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**Anatomy.** — *"On the topographical relations of the Orbits in infantile and adult skulls in man and apes"*. By Prof. L. BOLK.

(Communicated in the meeting of March 23, 1918).

In the Proceedings of this Academy of 1909 two papers by the present author were published, dealing with the position, shifting and the inclination of the Foramen magnum in the Primates. In these papers it was shown that the topographical relations of this Foramen in the infantile skulls of the Primates and more particularly with the Anthropomorphous apes present only small deviations from those in the human skull. It is only in their subsequent growth that a difference between the development in man and the Primates becomes apparent. This difference comes in the main to this that in man the original topograhical relations, such as are found in the infantile skull, are permanent, the skull retaining infantile characteristics; in the remaining Primates, on the other hand, and especially in the Anthropoid apes, these juvenile conditions are replaced by others. The chief phenomenon, which may be briefly stated afresh here, is that in infantile skulls of man and anthropoid apes the foramen magnum lies in the middle of the cranial base, and during growth is shifted backwards over a longer or shorter distance in the direction of the occipital pole of the cranium, while in man it remains situated in the anterior half of the cranial base. It is difficult to reconcile this result of my investigations with the conception, often met with in literature, that the more occipital position, as found in these apes, would be the original one, so that it would be in man that a forward shifting would take place. Now of such a forward displacement, presumed on theoretical grounds, nothing appears during individual development in man. On the contrary. From about the eighth year, i.e. in conjunction with the commencement of the loss of the milk-teeth, also in man a slight backward shifting is stated, which is not of much significance, however. So the characteristic difference between the human and anthropoid skulls is that in the former infantile, not to say foetal, characteristics are retained. While the infantile skulls of man and anthropoid apes thus show a great similarity in this respect, the adult skulls grow dissimilar, and it is not the human but the antropoid skull which deviates more and more from its original shape.

The object of the following communication is to draw the attention to an analogous phenomenon in an entirely different part of the skull, namely in the orbital region, and regarding more particularly the following question: what are the topographical relations of the orbits in infantile and adult skulls of Primates? The answer to this question gives an insight into the phenomena of growth in this border-region between the cerebral and facial skull. These are well fitted to give a definite shape to our conception about the morphogenetic relation between the human and anthropoid skull. In this communication the main points only will be stated, the more extensive paper will be published elsewhere. For the present purpose the best starting-point is a form in which the differences in topography between the infantile and adult skull are as large as possible, their character thus being clearly revealed. The Gorilla skull serves this purpose well.

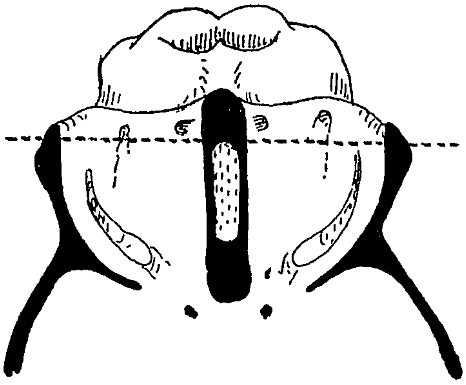

Fig. 1.

We shall mainly deal with the topographical relation of the orbits in regard to the cranial cavity. The easiest way of surveying this

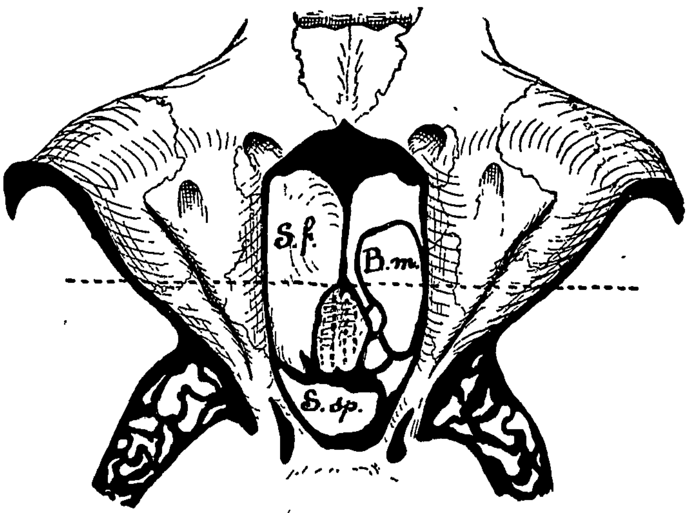


Fig. 2.

is by means of horizontal sections, passing through the middle of the orbits. In fig. 1 such a section is sketched through the skull of a young Gorilla child, in fig. 2 through that of an adult male individual.

