

# Vertebral Synostosis and its Clinical Importance: A Study in Dried Vertebrae of Gujarat Population

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## ABSTRACT

**Introduction:** The vertebral column possess two basic functions: provide protection to spinal cord and support the trunk, transmit body weight to the lower extremities. Two or more vertebrae that are normally separate may be fused to each other. Such fusion may occur in cervical region (Klippel feil syndrome). The atlas vertebra may be fused to the occipital bone (occipitalization of atlas), 5<sup>th</sup> lumbar vertebra may be partially or completely fused to the sacrum (sacralization of 5<sup>th</sup> lumbar vertebra). Vertebral synostosis may produce restriction of spinal movement and compression or distortion of neural structure.

**Aim:** To study the vertebral synostosis at various vertebral levels and most common affected part of the vertebra.

**Materials and Methods:** This cross-sectional study was carried out in Department of Anatomy, Banas Medical College and Research Institute, Palanpur, Gujarat, India. We studied 259

cervical vertebrae, 444 thoracic, 185 lumbar vertebrae and 40 sacrum. We examined each vertebra macroscopically for the presence of fusion. Each fused vertebra was counted as single vertebra. Photographs of the fused vertebrae were taken for the record. The data were collected and statistically analysed by SPSS version 25.

**Results:** In the present study, we found fusion in 1 (0.38%) cervical vertebra, 4 (0.90%) thoracic vertebrae, 2 (1.08%) lumbar vertebrae and 4 (10%) sacral vertebrae. Body of vertebra is most commonly fused part of vertebra. After lumbo-sacral region, lumbar region is most commonly affected.

**Conclusion:** Vertebral synostosis due to degenerative changes like growth of osteophyte is common in lumbar vertebra. If this type of variation can be identified in early phase, morbidity and mortality can be minimized by early medical or surgical intervention.

**Keywords:** Cervical vertebra, Lumbar vertebra, Sacrum, Thoracic vertebra

## INTRODUCTION

The entire vertebral column is composed of 33 vertebrae and their intervertebral disc. The vertebra are arranged as Cervical-7, Thoracic-12, Lumbar-5, Sacral-5, Coccygeal-4 (may vary from 3-5) [1]. Typical vertebra consists of vertebral body and posterior vertebral arch. Vertebral body is weight bearing part so it increases inferiorly as the amount of weight support increase [2]. Vertebral arch consist of Pedicle and Lamina. The pedicle forms the lateral wall of the vertebral foramen. It extends backward from posterolateral surface of the body to the base of laterally projecting transverse process, at this point where the pedicle meets the lamina. The spine is long and projects downward and backward in the midline so that its tip is palpable. Superior and inferior articular process projects from superior and inferior of junction of pedicle and lamina respectively [3].

During the 4<sup>th</sup> week, sclerotome cells transport around spinal cord and notochord to merge with cells from another side of somites of neural tube. As the development continues the sclerotome portion of each somite also undergoes process called resegmentation. This process occurs when the caudal half of each sclerotome grows into and fuses with cephalic half of each subjacent sclerotome [4]. Two or more vertebrae that are normally separate may be fused to each other such fusion may occur in cervical region (Klippel feil syndrome). The atlas vertebra may be fused to the occipital bone (occipitalization of atlas), 5<sup>th</sup> lumbar vertebra may be partially or completely fused to the sacrum (sacralization of 5<sup>th</sup> lumbar vertebra) [5]. If we clinically correlate this problem like particular nerve compression and irritation may be caused by prolapsed intervertebral disc or by bony entrapment as the size of foramen decrease. This decrease may result from facet joint osteoarthritis, osteophyte formation, disc degeneration and degenerative spondylolithiasis. Vertebral synostosis may produce restriction of

spinal movement and compression or distortion of neural structure. Premature degenerative changes in neighboring vertebra are due to increase biomechanical stress. Early detection and management can prevent further complication to develop [6]. This study was carried out with an aim to study the vertebral synostosis at various vertebral levels and to find out the most commonly affected part of the vertebra.

