Section: Anatomy

Original Research Article

A STUDY OF C2-C3 VERTEBRAL SYNOSTOSIS

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Abstract

Background: The study was done to estimate the incidence of c2-c3 synostosis in the population of south India and to examine its morphological features. **Materials and Methods:** In the Institute of Anatomy, Madurai Medical college, 186 C2 vertebrae were examined for its fusion with C3 vertebrae. **Findings:** 3 numbered C2-C3 anastomosis were detected. Height of the fusion including IVF and FT were taken into account for measurement. **Conclusion:** Incidence of the synostosis of C2-C3 vertebra is discussed in the study. The embryological significance in the fusion of the C2-C3 vertebra gained more importance which was associated with syndromes like Klippel-feil syndrome. These findings may help clinically for neurologist, orthopaedic surgeons etc. When performing any neck procedures.

INTRODUCTION

The human vertebral column consists of 33 vertebrae. Cervical 7, thoracic 12, lumbar 5, sacral 5 and coccyx 3-4.[1] The vertebral column develops from the somites, derived from paraxial mesoderm. In cervical vertebrae C1-Atlas, C2-Axis and C7-Cervicae prominens are atypical due to presence of special features in them. The other cervical vertebrae C3-C6 are typical. Axis (C2) vertebrae is atypical due to the presence of dens (odontoid process), projecting cranially from the superior surface of body of axis. The dens articulates anteriorly with the anterior arch of atlas (C1) and posteriorly with the transverse ligament of atlas, thereby providing an axle for rotation of atlas and head around the dens. The C3 vertebra is typical with features similar to other cervical vertebrae.

Anomalies in the vertebral column are common. One such anomaly is the fusion of cervical vertebrae (FCV), in which two vertebrae are fused together structurally and function as a single unit.[2] The fusion of cervical vertebrae can be congenital or acquired. Congenital fusion of axis (C2) with C3 vertebra limits the movements between these two vertebrae adversely and because of this C3 vertebra was given the name "vertebrae critica" by Cave.[3] This fusion of C2 with C3 may be either asymptomatic or associated with neurological manifestations such as limitation of the neck movements, muscular weakness, atrophy and sensory loss. Severe neck pain and unexpected sudden deaths may also occur due to this anomaly.[4]

Aims and Objectives

The present study was aimed to estimate the incidence of C2-C3 synostosis in South Indian population and to describe morphological features of specimens with C2-C3 synostosis.

MATERIALS AND METHODS

186 adult axis (C2) vertebrae of either sex from the osteology lab in the Institute of Anatomy, Madurai Medical College, Madurai, Tamilnadu, India were carefully examined for this study. Of those, three axis (C2) vertebrae were found to be fused with C3 vertebra. They were studied in detail. Measurements are taken using a standard ruler. The parameters measured were height of fused vertebral bodies, intervertebral foramen (IVF) and foramen transversarium (FT). Fusion in the vertebral bodies, pedicles, laminae, articular processes and spinous processes are noted.

RESULTS

Case 1: The bodies of C2 and C3 are partially fused along the margins both anteriorly and posteriorly and along the uncinate processes. The pedicles, laminae and spinous processes are not fused. The articular processes and facets are completely fused on both sides. The VF and FT appeared normal. The fused vertebral bodies together measured 3.6 cm. The FT in C2 measured

0.9 on Rt side and 0.8 cm on Lt side. The FT in C3 measured 0.7 cm on both sides.

Case 2: The bodies of C2 and C3 are partially fused anteriorly; completely fused posteriorly and along the uncinate processes. The pedicles are not fused. The laminae are completely fused on Lt side and partially fused on Rt side. The spinous process of C3 alone is present. The articular processes and facets are

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completely fused on both sides. The VF and Lt side FT appeared normal; the FT on Rt side is damaged. The fused vertebral bodies together measured 3.4 cm. The FT in C2 and C3 both measured 0.7 cm on Lt side.

Case 3: The bodies of C2 and C3 are partially fused along the uncinate processes only. The pedicles are not fused. The laminae are not fused on Lt side and partially fused on Rt side. The spinous processes are not fused. The articular processes and facets are completely fused on Rt side; partially fused on Lt side. The VF and FT appeared normal. The fused vertebral bodies together measured 2.8 cm. The Lt FT in C2 and C3 both measured 0.5 cm, whereas on Rt side both measured 0.4 cm.

