

## THE INTERNAL STRUCTURE OF THE SPHENOIDAL SINUS.

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THE internal structure of the sphenoidal sinus varies greatly in different skulls and on opposite sides of the same skull, and the great differences observed may be responsible for the total lack of any previous attempt to determine the arrangement and significance of the ridges and septa which are frequently found therein. Examination of a large number of sinuses (292 belonging to 180 skulls) reveals the fact that, though it is rare to find

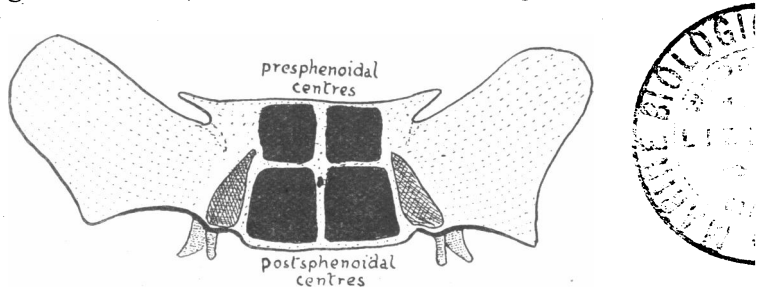


FIG. 1.—A scheme to show the centres concerned in the formation of the sphenoidal sinus. Body centres black, centres for lingulae cross-hatched.

two sinuses exactly alike, there are certain features which recur with such regularity as to enable us to bring a certain amount of order out of seeming disorderly chance-variations.

Before indicating these features we must prepare the way by a brief consideration of a few points relative to the development of the sinus.

The body of the sphenoid is developed from four symmetrically placed bony nuclei, two pre-sphenoidal centres in front and two basi- or post-sphenoidal centres behind. The cartilage between the pre- and post-sphenoidal portions disappears either shortly before or soon after birth; in a sagittal section the line representing its position begins above near the olivary eminence and extends obliquely downwards so that the section of the pre-sphenoidal area approaches the triangular rather than the quadrilateral shape. Along each side of the post-sphenoid area the bone is formed from the lingual centres. Each lingual centre leads to the formation of

a triangular portion of bone with a small base posteriorly (corresponding to groove for the internal carotid artery) and a thin tapering portion which ends in an acute angle opposite the posterior end of the pre-sphenoid. The major part of the lateral aspect of the pre-sphenoid is in contact with the bone formed from the great wing of the sphenoid. The lingual area unites with the body of the sphenoid before birth, but the fusion takes place from above downwards, and for some little time after birth indications of the groove between body and lingula can be seen (see fig. 2). The lingula unites with the great wing at a later date after birth.

The sphenoidal sinus is developed primarily at the expense of that portion of the bone formed from the pre-sphenoidal nucleus. During

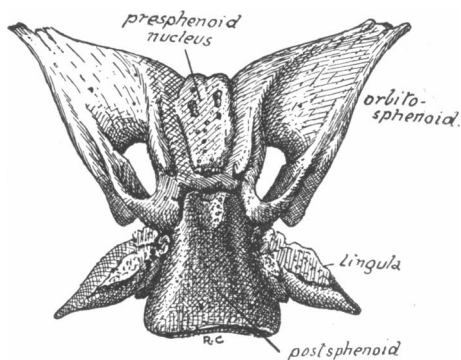


FIG. 2.—Under surface of sphenoid at birth (alisphenoid not present), to show incomplete fusion between lingulae and body centres.

childhood this area becomes almost completely hollowed out, but an antero-posterior septum remains between the two sinuses, and the burrowing air-cavity still respects the boundaries of the areas developed from the nuclei of the post-sphenoid, the lingula, and the great wing. This condition may persist until adult life, but as a rule some time between puberty and adult age the sinus extends backwards or sideways or in both directions. Now there is evidence to show that the bone formed at the line of fusion of two bony centres may be, and often is, of a denser and more resistant nature than the tissue on either side of that line. This fact would account for the restriction of the sinus to the pre-sphenoid during childhood, and would offer an explanation for the frequent incomplete destruction of some of these fusion-barriers by the increased growth-activity of puberty. We hope to show that there are often present in the sinus ridges, crests, or partial septa indicating the position of the lines of fusion between the areas

of bone formed from the nuclei of the pre-sphenoid, post-sphenoid, the lingula and great wing.

