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Case Series

UNDERSTANDING THE CLINICAL RELEVANCE OF FUSED VERTEBRAL SEGMENTS AT VARIOUS SITES

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ABSTRACT

Various vertebral abnormalities are found. The vertebral column makes the part of axial skeleton and body weight transmitted through it to appendicular skeleton. Three types of vertebral anomalies considered for present study. (1) Sacralization (complete fusion of 5th lumbar vertebrae with sacrum) commonest, (2) Occiptalization (fusion of atlas with occipital bone) rare, (3) Block vertebrae (partially fused typical cervical vertebrae). These anomalies can be categorized as partial or complete considering the disruption of merging of caudal and cranial process of sclerotome.

Such abnormalities causes altered weight distribution and biomechanical changes leading to increased stress over lumbosacral and sacroiliac joint which cause lower backache. Congenital and acquired anomalies of cervical region can be associate to syndromes like Arnold chairi malformation, Chorda dorsalis, Kippel fiel syndrome, syringomyeliia and other neuropathy due to its relation to surrounding structure. Therefore, our study would be beneficial to anaesthetists, anatomists, neurosurgeon and neurologist and even orthodontist.

KEYWORDS: Vertebra Fusion, Sacralization, Occipitalization, Vertebral Anomalies

Introduction

Vertebral column transmits the weight of the body and contributes to movements and posture. Any skeletal abnormalities related to the vertebrae may alter the normal function of an individual. Congenital or acquired fusion of vertebrae may be encountered by orthopedicians, neurosurgeons, neurologists and orthodontists, as well as by anatomists studying osteological specimens. These types of fusion may produce clinical manifestations ranging from limitation of movement to neurological complications[17,18,20].

Different sites of fusion of vertebrae, from commonest to rarest, include:

- Sacralization of the 5th lumbar vertebra, with reported prevalence ranging from 1–20%; sacralization/fusion involving the sacrum and coccygeal vertebrae has also been reported with variable frequency in different populations[3,9,13,14].
- Occipitalization of the atlas, with a reported prevalence of approximately 0.14–3.63%, and fusion involving typical cervical vertebrae[20–23].
- Fusion of C2–C3 has been reported in approximately

0.4–0.7% of individuals, without clear sex predilection; fusion at C5–C6 and other typical cervical levels is less common[18].

Aims and Objectives

In present study we tried to collect and describe the various sites of fusion of vertebrae with adjacent structures. Their probable cause of fusion and clinical finding related to these conditions.

Materials and Methods

We found variant fusion from commonest to rarest of dried bones, collection from Dept of Anatomy GMC, Haldwani (UK) as completely fused lumbar vertebra with sacrum along with coccyx, complete occipitilization of atlas and partially fused typical cervical vertebrae. All measurements were done with sliding digital vernier caliper.

Observation and Results

- Total length = 14.6 cm.
- Breadth (max)= 10.6 cm.
- Sacral Index =72.60 (range for male 90.5-106).
- Complete Sacralization of L5 vertebra.
- No angulation between L5 and S1.
- 5 pairs of sacral foramina present (prevalence is 7.9-8.9%).
- Lamina of S4 & S 5 not fused in midline.
- Height of sacral hiatus = 3cm, from tip of coccyx.
- Rarest occurrence here complete fusion of coccyx with sacrum, excessive long sacrum.

Clinical Relevance of Case 1

The congenital anomalies of the lumbosacral region include lumbosacral transitional vertebrae (LSTV), first described by Bertolotti in 1917[1]. LSTV can affect the position of the intercrestal line (Tuffier's line), which normally corresponds approximately to L4/L5. Reduced mobility at the L5/S1 junction may increase stress over the sacroiliac and lumbosacral joints and alter weight-transmission biomechanic[9,13].

Figure 1.Sacrum fused completely with 5th lumbar vertebra and coccyx

Symptoms may range from being asymptomatic to low back pain (Bertolotti syndrome), and may be associated with lumbar disc herniation, spinal or radicular pain and lumbar scoliosis. Abnormal stress may also affect ligaments and soft tissues, while degenerative joint changes and bursitis may contribute to symptoms[9,13].

In cases requiring caudal anaesthesia, such as hernia repair, lower-limb surgery or procedures below the umbilicus, altered sacral anatomy may make identification of landmarks difficult and contribute to caudal block failure[11]. In females, fixation of the coccyx associated with vertebral anomalies may limit the increase in anteroposterior diameter of the pelvic outlet, potentially contributing to prolonged second-stage labour and related obstetric complications[10].

- Vertebral foramen
- AP= 3.5cm, Transverse Width = 3.0cm.
- Anterior Arch fused completely with margin of foramen magnum (FM).
- Posterior arch gap in midline of 0.05 cm.
- Lateral mass joint cavity absent , foramen transversarium absent, costotransverse bar absent.
- Foramen magnum=AP= 3.8 cm & W= 3.4 cm (no compression dia >18mm).
- Postertior condylar canal on Lt side only.
- Superior sagittal sinus continues into Lt transverse sinus.

