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Variations of the superior articular facets of atlas vertebrae

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The description of the superior articular facets of the atlas vertebra as found in most of the text-books of anatomy makes no mention of its variations. The different shapes of the facets have been variously described as concave, deeply concave, oval, elongated, kidney-shaped by Schaeffer (1942), Brash (1951), Hamilton *et al.* (1958), Johnston, Davies & Davies (1958), Breathnach (1958), Woodburne (1961) and Sahana (1962). Constrictions or notches on the inner or outer border, or both borders of these facets tending to subdivide them are mentioned by some of these authors. The presence of a groove dividing the facet has been described by Bryce (1915), Huber (1936), and Wood Jones (1950). No information is available regarding the frequency of such a condition, the processes leading to it and its significance. The present description gives an account of the superior articular facets of 200 dried, adult atlas vertebrae collected from different sources and deals with the division of the facet, its frequency and possible explanation.

OBSERVATIONS

Shape and size. The superior articular facet of the atlas varies greatly in its shape and size. It occupies most of the upper surface of the lateral mass and lies obliquely, its anterior end being always nearer the mid-line than the posterior. Sometimes one facet is considerably smaller than the other (Fig. 1, 37). The facets are usually concave, some deeply so, but some are almost plane facets (Fig. 1, 37, 20).

Concavity is present in both longitudinal and transverse directions but more marked in the former. In the long and deeply concave facets the anterior part may face backwards and the posterior forwards in addition to the general direction, i.e. upwards and medial (Fig. 1, 129, 165). The facets are tilted downwards and inwards, the outer margin being at a higher level. Hence the general direction of the facets is upwards and medially.

The typical oval, elongated or kidney-shaped outline mentioned in various text-books is found in a very few cases. Most of the outlines are irregular. The presence of constrictions and various curvatures gives them a large variety of shapes. No two vertebrae are alike in this respect. Even the shape of the right and left superior facets in the same vertebra differs in a number of cases. A notch on the medial side of the facets makes it kidney-shaped, but such a notch is often present on the lateral side alone (Fig. 2, 102).

If a constriction or the notch is present on both sides of the facet the shape may become a figure of eight, specially when a groove is present connecting these constrictions (Fig. 2, 123). With the extension of these constrictions towards the centre of the facet, the outline becomes dumb-bell shaped (Fig. 2, 147, 157). The constric-

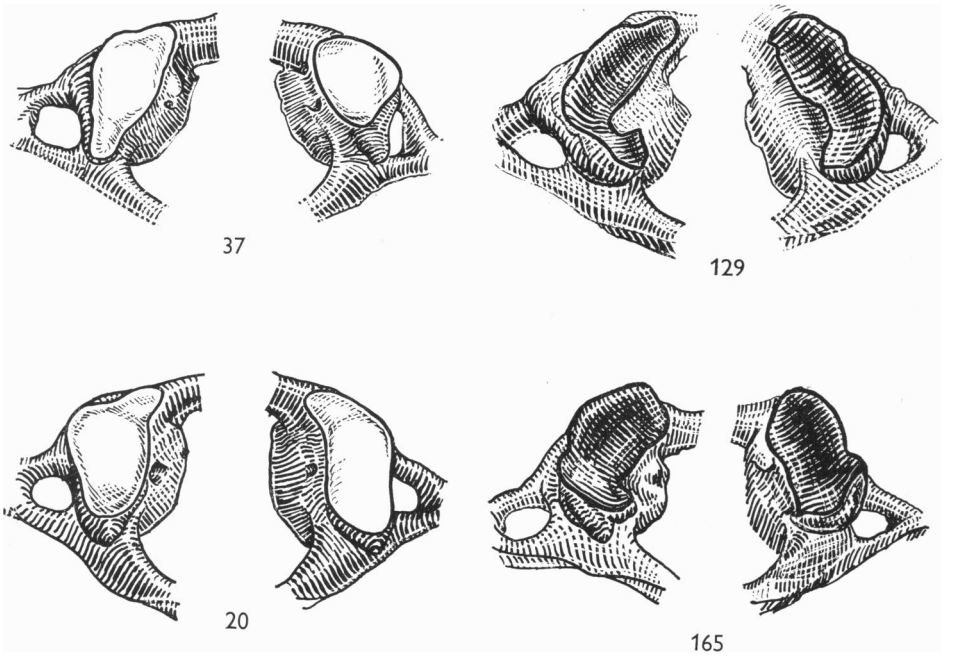

Fig. 1. A set of four atlas vertebrae, two showing almost plane facets (37, 20) in contrast to the markedly concave facets in the other two (129, 165). In vertebrae 37 and 20, the size of the two superior articular facets is different in the same vertebra.

