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Vertebral Synostosis: A Study in Dried Vertebrae of Western Odisha Population

*Mamata Sar[1],Srikanta Kumar Mishra[2],Sarita Behera[3],Dibya Prabha Bara[4], Manoj Kumar Dehury
(Department Of Anatomy, VSS Institute Of Medical Science And Research, Odisha, India,
*Corresponding Author: *Mamata Sar*

Abstract:
Aim: *To study the magnitude of problem of vertebral synostosis in western Odisha population and to study its embryological significance and clinical implications.*
Introduction: *As vertebrae develop through a complicated process from the paraxial mesoderm, different types of vertebral anomalies may appear either in isolation or in association with other congenital anomalies. Vertebral synostosis or block vertebrae is a condition where incomplete segmentation of somites results in fusion of adjacent vertebrae.*
Methods: *All intact dried adult vertebrae preserved in osteology section of Anatomy department of our institute were examined. All the fused vertebrae were collected and a detailed morphological study of individual vertebra was undertaken to know the nature of fusion. The embryological and clinical significance of such anomaly was searched from literatures and discussed.*
Results: *Lumbosacral fusion was most common followed by cervical . Fusion was more complete in cervical region compared to other vertebrae. Degenerative changes like growth of osteophytes was common in lumbar block vertebrae.*
Discussion*: Vertebral synostosis can lead to compression and distortion of neural structures. It may also interfere with muscular movements. Cervical vertebral fusion is collectively termed Klippel Feil syndrome. Individuals with this syndrome are often otherwise normal, but association of this anomaly with other congenital defects is not uncommon. Therefore other visceral anomalies are to be excluded whenever we come across a case of block vertebra.*
Keywords*: Block vertebra, Unsegmented vertebra, Notochord, Somites.*

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I. Introduction

Vertebral fusion or synostosis may occur due to congenital or acquired causes. Vertebra develops from sclerotome cells which surround the notochord and neural tube. The sclerotome undergoes second segmentation called resegmentation by the inducing effect of notochord and neural tube. Failure of resegmentation results in vertebral malformation like fusion of vertebrae. Vertebral fusion may also result from acquired causes like tuberculosis, juvenile rheumatoid arthritis and trauma. Vertebral synostosis leads to restriction of movement of spine and compression or distortion of neural structures. Premature degenerative changes occur in adjoining vertebrae due to increased biomechanical stress. Early detection and timely intervention can prevent these complications to develop.

II. Methods

All the dried vertebrae preserved in the osteology section of Anatomy, VSS Institute of Medical science and Research was taken as study material. All these bones were collected from population of western Odisha. All intact adult vertebrae were included for the study. Vertebrae with incomplete ossification and all broken vertebrae were excluded from our study. A total of 1662 number of vertebrae were examined, out of which 392 were cervical, 856 were thoracic, 399 lumbar and 15 were sacral vertebrae. We separated the fused vertebrae from them and looked for the type of fusion e.g. complete fusion, fusion of only anterior or posterior segment. We also observed any gross asymmetry or deformity affecting the fused vertebrae. Each fused vertebra, though multiple, was considered as single vertebra for our study purpose. To calculate the percentage of incidence, the thoracolumbar fused vertebrae were grouped under lumbar vertebrae. Similarly lumbosacral and sacrococcygeal fused vertebrae were grouped under sacral vertebrae. Thus we studied 392 cervical vertebrae, 856 thoracic, 399 lumbar and 15 sacral vertebrae. We calculated the percentage of fused vertebrae under each category, namely cervical, thoracic, lumbar, thoracolumbar, lumbosacral and sacrococcygeal synostosis. We compared our result with other authors.

III. Observations

Out of 392 intact cervical vertebrae 4 cases of cervical synostosis at different level were noticed (fig 1 to 8). One case of thoracic vertebral synostosis, two thoracolumbar, one lumbar, two lumbosacral and two sacrococcygeal synostosis were observed (fig 9 to16). The details of their level of fusion, nature of fusion etc are described in a tabulated form in table 1 & table 2. We observed more or less complete fusion of vertebrae in case of all cervical and lumbar synostosis where as thoracic, thoracolumbar and lumbosacral synostosis were incomplete. In many of these block vertebrae fusion was not symmetrical leading to some or other form of deformities like kyphosis, scoliosis or lordosis.