Table 1: Showing photographs of fused cervical vertebrae in various views

View	Case 1	Case 2	Case 3
Anterior			
Posterior			
Right lateral			

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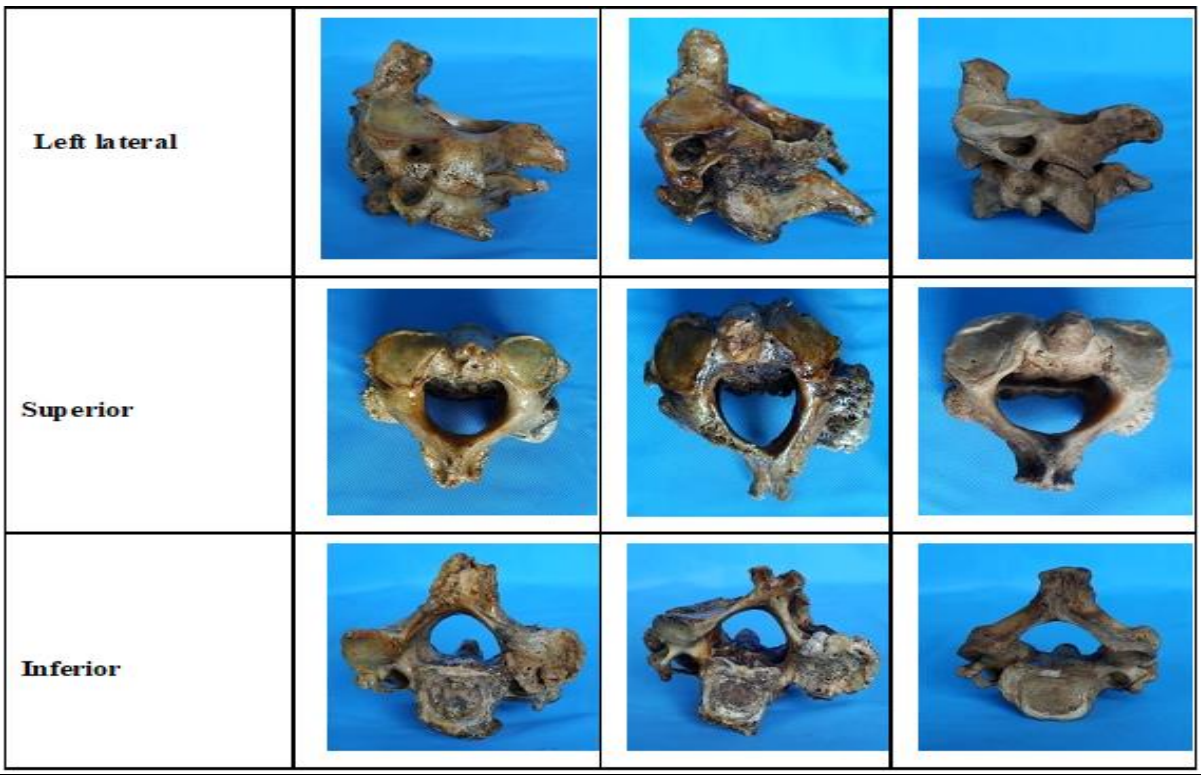

Table 2: Showing features and dimensions of block vertebrae

Feature	Case 1	Case 2	Case 3
Vertebral bodies Height	PF 3.6 cm	PF 3.4 cm	PF 2.8 cm
Pedicles	NF	NF	NF
Laminae	NF	CF on Lt side PF on Rt side	NF on Lt side PF on Rt side
Articular processes	CF	CF	PF on Lt side CF on Rt side
Spinous processes	NF	NF	NF
Vertebral foramen (VF)	Normal	Normal	Normal
Intervertebralforamen (IVF)Diameter	Rt-1.3 cm Lt-0.9 cm	Rt-1.1 cm Lt-0.7 cm	Rt-0.7 cm Lt-0.9 cm
Foramen transversarium (FT) Diameters	C2 Rt-0.9 cm Lt-0.8 cm C3 Rt-0.7 cm Lt-0.7 cm	C2 Lt-0.7 cm C3 Lt-0.7 cm	C2 Rt-0.4 cm Lt-0.5 cm C3 Rt-0.4 cm Lt-0.5 cm

Note: NF- No fusion; PF- Partial fusion; CF- Complete fusion; Lt- Left; Rt- Right.