When once the barrier between the pre- and post-sphenoid is penetrated, growth is rapid, so that the sinus which first penetrates has the advantage over that of the opposite side, and usurps some of the space which by right should belong to its neighbour. Sometimes, indeed, the sinus of one side fails to break into the post-sphenoidal area, and the other sinus may then occupy three parts of the sphenoidal body. More commonly the struggle

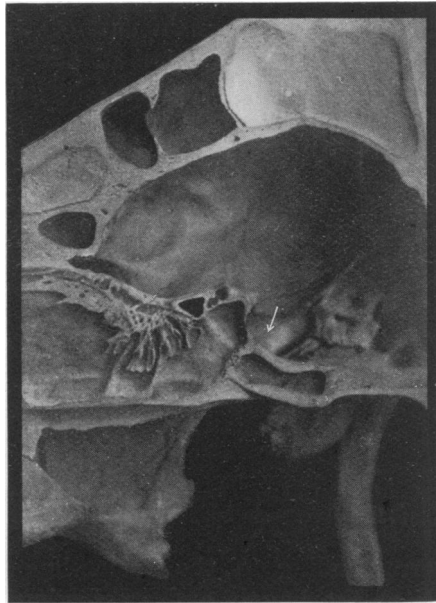


FIG. 3.—Sagittal section of skull of pig, to show synarthrodial joint between pre- and post-sphenoid. (Specimen in R.C.S. Museum, London.)

for the possession of the post-sphenoid results in the deviation of the posterior part of the main inter-sphenoidal septum to one or other side of the mid-line.

If we examine the skull of a pig we gain some help towards understanding the structure and development of the sphenoidal sinus. In the pig there is a synarthrodial joint between the pre-sphenoid and the post-sphenoid. The sinus pushes back through this joint, but the opening made is small, and even after the post-sphenoid has been excavated there remain well-marked medial and lateral elements of the septum between the pre- and post-sphenoid.

Consideration of the mode of development will show that for the sinus to extend laterally to any appreciable extent it must break through either the fusion-barrier between the body and great wing in front or that between the body and lingula behind. But lateral extension is more difficult behind because of the additional fusion-barrier between the lingula and great wing. We should therefore expect that the sinus would more frequently break through into the great wing anteriorly. Observation shows this to be the case, for, though the sinus in a considerable number of cases never bursts out of the body of the sphenoid, when a lateral recess is present it communicates with the main part of the sinus through an opening corresponding to the lateral aspect of the pre-sphenoid, and is separated from the posterior part of the sinus by an incomplete antero-

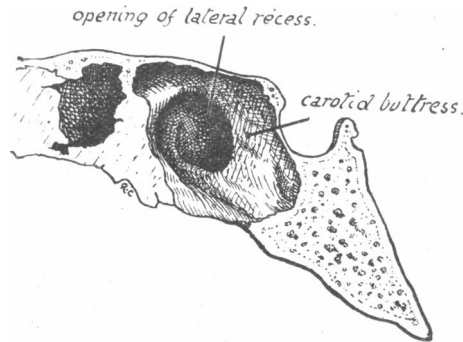


FIG. 4.—Sagittal section of sphenoid, showing opening into lateral recess in front of carotid buttress.

posterior septum corresponding to the fusion-line between the post-sphenoid and lingula or the lingula and great wing.

