Section: Anatomy

Original Research Article

MORPHOLOGY AND PREVALENCE OF FUSION OF THORACIC VERTEBRAE-A CROSS SECTIONAL STUDY IN SOUTH INDIA

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Abstract

Background: Congenital fusion of vertebrae most commonly involves cervical region, followed by thoracic and lumbar regions. The fusion of thoracic vertebrae can present clinical signs like congenital scoliosis early in life and shortening of trunk with scoliosis and or lordosis in older children. The block vertebrae may cause restricted movements, premature degenerative changes and associated neurological deficits. The symptoms may vary according to the extent and level of vertebral fusion. The thoracic vertebral fusion is often seen associated with ossification of anterior longitudinal ligament in Diffuse Idiopathic Skeletal Hyperostosis (DISH), ankylosing spondylitis, osteochondritis, etc. Awareness of this anomaly is important for correct diagnosis. **Materials and Methods:** The present study was conducted on 490 dry adult human thoracic vertebrae of unknown age & sex obtained from Government Medical Colleges of South Tamilnadu. **Results:** In this study the vertebrae were macroscopically observed to find any abnormal fusion between adjacent vertebral bodies, pedicles, laminae, spines or articular processes, transverse processes, shape of vertebral foramen, presence of ossified anterior longitudinal ligament. We found fusion in 6 thoracic vertebrae out of 490 thoracic vertebrae. **Conclusion:** In the present study we found thoracic fusion incidence 1.22%. The study has provided additional information on the anatomy and morphology of thoracic vertebral fusion with their embryological basis and clinical implications.

INTRODUCTION

The human adult vertebral column usually consists of 33 vertebral segments. The functions of the vertebral column are to support the trunk, to protect the spinal cord and nerves, and to provide attachments for muscles. Vertebral column morphology is influenced externally by mechanical, occupational and environmental factors and internally by genetic, metabolic and hormonal factors. These all affect its ability to react to the dynamic forces of everyday life, such as compression, traction and shear.

A typical vertebra consists of a body, vertebral arch and foramen. The vertebral arch comprises of a paired pedicle, paired laminae, paired superior and inferior articular processes, paired transverse processes and a spinous process.

Thoracic vertebrae compose the middle segment of the vertebral column, between the cervical and lumbar vertebrae. Presence of costal facets on vertebral body and transverse processes differentiates it from other vertebrae. In humans there are 12 thoracic vertebrae among which T1, T9, T10, T11 and T12 are atypical.

Congenital anomalies are common in the vertebral column. Awareness of vertebral anomalies are important to Anatomists, also to clinicians as these anomalies may result in pain, decreased mobility, muscular weakness of limbs and sensory deficits. Various vertebral anomalies of Anatomic interest have been reported viz.; occipitalisation, sacralisation, lumbarisation, absence of posterior elements of vertebral arch and vertebral synostosis.

Fusion of vertebra at single or multiple levels is referred to as block vertebrae or spinal fusion or vertebral synostosis. The fusion of two or more vertebrae can be congenital or acquired. The fusion

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may be congenital due to failure of segmentation of sclerotomes at certain levels at the time of organogenesis, manifesting into Klippel Feil Syndrome or other associated spinal deformities such as scoliosis. Though rare, the acquired fusion of vertebrae is secondary to trauma, tuberculosis or other infections and juvenile rheumatoid arthritis. The surgical fusion of two vertebrae is known as spondylodesis or spondylosyndesis.

Congenital fusion of vertebrae most commonly involves cervical region, followed by thoracic and lumbar regions. The fusion of thoracic vertebrae can present clinical signs like congenital scoliosis early in life and shortening of trunk with scoliosis and or lordosis in older children. The block vertebrae may cause restricted movements, premature degenerative changes and associated neurological deficits. The symptoms may vary according to the extent and level of vertebral fusion.

The thoracic vertebral fusion is often seen associated with ossification of anterior longitudinal ligament in conditions like Diffuse Idiopathic Skeletal Hyperostosis (DISH), ankylosing spondylitis, osteochondritis, etc. Previous authors named the fusion of vertebrae as Klippel Feil Syndrome in cervical region, synspondylism in thoracic region or block vertebrae in lumbar region. Awareness of this anomaly is important for proper diagnosis and management.

MATERIALS AND METHODS

The present study was conducted on 490 dry adult human thoracic vertebrae of unknown age & sex obtained from Government Medical Colleges in Tamilnadu. The vertebrae were macroscopically observed to find any abnormal fusion between adjacent vertebral bodies, pedicles, laminae, spines or articular processes, transverse processes, shape of vertebral foramen, presence of ossified anterior longitudinal ligament.

