery was reduced in caliber from C6 to C3; it began to re-increase in its caliber above C3 and reached its largest caliber at the C1 level.

Cagnie et al¹³ showed that at all levels, the greater diameter was noted on left side of vertebra than the right side. In the present study also, we observed a significant

increase in the diameter of the foramen transversarium on the left side compared to the right side.

The details of the contents of the accessory foramina are not available in the literature. There is no accurate evidence that whether the foramen is either occupied only by the artery or vein or by its branches and tributaries. This morphology is useful in the interpretation of radiographic films and computed tomogram scans for the operating spine surgeons and radiologists. The present study will provide further information on the incidence and morphometry of foramina transversarium.

5. Conclusion

Knowledge about the morphometry and variations of foramen transversarium is important to neurologists, radiologists, orthopedic surgeons, and physiotherapists, for making the proper diagnosis. The morphometric parameters of foramen transversarium studied on both sides in all vertebrae will be added data and can serve as a helpful guide while performing various surgeries of the neck region and for proper interpretation of X-rays and CT scan.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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Author biography

Prabavathy G, Associate Professor

Sadeesh T, Associate Professor

Jayaganesh J, Assistant Surgeon

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