In the lateral wall of the orbit in the infantile skull two parts may be distinguished, an anterior one which borders the orbit outwardly and forms the free outer wall of the orbit, and a posterior one forming a partition between the orbit and the fossa media of the cranial cavity. Between these two parts the lateral wall of the cerebral cranium is connected with the lateral wall of the orbit. This arrangement implies that the cranial cavity partly extends laterally of the orbit, in other words that this cavity partly enters into the Cavum cranii, so that there exists a common partition-wall between the Cavum orbitae and the Cavum cranii. Upwards in the direction of the roof of the orbit this partition-wall between the two cavities becomes larger, as the cranial wall frontally more and more joins the supra-orbital ridge. The free exterior wall thus becomes smaller and is entirely lacking near the roof of the orbit in the youthful Gorilla skull, as the cranial wall is attached to the orbital roof along the supra-orbital arch. Thus the whole orbital roof has become the partition between this cavity and the Cavum cranii. This means that in the infantile Gorilla the orbits lie entirely under the cranial cavity.

How is this in the adult skull?

It appears from fig. 2 that now on the lateral wall of the orbit the just-described two parts can no longer be distinguished; the posterior intracranial part has disappeared, since the lateral wall of the skull is attached as far backward as possible to the lateral wall of the orbit. The whole lateral wall has become an outer wall. From a topographical viewpoint this means that the orbit no longer enters into the cranial cavity, but has come to lie before it. This conclusion is confirmed by a closer examination of the orbital roof. In the infantile skull the frontal wall of the cranial cavity is attached to the orbital roof along the circumference of the orbit, which means that the whole roof of the orbit forms a partition between the cranial and orbital cavities and does not form a free exterior wall. In the adult individual, on the other hand, the cranial roof is attached to the orbital roof very much towards the back, as is seen from fig. 3, representing a sagittal section through the orbit of an adult Gorilla. The roof of the orbit has here for the greater part become a free exterior wall.

From this short comparison it already appears that the topographical relations of the orbit with regard to the cranial cavity are very different in the young and the adult Gorilla. This difference may be briefly summarised as follows: in the young individual the orbit for the greater part enters into the Cavum cranii, in the adult individual it lies *before* the cranial cavity. So there is a forward displacement during growth, caused by lengthening of the orbit in a forward direction only. By the aid of figs. 1 and 2 this can easily be proved if the Septum orbitale is particularly kept in view. In both figures the section passes exactly above the Lamina cribrosa, i. e. through the anterior extreme part of the cranial cavity.

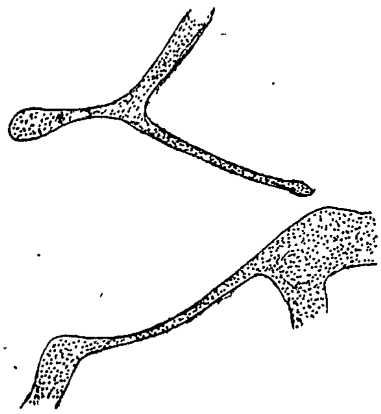

Fig. 3.

In the septum orbitale of the infantile skull three parts may be distinguished, a middle one, formed by the Lamina cribosa, an anterior and a porterior part. Also in the adult skull these three parts are visible in spite of the pneumatising. Comparison now shows that the lengthening of the septum is almost entirely brought about by the increase in length of that part of it which lies before the lamina cribrosa. One has only to compare the dotted lines in the two figures, indicating the plane through the anterior edge of the Lamina cribrosa. These lines are also serviceable for gaining an insight into the forward shifting, resulting from this mode of growth. In the small young skull almost the whole of the orbital cavity lies behind this line, in the adult skull only the posterior part.

Thus the growth of the skull of Gorilla has an evident influence on the position of the orbits with regard to the cranial cavity. That this is accompanied by a considerable change in the shape of the orbital cavity, is also perceived by comparing figure 1 and 2. In the adult skull the posterior part of the orbit has been drawn out in the shape of a funnel or canal.

