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An Osteological Study of Atlanto-Occipital Fusion with Embryological Basis and Clinico-Anatomical Correlations

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ABSTRACT

The first cervical vertebra also known as the 'atlas' is devoid of the center and exhibits articular facets on the upper and the lower surfaces of the lateral mass. The superior articular facets of atlas articulate with the articular facets of the occipital condyles to form the atlanto-occipital joint. There are various anatomical abnormalities and variants in the region of the atlanto-occipital junction. The atlanto-occipital fusion reduces the foramen magnum dimensions leading to the neurological complications due to compression of spinal cord, nerves, vessels or instability and mechanical immobility. A total of 150 human adult skulls were examined which were collected from Department of Anatomy, Sri Siddhartha Medical College, Tumkur, India. Each of the skulls was examined in detail. The variations which were present in the atlas vertebra and occipital bone of the skull were noted. Out of 150 dried human skulls studied, we observed atlanto-occipital fusion in one skull. The incidence of atlanto-occipital fusion was 0.67%. The sagittal and transverse diameters of the foramen magnum (36 mm X 34 mm) were within the normal range. Total or partial fusion of the atlas may be noted, the latter being the most common. Most of the time, it exists without any typical symptoms, but sometime may cause orthopedic problems or neurological effects. The serious consequences of upper cervical spinal manipulation with this type of anomaly may occur which may be fatal. Therefore the knowledge of such anomaly is essential for orthopedicians, anaesthetists, and clinicians.

Keywords: Atlanto-occipital fusion, Foramen magnum, Neurological complications.

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INTRODUCTION

The occipital bone forms the back and base of the cranium. The inferior surface of the occipital bone possesses articular processes necessary for articulation with the superior atlantal facets. The inferior articular facets on the occipital bone are usually oval or reniform in shape, with their axis converging anteromedially [1]. The first cervical vertebra also known as the 'atlas' is devoid of the center and exhibits articular facets on the upper and the lower surfaces of the lateral mass. The superior articular facets articulate with the inferior articular facets of the occipital condyles to form the atlanto-occipital joint [1,2]. There are various anatomical abnormalities and variants in the region of the atlanto-occipital junction. The fusion of atlas appears to be the most common in this region [3]. Atlanto-occipital fusion was published in 1911 by Schuller A by radiological examination [4]. Incidence ranges from 0.14% to 0.75% of population with equal sex distribution [5].

During the development of basilar occiput and atlas, the rostral half of the first cervical sclerotome combines with the caudal half of the last occipital sclerotome to form the base of the skull. While the caudal half of the first cervical sclerotome combines with the rostral half of second cervical sclerotome to form 1st cervical vertebra and odontoid process [6]. In small number of cases the disruption of this merging process may result in atlanto-occipital fusion. This condition may be partial or complete.

The atlanto-occipital fusion reduces the foramen magnum dimensions leading to the neurological complications due to compression of spinal cord, nerves, vessels or instability and mechanical immobility. When present, these symptoms (table–1) usually manifest very seldom at early age and present themselves at second decade onwards [7]. The sagittal diameter of the foramen magnum is an important landmark in symptomatic patients. This measure is accepted as abnormal when it is less than 30 mm [8]. Compressions of the spinal cord and vertebral artery may give rise to severe neurological disorders and hypoplasia of the basiocciput. It also causes muscle weakness, ataxia and muscle wasting. Sudden death is also reported in some cases. The present study was carried out to find incidence of atlanto-occipital fusion and discuss its embryological basis and clinical implications.

Table 1: Symptomatology of Atlanto-Occipital fusion

Sl no	Author	Year	Symptoms
1	Kussmaul & Tenner	1859	Convulsions in all 3 reported cases
2	Englander	1934	Cervical pain
3	Hadlay	1948	Neurological Symptoms
4	Keller	1961	Seizure disorder
5	Lopez Zanon et al	1964	Cervical Pain in all 3 reported cases with tonic clonic convulsions in two out of them
6	Budin & Sondheimer	1966	Cervical pain following hyperextension and Onset of cervical pain while putting sweater
7	Albert & Castrischer	1968	Cervical Pain
8	Childers & Wilson	1971	Pain in the neck in some of 25 reported cases; others being either asymptomatic or having insufficient clinical data
9	Vakili et al	1985	Sudden death.