Observation Table 1

Vertebrae	Total Number Studied	Total Number Of Fused Vertebrae	Percentage
Cervical	392	4	1.02%
Thoracic	856	1	0.11%
Lumbar	399	3*	0.75%
Sacral	15	4**	26.67%

*Includes 1 lumbar and 2 cases of thoracolumbar synostosis.
** Includes 2 lumbosacral and 2 sacrococcygeal synostosis.

Observation Table 2

SL	LEVEL OF SYNOSTOSIS	BODY	LAMINAE	ARTICULAR PROCESSES	TRANSVERSE PROCESSES	SPINOUS PROCESSES	SYMMETRICAL/ ASYMMETRICAL	DEFORMITY
1	$C_2+C_3+C_4+C_5$	Fused completely	Fused completely	Fused completely	Not fused	Partially fused	Asymmetrical	KYPHOSIS
2	C_2+C_3	Fused completely	Fused completely	Fused completely	Not fused	Partially fused	Symmetrical	No deformity
3	2 TYPICAL CERVICALS	Fused completely	Fused completely	Fused completely	Ant roots are fused on right side	Completely fused	Symmetrical	No deformity
4	2 TYPICAL CERVICALS	fused on the right side	Fused completely	Fused completely	Not fused	Not fused	Asymmetrical	Scoliosis
5	$T_{10}+T_{11}$	fused anteriorly	Not fused	Not fused	Not fused	Not fused	Asymmetrical	Kyphosis
6	$T_{12}+L_1$	fused anteriorly	Not fused	Not fused	Not fused	Not fused	Asymmetrical	Kyphosis
7	$T_{12}+L_1$	Fused posteriorly	Not fused	Not fused	Not fused	Not fused	Asymmetrical	Lordosis
8	L_1+L_2	Fused completely	Fused completely	Fused completely	Not fused	Not fused	Asymmetrical	Kyphosis
9	L_5+S_1	Fused on the left	Not fused	Fused completely	Lt side fused right side separate	Not fused	Asymmetrical	No deformity
10	L_5+S_1	Not fused	Not fused	Fused completely	Fused bilaterally	Not fused	Symmetrical	No deformity
11	S_5+Co_1(2nos)	Fused completely	Cornua fused bilaterally		No deformity		Symmetrical	No deformity


Figure 1


Figure 2


Figure 3


Figure 4

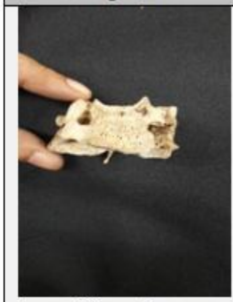
Figure 5


Figure 6


Figure 7


Figure 8

Fig 1-Anterior view of fused C $_2$+C_3+C_4+C_5 showing complete fusion of vertebral bodies with an anterior concavity.(case 1)
Fig 2- Posterior view of same specimen showing fused laminae and fused articular processes, partially fused spinous processes. Transverse processes remain separate. (Case 1)
Fig 3-Fused C_2+C_3 (anterior view)-bodies completly fused, independent transverse processes. (Case 2)
Fig 4- posterior view of same specimen. Completly fused laminae & articular processes but spines are partially fused. (case 2)
Fig 5- Fusion of two typical cervical vertebrae (anterior view)- Bodies completely fused, anterior roots of transverse processes fused on right side but remain separate on left.(case 3)
Fig 6- Posterior view of same specimen – laminae, articular processes and spines completely fused. (Case 3)
Fig 7- Fusion of two typical cervical vertebrae (anterior view)- Bodies are partially fused, independent transverse processes.(case 4)
Fig 8- Same specimen showing fused laminae and articular processes but spines are separate. (case4)