Sometimes the posterior ethmoidal cells push back into the pre-sphenoidal area and overlap the sphenoidal sinus, but I have never yet seen a specimen in which the ethmoidal cell had succeeded in penetrating the post-sphenoid area; the septum of bone separating the ethmoid and sphenoidal sinuses in these cases corresponds in position to the pre-post-sphenoidal fusion-line.

Sphenoidal sinuses may usefully be classified, according to the amount of their extension backwards, into (a) pre-sphenoidal sinuses which are confined to the pre-sphenoid; (b) post-sphenoidal sinuses which extend back almost to the clivus; and (c) sinuses of an intermediate size in which the post-sphenoid is only slightly encroached upon. Of the 292 sinuses which I examined, 155 were post-sphenoidal, 72 pre-sphenoidal, and 65 intermediate in type. It is quite clear that in a sinus confined to the pre-sphenoid there

are not likely to be any septa apart from the lamella which separates the right sinus from the left, so that the following account of the internal structure refers for the most part to the sinuses of the post-sphenoidal and intermediate types.

We will consider the internal structure of the sinus under the following heads:—

1. Inter-sphenoidal septum.
2. Transverse sphenoidal septum (trans-sphenoidal).
3. Carotid buttress.
4. Recesses from the main sinus.
5. Bulges into the sinus.

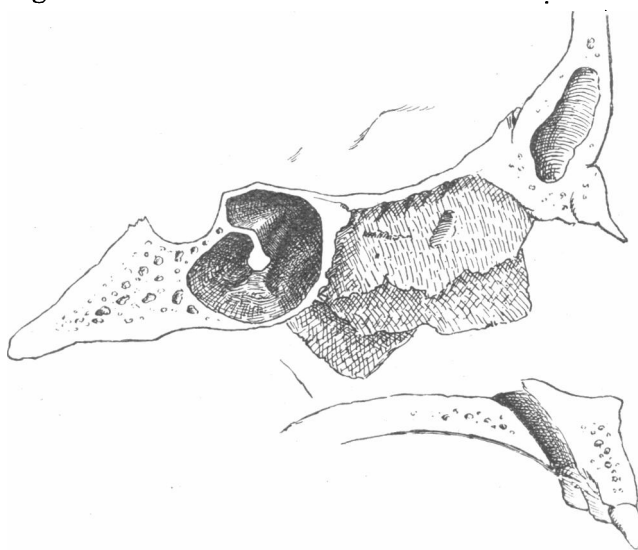


FIG. 5.—Sphenoidal sinus, showing trans-sphenoidal septum.

1. The pre-sphenoidal portion of the inter-sphenoidal septum is usually median in position and antero-posterior in direction. It is not uncommon, however, for it to be slightly to one or other side of the median line. The post-sphenoidal portion of the septum more commonly deviates from the middle line, and sometimes bends almost at right angles to the anterior part so as to form the posterior wall of the opposite sinus. Quite a common attachment posteriorly is to a point corresponding to the situation of the internal carotid artery, so that if the surgeon relied on the septum to guide him to the pituitary fossa he would frequently make a serious mistake.

2. The "trans-sphenoidal septum" is the name best suited to express the

remaining portion of the barrier between the pre- and post-sphenoid. If the element is small, the term "trans-sphenoidal crest" or "ridge" may be used. The common position for this ridge is in the roof of the sinus just behind the level of the olivary eminence or tuberculum sellæ. More rarely the ridge will be found on the floor of the sinus. When the unabsorbed part of the septum is that section attached to the lateral wall, it forms a buttress for the carotid artery, and will be described under that heading. The crest on the roof of the sinus is to be found in about a fourth or a fifth of all sinuses. Much more rarely that part of the septum attached to the floor of the sinus persists, so that we have some ground for concluding that the growing air-cell penetrates first into the lower part of the post-

