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MORPHOLOGICAL STUDY

Atlanto-occipital fusion: an osteological study with clinical implications

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Abstract: *Background:* Atlanto-occipital fusion may be symptomatic or asymptomatic in nature. The anomaly may be incidentally detected at autopsies or during routine cadaveric dissections. The fusion of the atlas with occipital bone may result in the compression of vertebral artery and first cervical nerve.
Methods: A total of 55 dried occipital bones in the Department of Anatomy, Universiti Kebangsaan Malaysia (UKM) and Department of Anatomy, Universiti Malaya (UM) were included in the study. The presence of atlanto-occipital fusion was closely observed and morphometric measurements were taken.
Results: Out of 55 dried occipital bones studied, we observed atlanto-occiptalization in two bones (3.63 %). A total of 53 occipital bones (96.37 %) did not exhibit any anomalous fusions. Out of the two anomalous atlanto-occiptal fusions, one was complete while the other had unilateral right-sided fusion of the atlas with the occipital bone.
Conclusion: Atlanto-occipitalization may result in the compression of vertebral artery thereby influencing the blood flow to the brain. Atlanto-occipitalization may also result in compression of the first cervical nerve. The action of the postural muscles on the extensor surface may be affected as a result of this anomaly. The present article discusses the clinical implications of atlanto-occipitalization, which may be beneficial for neurosurgeons, neurologists and radiologists in day-to-day clinical practice *(Fig. 3, Ref. 17)*. Full Text in free PDF *www.bmj.sk.*
Key words: Aalanto-occipital fusion, vertebra, anomaly, anatomy.

The occipital bone forms the back and base of the cranium (1). The inferior surfaces of the occipital bone posses articular processes necessary for articulation with the superior atlantal facets (1). 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 (1, 2). The upper articular facets i.e. superior articular facets articulate with the inferior articular facets of the occipital condyles to form the atlanto-occipital joint (1, 2).

The atlanto-occipital joint is a synovial type of joint covered with hyaline cartilage. The joint acts around transverse and antero-posterior axes but not around the vertical axis (1). Standard textbooks of anatomy do not highlight much on the fusion of the atlas with the occipital bone, hence the research reports are the only source of information.

The first radiological report of atlanto-occipital fusion was published in 1911 (3). A detailed search of the extant literature depicts only few isolated cases of craniocervical anomalies reported in the past (4, 5, 6). An earlier study on 25 cases revealed the presence of this craniovertebral anomaly in the early fifties (7).

In the normal population, the incidence of atlanto-occipital fusion varies between 0.14 – 0.75 % (8, 9). Reports depict that the incidence of atlanto-occipitalization ranges between 0.5 – 1.5 % in the Caucasian population (10). On many occasions, the presence of the anomaly may incidentally be detected during routine autopsies or cadaveric dissections.

The anomalies pertaining to the atlas and occipital region assume great clinical importance because of the presence of the first cervical nerve and vertebral artery on the superficial aspect of the atlas vertebra. It should be noted that the vertebral artery is an important blood vessel related superiorly to the atlas vertebra and any compression of the artery may compromise the blood flow to the brain. Similarly, the compression of the first cervical nerve may cause neurological symptoms. Many authors reported the neurovascular complications arising out of atlanto-occipitalization (11, 12). Thus, this craniovertebral anomaly assumes many clinical implications.

To the best of our knowledge, there are no research reports on the incidence of this anomaly in the South East Asian population. Keeping this in mind, we embarked on this study with the main aim of studying the anomaly in human dried bones in the Malaysian region. We as anatomists also believe that the knowledge and discussion on the atlanto-occipital fusion may be immensely beneficial to radiologists, neurologists and neurosurgeons in their clinical practice.

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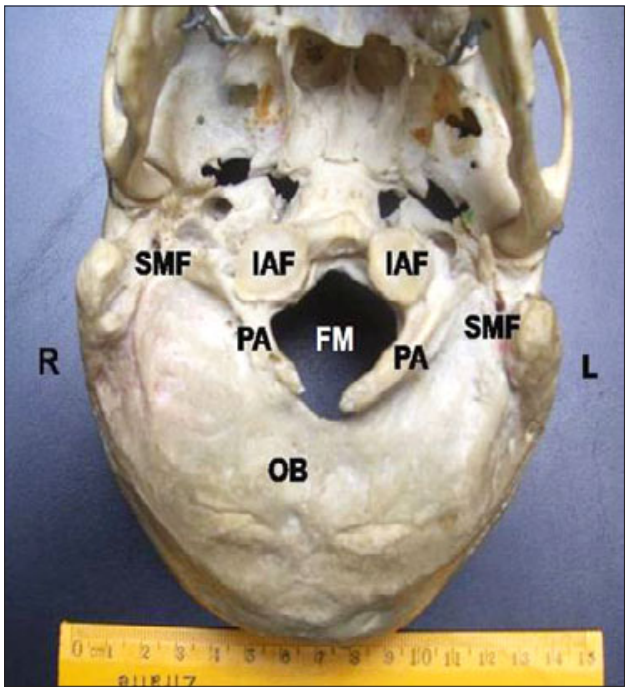