The change of position of the orbit caused by growth can be illustrated in a simple manner by projecting the outlines of this cavity on the median plane, which is easily done by means of the well-known Martin pantograph. Fig. 4 shows such a projection taken from the skull of a Gorilla child in which the tooth-change had commenced (the medial incisors have been changed; fig. 5 a similar projection of the skull of an adult man [1]). The cranial base is partly, the

[1]) Fig. 5 is on a smaller scale than fig. 4.

outline of the cranial cavity entirely indicated. Position and direction of the lamina cribosa are also shown. To the transformation of the cranial cavity during growth, chiefly consisting in a flattening,

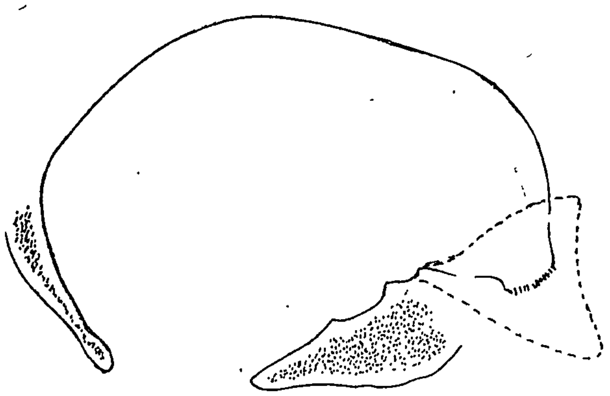

Fig. 4.

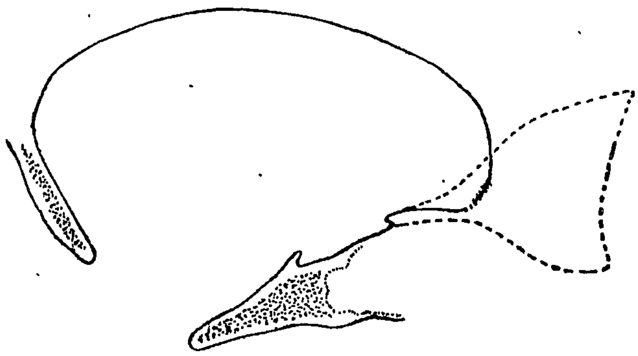

Fig. 5.

attention may be passingly drawn. These figures require little explanation, the change in the topographical relation of the orbits with regard to the cranial cavity is seen at a glance. It should only be, pointed out that the shifting of the orbits quite before the cranial cavity must be regarded as the direct cause of the origin of the very strong bony ridge characterising the anterior part of the cerebral skull of Gorilla. This bone-ridge is, as also appears from fig. 3, nothing but the necessary upward enclosure of the orbital cavity, the newly-grown roof of this cavity. Without this bone-ridge the orbit would lack an upper bony enclosure.

Before proceeding to a description of the conditions in man, we shall briefly sketch those in the two other anthropoids by means of a few projection figures. Figures 6 and 7 refer to a young Orang still in possession of its complete milk-dentition, and to an adult individual of this genus. More strongly still than was the case with Gorilla the topographical change of the orbits with regard to the cranial cavity appears in these two individuals. This is mainly the result of the circumstance that the little skull of the Orang child was so much younger than that of the Gorilla child. With this

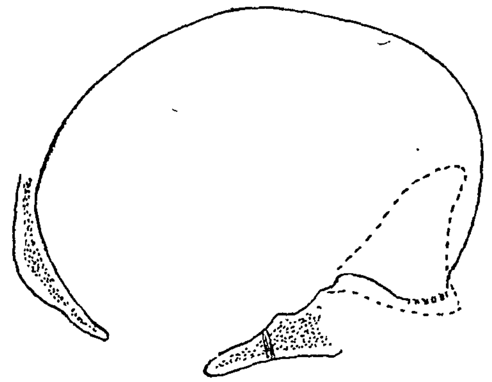

Fig. 6.

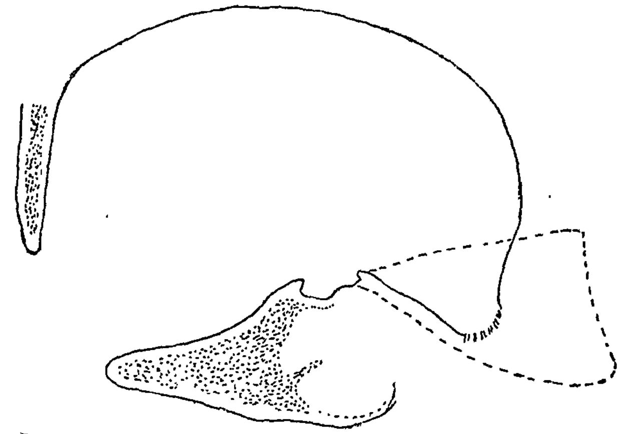

Fig. 7.