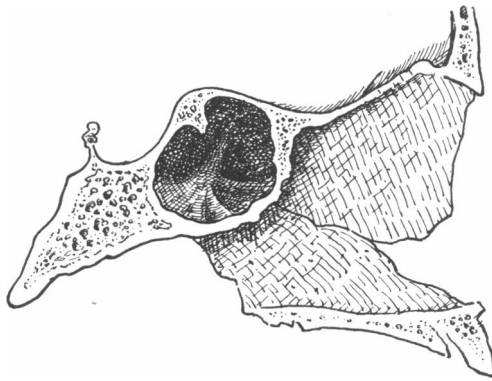


FIG. 6.—Sphenoidal sinus, showing trans-sphenoidal ridge and carotid buttress formed by lateral part of trans-sphenoidal element.

sphenoid. Sometimes the crest is present on both sides, but quite commonly only in the sinus of one side.

3. In skulls in which the sinus does not extend so far laterally the internal carotid artery is supported by the lingula and the lateral wall of the sphenoidal body; but in addition it may have other supports, and when lateral extension takes place there is need of some supporting process if the artery is not to encroach on the sinus. I have applied the term "carotid buttress" to the various special supports which prop up the roof of the sinus in the region of the carotid bulge. The carotid buttress may be derived from different elements:—

(a) It may be formed by the lateral portion of the trans-sphenoidal septum. In this case it will be found as a vertical ridge or partial septum with the free edge directed transversely towards the inter-sphenoidal septum.

(b) The buttress may be derived from the median part of the trans-

sphenoidal septum. In such a case, which is much rarer than the first variety, it is attached to the inter-sphenoidal septum, and the free crescentic edge extends across the sinus like part of a Gothic arch.

(c) The third type of buttress is found in those sinuses with a lateral extension into the lingula and great wing. It consists in an antero-posterior septum attached posteriorly and with a free crescentic edge in

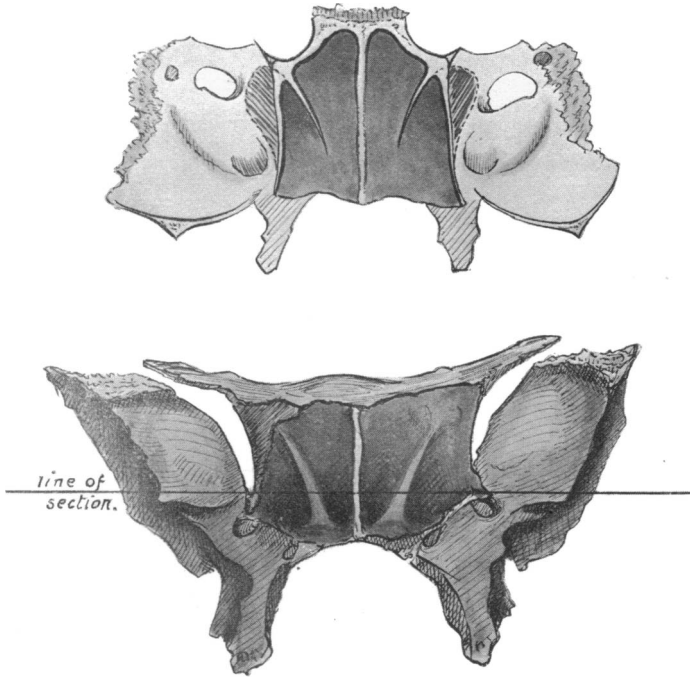


FIG. 7.—Sphenoid opened from the front to show antero-posterior type of carotid buttress. The upper figure is the upper aspect of lower part of bone divided at level of line.

front. It corresponds in position with the line of junction of the body of the sphenoid and the lingula, or in some cases possibly with the line between the lingula and great wing. External to this buttress is the lateral recess.

(d) Sometimes the posterior attachment of the inter-sphenoid septum is opposite the carotid bulge, and therefore a deviated septum should be regarded as an occasional carotid support or buttress.

In the pre-sphenoidal type of sinus one may often see a posterior ridge indicating the anterior end of the fusion-line between the body of the sphenoid and the lingula.

