

Original Research Article

Tubercles of transverse process of atlas with its developmental correlations

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ABSTRACT

Background: Atlas is the first cervical vertebra. The transverse process of atlas homologous with the posterior tubercle of the transverse process of a typical cervical vertebra. There is a controversy about the development of the tip of the transverse process of atlas vertebra.

Methods: The 300 human dry atlas vertebra or 600 transverse processes were selected from the anthropology museum of department of anatomy, SRMS medical college Bareilly and SGRRIM &HS Dehradun, Uttarakhand, India. The age and sex of the vertebrae were not taken into consideration. The tip of the Transverse process of atlas vertebrae was examined for its variants like having anterior and posterior tubercles like the typical cervical vertebrae.

Results: The anterior and posterior tubercles of the transverse process and the status of foramen transversarium were observed in 300 atlas vertebrae. In 1.33% of specimen the tips of the transverse process having bilateral anterior and posterior tubercles. In 0.83% of specimen transverse process having anterior and posterior tubercles on the left side and in 1% on the right side. The total percentages of transverse processes with anterior and posterior tubercles were found in 3.17% of specimens.

Conclusions: In present observation the tip of the transverse process of atlas presenting the feature of a typical cervical vertebra (with Anterior and posterior tubercles) observed in 3.17% of specimen. This study may be helpful for the embryologist, neurosurgeons and orthopedic surgeons.

Keywords: Atlas, Costal element, Transverse element, Transverse process

INTRODUCTION

A vertebra is an individual bone in the flexible column that defines vertebrate animals. The Vertebral column encases and protects the spinal cord, which runs from the base of the cranium down the dorsal side of the animal until reaching the pelvis. Cervical vertebrae are those in the neck area, and can range from a single vertebra in amphibians, to seven in most mammals and reptiles, and plesiosaur *Elasmosaurus*.¹ Individual vertebra is composed of a centrum (body), arches protruding from the bottom of the centrum, and various processes projecting from the centrum and / or arches. The Vertebral process can either give the structure rigidity help them articulate with ribs, or serve as muscle

attachment points. Common types are transverse process, diapophyses, and zygapophyses (both the cranial zygapophyses and the caudal zygapophyses). The transverse process is pierced by the foramen transversarium. It consists of an anterior and posterior root, connected to each other on the lateral side of the foramen transversarium by an intertubercular lamella of bone (often, quite incorrectly, called the costotransverse bar).²

The transverse process of atlas homologous with the posterior tubercle of the transverse process of a typical cervical vertebra and may be felt through the skin between the tip of the mastoid process and the angle of mandible (Figure 1). The atlantal slip of scalenus medius,

when present, arises from an ill-defined ridge which extends downwards and laterally from the region of the rudimentary anterior tubercle of the transverse process.

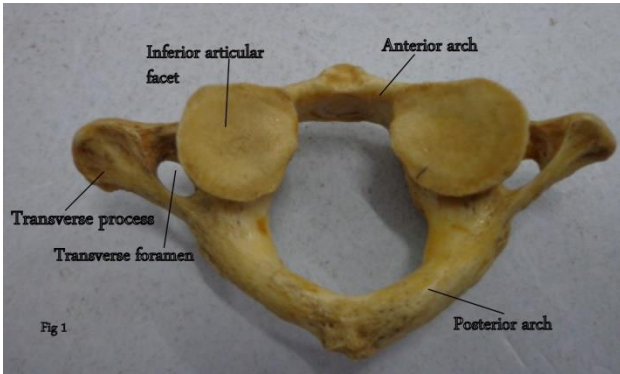


Figure 1: Morphology of normal atlas vertebra.

Development of vertebrae

The skeleton is a derivation of mesoderm (and in some part neural crest), including not only its axial and appendicular divisions but also all accessory ossicles. Most of these parts pass through a first, blastemal stage of mesenchymal condensation and a second, cartilaginous stage before becoming ossified. The transverse and articular processes are chondrified in continuity with the neural arches; intervening jones are mesenchyme which do not become cartilage mark the side of their intervertebral and costovertebral joints, and synovial cavities appear latter in these.

The costal processes chondrify separately and in the thoracic region they extend ventrally, the more cranial members curving round in the body wall to reach the developing sternal plates. They are separated from the developing transverse processes by non-chondrified mesenchyme in which the costotransverse joints will appear. At other than thoracic levels the developing costal process (or pleuropophysis) becomes incorporated into the transverse process of descriptive adult anatomy (Figure 2).²

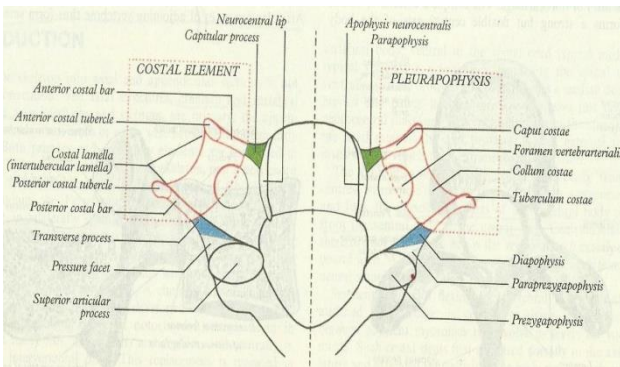


Figure 2: The morphology of generalized cervical vertebra, with particular reference to the pleuropophyses.