very young Orang the orbit is still entirely enclosed by the cranial cavity, the whole roof of the orbit is here still the floor of the anterior cranial cavity. In the adult Orang the orbit has come much more forward. So here also a considerable forward shifting has taken place. In orang this was not accompanied by the formation of a ridge as in Gorilla, firstly because the orbits and in particular their roof did not advance so far before the cranial cavity, and secondly because the anterior cranial wall in Orang had thickened evenly.

The changes in the topographical relations with Chimpanzee appears when we compare figures 8 and 9. With this genus the forward shifting is smaller again than with Orang, although still considerable. The projection in fig. 8 has been taken from a little skull with complete milk-dentition, that of fig. 9 from an adult skull.

From this short summary it appears that the three anthropoids agree in this that as the result of certain phenomena of growth the topographical relation of the orbits with regard to the cranial cavity

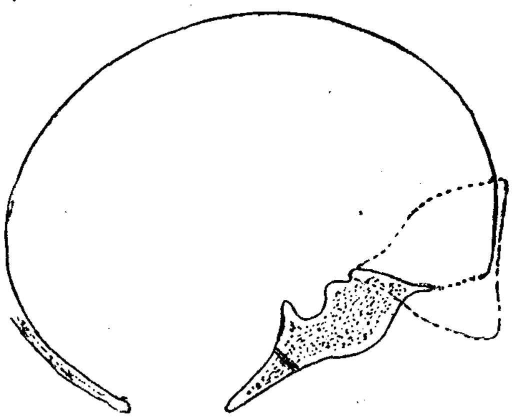

Fig. 8.

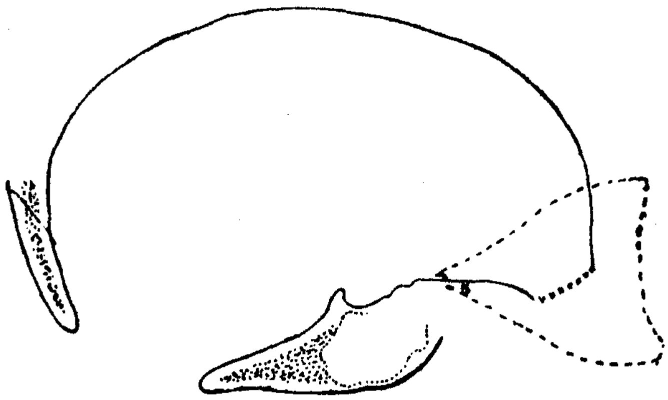

Fig. 9.

is altered. The chief change is that in the infantile antropoid ape the orbits lie under the cranial cavity, in the adult individual more in front of it. This is most strongly seen in Gorilla, where almost the whole orbit lies before the cranial cavity. The sagittal sections

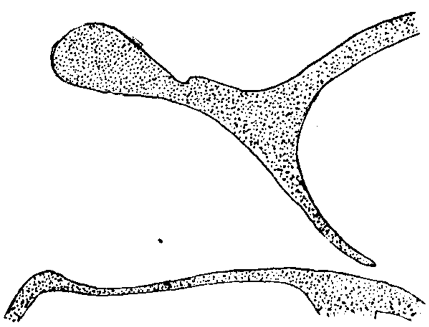

Fig. 10.

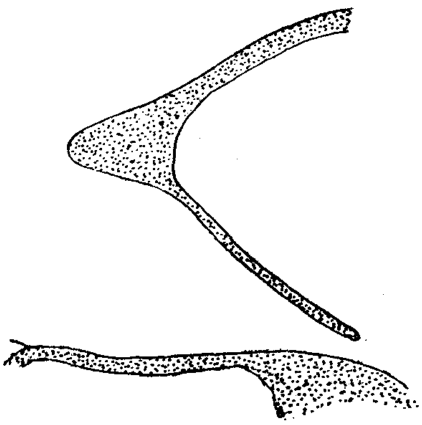

Fig. 11.

through the orbit in fig. 10 (Chimpanzee) and fig. 11 (Orang) when compared with those of fig. 3 (Gorilla) show this difference in shifting with the three Anthropoids very distinctly.