4. *Recesses from the main sinus.*—The fully developed sinus may confine itself to the body of the sphenoid, but more frequently there are extensions laterally, forwards or backwards.

The lateral recess extends outwards from the side of the body of the sphenoid into the great wing and lingula. I found a well-marked lateral recess in 72 cases out of 292 sinuses examined. Many others in which the septum between the body and lingula was not present should be included if we wish to estimate the relative frequency with which the sinus extends laterally from the body. The lateral recess is bounded medially by the antero-posterior carotid buttress when present, and laterally reaches out to a variable extent, frequently as far as the maxillary nerve, and rarely travelling through the pterygoid process to the surface of the skull below the infra-temporal crest. I have seen several specimens of the last-mentioned variety in human skulls—a fact of interest in that it is the normal condition in the gorilla and chimpanzee. Under the floor of the lateral recess lies the Vidian nerve, and above its roof are the carotid artery and cavernous sinus.

The anterior recess is not so frequently present. It was noted in 13 cases of the series examined, *i.e.* 5 per cent. It extends forwards, outwards, and slightly downwards from the region below the optic nerve, and usurps the position usually occupied by the posterior ethmoidal cells and cell of orbital process of palate, with which it has no communication. In 2 or 3 per cent. of all sinuses the anterior recess is in relationship with the postero-superior wall of the maxillary antrum, from which it may be separated by a transparent shell of bone.

Very rarely a backward prolongation of the sinus into the basi-occipital may merit the name of a posterior recess. There is sometimes a shallow sub-optic recess beneath the prominence caused by the optic nerve, and more rarely an extension into the lesser wing and anterior clinoid process above the optic nerve constituting a supra-optic recess.

We may here with advantage enumerate the various forms which the ground-plan of the sinus assumes. The accompanying diagrams (fig. 8) represent sections through the sinus parallel to its floor. Dotted lines indicate the junction between pre-sphenoid, post-sphenoid, lingula, and great wing; the outline of the triangular lingual area is thus clearly indicated.

1 and 2 show simple pre-sphenoidal and post-sphenoidal types respectively. 3 shows pre-sphenoidal sinuses with small lateral recesses. In 4 the lateral recess is well marked, and the antero-posterior carotid buttress is shown. 5 indicates a common type, in which the sinus of one side occupies the whole of the post-sphenoid. 6 is a rare form, which I have only seen once or twice, in which the sinus of one side has extended so far across as to



form a lateral recess on the opposite side; ridges corresponding to the post-sphenoid-lingula line were clearly seen in this case. 7 is the ground-plan of a pair of sinuses with lateral and anterior recesses. 8 shows a condition which is unique in the series I have examined; in it the sinus apparently was unable to break through the region of the trans-sphenoidal septum, and so on the right side it forced its way from the pre-sphenoid out into the great wing and then entered and hollowed out the post-sphenoid from its lateral aspect. The front part of this specimen was missing.