There is a controversy about the development of the tip of the transverse process of atlas vertebra. Arey LB described that it develop from true transverse element, and according Hamilton, Warwick and Williams, it develop from costal element.³⁻⁵ The ribs develop from the costal processes of the primitive vertebral arches, extending between the myotomic muscle plate. In the thoracic region of the Vertebral column these processes grow laterally to form a series of pre-cartilaginous ribs, and costotransverse and costovertebral joints are represented by mesenchymatous inter-jones between the cartilaginous neural arch and rib (Smith CPW).⁶

In cervical vertebrae the transverse process is dorsal to the foramen transversarium, while the costal process, corresponding to the head and neck of a rib, limit the foramen transversarium ventrolaterally. The distal parts of these cervical costal processes do not develop, but occasionally they do so in the case of the 7th cervical vertebra. In the lumbar region the costal element forms a strip, along the anterior margin of the transverse process. The morphological variants of foramen transversarium it's anterior and posterior bar and tips of the transverse process of atlas may be helpful when applied in developmental studies of the transverse process of atlas.

METHODS

The present study is based on the observation of 300 Atlas Vertebrae (600 transverse processes) randomly selected from stock of vertebrae, present in the Anthropology museum of Department of Anatomy, SRMS, medical college Bareilly and SGRIM & HS, Dehradun, Uttaranchal, India. The macerated atlas vertebrae were randomly selected. The age and sex of the vertebrae were not taken into consideration. The vertebrae were cleaned properly and following nonmetric variants in the atlas vertebrae were examined. The atlas vertebrae were carefully examined for the transverse processes its apex, foramen transversarium, anterior and posterior bar of the foramen transversarium. The tip of the Transverse process of atlas vertebrae normally having only one tubercle which is homologous to the posterior tubercles of the typical cervical vertebrae. Transverse processes of each atlas vertebrae were carefully examined for its variants like having anterior and posterior tubercles like the typical cervical vertebrae. It was also noted that incidence of having anterior and posterior tubercles are unilateral or bilateral.

RESULTS

The transverse processes are looked for the foramen transversarium; the bones which formed the foramen were examined carefully and looked for its boundary. The anterior and posterior tubercles of the transverse process and the status of foramen transversarium were observed in 300 atlas vertebrae or 600 specimens of transverse processes. The total 600 transverse processes were observed for the bifurcation of its tips in the 300

human atlas vertebrae. In 1.33% of specimen the tips of the transverse process having bilateral anterior and posterior tubercles (Figure 3).

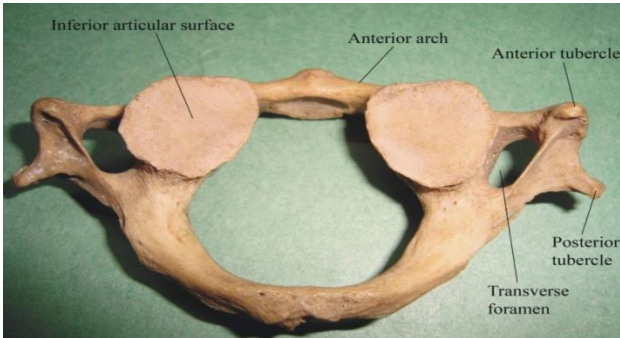


Figure 3: Transverse process showing anterior and posterior tubercle (bilateral).

In 0.83% of specimen transverse process having anterior and posterior tubercles on the left side (Figure 4) and in 1% on the right side (Figure 5).

The total percentages of transverse processes with anterior and posterior tubercles were found in 3.17% of specimens (Table 1 clearly shows these observations). On the basis of this study it was concluded that the tip of the transverse process of Atlas vertebra was developed from the true transverse element.

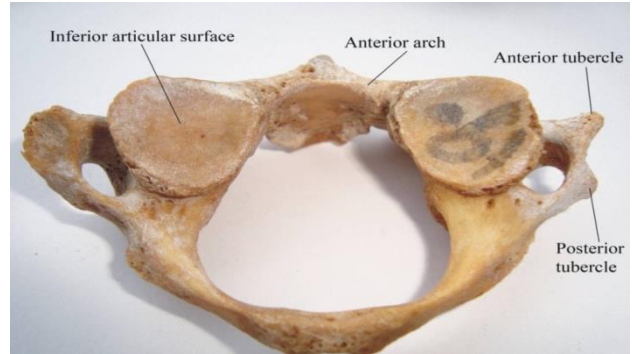


Figure 4: Transverse process showing anterior and posterior tubercle (left side).