What is now observed in man? We refer in the first place to figs. 12 and 13. In 12 a horizontal section is given through the orbits of a new-born infant, in 13 through the orbits of an adult individual. In both figures a dotted line indicates as before the frontal plane passing through the anterior edge of the lamina cribrosa, i.e.

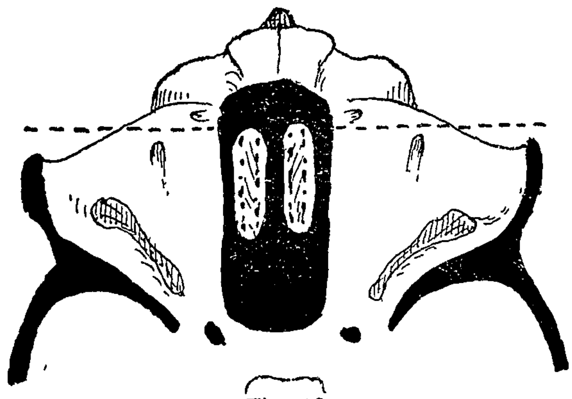

Fig. 12.

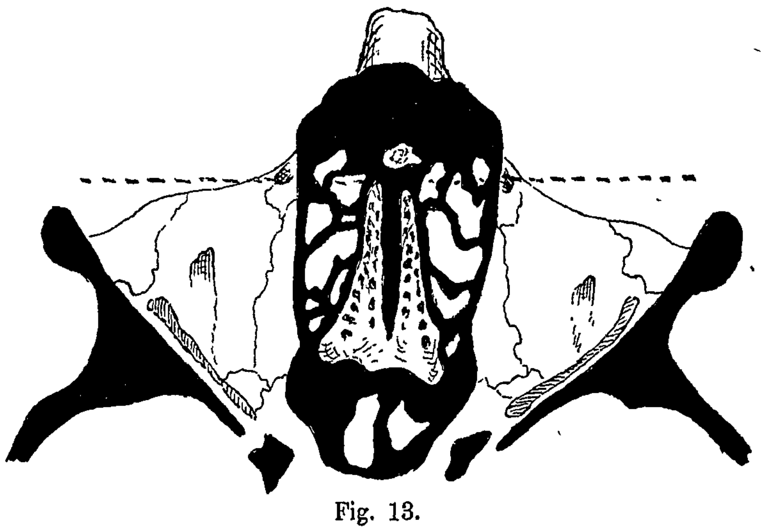

Fig. 13.

through the anterior border of the cranial cavity. When therefore we wish to answer the question whether the orbits are also in man shifted during growth, and, if the answer is affirmative, to what extent this happens, we have only to compare the position of the orbits in both figures with regard to this line. It then appears that there is no evidence of such a shifting. For in the infantile as well as in the adult skull nearly the whole orbit lies behind this line. As to the topography of the orbits with regard to the cranial cavity, in man no change is observed during growth, such as was found with the Anthropoids. We come to the same conclusion when comparing the anatomy of the lateral wall of the orbits in the two figures. When dealing with the Gorilla skulls it was pointed out that in the infantile skull two parts could be distinguished in this wall, an intracranial part, partitioning the orbital and cranial cavities, and an anterior part, bordering the orbit outwardly. Between these two parts the cranial wall joins the orbital wall. In the adult Gorilla the intracranial part has disappeared, the cranial wall is attached to the posterior part of the orbital wall.

In man nothing appears of these altered anatomical relations. As well in the young as in the adult skull the intracranial part is found, which means that in the adult as well as in the infantile skull the posterior part of the lateral wall of the orbit has remained a partition between this and the cranial cavity. In man the orbital cavity always enters into the cranial cavity, which is moreover proved by the fact that the frontal wall of the cranial cavity is attached along the anterior border of the roof of the orbital cavity, as well in infantile as in adult skulls.

Thus in regard to the phenomena of growth in the orbital region of the skull there is a very noticeable difference between man on one side and the Anthropoids on the other. This difference is that in man infantile topographical relations remain permanent. In their juvenile stage these relations are the same in man as in the antropoid apes. While in these latter they are replaced by other relations, however, so that the adult skull becomes very unlike the infantile one, the human skull retains its infantile cranial characteristics. As has been stated in the beginning of this paper, the same holds good for the Foramen magnum. From this ensues that when we compare the human and anthropoid skull those of the anthropoid apes may not be considered as primitive forms from which the human skull should be derived.