Fig. 1. Photograph of the base of the skull with right sided atlanto-occipital fusion showing: SMF – stylomastoid foramen, IAF – inferior articular facets, PA – posterior arch, OB – occipital bone, FM – foramen magnum, R – right side, L – left side.

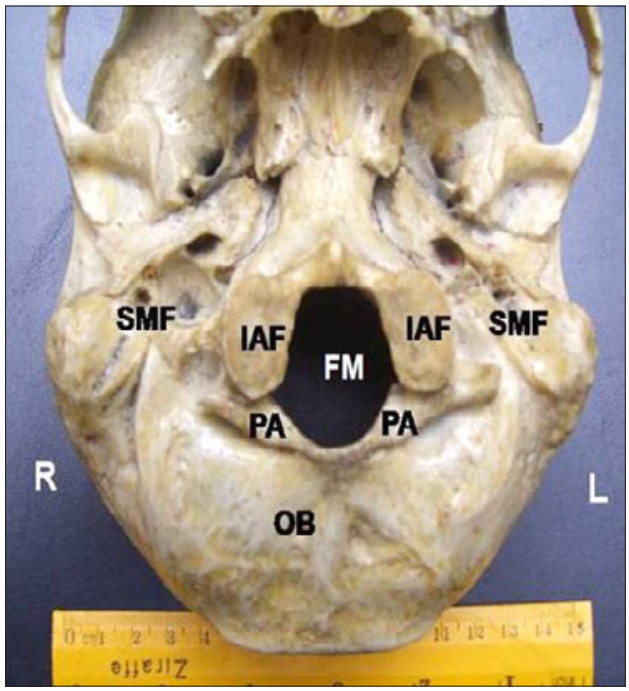

Fig. 2. Photograph of the base of the skull with atlanto-occipital fusion on both sides showing: SMF – stylomastoid foramen, IAF – inferior articular facets, PA – posterior arch, OB – occipital bone, FM – foramen magnum, R – right side, L – left side.

Materials and methods

A total of 55 occipital bones at the Department of Anatomy, Universiti Kebangsaan Malaysia (UKM) and Department of Anatomy, Universiti Malaysia (UM) were included in the study. The dried bones were studied in detail. Appropriate measurements were taken and the specimens were photographed (Figs 1, 2, 3).

Results

Out of 55 dried occipital bones studied, we observed atlanto-occiptalization in two bones (3.63 %). A total of 53 occipital bones (96.37 %) did not exhibit any anomalous fusions. Out of the two anomalous atlanto-occiptal fusions, one was complete while the other had unilateral right-sided fusion of the atlas with the occipital bone. The observations were recorded in detail

Unilateral atlanto-occipitalization (Fig. 1)

In one of the specimens, the atlas was fused to the occipital bone unilaterally on the right side. An aperture of 3.9 cm was present between the occipital and atlas bones. There was an asymmetry in the size of the inferior articular facets (IAF in Fig. 1) on the occipital bone. The maximum transverse width of the IAF measured 1.9 cm and 1.7 cm on the right and left sides, respectively. The maximum vertical dimensions of the IAF measured 1.6 cm and 1.3 cm on the right and left sides, respectively. The left posterior arch was complete. The right posterior arch extended 2.8 cm from the right inferior articulating facet leaving a deficit between it and the left posterior arch. A small canal was observed on the right side which may have transmitted the superficial structures on the superior surface of the atlas i.e. the vertebral artery and the first cervical nerve.