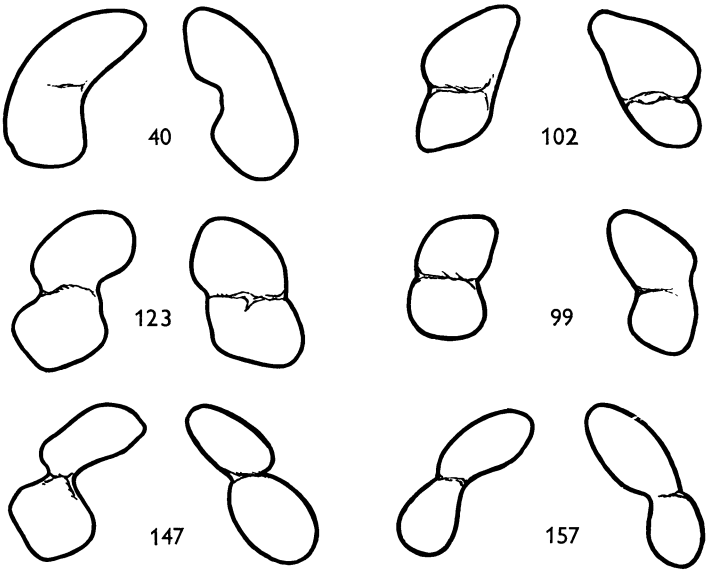

Fig. 2. A set of six atlas vertebrae showing various degrees of constrictions affecting the shape of the superior articular facets. Kidney-shaped (40), notched laterally (102), figure of eight (123, 99), dumb-bell shaped (147, 157). Grooves are also present along with some of the constrictions.

tions may extend further and the facet may be incompletely or completely divided into two. The divisions may lie close to each other or may be clearly separated (Fig. 4, 149, 153).

Constrictions. The presence of constrictions on one or both sides of a facet as described in the text-books has already been referred to. The presence of such a notch or notches as seen in the left and right facets of the 200 vertebrae is shown in Table 1.

Table 1. *Presence of constrictions in the superior articular facets*

	No constriction	Constriction on medial side only	Constriction on lateral side only	Constrictions on both sides	Total
Left facets	42	6	14	138	200
Right facets	53	8	5	134	200

These constrictions are marked in about 45 % of cases and well advanced in another 20 % cases. About 50 % of the vertebrae have similar degrees of constrictions on both borders of the superior facets and in 20 % of the vertebrae all the four constrictions in the two superior facets are alike and of the same degree.

Groove. A groove of variable depth and breadth has been seen to be present in these facets either throughout the whole or part of the breadth, i.e. in the centre or on the medial or lateral side (Figs. 2, 4). The surface of the superior articular facets as seen in the dry bones is not very smooth and presents roughness. Roughly circular pressure facets are present in most of the cases in the anterior and posterior parts of the superior facets, indicating possibly greater pressure at these sites during the movements at the atlanto-occipital joints. These pressure facets are separated from each other by a variable interval within the articular area (Fig. 3). Sometimes they adjoin and an irregular interval having grooves and ridges separates them. Sometimes the groove is well defined and deep and along with the constrictions may divide the facet into two. The width and depth of the groove are variable.

The frequency of such grooves in the 200 vertebrae is shown in Table 2. These are marked in about 30 % and are well advanced in 4–7 % of cases. Symmetrical grooves in both the facets of the same vertebrae have been seen in 27 % of cases. The presence of grooves is associated with the presence of constrictions in 94–98 % of cases and the grooves are found at the same level as the constrictions.

Pressure facets. The smooth roughly circular impressions, usually two on each articular surface, already referred to are present in most of the vertebrae. Such pressure facets do not seem to have been described previously. These are quite evident even in some of those vertebrae which show no signs of division of their superior articular facets by grooves or notches. In some cases these are so marked (Fig. 3) that the rest of the articular area looks non-articular, though it lies within the outline of the superior facet.

