STUDY OF NATIVE FORAMINA TRANSVERSARIA IN THE CERVICAL SPINE

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ABSTRACT

Background: Native Foramine Transversaria (NFTs) has varions sizes and geometrical shapes.**Objective:** To assess the size and shape of native foramina transversaria in the cervical spine. **Materials and Method:** Study design: Descriptive observational study. Place and duration of study: Anatomy department, Sheikh Zayed Medical College, Rahim Yar Khan and Wah Medical College, Wah Cantt., District Rawalpindi. Duration of this study was from 1st July 2012 to 30th June 2014. The study included 45 sets of cervical spine (315 human cervical vertebrae). Maximum and minimum mean values for the length and breadth of NFTs were measured by vernier calipers with accuracy of 0.01 mm. Size and shape of NFTs were assessed and analyzed. **Results:** The largest NFT was of C1, with mean length of 7.44 mm and breadth of 5.95 on right side, whereas smallest NFT was of C7 with mean length of 5.61 mm and breadth of 4.16 mm on right side. The rest of the NFTs showed measurement which fall between these readings. The frequency of different shapes possessing type 1 to 5 with number of all the NFTs was assessed. Type 3 was the most common (prevalent in NFTs of C3 & C4) and type 2 was least common (NFTs of C1). **Conclusion:** The size of NFT is larger in our population. The NFTs possess variant sizes and geometrical shapes at different cervical levels, which may help in facilitating the preoperative planning and avoid possible trauma to its contents during tissue dissection and instrument application.

Key Words: Native foramen transversarium, Cervical spine, Transverse process.

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INTRODUCTION

The cervical spine is made up of first seven vertebrae in the spine. It starts just below the skull and extends at the top of the thoracic spine. Approximately 8% of overall body length is accounted for by the cervical spine,[1] whereas for the cervical (neck) length, 80% is contributed by the cervical vertebral bodies and about 20% is provided by the intervertebral discs.[2]

The cervical vertebrae are characterized by right and left transverse processes which are compound structures; each containing a foramen named as normal or native foramen transversarium (NFT).[3] The NFT displays anterior and posterior roots or bars of bone which terminate laterally as anterior and posterior tubercles. The roots or bars are connected lateral to the NFT by an intertubercular lamella of bone known as costotransverse bar and this bar is grooved on its superior aspect. The anterior root & tubercle, the intertubercular lamella and the posterior tubercle represents the costal element of the vertebra; rest of the part of the transverse process present dorsal to the NFT is the true transverse process.[4] The cervical spinal nerves after emerging from the intervertebral foramen cross the vertebral vessels posteriorly; the anterior ramus of the nerve advances in its course laterally and downwards in the groove of the costotransverse bar. (Fig. I).

The NFT transmits the vertebral artery & vein and a branch from the cervicothoracic ganglion (vertebral nerve) in all the cervical spines except the seventh.[5] Derangements of these structures because of narrowing or deformation of the foramina have been investigated by many authors using X-rays[6]and CT scans.[7]Anatomic examination and variants involving the basic & qualitative features of the NFTs of the cervical spines on dried bones were determined and analyzed by very few researchers.[8,9] The aim of the present study was to investigate the variability of size and shape of NFTs. Knowledge of this variability is important for clinicians such as: otolaryngologists, neurologists, orthopedists and radiologists who in everyday practice are in contact with disorders of the spine & their consequences.

MATERIALS AND METHODS

This was a descriptive observational study conducted from 1st July 2012 to 30th June 2014. Forty five sets of dried human cervical spines (315 cervical vertebrae) of both sexes belonging to different ages (25 to 60 years) were procured for this study from the bone collections of the Anatomy Department of Sheikh

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Zayed Medical College, Rahim Yar Khan and Anatomy Department of Wah Medical College, Wah Cantt, District Rawalpindi. All the required linear measurements were carried out by vernier calipers (Peacock Co., Tokyo, Japan). The accuracy was 0.01 mm. The data was collected on a designed proforma for further statistical analysis. The variant spines were photographed with a digital camera. The following parameters were determined in the cervical spines during this study:

1. Size of Native Foramina Transversaria (NFTs)

Maximum diameter (length) and minimum diameter (breadth) of NFTs present in the right & left transverse processes of all the cervical spines were measured. The data was analyzed using the SPSS software version 16. Based on the maximal and minimal diameters of the NFTs, an index of these two values (coefficient of roundness) was calculated as max. breadth x 100 / max. length, and classified[9] accordingly as:

A. Brachymorph: more than 85 (maximal roundness 100).
B. Mesomorph: between 75 - 85.
C. Dolichomorph: less than 75.

2. Shape of Native Foramina Transversaria (NFTs)

According to shape and direction of the main diameter, the NFTs were classified into five types; all the cervical vertebrae were studied as seen from above in an anteroposterior direction, the body of the vertebra facing the examiner. Type 1 round (○), type 2 elliptical with main diameter (length) anteroposterior (⬯), type 3 elliptical with main diameter transverse (⬭), type 4 elliptical with main diameter oblique, from right to left (⬯), type 5 elliptical with main diameter oblique, from left to right (⬯). (Table-II.)

The NFT of the C2 was different from the foramina of the other cervical vertebrae because it is not a simple short foramen rather it is in the form of an angulated canal with two openings; superiorly the aperture is just lateral to the superior articular facet (lateral aperture) and inferiorly just lateral to body of the vertebra (inferior aperture).[10,11]

RESULTS

1. Size of NFTs: Minimum and maximum mean values for the length and breadth of the native foramina transversaria of both sides in all the cervical vertebrae are documented in Table-I. It shows that the NFTs of the C1 possess the highest mean value, while NFTs of C7 have the lowest value; the mean values for the NFTs of C3 through C7 are higher on the left side than on the right. Asymmetry of the NFTs was observed in many vertebrae (Fig. II). One of the C7 vertebra showed absent NFT on right side (Fig. III).

2. Shape of NFTs: The frequency of different shapes of the NFTs in all the cervical vertebrae of both sides are presented in Table II with the following observations:

i. The C1 showed the highest frequency of type 4, 5 (Fig. IV) and type 2 (Fig. V) NFTs.
ii. The lateral aperture of C2 was predominantly type 1 and inferior aperture is of type 3, 4 and 5.
iii. The C3, C4 and C5 showed high frequency of type 3 (Fig. VI) in NFTs.
iv. The NFTs of C6 showed high prevalence of type 3 and type 1 (Fig. VII).
v. The NFTs of C7 showed high frequency of type 4 (Fig. III) and type 5 (Fig. IV).

Table III shows that the great majority of NFTs in both sides are of mesomorph type. Dolichomorphare predominant in NFTs of C7 and brachymorph are more in lateral aperture of C2 and NFTs of C6 & C5.

DISCUSSION

The native foramen transversarium varies in size and shape for each vertebra and individual. Absence, duplication or asymmetry of the NFTs have been observed in different people.[12]

Size of Native Foramina Transversaria: Size of the NFTs were measured by Taitz et al[9] in which NFTs of the atlas showed the highest mean value (length 7.26 mm, breadth 5.52 mm) while NFTs of C7 had the lowest mean value (length 6.31 mm, breadth 4.37 mm). The mean values for the NFTs from vertebral levels C3 to C7 were seen to be higher on the left side than on the right side. Our study results showed slightly higher mean values when compared with Taitz et al .[9] (Table I).

Table I:

Size of NFTs with maximum & minimum values for the length & breadth in both sides of 45 sets of the cervical spines (n=45)