Inclusion Criteria: All intact adult dry vertebrae were included in the present study.

Exclusion Criteria: Broken, damaged and neonatal bones were excluded from the study.

RESULTS

In this study we found fusion in 6 thoracic vertebrae out of 490 thoracic vertebrae.

In the first specimen, fusion between two typical thoracic vertebrae present. Vertebral Body completely fused, Laminae partially fused. Vertebral foramen is circular.

In the second specimen, fusion between three typical vertebrae present. Vertebral Body partially fused. Ossification of anterior longitudinal ligament present. Vertebral foramen is circular.

In the third specimen, fusion between two atypical vertebrae T1-T2 present. Vertebral Body partially fused. Laminae, Articular processes and Spinous processes completely fused. Vertebral foramen is irregular in shape.

In the fourth specimen, fusion between three typical vertebrae present. Vertebral Body partially fused. Vertebral foramen is circular.

In the fifth specimen, fusion between two typical vertebrae present. Laminae, Articular processes were completely fused. Vertebral foramen is circular.

In the sixth specimen, fusion between two typical vertebrae present. Vertebral Body partially fused. Ossification of anterior longitudinal ligament present. Vertebral foramen is circular.

The results were tabulated below for the six fused thoracic vertebrae as follows in Table 1:

Figure 1: Vertebral body-CF

Figure 2a:3 Thoracic vertebrae-Fused

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Figure 2b: Ossified Anterior longitudinal ligament

Figure 4a:3 Fused Thoracic vertebrae

Figure 3a: Laminae, AP, SP-CF

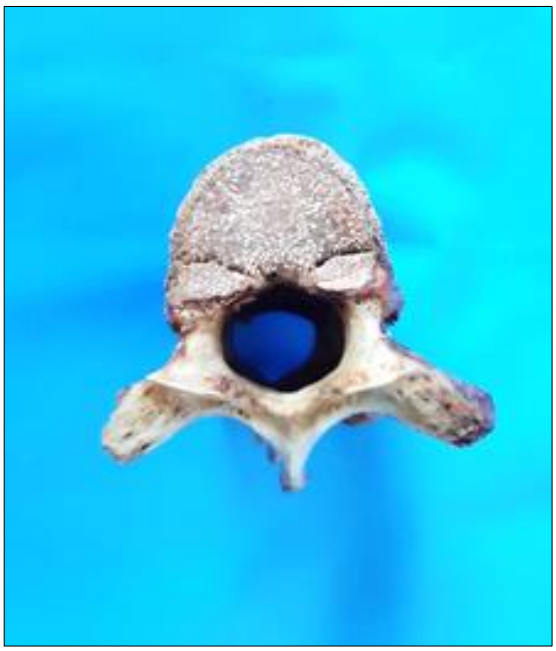

Figure 4b: Circular vertebral foramen

Figure 3b: Irregular vertebral foramen

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Figure 5: Laminae -CF

Figure 6: Vertebral body-PF, Ossified anterior longitudinal ligament

Table 1: Morphological features of fusion of thoracic vertebrae

Fused specimen number	No. of vertebrae involved	Type of vertebrae	Site of fusion	Extent of fusion		Vertebral foramen	Ossification of anterior longitudinal ligament
				CF	PF		
1	Two	Typical	Body, Laminae	Body	Lamina	Circular	Absent
2	Three	Typical	Body	-	Body	Circular	Present
3	Two	Atypical T1-T2	Body, Laminae, AP, SP	Lamina AP, SP	-	Irregular	Absent
4	Three	Typical	Body	-	Body	Circular	Absent
5	Two	Typical	Laminae, AP	Lamina AP	-	Circular	Absent
6	Two	Typical	Body	-	Body	Circular	Present

AP- Articular processes
SP- Spinous process
CF-Completely fused
PF-Partially fused

DISCUSSION

Incidence of fused thoracic vertebrae varied in literature from 1.6% to 4.16%. In the present study we found fusion in 6 thoracic vertebrae out of 490 thoracic vertebrae 1.22%.