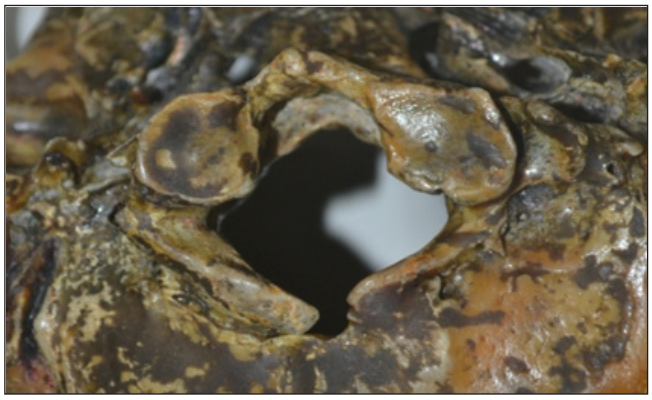

Figure 2.Complete occipitilization of Atlas

Clinical Relevance of Case 2

Atlanto-occipital fusion may cause neurological deficits when the dimensions of the foramen magnum are reduced. Compression of the medulla oblongata, spinal cord, vertebral artery or venous plexus can produce clinical symptoms. Reported manifestations of atlas occipitalization include neck pain, abnormal head and neck pressure, imbalance, lower-limb numbness and ataxia. Vertebral artery compression has also been associated with neurological symptoms such as seizure, syncope and mental deterioration[20]. These clinical associations have been described in case reports and morphologic studies of atlas occipitalization [20–23].

C3-4 / C4-5
Height altogether of both the vertebra = 3 cm

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Figure 3.Partial fusion of body of typical cervical vertebrae

Clinical Relevance of Case 3

Congenital fused cervical vertebrae (CFCV) have been described as "vertebrae critica" and "cervical sacrum." Fusion may increase biomechanical stress at adjacent motion segments, predisposing them to premature degenerative changes, disc injury, fracture of the odontoid process and spondylosis[18].

Clinical manifestations may range from asymptomatic presentation to limitation of movement, myelopathy, muscular weakness or atrophy and sensory loss, particularly in association with Klippel–Feil syndrome[8,17,18].

Discussion

During development, vertebrae originate from somites on either side of the notochord along the craniocaudal axis. The somites differentiate into sclerotome and dermomyotome. The sclerotome undergoes cranial and caudal segmentation, with cells contributing to the intervertebral disc and vertebral body. The mesenchyme surrounding the neural tube subsequently forms the neural arch[19].

The remaining densely packed cells fuse with the loosely packed cells of the immediately adjacent caudal sclerotome to form the vertebral body (mesenchymal centrum). The mesenchyme around the neural tube later forms the neural arch. Vertebral ossification begins during the eighth week of intrauterine life and continues into early adulthood, with primary and secondary ossification centres contributing to the mature vertebra[19].

These developmental processes are regulated by homeobox genes, including Hox genes. During the embryonic period, disturbances in vascular supply and segmentation may contribute to congenital vertebral fusion and abnormal segmentation. Faulty formation, migration and differentiation of sclerotomes can result in cranial and caudal border shifts, producing segmental vertebral anomalies. Experimental studies have shown that deficient functional copies of Pax1 and mutations involving Pax9 can result in vertebral malformations, while Hox gene alterations influence the normal patterning of lumbar and sacral vertebrae and the axial skeleton[12,19]. These developmental mechanisms support the proposed embryological basis of transitional vertebral anomalies[13].

Cervical vertebral fusions may be congenital or may occur secondary to traumatic, degenerative or inflammatory processes[17,18]. An embryological vascular disorder, including the subclavian artery supply disruption sequence, has been hypothesized in relation to Klippel–Feil syndrome [17]. Occipitalization of the atlas may be congenital, related to developmental/genetic factors, or acquired following infection or mechanical injury. Embryologically, occipital and cervical sclerotomes develop early in intrauterine life, and occipitalization may occur when the first cervical sclerotome fails to divide normally, resulting in assimilation of the atlas into the occipital component[20-23].

Conclusion

These anomalies cannot be corrected by surgically interventions as these cases of vertebral malformations carries high mortality and morbidity risks. For avoiding serious consequences of sacralization (fused Lumbar5 & Coccyx1) surgeons and anaesthetist must consider such vertebral anomalies pre-operatively. These vertebral anomalies must be ruled out before operating and injecting anesthesia by radiological techniques along with expert opinion of radiologist. Restriction or absence of movement at atlantocciptal joint is a first sign to draw attention towards occipitlization of atlas. In person with block cervical vertebra, on endotracheal intubation and cisternal puncture, extension of the neck may precipitate disc prolapsed.

The authors confirm contribution to the paper as follows:

- RN– Drafting the article,
- RN & NC-data collection
- RN & HF – draft manuscript preparation
- PS & VSD- analysis and interpretation of results
- All authors reviewed the results and approved the final version of the manuscript.

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Conflicts of Interest

None

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