## MATERIALS AND METHODS

This cross-sectional study was carried out in Department of Anatomy, Banas Medical College and Research Institute, Palanpur, Gujarat, India from January 2018 to February 2019 with prior approval from institutional ethics committee. All the dried vertebrae preserved in the osteology section were taken in this study. Vertebra with incomplete ossification and damaged or broken vertebrae were excluded from the study. We examined each vertebra macroscopically for presence of fusion, than we separated fused vertebra and find out type of fusion like complete or incomplete, unilateral or bilateral, fusion of only anterior or posterior segment. Each fused vertebrae was counted as single vertebra. To calculate percentage of incidence lumbosacral and sacrococcygeal fused vertebrae were grouped under sacral vertebra. Total of 259 cervical vertebrae, 444 thoracic vertebrae, 185 lumbar vertebrae and 40 sacrum were studied. Photograph was taken for record purpose. The data was collected and analysed by SPSS version 25.

## RESULTS

In the present study, we found fusion in 1 (0.38%) cervical vertebra, 4 (0.90%) thoracic vertebrae, 2 (1.08%) lumbar vertebrae and 4 (10%) sacral vertebrae [Table/Fig-1]. Body of vertebra was most commonly fused part of vertebra. Most of fusion was shown in symmetrical fashion [Table/Fig-2].

In our study as shown in [Table/Fig-3-5] complete fusion of all part of vertebra in C2-C3. [Table/Fig-6] show complete fusion of only body part of T3-T4. [Table/Fig-7-9] shows symmetrical fusion of body part, But symmetrical fusion of articular process and spinous process of T5-T6 not present. [Table/Fig-10] show fusion of only body part of T11-T12 but [Table/Fig-11,12] show incomplete fusion of body part of T8, T9, and T10. [Table/Fig-13,14] show fusion of body of L1-L2. [Table/Fig-15,16] show fusion of body of L2-L3-L4. [Table/Fig-17,18] show incomplete fusion of body, articular process and spinous process, while complete fusion of transverse process of L5-S1. Vertebral fusion was more common in sacral region and next in lumbar region. Out of vertebral parts, body of vertebra was most commonly fused, that may be due to biomechanical pressure. Most of the fusion shows symmetrical appearance.

Vertebrae	No. of studied vertebrae	Total no. of fused vertebrae	Percentage (%)
Cervical	259	1	0.38
Thoracic	444	4	0.90
Lumbar	185	2	1.08
Sacrum	40	4	10

[Table/Fig-1]: Number of fused vertebra.

Sr.no.	Observation	Body	Lamina	Articular process	Transverse process	Spinous process	Symmetrical/Asymmetrical
1	C2-C3	Yes (Complete)	Yes	Yes	No	Yes	Symmetrical
2	T3-T4	Yes (Complete)	No	No	No	No	Symmetrical
3	T5-T6	Yes (Incomplete)	Yes	Yes	No	Yes	Asymmetrical
4	T8-T9-T10	Yes (Complete)	No	No	No	No	Symmetrical
5	T11-T12	Yes (Incomplete)	No	No	No	No	Asymmetrical
6	L1-L2	Yes (complete)	Yes	No	Yes	No	Symmetrical
7	L2-L3-L4	Yes (Incomplete)	Yes	No	No	No	Symmetrical
8	L5-S1 (2 sample)	Yes (Incomplete)	Yes	No	Yes	No	Symmetrical
9	L5-S1 (2 sample)	Yes (complete)	Yes	Yes	Yes	Yes	Symmetrical

[Table/Fig-2]: Extent of fusion of vertebra.



[Table/Fig-3]: Fusion of C2-C3 (Anterior view).

## DISCUSSION

Embryogenesis: Normal vertebra develops from sclerotome around notochord and neural tube, and then it passes through



[Table/Fig-4]: Fusion of C2-C3 (Posterior view).