The present study compared with other studies as follows in Table 2:

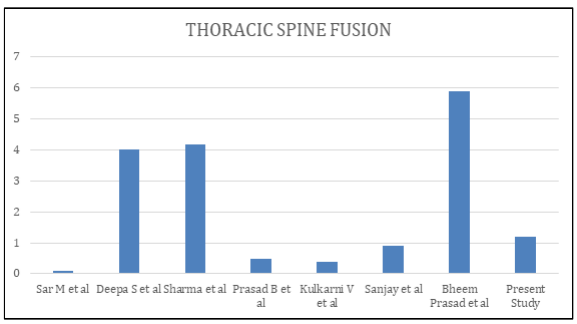

Chart 1: Comparision of prevalence of fusion of thoracic vertebrae

Vertebral synostosis is the hallmark of KFS, a triad of short neck, low posterior hairline and restricted neck mobility.[11] Acquired fusion of vertebrae may be differentiated from congenital anomalies by a history of trauma or infection and by x-ray evidence of degeneration of the involved functional spinal unit. The congenital fusions are characterized by absence of the intervertebral disc, or its replacement by a radio opaque line; the 'Wasp-Waist' appearance; smooth intervertebral foramina; a single spinous process for two vertebral bodies; and maintenance of vertebral body height on x-ray examination.

Block Vertebrae results in disturbance in postural biomechanics causing degenerative changes and disc prolapse at the adjoining segments in advanced age. Fusion between the typical thoracic vertebrae and lumbar vertebrae can cause low back pain. Early diagnosis of these anomalies will be helpful in documenting the changes due to an injury, ageing or progression of a degenerative process and also to motivate the patients to change their life styles to lead a normal life.

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4.1 Embryological Significance

The vertebrae develop from sclerotome part of the somite, derived from paraxial mesoderm of intraembryonic mesoderm. Migration of sclerotome cells around the neural tube and notochord occurs during the fourth week of the intrauterine life. In due course, the sclerotome part of each somite undergoes a process called re-segmentation. This leads to the formation of definitive vertebra being derived from adjacent sclerotomes. Any defect in the above process can lead to congenital anomalies.[1]

Normal segmentation of the sclerotomes is important for the development of a vertebral column. But in certain cases due to decrease blood supply during 3rd to 8th week of intrauterine life the block vertebrae results. Vertebral fusion anomalies are likely to be associated with disturbance of Pax-1 gene expression in the developing vertebral column. A combination of environmental and genetic factors mainly during the 3rd week after conception is thought to be the main causative factor for this anomaly.[2]

4.2 Clinical Significance

Anatomically, the intervertebral discs form 1/5th of the vertebral column. Therefore, absence of intervertebral disc leads to shortening of the column and subsequently shortening of the trunk. The thoracic vertebrae and the intervening disc along with the ribs help in maintaining the shape and length of the thorax. Fusion of the vertebrae and the absence of the disc will narrow the thorax that can lead to respiratory distress. Asphyxiating thoracic dystrophy is caused by narrow thorax and short ribs.[6]

4.3 Clinical Complications

Congenital block vertebrae maybe associated with other systemic anomalies that include abnormal spinal curvatures (scoliosis, etc), hemivertebrae, spina bifida, clubfoot, anomalies involving kidney (Unilateral horse shoe kidney, duplicated kidney, etc) and the ribs (cervical rib), cleft palate, respiratory problems, deafness or hearing impairment and cardiac anomalies (congenital heart disease).[14]

Various syndromes associated with vertebral fusion are segmentation syndrome with laryngeal malformations, VACTERL (S) (Vertebral, Anal, Cardiovascular, Tracheoesophageal, Renal and Limb abnormalities ± single umbilical artery), MURC (Mullerian duct aplasia, Renal aplasia, Cervicothoracic somite dysplasia).

Pathological causes of fusion of vertebrae are fibro-dysplasia, progressive Juvenile Rheumatoid Arthritis, post infectious, post-surgical, post traumatic, etc. The differentiation and re-segmentation of vertebrae occurs at the time of organogenesis. It explains the association of vertebral synostosis with cardiac, renal, musculoskeletal and neural abnormalities.

Table 2: Comparision of prevalence of fusion of thoracic vertebrae

S.NO.	STUDY	THORACIC SPINE FUSION(%)
1	Sar M et al	0.11
2	Deepa S et al	4
3	Sharma et al	4.16
4	Prasad B et al	0.49
5	Kulkarni V et al	0.37
6	Sanjay et al	0.9
7	Bheem Prasad et al	5.88
9	Present Study	1.22

CONCLUSION

In the present study we found fusion in 6 thoracic vertebrae out of 490 thoracic vertebrae with incidence 1.22%. The study has provided additional information on the anatomy and morphology of thoracic vertebral fusion with their embryological basis and clinical implications. These details are clinically important as they might be associated with genitourinary, neurological and musculoskeletal abnormalities.

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