Figure 9


Figure 10


Figure 11


Figure 12


Figure 13


Figure 14

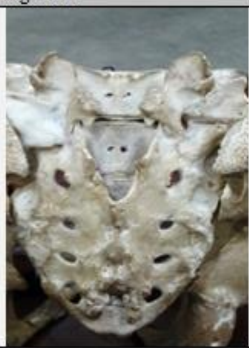
Figure 15


Figure 16

Fig 9- Fusion of T_{10} and T_{11}. Bodies partially fused only anteriorly. Laminae,articular processes, transverse processes and spinous processes remain separate. Anterior longitudinal ligament ossified.(case 5)
Fig 10- Fusion of T_{12} and L_1.Bodies partially fused only anteriorly. Laminae, articular processes, transverse processes and spinous processes remain separate. Osteophytic growths from margins of body. Anterior longitudinal ligament ossified (Case 6).
Fig 11-- Fusion of T_{12} and L_1.Bodies partially fused only anteriorly. Laminae, articular processes, transverse processes and spinous processes remain separate. Osteophytic growths from the lower margin of body. (case 7).
Fig 12- Fusion of $L_1$and $L_{2.}$ Complete fusion of body, laminae and articular processes. Transverse processes and spinous processes are separate. (case 8)
Fig 13- Fusion of L_5 and S_1 (sacralisation of lumbar vertebra).Bodies and transverse processes fused on the left and remain separate on the right side. (Case 9)
Fig 14- Fusion of L_5 and S_1 (sacralisation of lumbar vertebra).Bodies are separated by a narrow disc space, transverse processes are bilaterally fused. (Case 10)
Fig 15 &16- Fusion of S_5 with coccyx (case 11&case 12)

IV. Results

Vertebral fusion was more common in sacral followed by cervical region . It was also more frequent in transitional vertebrae e.g. thoracolumbar, lumbosacral and sacrococcygeal synostosis. Synostosis was more complete in cervical region compared to other regions. Fusion was asymmetrical in 7 out of 12 cases leading to vertebral deformities like, kyphosis or scoliosis. Thoracolumbar and lumbar block vertebrae were found to have developed degenerative changes in the form of osteophytic growth from the margins of vertebral bodies and ossification of ligaments.

V. Discussion

5.1- Embryogenesis

Normal vertebrae develop from sclerotome cells which surround the notochord and neural tube. Then they pass through mesenchymal, cartilaginous and osseous framework of vertebral bodies and neural arches. The neural tube is found to have inducing roles in the formation of posterior neural arch whereas notochord has similar inducing control over vertebral bodies and their segmentation. Incomplete segmentation or block vertebra is common in cervical spine and most commonly involves axis and 3rd cervical vertebra[1].

The sclerotome undergoes second segmentation called resegmentation in which rostral and caudal half of somites segregate and refuse with their neighbouring somites to form vertebrae. The rostral compartment of the somite gives rise to caudal half of the vertebral body and intervertebral disc, whereas the caudal compartment generates the rostral half of vertebral body and pedicle of neural arch[2]. The axial structures like notochord and neural tube are essential for resegmentation of the sclerotome. This has been shown by ablation studies, where surgical removal of notochord resulted in fused vertebral bodies and removal of neural tube resulted in fused neural arches. When both notochord and neural tube were removed, no segmentation appeared at all and a solid vertebral column is formed[3].

5.2- Genetics And Aetiology

Hox genes are a family of genes that regulates among other things, the differentiation process of the axial and appendicular skeleton. These genes regulate the embryonic differentiation of cranio caudal axis. Mutation of Homeobox genes may be responsible for congenital anomalies of spine[4]. Takayuki Seki et al in their study on Ishibashi rat as animal model observed that fusion of adjacent primary ossification centres in embryonic period causes failure of segmentations. In these cases expression of Hox 10 and Hox 11 paralogs which regulates lumbar and sacral vertebrae was extremely low. They concluded that mutation and hyper- and hypo expression of genes is responsible for such skeletal malformation[5].