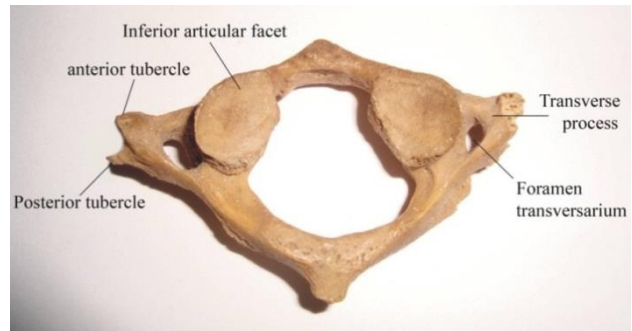


Figure 5: Transverse process showing anterior and posterior tubercle (right side).

Table 1: Transverse process with anterior and posterior tubercles.

Specimen	Incidence	Transverse process with anterior and posterior tubercle			Total (Unilateral + bilateral)	Percentage
		Left	Right	Total		
Atlas	Unilateral	5 (0.83%)	6 (1.0%)	11	19	3.17
	Bilateral	8 (1.33%)				

DISCUSSION

There is a definite embryological controversy in the literature about the development of transverse process of cervical vertebrae. Whether the tip of the transverse process of atlas vertebra, representing the posterior tubercle of a typical cervical vertebra, develop from costal element or true transverse element. Smith CPW et al stated that in the cervical region each costal process remains short, and the corresponding interzones fuse.⁶

The foramen transversarium is bounded ventrally and laterally by the cartilaginous costal process and dorsally by the transverse process, in the lumbar and sacral region area of rarefaction do not appear in the short blastemal costal processes and the cartilaginous transverse and costal processes fuse. Warwick et al revealed that the

apex of the transverse process of atlas vertebra is homologous to the posterior tubercle of typical cervical vertebrae, develops from the costal element.⁵

Cave AJE et al has examined the morphology of the mammalian, including the human, cervical 'costal element' or pleurapophysis, and has defined its extent more precisely, especially in relation to cervical ribs.⁷

Snell RS stated that in the cervical region the costal processes remain short and form the lateral and anterior boundaries of foramen transversarium of each vertebra.⁸ Hamilton, WJ reported foramen transversarium is due to the fact that the costal element, which is vestigial, is fused with the true transverse element to form a composite transverse process.⁴ Williams, PL et al explained that the transverse process displays anterior

and posterior roots which terminate laterally as anterior and posterior tubercles.² All except the medial portion of the posterior root constitute the homologue of a rib. The medial moiety of the posterior root is homologous with a true transverse process (diaphophysis) such as exists in a thoracic vertebra. McMinn RMH reported that there is usually no distinct formation of anterior and posterior tubercles of cervical vertebrae but all the bone anterior and lateral to the foramen transversarium is costal in origin.⁹ Hamilton explained that tip of the transverse process of atlas vertebra develops from costal element.⁴

Warwick et al also reported that the apex of the transverse process of atlas Vertebrae is homologous with the posterior tubercle of a typical cervical vertebra, developed from the costal element.⁵ But according to the Arey LB the tip of the atlantal transverse process, representing the posterior tubercle of a typical cervical vertebra, developed from the true transverse element.³

The result of the present study is very close to the description of Arey LB et al stated that in the cervical region the costal processes remain short and form the lateral and anterior boundaries of foramen transversarium of each vertebra.⁸ The bifurcation of the tip of the transverse process of atlas vertebra was reported by Allen W, which is the feature of typical cervical vertebra.¹⁰ In present study it was noted that the transverse processes of atlas vertebrae having anterior and posterior tubercles, which are the feature of a typical cervical vertebrae. The percentage of incidence of anterior and posterior tubercle was rarely reported by the previous researchers. It was observed in 3.17% of specimens in our study (Table 1).

There is a definite embryological controversy in the literature about the development of the transverse process of cervical vertebrae, whether the tip of the transverse process of the atlas vertebra, representing posterior tubercle of a typical cervical vertebra, develops from costal element stated by Hamilton et al or true transverse element described by Arey LB.^{3,5} The result of the present study is very close to the description of Arey LB.

CONCLUSION

In present observation the tip of the transverse process of atlas presenting the feature of a typical cervical vertebra (with Anterior and posterior tubercles) observed in 3.17% of specimen. This study may be helpful for the embryologist, neurosurgeons and orthopedic surgeons.

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