[Table/Fig-5]: Fusion of C2-C3 (Lateral view).



[Table/Fig-6]: Fusion of T3-T4.



[Table/Fig-7]: Fusion of T5-T6 (Anterior view).



[Table/Fig-8]: Fusion of T5-T6 (Right lateral view).



[Table/Fig-9]: Fusion of T5-T6 (Left lateral view).



[Table/Fig-10]: Fusion of T11-T12.



[Table/Fig-11]: Fusion of T8-T9-T10 (Anterior view).



[Table/Fig-12]: Fusion of T8-T9-T10 (Lateral view).



[Table/Fig-13]: Fusion of L1-L2 (Lateral view).



[Table/Fig-14]: Fusion of L1-L2 (Anterior view).



[Table/Fig-15]: Fusion of L2-L3-L4 (Lateral view).



[Table/Fig-16]: Fusion of L2-L3-L4 (Anterior view).



[Table/Fig-17]: Fusion of L5-S1 (Anterior view).



[Table/Fig-18]: Fusion of L5-S1 (Posterior view).

mesenchymal, cartilaginous and bony framework of vertebral bodies and arches. Incomplete segmentation or fused vertebra is more common in cervical region, mostly C2-C3 [7]. The axis structure like notochord and neural tube are most important for resegmentation of sclerotome. In ablation studies, surgical removal of notochord resulted in fused vertebral bodies and removal of neural tube resulted in fused neural arches. When both structure (notochord and neural tube) were removed, absence of segmentation shown

and a solid vertebral column developed [8]. This vertebral synostosis may undergo undetectable thorough life or may produce various musculoskeletal, cardiovascular and urogenital deformities based on site of synostosis. Most of the studies shows higher incidence of synostosis in lumbosacral region and next higher in cervical region [Table/Fig-19] [9-13].

Sr. No.	Study	Cervical (%)	Thoracic (%)	Lumbar (%)	Sacral (%)
1	Present study	0.38	0.90	1.08	10
2	Sar M et al., [9]	1.02	0.11	0.75	26.67
3.	Deepa S et al., [10]	2	4	2	4
4	Sharma M et al., [11]	6.25	4.16	2.08	10.41
5	Prasad B et al., [12]	-	0.49	-	-
6	Kulkarni V et al., [13]	0.74	0.37	-	-

[Table/Fig-19]: Comparison with other study [9-13].

In present study, we were able to find vertebral synostosis in each region like cervical, thoracic, lumbar and sacral. In present study the incidence of sacralization was 10% which is almost same as the finding of study by Sharma M et al., while Sar M et al., found 26.67% which was much higher than our study and Somnath M et al., found 4% which was less than our finding, but all the studies conclude that, there is higher chance of fusion between L5-S1. Next to sacral region lumbar vertebra shows synostosis which is 1.08%, which is same as study by Sar M et al., (0.75) but other author study like Deepa S et al., shows 2% and 2.08% lumbar synostosis, which was higher than our study [9,10]. Thoracic region 0.90% synostosis was much less compare to study of Deepa S et al., [10]. In cervical region 0.38% vertebral synostosis was lowest among other studies like Sar M et al., (1.02%), Deepa S et al., (2%), Sharma M et al., (6.25%), Kulkarni V et al., (0.74%) [9-11,13]. The knowledge of vertebral synostosis can be used in medico legal cases. In case of unidentified bodies with vertebral synostosis, one can compare the antemortem and postmortem radiograph for identification of body. The incidence of congenital vertebral synostosis is 1 in 1000 live birth. These types of anomalies can be associated with kidney problem [14].

## CONCLUSION

Based on present study we can conclude that synostosis of vertebrae can be congenital or acquired. After lumbo-sacral region thoracic region is most commonly affected in fusion of vertebra. Knowledge about any alteration from normal anatomy of vertebral column can affect various system of body as major or minor complication. If this type of variation can identified in early phase, morbidity and mortality can be minimised by early medical or surgical intervention.

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