Cervical Spine		Diameter (mm)	Right				Left			
			Mean	S.E.M	S.D	Range	Mean	S.E.M	S.D	Range
C1		Length	7.44	0.126	0.849	6.20-9.85	7.42	0.132	0.887	5.60-10.35
		Breadth	5.95	0.100	0.676	4.70-7.65	6.03	0.097	0.653	4.30-7.40
C2	Lateral Aperture	Length	6.32	0.131	0.880	4.40-8.70	6.42	0.155	1.042	4.65-10.90
		Breadth	5.26	0.075	0.509	4.40-6.45	5.39	0.101	0.678	3.80-6.90
	Inferior Aperture	Length	7.67	0.188	1.264	5.60-10.20	7.75	0.170	1.144	4.90-9.80
		Breadth	5.77	0.095	0.639	4.45-7.20	6.10	0.119	0.802	3.00-7.90
C3		Length	6.43	0.123	0.829	4.15-9.00	6.76	0.134	0.905	3.25-8.20
		Breadth	4.97	0.104	0.703	3.15-6.30	5.16	0.098	0.662	3.20-6.35
C4		Length	6.62	0.100	0.671	5.20-8.20	6.82	0.113	0.761	3.85-8.45
		Breadth	5.26	0.073	0.495	3.95-6.20	5.42	0.093	0.627	3.85-6.60
C5		Length	6.59	0.126	0.849	5.10-8.85	6.60	0.155	1.040	3.00-8.45
		Breadth	5.27	0.112	0.757	3.80-7.00	5.46	0.138	0.931	2.20-6.90
C6		Length	6.68	0.129	0.869	5.15-10.00	7.08	0.131	0.880	4.00-8.65
		Breadth	5.39	0.100	0.671	3.90-6.75	5.69	0.141	0.951	3.00-7.55
C7		Length	5.61	0.158	1.051	2.75-7.80	5.87	0.228	1.529	2.70-11.00
		Breadth	4.16	0.142	0.945	2.00-6.20	4.25	0.131	0.882	2.25-6.40

Table II:

Frequency of different shapes of the NFTs on both sides of the cervical spines.

Shapes and direction of axes		C1		C2 (Lateral)		C2 (Inferior)		C3		C4		C5		C6		C7	
		Rt. %	Lt. %	Rt. %	Lt. %	Rt. %	Lt. %	Rt. %	Lt. %	Rt. %	Lt. %	Rt. %	Lt. %	Rt. %	Lt. %	Rt. %	Lt. %
Type 1	○	13.33	17.78	46.67	44.45	13.33	17.78	11.11	6.67	26.67	22.22	17.78	26.67	31.11	26.67	6.82	15.56
Type 2	⬯	26.66	17.78	2.22	11.11	2.22	00	00	4.44	4.44	00	00	00	4.44	00	00	00
Type 3	⬭	00	2.22	8.89	11.11	35.56	44.45	60.00	62.23	48.89	55.56	37.78	37.78	35.56	31.11	6.82	6.67
Type 4	⬯	48.90	2.22	40.00	00	8.89	33.33	15.56	11.11	13.33	13.33	33.33	4.44	17.78	22.22	9.09	77.77
Type 5	⬯	11.11	60.00	2.22	33.33	40.00	4.44	13.33	15.55	6.67	8.89	11.11	31.11	11.11	20.00	77.27	00

Table III :

Number of NFTs in right and left sides of 45 sets of the cervical spine showing the coefficient of roundness.

Vertebral Level	Coefficient of Roundness											
	Brachymorph More than 85				Mesomorph 75-85				Dolichomorph Less than 75			
	Right		Left		Right		Left		Right		Left	
C1	13 (14.44%)		14 (15.56%)		20 (22.22%)		25 (27.78%)		12 (13.33%)		6 (6.67%)	
C2	*Lat. 20 (22.22%)	*Inf. 11 (12.22%)	Lat. 26 (28.89%)	Inf. 15 (16.67%)	Lat. 17 (18.89%)	Inf. 13 (14.44%)	Lat. 11 (12.22%)	Inf. 15 (16.67%)	Lat. 8 (8.89%)	Inf. 21 (23.33%)	Lat. 8 (8.89%)	Inf. 15 (16.67%)
C3	6 (6.6%7)		4 (4.44%)		24 (26.67%)		20 (22.22%)		15 (16.67%)		21 (23.33%)	
C4	9 (10%)		13 (14.44%)		27 (30%)		17 (18.89%)		9 (10%)		15 (16.67%)	
C5	9 (10%)		16 (17.78%)		25 (27.78%)		20 (22.22%)		11 (12.22%)		9 (10%)	
C6	17 (18.89%)		13 (14.45%)		19 (21.11%)		20 (22.22%)		9 (10%)		12 (13.33%)	
C7	8 (8.98%)		7 (7.87%)		14 (15.74%)		14 (15.74%)		22 (24.71%)		24 (26.96%)	

*Lat. = Lateral aperture, *Inf. = Inferior aperture

Figure I: Schematic cervical vertebra showing the right and left NFTs with the various structures passing through them. Shaded portion of transverse process represents rib element.