5.3- Clinical Implication

Vertebral synostosis may go undetected throughout life or may appear with serious clinical manifestations. Musculoskeletal, cardiovascular and urogenital anomalies are strongly associated with congenital spine deformities. Most of the studies showed higher incidence of fused vertebrae in the cervical region. But we observed highest percentage of segmentation abnormalities in sacral region followed by cervical. This is because other authors have not included sacral vertebrae in their studies. Congenital block vertebrae may be associated with other systemic anomalies. Tredwell et al reported that 19(50%) out of 38 patients with foetal alcohol syndrome had congenital fusion of cervical vertebrae on radiographs of the neck. 16 of the 19 had fusion involving 2nd and 3rd cervical vertebrae[6]. Klippel-Feil syndrome is a condition which is characterised by congenital cervical block vertebrae, shortness of neck, low hair line and restricted neck movement. Individuals with this syndrome are often otherwise normal, but association of this anomaly with other congenital defects is not uncommon[7]. Other syndromes associated with vertebral fusion are, VACTERL and MURC. VACTERL includes vertebral, anal, cardiovascular, tracheoesophageal, renal and limb abnormalities. MURC includes mullerian duct aplasia, renal aplasia, cervicothoracic somite dysplasia. Block vertebrae in cervical and thoracic areas as well as facial and ear deformities have been reported in patients with oculo-auriculo-vertebral dysplasia or Goldenhar syndrome[8]. Observations from Adriamycin induced rat models suggest that an abnormal notochord may lead to the development of foregut malformation and cervicothoracic vertebral defect at its rostral end or hindgut malformation and lumbosacral vertebral anomalies at its caudal end. There is accumulating evidence that notochord serve as a key central organiser during early organogenesis. Vertebral abnormalities and some congenital gastro intestinal malformations follow abnormal development of notochord[9].

Kaur D et al reported that presence of lumbar block vertebrae is less common compared to other regions but when present, it results in premature degenerative changes owing to altered biomechanics[9]. Erdil H. Et al also observed degenerative changes in nonsegmented cervical region both in x-ray and MRI[10]. Other complications of synostosis includes spinal deformities, interference in muscular movements and compression or distortion of the neural structures.

VI. Conclusion

As vertebral synostosis is found to be associated with many serious clinical problems, an early diagnosis and timely surgical management can prevent complications. Degenerative changes are more pronounced in lumbar block vertebrae in contrast to other regions. Vertebral deformities in the form of kyphosis, scoliosis or lordosis was also a constant feature in most of the fused vertebrae.

Referenses

[1]. Standring S.Gray's Anatomy.The Anatomical Basis Of Clinical Practice . 40th ed.London:Elsevier , Churchill Livingstone Edinburg ; 2008 : 768-770
[2]. Saga Yumiko, Takeda Hiroyuki. The making of somites: Molecular Events on Vertebral Segmentation. Nature Reviews. Genetics; London.2001;2(11): 835-845
[3]. Karen Colbjorn Larsen, Ernst-Martin Fuchbaker.The Neural Tube is required to maintain Primary Segmentation in the Sclerotome. Cell Tissue Organ. 2006; 182: 12-21
[4]. James T.Guille and Henry H.Sherk. Journal of Bone and Joint Surgery.2002;84(2):277
[5]. Takayuki Seki,Noriaki Shimokawa. Abnormalities of Vertebral Formation and Hox expression in congenital Kyphoscoliosis. Mol.Cell Biochem. 2008;312:193-199
[6]. Tredwell S J,Smith DF,Macleod PJ. Cervical Spine Anomalies in Fetal Alcohol Syndrome. Spine. 1982;7: 331-334
[7]. Keith L. Moore, T.V.N. Persaud. The Developing Human. Clinically Oriented Embryology. 8th edition. Saunders An imprint of Elsevier.2008 : 348
[8]. Somanath Deepa ,Rajasekar SS. Series Of Vertebral Synostosis: Clinically Implied.International Journal of Health Care and Biomedical Research. 2014;3(1):36-40
[9]. Bao Quan Qi. Spencer W. Baesley. Abnormalities of the vertebral column and ribs associated with anorectal malformation. Paed.Surg.Int.2004;20:529-533
[10]. Kaur D et al..Congenital Block lumbar Vertebrae. BMJ case reports.2013
[11]. Erdil H, Ylldiz N,Clmen M. Congenital Fusion Of Cervical Vertebrae and its Clinical Significance. Journal of Anatomical Society of India. 2003;52(2):125-127

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