Tendency for separation. Division of one facet into two, or the tendency towards it as indicated by the presence of constrictions or grooves or both, has been seen in a large number of cases. Only twenty-nine vertebrae out of the 200 show no such tendency on either superior facet while the rest, 171 vertebrae, show it on

one or both the facets. The tendency to separation has been divided into three degrees; present, marked and well-marked and separation into two categories, incomplete and complete. Table 3 shows the findings in the 200 vertebrae.

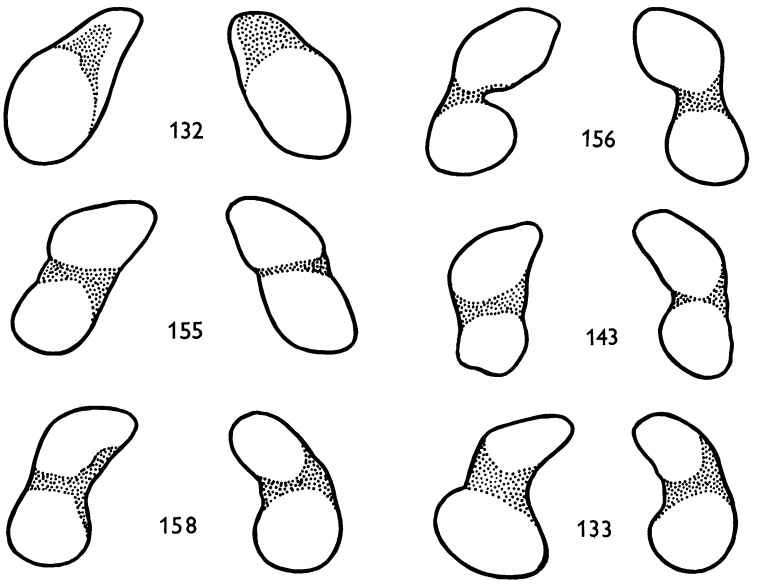

Fig. 3. A set of six atlas vertebrae showing pressure facets within the articular areas. The stippled areas, though within the margin of the articular facets, are rough and irregular in contrast to the uniformly smooth concave areas. The stippled areas may in due course get converted into grooves, separating adjacent pressure facets.

Table 2. *Presence of grooves in the superior articular facets*

No groove	Groove on left facet only	Groove on right facet only	Groove on both the facets	Total
52	23	16	109	200

Table 3. *Tendency to separation in the superior articular facets*

Amount of separation	Left facet only	Right facet only	Both facets
None	11	17	29
Present	17	18	12
Marked	40	36	22
Well-marked	17	27	15
Incomplete	19	10	5
Complete	10	6	3
Total	114	114	86

Thus the tendency to separation is almost equal on both the left and the right sides though the separation (incomplete or complete) into two facets is more frequent on the left side. Complete division of one superior facet into two is present in twenty-two out of the 400 facets, i.e. 5·5%. In some cases the completely separated facets are 5 mm. apart (Fig. 4, 153).

DISCUSSION

The large number of variations seen in the shape, size and depth of the superior articular facets of the atlas vertebrae indicate that the atlanto-occipital joint is correspondingly variable. Pressure facets present in the anterior and posterior parts of the articular area seem to be due to greater pressure of the occipital condyles at these sites. The intervening and surrounding areas probably take a lesser part in the movements and tend gradually to become non-articular. Constrictions appear at the borders of the facets and the rough area between the pressure facets tends to form a groove.