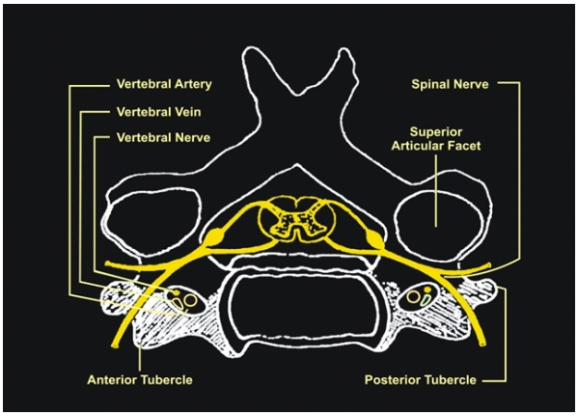


Figure II: C5 with asymmetry of the NFTs.

Figure III: C7 with absent NFT on right side and type 4 on left side.

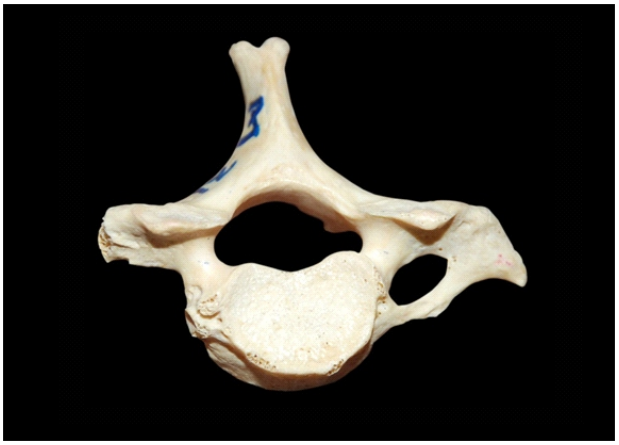


Figure IV: C1 showing NFT of type 4 on right side and NFT of type 5 on left side.

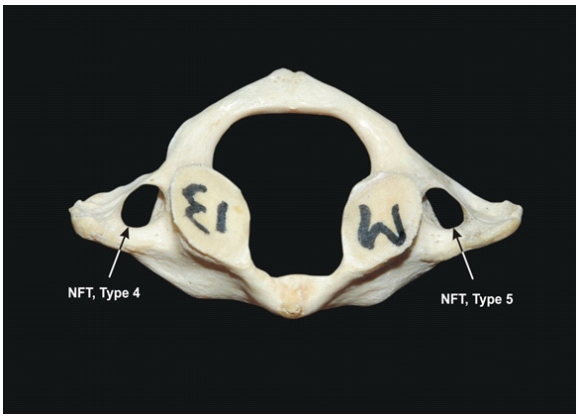


Figure V: C1 with NFTs of type 2.

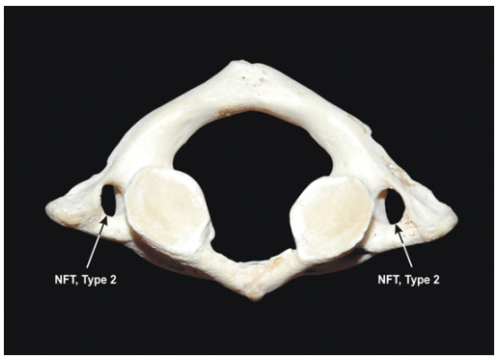
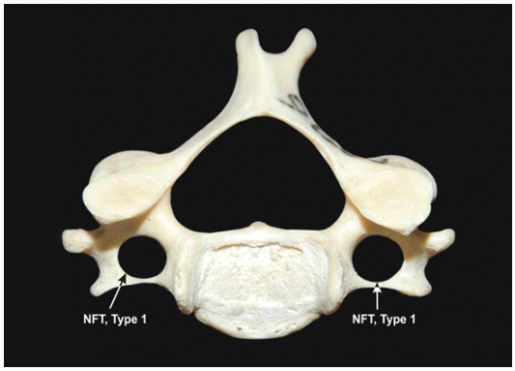


Fig. VI: C5 with NFTs of type 3.

Figure VII: C6 with NFTs of type 1 (brachymorph).