MATERIAL AND METHODS

A total of 150 human adult skulls of Indian origin were examined. These skulls were collected from Department of Anatomy, Sri Siddhartha Medical College, Tumkur, Karnataka, India. Each of the skulls was examined in detail. The variations which were present in the atlas vertebra and occipital bone of the skull were noted and photographed.

RESULTS

Out of 150 dried human skulls studied, we observed atlanto-occipital fusion in one skull. Thus the incidence of atlanto-occipital fusion was 0.67%. A total of 149 skulls (99.33%) did not exhibit any anomalous fusion. The observations were recorded in detail and photographed (fig 1&2). The atlas was completely fused with the occipital bone bilaterally. The maximum transverse width of inferior articular facets on the occipital bone measured 13mm and 22mm on the left and right sides respectively. The maximum vertical length of inferior articular facets on the occipital bone measured 23mm and 14mm respectively. The right and the left transverse process of the atlas were normally developed, each of them containing the transverse foramen, and they were not fused with the occipital bone. The sagittal and transverse diameters of the foramen magnum (36 mm X 34 mm) were within the normal range.

DISCUSSION

The human occipital bone develops from four primary cartilaginous centres laid down in the chondrocranium around the foramen magnum and from a fifth membranous element. Therefore, the occipital bone has a dual developmental origin from the cartilage as well as the membrane. Developmentally, the four cartilaginous elements comprise the basioccipital part lying anterior to the foramen magnum, lateral or the exoccipital part lying on each side of the foramen magnum and the supraoccipital part, which lies posterior to foramen magnum [9]. Researchers have attributed the embryological reasons for the atlanto-occipital fusion due to the failure to differentiate the fused caudal and cranial segments of the fourth occipital and first cervical sclerotomes and the lack of segmentation and separation between the loose and dense zones of the first cervical sclerotome [10]. Jayanti et al [11] have reported two cases of atlanto-occipital fusion with spina bifida of atlas. In the first case there has complete fusion of only one of the transverse process with occipital bone, and anterior arch has fused incompletely. In the second case the anterior arch of the atlas has fused with occipital bone. This skull also has showed complete fusion of only one of the transverse process with occipital bone. Ranade et al⁷ have examined 98 Indian human skulls for atlanto-occipital fusion and noted two cases showing various degree of assimilation of atlas. Gholve et al [12] have retrospectively reviewed all cases of atlanto-occipital fusion in children included in their spine database by reviewing patient charts and imaging studies, in which they have observed 24 boys and 6 girls with atlanto-occipital fusion. Fused anterior arch of atlas has been present in 6 cases; fused lateral masses in 5 cases; fused posterior arch in 4 cases and a combination of these in 15 cases. Nayak et al [13] have observed a skull in which the lateral masses of the atlas have been fused with occipital bone and a foramen between the anterior arch of the atlas and basilar part

of the occipital bone along with absence of hypoglossal canal. Posterior arch has been fused with squama of the occipital bone. The sagittal diameter in our case has been 34 mm and transverse 36 mm. The standard dimensions for foramen magnum range between 28-38mm for the sagittal diameter and between 25-40 mm for the transverse diameter [3].



Fig-1. Showing fusion of Atlas (posterior view) and irregular shape of foramen magnum.



Fig-2. Showing fusion of Atlas (lateral view).

Even though the fusion of atlas is the most common anomaly found in cranio-cervical junction, head and neck surgeons should be aware that such an anomaly may exist without any typical symptoms. Restriction or absence of movement in this articulation may be the first sign which attract the attention of surgeons regarding fusion. The knowledge of fusion may be of importance to orthopedic surgeons. It may be the cause of failure of cisternal puncture, so may be of importance for anesthetist. Physiotherapist dealing with the neck pain and radiologist dealing with abnormalities of cervical spine must also be aware of this condition [13].



CONCLUSION

Total or partial fusion of the atlas may be noted, the latter being the most common. Most of the time, it exists without any typical symptom, but sometime may cause orthopedic problems or neurological effects. The serious consequences of upper cervical spinal manipulation with this type of anomaly may occur which may be fatal. Therefore the knowledge of such anomaly is essential for orthopedicians, anaesthetists, and clinicians.

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