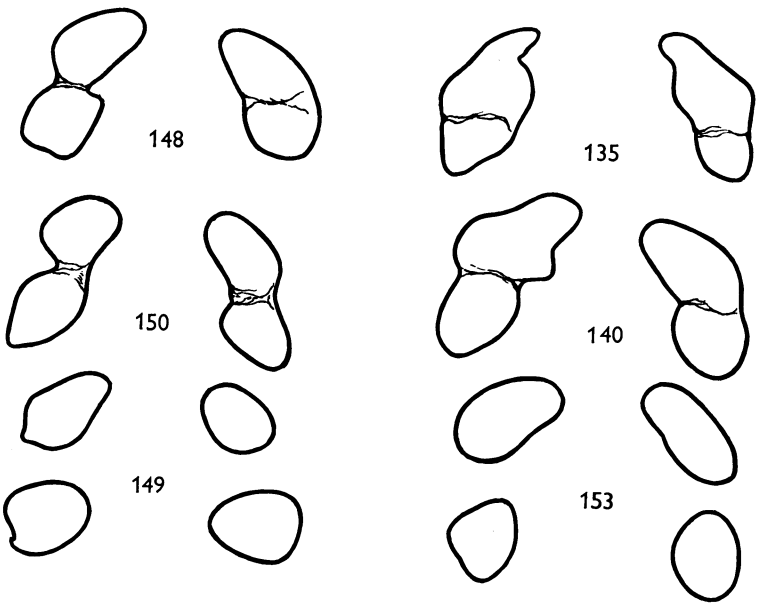

Fig. 4. A set of six atlas vertebrae showing various degrees of separation due to the presence of grooves and notches. In vertebrae 148 and 135 there is a tendency for separation, well-marked in the left facet of the former. Vertebra 150 shows almost a complete separation. Vertebra 149 and 153 show complete separation of one facet into two which are lying well apart from each other.

The formation of a craniocervical joint has been the result of many trials. Every imaginable combination has been present and is still seen in some fish. The morphological trends have been the result of trial and error as determined by the chief function of the joint required by the mode of life of the creature. There are many different ways in which creatures use their heads and each habitual motion reacts upon the articulating units. The primitive triple condyle of the occipital has all these units of equal size, i.e. the basioccipital with a ventral median condyle nearly circular and the lateral occipitals with elongated lateral condyles situated dorsally on each side (Fig. 5).

This has been followed either by preponderance of the lateral units as in amphibia or the gradual enlargement of the median unit combined with the recession of the lateral ones until the single condyle of the birds is reached. In mammals the large

paired, lateral condyles are the prominent feature and the basioccipital has withdrawn from the odontoid. The bicondylar joint thus restricts the movements of the head to nodding, the turning to one side being possible at other vertebral joints. The occipital and the vertebral components of the atlanto-occipital joint have been both in a state of flux. Large number of variations are seen in the two bones and varieties of atlanto-occipital fusion have been described (Lanier, 1939; Jain, 1956; Kolte & Mysorekar, 1963). Nor are fusions of atlas with axis uncommon. The first two cervical vertebrae are still capable of variations which may lead to new adaptive changes (Gaskell & Green, 1933). The tendency of the superior articular facets of the atlas to split into two separate facets seems a step in that direction and this tendency is probably an indication of further restriction of movements at the atlanto-occipital joint.

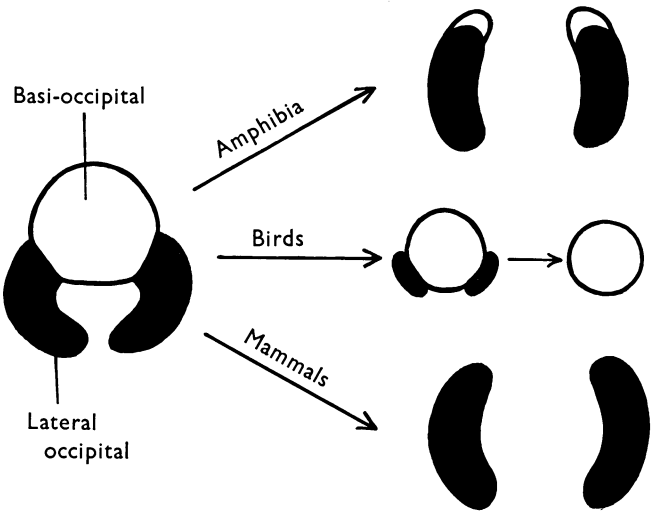

Fig. 5. The primitive triple condyle of the occipital bone and its modifications that have occurred during evolution. In amphibia the lateral units have become dominant. In birds the median unit has gradually increased along with recession and ultimate exclusion of the lateral units while in mammals reverse changes have taken place where only lateral units are present.

SUMMARY

The superior articular facets of atlas have been studied in 200 vertebrae. The large variety of shapes of the superior facets present a marked contrast to the almost constant shapes of the inferior articular facets. Pressure facets within the articular area have been observed. The frequency of the constrictions and grooves on the superior facets has been noted, this indicating a tendency for division of one facet into two. Such a tendency has been found in 171 out of the 200 vertebrae. Complete separation of one superior facet into two has been seen in twenty-two facets, i.e. 5·5 %. The significance of these observations is discussed.

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