Evangelopoulos et al[7] analyzed all the cervical vertebrae by CT scan and reported the sagittal and transverse diameter of NFTs of C1 on right side as 7.05 mm and 7.24 mm and on left side 7.56 mm and 7.48 mm respectively. In NFTs of C7, sagittal & transverse diameters on right were 4.51 mm and 5.12 mm and on left side they were 4.65 mm and 5.21 mm respectively. Madawi et al[10] studied dry specimens of C2 and reported the mean height of NFT 5.7± 1.0 mm (range 3.9 to 9.0) and a mean width 5.6 ± 0.9 mm (range 4.3 to 8.0). Kaya et al[13] measured the diameter of the NFT in cervical vertebrae and reported to be 6.2 mm (5.7 - 6.5 mm) in right side and 6.4 mm (2.3 - 6.7 mm) in the left side.

In our study, as well as in several other investigations,[14,15] a gradually enlarging diameter of NFTs from C3 to C6 was found, whereas the NFT of the C7 showed the smallest diameter. This may be explained by the fact that the NFT of C7 usually does not contain the vertebral artery and serves as a passage way for the vertebral vein only. Our observations of a left NFT being larger than the right one corresponds to the observations of Taitz et al.[9] This could probably be related to the fact that the arteries of the left side are generally of larger caliber than those of the right side,[16] and a possible asymmetric blood supply of these arteries.[17]

Cavdaret al[18] showed that normal vertebral artery did not have a constant caliber during its course within the NFT. It is reduced in caliber from C6 to C3; above C3 it began to re-increase its caliber, and at C1 level reached its largest caliber. The distortion of the vertebral artery and its largest caliber at the level of the C1 could be considered as a mechanical factor responsible for the larger size of the foramen in C1 as is observed in our study. In one of the C7 vertebrathe NFT was absent on right side which might illustrate the inability of the costal process or element to develop from the lateral sclerotome and somitocele cells in the embryonic life;[1] whereas the true transverse process developed normallyon that side.

Shape of Native Foramina Transversaria: The shape of NFT has attracted very few researchers. Taitzet al[9] have done a detailed work on the shape of the NFTs. They classified the shapes of NFTs into five types. They reported that type 4 & 5 are predominant in the C1, inferior aperture of C2 and C7 NFTs. Type 3 is predominant in C3, C4 & C5 NFTs. Type 1 predominates in NFTs of C6 & lateral aperture of C2. Type 2 is rare and is present in low percentage in most of the vertebrae. Regarding the shape of NFTs, our results nearly correspond with their study.

The aetiology of variations on the size and shape of the NFT is not well known.The vertebral vessels outline one of the important factors in the formation of the NFTs. The different variants of these vessels and their course will lead to changes in the size and shape of the NFTs. In other words, changes or variations of NFTs may be helpful for estimating changes or variations of the vessels and

accompanying nerve structures. An absence of FT could mean absence of the vertebral artery. A narrowing of the foramina indicates narrowness of the vessels and so on.

Moderate to marked erosion of lateral mass & pedicle of C2, and erosion of bone surrounding the NFTs by stretching & compression of the vertebral artery has been reported by many researchers.[19,20]Freilich et al[21] in their research by CT scans discussed a variety of aetiologies of enlargement of the foramen transversarium. They recognized that enlarged vertebral arteries, as they pass through foramina in the transverse processes of the upper six cervical vertebrae, can produce pressure erosion of the adjacent bone. As mentioned, the inferior aperture of the axis showed a mesomorph (oval) type of foramen in contrast to a marked brachymorph (circular) form of the lateral aperture located above it. This difference in shape may be related to the mechanical stresses due to movements. Pathological changes of the movements could therefore be expressed in changes of the foramina. The direct correlation between the size of the NFT and the artery is under debate. Taitz and Arensburg,[22] found that tortuosity of the vertebral artery may cause erosion of the bone. Thus, it may be a factor in producing the variations of the size and shape of the foramina.

CONCLUSION

The present study concludes that the measurements of native formina transversaria diameter may be variable provide important information to the spinal surgeons on the dimensions of the foramen and on its geometrical changes according to the cervical level. Such altered anatomical configurations are of major clinical significance, as spinal manipulations or other interventions in the area may result in dissection of the vertebral artery with serious consequences for the blood supply to the vertebrobasilar region. Knowledge of variations in the size and the shape of NFTs may help in facilitating the preoperative planning and avoid possible trauma to the vertebral arteries during tissue dissection and instrument application. The data provided in this study can also be helpful in the interpretation of X-rays or CT scans for diagnostic purposes.

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