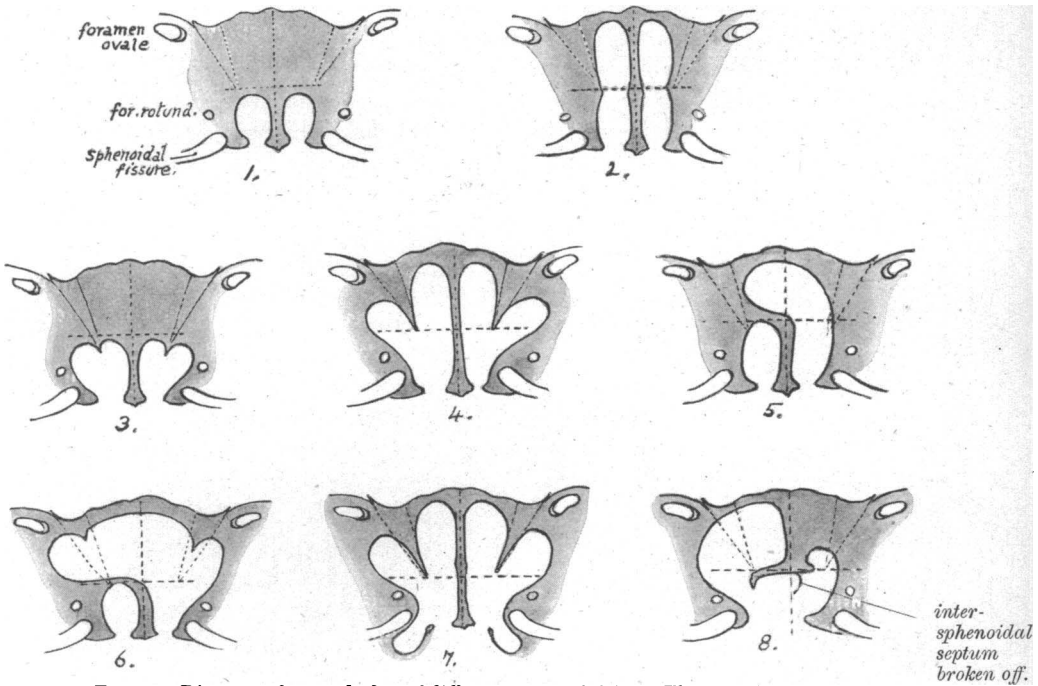


FIG. 8.—Diagram of ground-plan of different types of sinus. The cavities are as they would be seen from above.

5. *Bulges into the sinus.*—The following bulges, caused for the most part by vessels and nerves, may be seen in the walls of the sphenoidal air sinuses:—

- (1) Pituitary.
  - (2) Carotid.
  - (3) Optic.
  - (4) Vidian
  - (5) Maxillary
  - (6) Spheno-palatine—in the anterior recess.
- } in the lateral recess.

(1) The varying relations of the pituitary fossa to the sphenoidal sinus may be shown by diagram. The bulge is absent in the pre-sphenoidal type, slight in the intermediate form, and well marked in a fair proportion of the post-sphenoidal sinuses. When a trans-sphenoidal crest is present it may mask the pituitary bulge, but at the same time indicate accurately the antero-inferior part of the fossa. The pituitary bulge is frequently not so marked as the carotid bulge with which it is continuous, and it is sometimes a little difficult to say from an internal inspection of the sinus where one ends and the other begins.

(2) The most constant part of the carotid bulge is that corresponding to the bend under the anterior clinoid process. This frequently causes a prominence even in sinuses of the pre-sphenoidal type. In sinuses of the post-sphenoidal type the artery may cause a sinuous convexity along the lateral aspect of the wall of the cavity. The carotid bulge is frequently partly hidden by the bony buttresses which support it. When there is a well-developed lateral recess the artery lies wholly on the roof of the sinus.

(3) The optic nerve frequently causes a bulge into the antero-superior part of the sinus, and, according to the degree of its projection into the cavity, there may be developed supra- or infra-optic recesses.

(4) When the lateral recess extends sufficiently far out, there may be slight or even well-marked bulging caused by the maxillary division of the fifth cranial nerve. When the sinus extends beyond the foramen rotundum the nerve will sometimes bulge into the roof of the cavity. In 50 cases of this series there was a maxillary bulge.

(5) The Vidian nerve may also cause a bulge, or, strictly speaking, a ridge, on the floor of the lateral recess. In two or three specimens part of this ridge has been wanting in the dried bone, and clearly the nerve must have been separated from the interior of the cavity by a thin layer of soft tissues. The Vidian ridge or bulge was seen in 25 cases in this series.

(6) When the anterior recess is well marked, a vertical bony pillar will be seen leading down from the spheno-palatine foramen and marking the lateral boundary between the main cavity and the anterior recess. This bulge could appropriately be called the spheno-palatine pillar. It is caused by the vessels and nerves descending from the spheno-maxillary fossa.