DISCUSSION

The fusion of cervical vertebra (FCV) has clinical and embryological significance. FCV includes facet fusions, neural arc fusions and block vertebrae. Block vertebrae means the partial or complete fusion of two or more vertebrae, either cartilaginous or bony. In FCV, two vertebrae appear structurally and function as one. In many cases these anomalies are asymptomatic and early diagnosis is by incidental radiographic findings. The fusion may be either congenital or acquired. The fusion could be an isolated feature or a part of the Klippel-Feil syndrome. Congenital FCV is one of the primary malformations of chorda dorsalis, associated with genetic and environmental factors affecting the normal development of occipital and cervical somites during 3rd to 8th week of intrauterine life which is the critical period for vertebral development.[5] Acquired FCV is mostly associated with diseases like tuberculosis, juvenile rheumatoid arthritis or trauma (6). In symptomatic cases the symptoms and signs are shortening of spine in the cervical region, webbed appearance of neck due to unduly prominent trapezius, limited neck movements, torticollis, scoliosis, kyphosis, signs of nerve compression such as hypoesthesia /anesthesia, weakness/paralysis, reduced deep reflexes, and fibrillations.

The incidence of fused cervical vertebrae varies in literature. In a study conducted by Sharma M, on 48 adult dried vertebral columns, the incidence was found to be 6.25% in cervical vertebrae.[7]

Sampada P Kadadi reported an incidence of 1.33% of C2-C3 synostosis on 75 dried adult human axis.[8]

In the present study we observed three axis (C2) vertebra fused with C3 vertebra, accounting for an

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incidence of 1.61% (3 out of 186). Previous reports have shown that upper fused cervical vertebrae cause laxity of ligaments between the atlas (C1) and occiput, resulting in brainstem or cord compression and associated neurological signs and symptoms.[9] The fused cervical vertebrae can cause segmental dysfunction leading to Cervicogenic angina due to cervical nerve root irritation, mimicking true cardiogenic angina.[10] An anatomical explanation to this is narrowing of intervertebral foramen (IVF) in between the fused vertebrae, compressing the structures passing through it. Fused cervical vertebrae may result in disturbance in postural biomechanics causing degenerative changes and disc prolapse at the adjoining segments in advanced age.[4] Hyperextension of neck during endotracheal intubation may precipitate disc prolapse in persons with block vertebrae.

Embryology

Each vertebra develops in three stages successively – blastemal or membranous, cartilaginous and bony.

The vertebral column develops from the paraxial mesoderm, which is divided into a series of cuboidal blocks known as mesodermal somites. Each somite is further differentiated into a ventro-medial sclerotome and a dorso-lateral dermo-myotome. The polymorphous cells of the sclerotome migrate ventro-medially to form rudiment of centrum around the notochord during 4th week of intrauterine life. Then the sclerotome cells extend dorsally to enclose the neural tube, forming neural arches which meet at the mid-dorsal line to form rudimentary spines. Neural arches on both sides near the centrum give rise to costal elements extending laterally to the segmental myotomes. The adjacent segments of sclerotome are related to an intersegmental artery on each side. A sclerotomic fissure appears in each somite segment dividing the segment

into a less dense cranial part and a more dense caudal part. The caudal part of a somite segment fuses with the succeeding somite's cranial part to form definitive centrum of blastemal vertebra.

The sclerotomic fissure and the surrounding mesenchymal condensation together forms the perichordal disc, which persists as intervertebral disc in adult. The notochordal cells disappear in the centrum except in the center of the disc as nucleus pulposus. The mesenchyme of the perichordal disc persists as annulus fibrosus at the periphery of the disc. Thus the definite centrum of each vertebra is intersegmental and the arteries in adult position are also intersegmental on each side near the middle of vertebral body.

The cartilaginous and bony stages of development then start during the sixth and seventh weeks of intrauterine life respectively. The adult derivatives of the blastemal stage are i) the primitive centrum and parts of vertebral arch joining the centrum form the vertebral body, ii) the vertebral arch (neural arch) form lamina, spine, articular process and transverse process and iii) the costal process form the costal elements of the transverse process. The costal elements of transverse process in thoracic vertebrae form ribs.

Block vertebra results from to embryological failure or alteration in normal somite segmentation and fusion during the third to eighth week of fetal development. Disturbance of Pax-1 gene expression in the developing vertebral column is associated with vertebral fusion anomalies.[11] Decrease in local blood supply to the developing vertebral column can also lead to vertebral anomalies.

CONCLUSION

The knowledge of fused cervical vertebra (FCV) is important for anatomists, orthopaedicians, neurologists, neurosurgeons and orthodontists. Most importantly, anesthetists must be aware of FCV while doing endotracheal intubation where extension of neck is done, which may lead to undue complications ranging from severe neck pain, limited neck movements, hypoesthesia /anesthesia, weakness/paralysis, reduced deep reflexes, fibrillations and even sudden death.

Hence a thorough evaluation of cervical vertebrae should be done using X-ray or Magnetic Resonance Imaging (MRI) for preventing any serious damage. The knowledge of C2C3 synostosis is important for clinicians to rule out syndromes such as Klippel-feil syndrome, Crouzon syndrome, which causes abnormalities in neck movements.

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