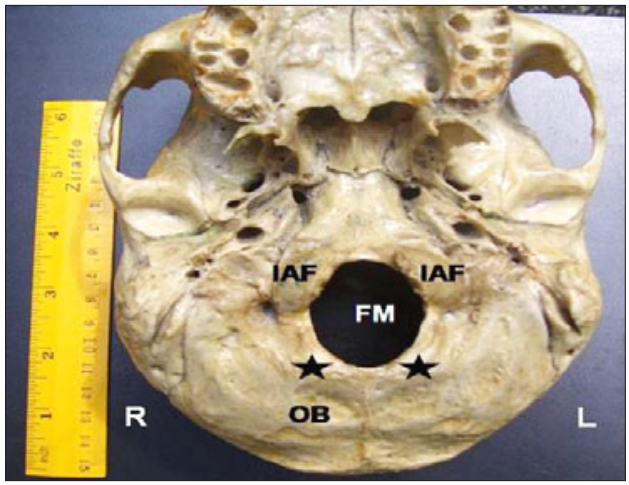

Fig. 3. Photograph of normal base of the skull showing: IAF – inferior articular facets, PA – posterior arch, OB – occipital bone, FM – foramen magnum, R – right side, L – left side, * – the margins of the foramen magnum devoid of any anomalous fusion of atlas.

Bilateral complete atlanto-occipitalization (Fig. 2)

In the other specimen, the atlas was fused with the occipital bone bilaterally on both sides. A small foramen was present an-

terior to the anterior tubercle of the atlas. The maximum transverse width of IAF on the occipital bone measured 1.4 cm and 2.2 cm on the left and right sides, respectively. The maximum vertical length of the IAF on the occipital bone measured 2.2 cm and 1.5 cm, respectively. A small foramen was observed on the superior surface of the atlas vertebra on both sides. We assume that this foramen may have transmitted the vertebral artery, as there was no gap between the inferior aspect of the occipital bone and the atlas vertebra on both sides.

The normal occipital bone did not exhibit any fusion of the atlas (shown with asterisk in Fig. 1). They were photographed to compare the anomalous findings (Fig. 3).

Discussion

The human occipital bone develops from four primary cartilaginous centers laid down in the chondrocranium around the foramen magnum and from a fifth membranous element (13). 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 the foramen magnum (13). The membranous part gives rise to the interparietal bone (13).

Researchers have attributed the embryological reasons for the atlanto-occipitalization 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 (14).

Research reports depict that atlanto-occipital fusion is often associated with bony torticollis (7, 15). There are reports of a wide range of neurological signs and symptoms, which may even vary from a transitory headache to a fully-fledged neurological syndrome (14). Admittedly, we did not have any clinical history of the subjects to corroborate this fact. Research reports have also depicted a high incidence of vertebral artery anomaly, which may be associated with anomalies of the atlanto-occipital region (16).

In the present study, we observed unilateral and bilateral atlanto-occipital fusions in two of the specimens and on both sides, small foramina were present. Perhaps this small foramen might have been responsible for the transmission of the vertebral artery and the first cervical nerve but this is a mere assumption. An earlier research study also observed the presence of a bony tunnel on the upper surface of the posterior arch of atlas vertebra with an aberrant course of vertebral artery (14). Based on our findings and past reports, it may be opined that anomalous atlanto-occipital fusion may be associated with the bony tunnel and aberrant course of vertebral artery.

In the unilateral right-sided atlanto-occipital fusion, we found a tilting of the atlas towards the right side thereby giving rise to an asymmetry of the skull base. Earlier studies have described the asymmetries of the skull base altering the neurocranial morphology due to occipitocervical synostosis (14).

An important aspect of the atlanto-occipital fusion is that not all cases can be easily distinguished from the Arnold Chiari malformations as the pathophysiology of both are similar (17). The presence of anomaly may even compress the spinal cord giving rise to neurological complications.

In the present study, the atlanto-occipital fusion may have compressed the vertebral artery, the first cervical nerve and the posterior atlanto-occipital membrane, all of which are related to the posterior arch of the atlas. The involvement of the first cervical nerve could have affected the four important suboccipital muscles i.e. rectus capitis posterior major, rectus capitis posterior minor, obliquus capitis superior and the obliquus capitis inferior muscles. These are postural muscles with the primary action of extension of the head. Thus, atlanto-occipital fusion could have given rise to an abnormal posture of the head. In the present study, the unilateral right-sided atlanto-occipital fusion might have resulted in the possible symptoms being more pronounced on the right side.

Conclusion

Neurosurgeons operating on the atlanto-occipital region may need to have prior knowledge about the presence of such anomalies. The presence of the atlanto-occipital fusion may also lead to erroneous interpretation of skiagrams. Often, it may mimic a displacement of the vertebra or any other pathological conditions. We as anatomists thereby conclude that the knowledge of the atlanto-occipital fusion may be important for neurosurgeons, neurologists, radiologists in their day-to-day clinical practice.

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